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Evaluation of a residential nutrition rehabilitation center in rural Bolivia: Short-term effectiveness and follow-up results

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Abstract

Background—Nutrition rehabilitation centers (NRCs) have shown mixed results in reducing morbidity and mortality among undernourished children in the developing world. Follow-up on children after leaving these programs remains undocumented.

Objective—To assess the nutritional improvement of children attending the Centro de Rehabilitación Infantil Nutricional (CRIN), a residential NRC in rural Bolivia, from entrance to exit and to a household follow-up visit 1 month to 6 years later, and to identify factors associated with nutritional improvement.

Methods—A retrospective analysis was conducted of clinical records collected by CRIN staff from 135 children under 3 years of age attending CRIN in rural Cochabamba, Bolivia, from 2003 to 2009, and of clinical records of household follow-up measurements on a subset of 26 children that were taken between 1 month and 6 years postexit. Nutritional status was evaluated by calculating z-scores for weight-for-height (WHZ), weight-for-age (WAZ), and height-for-age (HAZ). Children with z-scores < -2 were considered to be wasted, underweight, or stunted, respectively.

Results—The prevalence of wasting decreased significantly, while the prevalence of stunting did not change significantly between entrance and exit from the program. From entrance to exit, the mean changes in WHZ (0.79) and WAZ (1.08) were statistically significant, while the mean change in HAZ (-0.02) was not significant. Linear regression analysis suggested that nutritional status and diarrhea at entrance had the greatest effect on WHZ and HAZ changes between

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Authors' contributions Kristen M. Forney and Lauren S. Polansky contributed equally to study concept and design and to all phases of data collection and cleaning, performed statistical analyses, and drafted the initial manuscript. Paulina A. Rebolledo contributed to statistical analysis and drafting the manuscript. Katherine Foy Huamani and Katherine E. Mues contributed to the study concept and design and assisted in the initial analysis. Usha Ramakrishnan and Juan S. Leon conceived the study, participated in its design and coordination, and helped to finalize the manuscript. All authors approved the final manuscript.

entrance and exit. Children maintained their nutritional gains from the program between exit and follow-up and showed statistically significant improvement in WAZ (but not HAZ).

Conclusions—CRIN is effective at rehabilitating nutritional deficits associated with wasting, but not those associated with stunting.

Keywords

Childhood undernutrition; diarrhea; stunting; wasting

Introduction

Undernutrition remains a significant cause of morbidity and mortality in children under 5 years of age in the developing world. The impact of undernutrition is most apparent during the critical period for rapid growth and development in a child's life, from conception to 3 years of age [1]. Thus, any intervention addressing childhood undernutrition is most effective when targeting this age range. A variety of approaches are utilized globally to address childhood undernutrition, and it is essential to determine the effectiveness of these strategies for producing positive outcomes. One intervention lacking in evidence-based support is the nutrition rehabilitation center (NRC).

The NRC model was proposed by J. M. Bengoa in the 1950s as a way to address the high rate of child undernutrition in the developing world [2]. Bengoa conceptualized the NRC as a residential or daycare center targeting moderately to severely malnourished children under 5 years of age. Residential nutrition centers were a popular intervention in the 1960s and 1970s; however, their popularity has waned with the development of community- and home-based methods of nutrition rehabilitation. Nonetheless, the NRC model is still being utilized by small nonprofit and nongovernmental organizations in some settings, primarily rural areas where routine access to dispersed communities is difficult.

Globally, there is limited literature evaluating the effectiveness of NRCs, particularly those that are currently operating. Moreover, what literature does exist provides mixed conclusions as to whether NRCs are a successful tool in rehabilitating malnourished children. A review by the World Health Organization (WHO) in 2006 examined results from four studies of NRCs in the Philippines, India, South Africa, and Nigeria [3] and found only the center in South Africa to be effective based on WHO criteria for nutritional rehabilitation. In Ceará State of northeastern Brazil, a World Bank-funded study evaluated 34 NRCs between 1992 and 1994 [4]. Overall, the centers' effectiveness was found to be low, with inadequate rates of weight gain in children and a mean duration of rehabilitation of 8.7 months, exceeding the 4-month recommendation from WHO. Evaluation of two NRCs in an urban area of Brazil showed that although improvement in weight-for-age and weight-for height was substantial, no significant change occurred in the degree of stunting experienced by children over the course of the program [5, 6].

In 1996, the Centro de Rehabilitación Infantil Nutricional (CRIN), a comprehensive residential NRC, was created by the Centro de Promoción Rural “Jesús María” (CEPRUJEM), a faith-based nongovernmental organization (NGO), in response to the high

rates of undernutrition observed in rural indigenous communities located in the Department of Cochabamba, Bolivia [7]. It is the only emergency nutrition program within the area and provides care free of charge for all beneficiaries. Children under 5 years of age are referred to CRIN by affiliated medical doctors if weight-for-height measurement indicates moderate to severe wasting or if marasmus or kwashiorkor is clinically evident. Given the limited access to healthcare facilities in the area, children may also be admitted for severe diarrhea or other infections that might compromise their immediate health.

Although the NRC intervention model continues to be utilized in Latin America, documentation of outcomes is lacking, particularly in rural areas of countries such as Bolivia. Furthermore, there is limited utilization of multivariable modeling approaches in these evaluations to simultaneously assess multiple risk factors. To address many of these needs, the goal of this study was to determine the effectiveness of CRIN in rural Bolivia in reducing the incidence of wasting (low weight-for-height) and stunting (low height-for-age) in children under 3 years of age at the time of exit from the program, and to identify predictors of improved nutritional status within the current NRC program. The results will contribute to the overall evaluation of the NRC model as a potential intervention for malnutrition rehabilitation in rural contexts and add to the nutrition literature utilizing modeling techniques to predict participant success in rehabilitation interventions.

Methods

Study site and study population

The Centro de Rehabilitación Infantil Nutricional (CRIN) is a residential NRC located in the rural community of Anzaldo in the Esteban Arce Province of the Department of Cochabamba, Bolivia, serving children from neighboring indigenous communities.

Children were identified as malnourished by CRIN medical staff during monthly field visits to 65 rural communities if they had moderate-to-severe wasting or clinical evidence of kwashiorkor or marasmus. Following consent from the caregiver, the child was then brought to CRIN for nutritional assessment. Upon admission to CRIN, the child was given a clinical examination, including laboratory tests of blood, urine, and stool. Daily nutritional therapy was based on the WHO guidelines for the inpatient treatment of severely malnourished children [8] and consisted of a freshly prepared milk-based liquid formulation initially containing moderate amounts of energy (75 kcal/100 mL) and protein (0.9 g/100 mL). As the child's clinical condition and appetite improved, a milk-based formula with higher energy (100 kcal/100 mL) and protein (2.9 g/100 mL) contents was substituted. During their stay at the center, the children received psychosocial stimulation from four full-time caregivers, and their growth was monitored by a trained registered nurse and a pediatrician.

This study included only children under 3 years of age who were enrolled in the program between 2003 and 2009. Data from 230 deidentified records of CRIN participants over this time period were reviewed for possible inclusion in the analysis. Records were excluded for any of the following reasons: the child was over 3 years of age at entrance; the child had previously completed treatment at CRIN; the child had edema (which would invalidate z-scores); the child had implausible z-scores for weight-for-height, height-for-age, or weight-

for-age (according to WHO guidelines [9]); or the child stayed less than 7 days in CRIN. Application of the exclusion criteria resulted in a final sample size of 135.

Ethical approval

This study was submitted to the Emory University Institutional Review Board and found to be exempt from review, as it involved secondary analysis of deidentified records received by Emory University researchers from CRIN staff and did not qualify as human subject research.

Data collection

Data corresponding to the child's stay in CRIN were prospectively collected by CRIN staff independently of Emory University staff. Demographic, anthropometric, and clinical data were collected as part of the standard clinical assessments made at admission, at exit, and during weekly evaluations by CRIN medical staff. Demographic variables collected included sex and date of birth (obtained from the child's health card). Clinical data were collected upon admission and included clinical symptoms such as diarrhea, dehydration, respiratory infection, anemia, vomiting, and edema, as well as vaccination status obtained from the child's health card. Anthropometric data collected included height (or length if the child was under 2 years of age) and weight measurements recorded at admission, at exit, and three times weekly for the duration of the stay in the program. Anthropometric measurements were taken and recorded by a trained nurse using a balance beam scale that included a height-measuring rod (SECA) for children 2 years of age or older, or a pediatric balance and an infant meter (SECA), donated by UNICEF-Bolivia, for children under 2 years of age. The dates of admission to and exit from CRIN were also recorded.

Collection of follow-up data from the children was performed independently by CRIN staff during 2008 and 2009, as part of their standard internal CRIN evaluation, on a convenience sample of children who could be located following discharge. Follow-up took place between 1 month and 6 years after the child's exit from CRIN. The criteria for inclusion in the follow-up evaluation by CRIN staff were the following: the child exited CRIN between 2003 and 2009; and a clinical record on file included the child's name, community, sex, date of birth, and height and weight upon entrance and exit from CRIN. A subset of 26 children met the inclusion criteria for follow-up and could be located by CRIN staff. Measurements of height (using measuring tape with the child standing against a wall) and weight (using a SECA floor scale) were taken for each child in duplicate and averaged by CRIN medical staff during the follow-up visit.

A comparison population ($n = 129$) for 26 of the study children at the time of follow-up served to assess the background levels of undernutrition in children from 65 neighboring communities who had never attended the nutritional rehabilitation program. In order to determine background levels of undernutrition in these communities, CRIN medical staff independently performed routine anthropometric surveillance, among other preventive health checks. Upon request from Emory University staff, CRIN staff provided these deidentified community records and restricted the community records to children between 6

and 93 months of age in order to match the age range of the subset of CRIN children at follow-up. After data cleaning, there were 129 records for the community controls.

Data management

CRIN child records created in Bolivia by CRIN staff were deidentified prior to transfer to Emory University researchers, who double-entered the records into Excel, compared and resolved discrepancies to ensure data quality. The data were then imported into SAS statistical software package, version 9.2, for analysis. Entrance and exit z-scores were calculated using the WHO 2007 International Standard Reference Population with the SAS Macro provided free of charge from the WHO Nutrition Database [9]. Z-scores of < -3 , -3 to -2 , -2 to -1 , and > -1 represent severe, moderate, mild, and no malnutrition for each of the three categories of z-score (weight-for-height, height-for-age, and weight-for-age).

Statistical analysis

Statistical analysis was performed with SAS version 9.3. Chi-square tests were used to determine significant differences in wasting, underweight, and stunting prevalence between entrance and exit from the program. The *t*-test was used to compare normally distributed continuous values such as z-score at entrance and change in z-score between demographic groups (e.g., male and female). For all statistical tests, a two-sided *p*-value of less than .05 was considered to indicate statistical significance. For follow-up results, nonparametric tests (e.g., Mann–Whitney) were used due to the small sample size and non-normal distribution of the data. However, for convenience to the reader and in order to compare our results with the results of previous studies, mean values (instead of the median values normally used for nonparametric comparisons) are reported.

Linear regression modeling was used to identify factors associated with changes in weight-for-height z-scores (WHZ) and height-for-age z-scores (HAZ) between entrance to and exit from the program. After determining that linear regression assumptions were met, collinearity and all possible interaction and confounding terms were assessed. Goodness-of-fit assessment and regression diagnostics were also conducted in order to determine the most appropriate model.

Results

Demographics and clinical characteristics of CRIN population

One hundred thirty-five children attending CRIN between 2003 and 2009 were included in the study. At entrance, the majority of the children were stunted or underweight and a smaller proportion were wasted (table 1). Twenty-eight of the 135 children (20.7%) were at high nutritional risk, being both stunted and wasted at entrance.

In order to determine the demographic and clinical factors associated with nutritional status at entrance, we compared z-scores at entrance among demographic and clinical groups. Nutritional status, as measured by WHZ and HAZ, was significantly better (closer to zero) in girls than in boys (table 2). WHZ at entrance was significantly higher in children with parasitic infections than in those who were negative for parasites. Diarrhea status at

entrance, vaccination status, and length of stay in CRIN were not significantly associated with nutritional status at entrance.

Changes in nutritional status between entrance and exit

In order to determine the factors associated with a child's improvement in nutritional status between entrance to and exit from CRIN, changes in WHZ and HAZ were compared according to demographic and clinical characteristics (table 2). Diarrhea at entrance was associated with a significant improvement in WHZ at exit, compared with those without diarrhea. HAZ decreased slightly for nearly all groups, but parasite infections at entrance were associated with a smaller decrease in HAZ between entrance and exit ($p = .054$) compared with those who were negative for parasites. Diarrhea at entrance was associated with a greater decrease in HAZ between entrance and exit ($p = .065$) compared with those without diarrhea. Neither vaccine status at entrance nor length of stay (greater than or less than the median of 60 days) was associated with significant differences in nutritional status at exit.

In order to determine whether the program was successful at reducing levels of wasting and stunting across different age groups, we compared changes in wasting and stunting prevalence between entrance and exit for four different age groups. Wasting prevalence showed a significant decrease between entrance and exit for each age group, with the exception of those over 2 years of age (fig. 1). Stunting prevalence did not differ significantly between entrance and exit for any of the age groups. WHZ (mean change, 0.79 ± 0.94) and weight-for-age z-score (WAZ) (mean change, 1.08 ± 1.37) were significantly higher at exit from the program than at entrance, while changes in HAZ (mean change, -0.02 ± 0.97) were not significant. In summary, CRIN significantly improved weight deficits in children younger than 2 years of age but had little effect on deficits in height.

We were also interested to know whether CRIN was effective at helping children at highest nutritional risk: those who were both stunted and wasted at entrance ($n = 28$). These children showed significant improvement in weight-for-height, with 21 out of 28 (75%) exiting the program with mild to no wasting ($WHZ > -2$) and a mean improvement in WHZ of 2.1. Height-for-age generally did not improve, with only 1 of the 28 children (4%) exiting the program with mild stunting ($HAZ > -2$), and a mean change in HAZ of -0.2 . Similar to the results from the general study population, these especially high-risk children improved significantly in weight-for-height but did not show improvement in height-for-age.

Because of the complexity of child growth and the multiplicity of factors that are potentially involved, we felt that multivariable regression modeling was a more comprehensive approach than looking at pairwise comparisons alone. Two linear regression models, one for change in HAZ and one for change in WHZ, were used to elucidate the factors associated with improvements in z-score between entrance and exit from the program while controlling for age and sex (table 3). The covariates included in the model were selected based on associations that have been described in the literature [6, 10] as well as significant associations found in bivariate analyses (table 2). Although diarrhea was not a statistically significant predictor for change in WHZ, it was left in the model to remain consistent with model 1 and because it was significant in bivariate analysis. For both models, the strongest

significant predictor of change in z-score was the child's z-score at entrance, with z-score at entrance inversely related to change in z-score. This suggests that those who entered the program with the poorest nutritional status (a larger negative z-score) experienced the greatest gains in z-score between entrance and exit. For change in HAZ, an interaction between z-score at entrance and diarrhea at entrance emerged as significant in the model and was positively correlated with change in HAZ.

Changes in nutritional status from exit to follow-up

Given the positive improvement in average weight deficit during the children's stay at CRIN, we decided to analyze the data from follow-up visits with the children between 1 month and 6 years after exit from the program to establish whether these nutritional benefits were maintained in the long term. The mean time between exit and follow-up was 2.5 years. Because several children were over 5 years of age at the time of follow-up and WHZ is not considered a valid measure for children over five, we examined body-mass-index-for-age z-scores (zBMI) instead in this population. Within the follow-up population ($n = 26$), WAZ showed a statistically significant increase from entrance into to exit from CRIN, while HAZ did not change significantly (fig. 2). Both WAZ (mean change, 0.58) and zBMI (mean change, 1.01) increased significantly between exit and follow-up, but the increase in HAZ was not statistically significant (mean change, 0.68). Only four children were underweight at follow-up, compared with 10 who were underweight at exit. In contrast, there was no difference in the number of stunted children between exit and follow-up ($n = 16$). From this follow-up sample, it appears that children maintained their nutritional gains from CRIN and on average showed a small increase in their nutritional status between exit and follow-up. It is of note that the prevalence of stunting continues to be high (60%) among CRIN children, even at follow-up. However, it is encouraging that CRIN children had a mild and slightly higher mean HAZ (-1.9 , $n = 25$) at follow-up compared with their community peers who had a moderate mean HAZ of -2.45 ($n = 129$). Mean WAZ was slightly lower among CRIN children at follow-up (-1.1 , $n = 26$) than among their peers (-0.7 , $n = 127$). In summary, CRIN children are maintaining nutritional benefits beyond the duration of the program and are improving to levels nearly comparable to community averages (fig. 2).

Discussion

This study aimed to assess the nutritional improvement of children at the Centro de Rehabilitación Infantil Nutricional (CRIN) in rural Bolivia and at follow-up 1 month to 6 years later. We also attempted to determine factors associated with nutritional status at admission and changes in nutritional status during children's stay at CRIN. We found that CRIN was effective in improving children's weight gain, but less effective at achieving gains in height. Factors associated with nutritional status at entrance included sex and parasite infection. Factors that were associated with change in nutritional status between entrance and exit included nutritional status (z-score) at entrance and diarrhea status at entrance. Follow-up results indicated that children maintained their nutritional gains beyond exit from the program, although the prevalence rates of moderate and severe stunting remained high.

Our findings are generally consistent with other studies of NRCs. A significant change in weight-for-height and weight-for-age and a minimal change in height-for-age have been reported in several other studies of nutrition rehabilitation programs [5, 11]. Our finding that nutritional status at entrance is a strong predictor of changes in z-score during the program is supported by a study of a daycare rehabilitation center in Brazil [6].

Of all the clinical and programmatic factors examined, only diarrhea seemed to show a negative association with nutritional status at entrance and a positive association with nutritional gains between entrance and exit (table 2). This association may be related to the effects of diarrheal illness on appetite and absorption of nutrients but may also be partially explained by hydration status [12]. Although few of the children were clinically diagnosed as dehydrated, diarrhea probably resulted in water weight loss, and thus some of the weight gain observed probably resulted from rehydration [13].

We found that the NRC was effective at decreasing the prevalence of wasting among program participants but was not effective at reducing the prevalence of stunting. In light of the high prevalence of stunting (50%) observed in the youngest age group (fig. 1), the low rate of stunting rehabilitation is worrisome. However, this finding is not surprising, given several factors. For physiological reasons, height-for-age is less responsive to short-term, intensive nutritional interventions than weight gain [14]. Height gain has been hypothesized to lag behind weight gain until weight-for-age reaches 85% of the median reference value [15]. For example, although a study of a nutrition daycare center in Brazil found reductions in wasting and underweight in the second and third months of program participation, a reduction in stunting was not observed until the fourth month of participation [5]. Given that the average length of stay at CRIN was less than 3 months (78 days), the children may not have stayed in rehabilitation long enough to improve their height deficit.

The lack of improvement in stunting may also be related to the age at which the intervention occurs. Beaton reviewed evidence that suggests that active stunting occurs in children primarily between 6 and 18 months of age, the period during which an intervention would be expected to have the greatest impact [16]. Over half of the children (73 of 135) in the present study entered CRIN between 1 and 2 years of age and thus were approaching the end of the period of greatest vulnerability to stunting and the optimal window for intervention.

Modeling results suggested that nutritional status at entrance was the most significant predictor of change in nutritional status. WHZ and HAZ at entrance were negatively associated with change in z-score, suggesting that those who entered with lower z-scores showed greater changes in z-score from entrance to exit. This finding corroborates the modeling results of the nutrition study in Brazil [6]. This is encouraging, as it indicates that those who enter with the poorest nutritional status are benefiting the most as a result of the program. Our model also suggests an interaction between HAZ at entrance and diarrhea status at entrance. HAZ at entrance is significantly negatively associated with change in HAZ at exit among children who do not have diarrhea. This strong and significant association does not hold for children who enter the program with diarrhea. This interaction in the HAZ model shows that diarrhea at entry attenuates improvement in height-for-age.

Length of stay was not associated with changes in nutritional status in either of our models, which could be attributed to the well-described phenomenon of regression to the mean that can result from measurement error [17]. Although this could help explain why children at follow-up had improved their average nutritional status only up to community norms, it is also plausible that the root determinants of high rates of undernutrition in a community may ultimately determine the nutritional status of rehabilitated children. Length of stay was positively associated with nutritional improvements in two studies of nutrition rehabilitation programs in Brazil [5, 6] as well as a study of NRCs in Ghana [11]. One hypothesis for the lack of association observed in our study is that there was a threshold after which more time spent at CRIN does not result in added benefits. Although the average length of stay was 78 days, the median was only 60 days, and there was wide variation, with stays ranging from 9 to 332 days. It seems that those children staying for more than 3 to 4 months did not experience any additional nutritional benefits as a result of their extended stays in the program.

Upon follow-up, we found that the majority of children had maintained or slightly improved the z-score they had achieved at exit from the program, although only WAZ showed a statistically significant improvement. In addition, children attending CRIN had similar or better nutritional recovery at follow-up compared with children in other NRC follow-up studies, such as those in Kenya [18] and Bangladesh [13]. The explanation for the maintenance and improvement of nutritional status among children attending CRIN at follow-up is not entirely clear. It is possible that children were discharged from CRIN when they were no longer at the age at which they were especially vulnerable to environmental influence on their nutritional status [1], or that previous child participants in NRC programs receive better nutrition and care from their family members than their siblings receive because of their perceived vulnerability [19].

Strengths and limitations

The main strength of our study is that it is one of the few studies to follow up on children after they have left an NRC, and, to our knowledge, it is the first such study from Latin America. Our approach to analyzing factors associated with nutritional improvement through the use of linear regression modeling allowed us to account for multiple factors that may have influenced changes in nutritional status. Additionally, the fact that our study took place at a residential center provides some standardization, eliminating possible confounding factors that might arise from differences in children's home environments and home feeding practices.

Our main limitation in retrospectively analyzing CRIN records was that some information was lacking because we depended on records collected from an internal evaluation (e.g., socioeconomic status, birth weight, breastfeeding practices, reason for discharge, and home diet). Similarly, field base measurements are prone to error, which may have impacted the changes observed in anthropometric indicators from entry to exit. All children at follow-up, as well as their community peers, were measured by the same methods, and therefore their measurements were at least equally biased. Because of the absence of a community control group followed during the same period, we were unable to distinguish between effects of the

program and effects of the normal growth process. With regard to follow-up, the sample size of children located in their communities was small because of high urban migration rates and geographic and logistical constraints to reaching all children by CRIN staff, which limited our ability to make any statistical inferences and could have resulted in selection bias. Also, the time lapse between exit and follow-up for each child in the sample was highly variable, and nutritional gains may not be uniformly maintained in such disparate time periods.

Implications and conclusions

The finding that CRIN was effective at improving weight gain and wasting is important, because catch-up in weight is often a prerequisite for catch-up in linear growth. Additionally, decreasing the prevalence of wasting has important implications for decreasing the risk of morbidity and mortality in children due to infectious disease [20]. Our results indicate that in this community, stunting occurs early in life (before 1 year of age) and does not improve during a child's stay at CRIN. Additional nutritional interventions geared toward promotion of optimal breastfeeding and child feeding practices could potentially supplement CRIN activities.

In conclusion, the results from the CRIN program suggest that this residential NRC is effective at addressing nutritional problems due to wasting, but not those due to stunting. These findings support existing evidence that height gain may be less responsive than weight gain to interventions aimed at nutritional recovery and is more difficult to impact in a short period of time [21]. Published studies on the impact of food supplementation on growth faltering emphasize the need for large-scale nutrition programs to target the prenatal period as well as the first 2 years of life [22]. Although residential NRCs have waned in popularity, they may be a viable alternative in rural areas where the presence of many small, geographically dispersed communities makes household- and community-based programs less feasible. Although the positive effects of CRIN on weight gain should be recognized, future work is necessary to explore additional interventions to prevent and treat stunting in these communities.

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Fig. 1. Wasting decreased significantly between entrance and exit for most age groups while stunting remained virtually unchanged for all age groups. WHZ, weight-for-height z-score; HAZ, height-for-age z-score. *Two-sided $p < .05$ compared with entrance

Fig. 2.

In a follow-up sample of 26 children, weight-for-age z-score (WAZ) ($n = 26$) increased significantly between entrance and exit and continued to increase between exit and follow-up. There was no significant difference in WAZ between follow-up children and community controls ($n = 127$). Height-for-age z-score (HAZ) ($n = 25$) showed no change between entrance and exit and a slight increase (but not significantly) between exit and follow-up. Follow-up children had slightly higher (but not significantly) HAZ than community controls ($n = 129$). Follow-up was completed between 1 month and 6 years postexit. Boxes represent the 75th percentile, 50th percentile (median), and 25th percentile of the samples. Lines extend to 1.5 IQRs of the upper and lower quartile. Circles indicate outlying data points.

*Two-sided $p < .05$ compared with entrance; **two-sided $p < .05$ compared with exit

TABLE 1

Demographics of CRIN children at entrance

Characteristic	No. (%) or mean $\pm$ SD
Nutritional status at entrance	
Wasted (WHZ < -2)	40 (30)
Underweight (WAZ < -2)	103 (76)
Stunted (HAZ < -2)	98 (73)
Female sex	77 (57)
Age at entrance (mo)	14 $\pm$ 7.3
Age group (mo)	
< 6	19 (14)
6–12	25 (19)
13–24	76 (56)
25–36	15 (11)
Parasites ^a	
Positive (any)	51 (54)
<i>Giardia lamblia</i>	24 (25)
<i>Entamoeba histolytica</i>	19 (20)
<i>Escherichia coli</i>	11 (12)
Clinical symptoms	
Diarrhea	60 (44)
Respiratory infection	31 (23)
Anemia	15 (11)
Vomiting	16 (12)
Dehydration	7 (5)
Vaccination complete at entrance ^a	48 (49)
Length of stay (days)	78 $\pm$ 61

HAZ, height-for-age z-score; WAZ, weight-for-age z-score; WHZ, weight-for-height z-score

^aSample size is smaller than 135 because of incomplete data.

TABLE 2

Factors associated with nutritional z-score at entrance and change in nutritional z-score during the program (means $\pm$ SEM)

Variable	N	WHZ at entrance		HAZ at entrance		Change in WHZ at exit ^a		Change in HAZ at exit ^a	
		Yes	No	Yes	No	Yes	No	Yes	No
Female sex	77	-1.4 $\pm$ 0.1	-1.9 $\pm$ 0.1*	-2.7 $\pm$ 0.1	-3.2 $\pm$ 0.2*	1.1 $\pm$ 0.2	1.1 $\pm$ 0.2	0.1 $\pm$ 0.1	-0.1 $\pm$ 0.1
Diarrhea at entrance	60	-1.7 $\pm$ 0.1	-1.4 $\pm$ 0.1	-3.0 $\pm$ 0.2	-2.8 $\pm$ 0.2	1.4 $\pm$ 0.2	0.9 $\pm$ 0.2*	-0.2 $\pm$ 0.1	0.1 $\pm$ 0.1
Parasites at entrance	51	-1.5 $\pm$ 0.1	-1.9 $\pm$ 0.2*	-3.1 $\pm$ 0.2	-2.9 $\pm$ 0.2	1.1 $\pm$ 0.2	1.5 $\pm$ 0.2	0.0 $\pm$ 0.1	-0.3 $\pm$ 0.1
Vaccination complete at entrance	48	-1.5 $\pm$ 0.2	-1.7 $\pm$ 0.2	-2.9 $\pm$ 0.2	-2.8 $\pm$ 0.2	0.9 $\pm$ 0.2	1.2 $\pm$ 0.2	0.3 $\pm$ 0.2	-0.1 $\pm$ 0.1
Length of stay < 60 days	69	-1.5 $\pm$ 0.1	-1.7 $\pm$ 0.2	-2.9 $\pm$ 0.2	-2.8 $\pm$ 0.2	0.9 $\pm$ 0.1	1.3 $\pm$ 0.2	0.1 $\pm$ 0.1	-0.1 $\pm$ 0.1

HAZ, height-for-age z-score; WAZ, weight-for-age z-score; WHZ, weight-for-height z-score

* Two-sided $p < .05$ between “yes” and “no” group.

^a Median of 60 days from entrance into to exit from CRIN.

TABLE 3Linear regression models for change in HAZ ($n = 134$) and change in WHZ ($n = 135$) from entrance to exit

Variable	B estimate	SE	p-value
Model 1: Change in HAZ from entrance to exit ^a			
Intercept	− 1.13	0.34	< .01 *
HAZ at entrance	− 0.33	0.07	< .01 *
Age at entrance			
< 6 mo	0.14	0.29	.63
6–12 mo	− 0.14	0.26	.59
1–2 yr	0.22	0.23	.33
2–3 yr	Reference		
Sex (1 = female)	0.26	0.14	.07
Diarrhea (1 = yes)	0.40	0.34	.25
HAZ_ diarrhea	0.24	0.11	.03 *
$R^2 = 0.20$, adjusted $R^2 = 0.16$			
$F = 4.64$, $p < .01$			
Model 2: Change in WHZ from entrance to exit ^a			
Intercept	− 0.26	0.34	.43
WHZ at entrance	− 0.76	0.08	< .01 *
Age at entrance			
< 6 mo	− 0.13	0.38	.72
6–12 mo	− 0.36	0.36	.32
1–2 yr	− 0.15	0.31	.62
2–3 yr	Reference		
Sex (1 = female)	0.32	0.19	.09
Diarrhea (1 = yes)	0.32	0.19	.10
$R^2 = 0.42$, adjusted $R^2 = 0.39$			
$F = 15.22$, $p < .01$			

HAZ, height-for-age z-score; WHZ, weight-for-height z-score

* Significant at the .05 level.

^a Age and sex were forced into the model.