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Intervention study shows suboptimal growth among children receiving a food supplement for five months in a slum in Bangladesh

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Abstract

Aim—This study assessed weight and height changes among underweight children who received a locally produced, cereal-based, ready-to-use supplementary food.

Methods—We recruited 500 underweight Bangladeshi children aged 6–23 months from a Dhaka slum and individually matched them by sex and neighbourhood with 480 well-nourished controls. The intervention group received the daily food supplement for five months and both groups received daily micronutrient supplements. Their weight, height, mid-upper-arm circumference and head circumference were measured monthly.

Results—The children's mean daily weight gain decreased from 1.27 to 0.66 grams per kilogram per day (g/kg/day) in the intervention group and 0.77 to 0.49 g/kg/day in the controls after adjusting for age differences between the two groups from baseline to five months of follow up. The mean monthly height gain decreased from 1.13 to 1.03 millimeters per metre per month in the intervention children and 1.26 to 1.01 in the controls. The weight gain was highest in the intervention children who were most wasted at baseline and the controls who were least stunted.

Conclusion—The children showed suboptimal growth despite food supplements, highlighting the need for ongoing research to develop inexpensive, locally-sourced food supplements to improve the nutrition of underweight children in Bangladesh.

Keywords

Bangladesh; children; growth; malnutrition; ready-to-use supplementary food

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INTRODUCTION

Childhood under-nutrition remains a serious global health problem, particularly in South Asia and sub-Saharan Africa, and is recognised as the leading underlying cause of mortality among children in low and middle-income countries (1). Moderate childhood underweight, one manifestation of childhood under-nutrition, is defined by weight-for-age Z scores (WAZ) of -3 and <-2 . Globally, more than 100 million children under five years of age are underweight, and these children account for 14% of total mortality among under fives (2). In Bangladesh, 33% of children under five are underweight (3), as a result of poverty and food insecurity, a lack of variety in their diet, inadequate child feeding practices, poor access to and use of health services and poor sanitation (4). The caregivers of these children in Bangladesh are typically given just health and nutrition education, but this type of intervention has shown limited effectiveness (5).

The former National Nutrition Program of Bangladesh provided a cereal-based, ready-to-use supplementary food called the Pushti packet, which was prepared by local community health workers, in addition to dietary counselling, for the management of underweight children. The Pushti packet was an unfortified mixture of toasted rice powder (26.3g), roasted lentil powder (13.2g), molasses (6.6g) and vegetable oil (3.9g) (6). The total energy obtained from one 50g Pushti packet was 188 kilocalories. Moderately underweight children were prescribed two packets per day and severely underweight children were prescribed three packets. However, there is limited evidence to suggest that the Pushti packet was an effective choice for increasing body weight among underweight children. Severely malnourished children are capable of supporting a weight gain of 8g/kg/day (7) and it has been recommended that the diets of moderately malnourished children support a weight gain of at least 5g/kg/day (8). However, there are few details in the literature on the desired, practicably attainable or actual rates of growth among moderately underweight children in a country like Bangladesh, particularly in the context of a community intervention programme. The lack of evidence regarding an optimal intervention, and its expected impact, has been a major deterrent to effective programming for the huge population of rural and slum children living in Bangladesh and other low and middle-income countries.

This study was conducted to measure the weight and height gain among underweight slum children supplemented with daily Pushti packets for five months, and among un-supplemented well-nourished controls. We compared each groups' rates of absolute and relative weight and height gain at baseline, five months and 12 months after enrolment. The study also sought to identify the independent contributions of different baseline characteristics on predicted gains in both weight and height within each study group from baseline to five months of follow up.

PATIENTS AND METHODS

Participants

This intervention study was conducted in the Bauniabadh section of Mirpur, a sub-district of the Bangladeshi capital, Dhaka. Bauniabadh, a typical urban slum, is one of eight field sites

covered by the Malnutrition and Enteric Infections: Consequences for Child Health and Development Network study (MAL-ED) (9). In 2009, a child feeding centre was established in Bauniabadh to provide supplementary feeding for moderately and severely underweight children. The feeding centre is staffed by trained and experienced field workers and supervised by a physician. In this study, local children aged 6–23 months presenting with moderate or severe underweight at the centre between February 2009 and April 2011 were eligible for inclusion in the study's intervention group. If a child was severely underweight with a WAZ of <-3 , he or she was referred to the site clinic for nutrition counselling and treatment. Children who were identified as severely malnourished, with a weight-for-height Z-score (WHZ) of <-3 and, or, bilateral pedal oedema were referred to icddr,b, formerly known as the International Centre for Diarrhoeal Disease Research, Bangladesh at Dhaka hospital, for treatment. Each intervention child was matched with a well-nourished control, with a WAZ of >-1 , of the same sex and from the same neighborhood in the Bauniabadh area. We excluded Children with evidence of severe diarrhoea or pneumonia, persistent diarrhoea, a cleft lip or palate, blindness, tuberculosis, jaundice, neurologic handicap, renal or cardiac failure at enrolment.

Description of study groups

The intervention children began receiving the Pushti packet supplements when they enrolled in the study and moderately underweight children were provided with two Pushti packets, containing 376 kilocalories, every day for a maximum of five months. At least one daily sachet was administered under direct observation at the feeding centre and the other was to the child to eat at home. Severely underweight children received a third Pushti packet per day, giving them an additional 188 kilocalories. Both the intervention and control groups initially received one sachet of *Monimix* micronutrient powder (Renata Limited, Dhaka, Bangladesh), containing 12.5mg of iron, 5mg of zinc, 300µg of vitamin A, 150µg of folic acid and 50mg of vitamin C, every day for two months. Participants who enrolled after August 2010 received daily packets for four months. The intervention and control children who were at least one year of age received 200mg of the antihelminthic drug albendazole upon enrolment. In both groups, diarrhoeal episodes were treated with oral rehydration solution and oral zinc treatment in line with the World Health Organization and UNICEF recommendations, which are 20mg of zinc sulfate daily for 10 days, with a half the dose for infants. All the children received typhoid, hepatitis B and *Hemophilus influenzae* vaccines. In addition, the caregivers of the intervention and control group children were encouraged to have their children vaccinated against poliomyelitis, tuberculosis, diphtheria, pertussis, tetanus and measles at the nearest vaccination centre.

Health and nutrition education was at the core of the behavioural change communication for both the intervention and control groups. Caregivers of all children were strongly encouraged to attend health and nutrition sessions that took place at the feeding centre every week. Each session focused on selected health and nutrition issues, preferably one issue at each session. Issues included preparation of nutritious food using ingredients available to the family, the importance of hand washing, sanitation and immunisation, home management of diarrhoea, and how to recognise the warning signs of common childhood illnesses. Pretested

information, education and communication materials were used during the sessions, which were conducted by trained field research supervisors.

Data collection

Each child had his or her weight, height, mid-upper-arm circumference (MUAC) and head circumference measured at baseline and every following month for 12 months. Seca 727 digital scales were used to measure weight to the nearest 100 grams (Seca, Hamburg, Germany). Trained field staff measured standing height or length to the nearest 0.1cm using a locally manufactured stadiometer (icddr,b, Dhaka, Bangladesh). MUAC and head circumference were measured using specialised tape measures. Data on household food insecurity, the child's early feeding practices, household assets, income and size and the mother's age, index (BMI) and education were obtained at enrolment using questionnaires from the MAL-ED study. Of these variables, only infant and young child feeding practices were assessed after baseline at months one, two, three, four, five, nine and 12 using a monthly recall instrument administered to the caregiver, which included 24-hour recall of food groups and indicators of appropriate breastfeeding and complementary feeding practices.

Statistical analysis

The mother's BMI was calculated using her height and weight. For each month, each child's Z scores of weight-for-height (WHZ) and height-for-age (HAZ) were calculated based on World Health Organization child growth standards (10). Baseline household food security data were used to calculate a household food insecurity access index scaled from zero to 27 (11) and principal component regression was applied to household assets data to derive an assets scale (12) from zero to 100. A monthly average dietary diversity score was calculated for each child by averaging the number of food groups recalled across all available monthly recalls for the infant and young child feeding practices.

Baseline characteristics were tabulated as means and standard deviations for continuous measures and numbers and percentages for categorical measures. For each monthly interval, we estimated the mean daily absolute change in weight in grams per day and the monthly absolute change in height in millimetres per month (mm/mo) were estimated by subtracting the previous month's measure from that of the current month and dividing the result by 30 days in the case of weight (7). Mean relative weight and height change were expressed as grams per kilogram per day (g/kg/day) and millimetres per metre per month (mm/m/mo) respectively, by dividing daily absolute weight changes and monthly absolute height changes by the previous month's recorded mass and height measurement in terms of kilograms and metre, respectively. To control for differences in the baseline age distribution between the intervention and control groups, the mean rates of growth were adjusted for a third-order polynomial of baseline age, calculated as age plus age squared plus age cubed. For selected monthly intervals - zero to one, five to six and 11 to 12, two-tailed independent-samples t-tests were conducted to determine whether differences in absolute and relative changes in weight and height between the intervention and control children were statistically significant at $\alpha=0.05$. With 95% confidence and 20% attrition, a minimum sample size of 500 for each

study group was identified as necessary to detect a difference in mean relative weight gain of at least 0.2g/kg/day between the groups (13).

Within each study group, two multivariable linear regression models were run to estimate the independent effects of baseline child, maternal and household characteristics on absolute changes in weight-adjusted-for-height in grams and height in millimetres between zero and five months. Weight-adjusted-for-height is a residual-adjusted measure that is assumed to be independent of height, calculated by regressing weight onto height and extracting the resulting residuals (14). Given the degree of heterogeneity with respect to the baseline characteristics between groups, stratified models were run by study groups rather than a pooled model in which a group term was included as a covariate. Comparisons of stratified models were strengthened by including the same covariates in both the intervention and control models. In both the intervention and control models we included the child's baseline WHZ, HAZ, age, sex, length of exclusive breastfeeding and dietary diversity score, household food security score, mother's baseline age, education and BMI and household income and size. The child's baseline age was modelled using both a linear and a quadratic term to account for nonlinear associations. For each model, all pair-wise interactions were tested between the variables sex, baseline age, WHZ and HAZ. Linear models were fit using the GENMOD procedure in SAS version 9.13 (SAS Institute, Cary, North Carolina, USA).

A separate set of multivariable regression models were run for each study group using the same outcome and explanatory variables as in the linear models, in which child's baseline WHZ, HAZ and age were modelled as generalised additive functions (15) using penalised splines (16) to assess potential nonlinearity in these variables' associations with change in weight-adjusted-for-height and height across the range of the observed distributions of the explanatory variables. The statistical significance of each predictor was calculated using a Wald test comparing the estimated effect of each predictor to the null hypothesis of no effect (17). Nonlinear models were fitted using the GAM package in R version 3.11 (R Foundation for Statistical Computing, Vienna, Austria).

Ethical approval

Ethical approval was obtained from the icddr Institutional Review Board. Informed and signed consent were obtained individually from the caregivers of the participants and all data were coded to remove identifying information and to ensure confidentiality.

RESULTS

Of 1,156 children we screened, 980 (87%) were enrolled in the study, with 500 assigned to the intervention group and 480 to the control group. The numbers of intervention and control children who were followed up for at least five months were 391 (78.2%) and 371 (77.2%), respectively. Figure 1 describes the study profile. No two children came from the same household. No adverse reactions to the Pushti packet were observed or reported. Baseline characteristics of the intervention and control children are provided in Table 1.

Figure 2 provides plots of the age-adjusted mean rates of absolute and relative weight and height gain for each study group for each monthly interval, as well as each group's mean

monthly WAZ and HAZ. The corresponding numerical estimates for rates of weight and height growth are provided in Table 2 for selected intervals. Between months zero and one, the mean daily absolute weight gain among the intervention children significantly exceeded that of the control group (8.70 versus 6.57 g/day, $p<0.001$), as did the mean daily relative weight gain (1.27 versus 0.77 g/kg/day, $p<0.001$). Differences in the mean daily absolute weight gain between the study groups were not significant at months five to six or 11 to 12, but the mean relative weight gain was significantly greater in the intervention than the control group at months five to six (0.66 versus 0.49 g/kg/day, $p=0.036$) and months 11 to 12 (0.69 versus 0.52 g/kg/day, $p=0.045$). The difference in the mean absolute change in height was only significant at months zero to one, at 7.70 mm/mo in the intervention versus 8.97 in the controls ($p=0.011$).

In both study groups, a precipitous and lasting decline in the mean rate of absolute and relative weight gain was observed after the first month of enrolment, while mean absolute and relative height gain peaked during the third month and steadily declined over the course of the study (Figure 2). Mean WHZ remained close to zero among control children throughout the study period, while WHZ increased steadily among the intervention children, who were significantly more wasted at baseline. Mean HAZ decreased at approximately the same rate in both groups and the intervention children were significantly more stunted at baseline than the control group..

The results of the linear regression models for change in weight-adjusted-for-height are displayed in Table 3. Intervention children who were more wasted at baseline gained significantly more weight-adjusted-for-height after five months of follow up, with 17.6g gained for each 0.1 unit decrement in baseline WHZ ($p<0.001$). Baseline WHZ was not significantly associated with the change in weight-adjusted-for-height among controls. Conversely, baseline HAZ was not associated with the change in weight-adjusted-for-height among intervention children, but was positively associated with gains among the controls (10.1g per 0.1 increase in HAZ, $p=0.004$). In both study groups, the baseline age in months exhibited a U-shaped association with the changes in weight-adjusted-for-height, particularly among the controls. The estimated contributions of baseline WHZ, HAZ and age on changes in weight-adjusted-for-height in each study group are plotted in Figure S1 as predictions from the nonlinear model.

Table 4 shows the results of the linear regression models for change in height. Among the intervention children, baseline WHZ was positively associated with change in height (0.4mm per 0.1 increment in WHZ, $p<0.001$). The association between baseline WHZ and height gain in controls was also positive but marginally significant ($\beta=0.2$, $p=0.069$). In both study groups, baseline HAZ was negatively associated with height gain (−0.4mm in intervention and −0.2mm in controls, $p<0.001$ and $p=0.006$, respectively). Baseline age was negatively associated with height gain among the intervention group in a linear fashion (−1.4mm per month, $p=0.072$), while being marginally negatively associated among the controls ($\beta=-1.3$ mm per month, $p=0.085$). Figure S2 provides predictions for the effects of baseline WHZ, HAZ and age on height gain from the nonlinear model.

Average monthly reported dietary diversity was associated with increased height gains in both the intervention and controls of 2.4mm and 1.6mm respectively ($p=0.001$ and $p=0.013$) (Table 4). Other variables positively associated with height gain among the intervention children were length of exclusive breastfeeding (0.8mm per month, $p=0.024$), mother's baseline age (0.3mm per year, $p=0.027$) and mother's education (0.6mm per year, $p=0.009$). Although sex was not significantly associated with height gain in the intervention or control groups, a significant interaction was observed between sex and baseline HAZ in the intervention group ($p=0.007$), with each 0.1 decrement in baseline HAZ being associated with a 0.4mm greater change in height among the girls than in boys (data not shown).

DISCUSSION

Ready-to-use supplementary foods made from local ingredients are an appealing choice for improving complementary feeding, in that they are relatively cheap to manufacture, are usually accepted by children and have been shown to be effective in preventing or ameliorating child malnutrition in diverse populations (18). In this intervention study, malnourished Dhaka slum children with a WAZ of less than -2 were provided a locally-prepared, rice and lentil-based food supplement daily for five months and their growth was compared to that of well-nourished un-supplemented controls individually matched by sex and neighbourhood and with a WAZ of more than -1 . Exceedingly suboptimal growth was observed in both groups during the study and this indicates that the Pushti packet was an ineffective measure for improving public nutrition and further highlights the severity of malnutrition among slum children. These results provide support for the development of more nutritious food supplements in Bangladesh and evidence about how such supplements might be strategically administered and what kind of gains might be elicited.

Ethical considerations precluded the use of a malnourished control group in this study. The study was therefore unable to isolate the effect of the food supplement per se, as there were important biological and socioeconomic differences between the intervention and control children, aside from the provision of the food supplement, which might have been responsible for the observed differences in growth between the two groups. Instead, this study was designed to describe the pattern and determinants of growth within a group of malnourished food-supplemented and well-nourished un-supplemented controls and, while the food supplement may have improved growth in the intervention group, this effect could not be quantified. Furthermore, lack of a malnourished control group warranted analyses stratified by study group, which reduced our statistical power to identify the factors associated with growth. On the other hand, as the growth of malnourished controls was expected to be slower than that observed in the intervention group, the well-nourished controls provided a useful alternative contrast as they gave an idea about whether the food supplementation would allow their malnourished counterparts to attain similar growth rates and anthropometry. A similar experimental design was employed effectively in a study of multiple micronutrient supplementation among premenarchal girls in India (19). A second important limitation of our study was that children in the intervention and control groups were not matched by baseline age and this meant that the age-distributions of the children in each group were significantly different from one another. To address this, we have presented

baseline age-adjusted measures of growth in each study group, in order to validly compare the monthly growth of children aged 6–23 months at baseline.

Despite variations attributable to baseline age and anthropometry, and the positive effects of other selected predictors such as dietary diversity of complementary foods, length of breastfeeding and the mother's age and education, the overall pattern of growth was extremely suboptimal in both study groups. Among the malnourished intervention children, the maximum observed relative weight gain did not exceed 1.27 g/kg/day. Despite some improvement in WHZ among the intervention children over the full 12 months of observation, a significant secular decline in mean HAZ was observed in both study groups. There are several possible reasons for these findings. Our results show that 43% of the study households were food insecure, which was 8% above the national average (3), and food insecurity has been associated with insufficient or inconsistent provision of calories, nutrients, and inadequate feeding practices (4). Secondly, the Pushti packet was only moderately dense in carbohydrates and energy and a poor source of oils, protein or micronutrients. Based on its composition, supplementation would not necessarily have been expected to dramatically improve the quality of complementary feeding, which is generally poor in Bangladesh (20,21). To attain the desired weight gain, a severely malnourished child weighing 7.0–8.4kg would need three 92g food supplement packets per day, containing 1,500 kilocalories in total, which is 266% of the calorific content of three Pushti packets (22). Severely malnourished children in this study would have therefore had to consume 936 kilocalories per day through complementary foods, which may have been difficult to achieve. Thirdly, environmental enteropathy, which has been implicated in poor growth among children in rural Bangladesh (23), may also be an important factor with respect to this study population, in which over a third of households lacked access to a sanitary latrine, despite almost universal (98%) access to piped water, and in which incidence of diarrhoeal disease was high at 4.69 episodes per child per year (24). The environmental and economic deprivation observed in this slum population may have significantly blunted the response to food supplementation in both study groups. Such effects were difficult to characterise given our stratified analysis and the fact that all of the children lived in the same slum, but were probably at least as important as the apparent contributions of baseline age and anthropometry. It is likely that improving sanitation, food security and poverty would have augmented the effectiveness of food supplementation in this setting (25).

When we controlled for baseline WHZ, HAZ and age, gains in weight-adjusted-for-height were observed to be greatest among the most wasted and least stunted children, whereas gains in height were greatest among the least wasted and most stunted. These findings imply that the wasted children, independent of baseline HAZ and age, were metabolically optimised for weight gain, while the stunted children, independent of baseline WHZ and age, were optimised for catch-up linear growth. Conversely, these findings implicate adequate HAZ as a prerequisite for healthy weight gain and adequate WHZ as a prerequisite for healthy linear growth. Without such prerequisites, metabolic resources may not be optimally allocated for growth. Older children, independent of baseline WHZ and HAZ, exhibited smaller gains in height, presumably because of a more advanced chronological phase that was less conducive to linear growth. The observation that intermediate age children in both study groups, of 12–15 months at baseline, gained the least weight-adjusted-

for-height may reflect a chronobiological effect combined with age-related differences in the intra-household distribution of complementary feeding and childcare.

Taken together, the results of this study suggest that new food supplements the aim to elicit maximum weight gain should be targeted at the most wasted, least stunted children, whereas programmes that aimed to elicit maximal gains in height should target the most stunted, least wasted and youngest children. Such recommendations rely on the assumption that the associations estimated between the baseline characteristics and Pushti packet consumption would be reasonably comparable to those that would be found in another study of a food supplement in Bangladesh. As such, multiple products may warrant formulation to elicit improvements in wasting and stunting most efficiently. In practice, such recommendations should also be aware of not only the maximal attainable growth, but of the appropriate rate at which malnourished children could and should gain weight-for-height relative to gains in height-for-age, in order to prevent wasting as a result of rapid catch-up growth. This important possibility was studied by the pioneering Kingston Project, which provided food supplementation to malnourished Jamaican children (26).

In a preliminary analysis of an earlier study comparing the effectiveness of the Pushti packet and a ready-to-use therapeutic food called Plumpy'Nut (Nutraset, Normandy, France) in underweight Dhaka children, with a WAZ of less than -2 from the same slum of Bauniabadh, Plumpy'Nut was found to be significantly more effective in increasing weight at every month for five months of follow up (Mustafa Mahfuz, personal communication, November 2015). Nonetheless, the potential cost-savings of using a locally produced food supplement has spurred research into more effective alternatives to the Pushti packet. A much larger study of rural Bangladeshi children compared locally developed fortified rice and lentil and chickpea-based food supplements, a fortified-blended supplement called WSB++ (World Food Programme, Rome, Italy), and the Plumpy'Doz (Nutraset, Normandy, France) supplement. This showed that declines in WHZ were smaller in the chickpea-based and Plumpy'Doz groups, but not in the rice and lentil or WSB++ group (27). Although length-for-age (LAZ) declined with age in all study groups, as observed among both groups in this study, the predicted LAZ at 18 months was slightly lower in the rice and lentil group than among the other intervention groups. However, it is likely that both locally produced food supplements would elicit significant improvements over the Pushti packet, which is nutritionally inferior and not as well accepted by children (6). The Bangladeshi National Nutrition programme was phased out in 2011 citing the Pushti packet as an inadequate source of calories and micronutrients (28). This study provides experimental evidence that this was a good decision.

CONCLUSION

Our findings agree retrospectively with the decision to discontinue the Pushti packet. While this experiment was not designed to isolate the effect of this food supplement, the exceedingly poor growth observed among supplemented children strongly suggests that it could not have been highly effective as administered in this setting. These data support ongoing research to develop inexpensive, locally sourced, ready-to-use supplementary foods to improve the nutrition of underweight children in Bangladesh, as well as recommendations

on how such supplements could be most effectively administered to improve growth in weight and height in a population of slum children. This study also suggests that the environmental and economic conditions in slums need to be improved before such food supplements can be effective.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Key Notes

- This study assessed weight and height changes among 500 underweight children from a Bangladesh slum who received a locally produced, cereal-based, ready-to-use supplementary food and 480 well-nourished controls.
- After five months, suboptimal weight and height gain were observed among both the underweight, food-supplemented slum children and well-nourished, un-supplemented controls.
- Research should continue to develop effective, fortified, locally-produced ready-to-use supplementary foods to improve the nutrition of underweight children in Bangladesh.

Figure 1. Study profile

Figure 2. Mean monthly growth rates and anthropometric Z-scores in intervention and control groups

Means are linear least-square means adjusted for a third-order polynomial of baseline age ($\text{age} + \text{age}^2 + \text{age}^3$). Intervention (0–5 months): $n=397$, Control (5–12 months): $n=326$, Intervention (0–5 months): $n=377$, Control (5–12 months): $n=286$.

Table 1

Enrolment characteristics of study population

Characteristic	Intervention		Control		P
	No of obs.	Mean/median or proportion	No of obs.	Mean/median or proportion	
Subject characteristics at enrolment					
Sex (% female)	500	48.4	480	48.33	ns
Birth weight (kg), mean±SD	47	2.66±0.54	83	2.99±0.48	<0.001
First born (%)	499	46.89	479	45.09	ns
Age at enrolment (mo), mean±SD	500	14.23±5.32	480	12±4.91	<0.001
Age distribution at enrolment (%)					
6–8 months	115	23.0	182	37.92	<0.001
9–11 months	81	16.2	88	18.33	
12–23 months	304	60.8	210	43.75	
Weight at enrolment (kg), mean±SD	500	7.14±1.07	480	8.82±1.2	<0.001
Height at enrolment (cm), mean±SD	500	70.35±5.47	480	72.53±5.75	<0.001
MUAC at enrolment (cm), mean±SD	499	13±0.83	479	14.69±1.5	<0.001
Head circumference at enrolment (cm), mean±SD	499	43.19±2.01	480	43.97±1.96	<0.001
Practices optimum IYCF (consuming milk, 4+ food groups, age specific minimum time frequency), %	500	42.0	479	39.04	ns
Length of exclusive breast feeding (mo), mean±SD	494	6.38±1.79	474	6.28±1.58	<0.001
Maternal characteristics					
Age (y), mean±SD	500	24.78±5.37	480	25.05±4.9	ns
Weight (kg), mean±SD	498	43.97±7.72	478	50.11±9.08	<0.001
Height (cm), mean±SD	498	148.24±6.19	478	150.46±5.36	<0.001
BMI, mean±SD	498	20.01±3.25	478	22.12±3.79	<0.001
Education (% , minimum primary)	500	43.4	480	58.54	<0.001
Marital status (% , currently married)	500	98.8	480	99.79	ns
Household characteristics					
Using pipe water for drinking (%)	500	98.8	480	99.38	ns
Using sanitary latrine (%)	500	65.6	480	63.54	ns
Median monthly income, BDT (range)	500	7000 (5000–9000)	480	8000 (6000–12000)	<0.001
Family size, mean±SD	500	4.66±2.0	480	4.69±1.92	ns

Characteristic	Intervention		Control		P
	No of obs.	Mean/median or proportion	No of obs.	Mean/median or proportion	
Living in the same household (<1 year), %	500	42.6	480	36.04	0.036
Wealth index, %					
Poorest	145	29.0	52	10.83	<0.001
Poor	114	22.8	82	17.08	
Middle	96	19.2	99	20.63	
Rich	84	16.8	112	23.33	
Richest	61	12.2	135	28.13	
Household food insecurity access (%)					
Food secure	252	50.4	302	62.92	<0.001
Mildly food insecure	58	11.6	51	10.63	
Moderately food insecure	114	22.8	83	17.29	
Severely food insecure	76	15.2	44	9.17	

ns: not significant at $\alpha=0.05$ level.

Table 2

Mean absolute and relative change in weight and height between 0 and 1, 5 and 6, and 11 and 12 months

Interval	Mean absolute change, g/day or mm/mo (SD)		P	Mean relative change, g/kg/day or mm/m/mo (SD)		P
	Intervention	Controls		Intervention	Controls	
<u>0 to 1 months</u>						
Change in weight	8.70 (8.72)	6.57 (8.96)	<.001	1.27 (1.32)	0.77 (1.05)	<.001
Change in height	7.70 (8.08)	8.97 (8.63)	0.011	1.13 (1.18)	1.26 (1.22)	0.061
<u>5 to 6 months</u>						
Change in weight	5.00 (7.31)	4.86 (8.82)	0.831	0.66 (0.95)	0.49 (0.92)	0.036
Change in height	7.43 (8.64)	7.79 (7.37)	0.529	1.03 (1.16)	1.01 (0.95)	0.776
<u>11 to 12 months</u>						
Change in weight	5.84 (7.60)	5.55 (9.41)	0.689	0.69 (0.88)	0.52 (0.86)	0.045
Change in height	6.54 (5.04)	7.08 (5.28)	0.368	0.86 (0.66)	0.86 (0.66)	0.981

Means are linear least-square means adjusted for a third-order polynomial of baseline age (age + age² + age³). Standard deviations were estimated prior to adjustment. Intervention: n(0–1mo)=347, n(5–6mo)=359, n(11–12mo)=304. Controls: n(0–1mo)=446, n(5–6mo)=343, n(11–12mo)=286.

Table 3

Multiple linear regression to identify factors associated with absolute change in weight-adjusted-for-height (g) between 0 and 5 months

Parameter	Intervention		Controls	
	β	<i>P</i>	β	<i>P</i>
Baseline WHZ (0.1 unit)	-17.6	<.001	-1.1	0.798
Baseline HAZ (0.1 unit)	-1.3	0.583	10.1	0.004
Baseline age (mo.)	-66.6	0.006	-128.8	<.001
Baseline age ² (mo. ²)	2.2	0.006	4.3	<.001
Female sex	-22.9	0.561	-16.0	0.749
Length of exclusive breastfeeding (mo)	13.3	0.258	1.2	0.945
Dietary diversity (avg # food grps/mo)	16.1	0.493	21.1	0.410
HFIA score (0 – 27)	-2.9	0.493	-5.9	0.377
Mother's baseline age (yrs)	-1.0	0.810	2.9	0.606
Mother's education (yrs)	-6.5	0.371	5.1	0.555
Mother's baseline BMI (kg/m ³)	-0.0	0.997	1.6	0.822
Household income (per 1,000 BDT)	0.5	0.925	0.6	0.856
Asset index (0 – 100)	1.6	0.447	-1.2	0.583
Household size (persons)	-9.3	0.437	11.8	0.444

Intervention: n=391, Controls: n=371.

Table 4

Multiple linear regression to identify factors associated with absolute change in height (mm) between 0 to 5 months

Parameter	Intervention		Controls	
	β	P	β	P
Baseline WHZ (0.1 units)	0.4	<.001	0.2	0.069
Baseline HAZ (0.1 units)	-0.4	<.001	-0.2	0.006
Baseline age (mo)	-1.4	0.072	-1.3	0.085
Baseline age ² (mo ²)	0.0	0.815	-0.0	0.699
Female sex	2.1	0.099	-0.1	0.932
Length of exclusive breastfeeding (mo)	0.8	0.024	0.4	0.319
Dietary diversity (avg # food grps/mo)	2.4	0.001	1.6	0.013
HFIA score (0 – 27)	0.1	0.635	-0.1	0.441
Mother's baseline age (yrs)	0.3	0.027	0.0	0.895
Mother's education (yrs)	0.6	0.009	0.1	0.807
Mother's baseline BMI (kg/m ³)	-0.3	0.158	-0.1	0.438
Household income (per 1,000 BDT)	0.3	0.112	-0.1	0.159
Asset index (0 – 100)	-0.1	0.155	0.1	0.207
Household size (persons)	-0.0	0.985	0.2	0.679

Interaction observed between female sex and baseline HAZ (0.1 units) in intervention group: $\beta=-0.4$ ($p=0.007$) (model including interaction term not shown). Intervention: n=391, Controls: n=371.