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Inpatient and outpatient treatment by specialist infant nutrition centres in Argentina effectively reduced child malnourishment

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Short title: Evaluation of recovery of malnourished children

Abstract

Aim: We evaluated the impact of inpatient and outpatient treatment provided by an infant nutrition foundation in Las Heras, Mendoza, Argentina, and identified the factors that influenced nutritional recovery.

Methods: This 2010-2018 retrospective study was based on 300 children up to five years of age with primary malnutrition, who were treated by an inpatient recovery centre then an outpatient prevention centre. We analysed the children's height, weight, psychomotor development and living conditions when they were admitted, discharged and had received one year of outpatient treatment. There were full data on 241 children and just admission and discharge data for 59.

Results: The children's mean age on admission and weight were 14.8 ± 12.4 months and 6.9 ± 2.3kg and they stayed in hospital for a mean of 59.5 ± 49.7 days. We observed a significant increase in the weight-for-age, height-for-age and weight-for-height z-scores when all three time points were compared ($p < 0.001$). Psychomotor development improved considerably in all patients after treatment. The factors that negatively influenced nutritional recovery were higher age at admission, sub-optimal breastfeeding practices, low birth weight, longer hospital stays, younger maternal age and overcrowded housing.

Conclusion: Combining inpatient recovery and outpatient preventive treatment was effective for undernourished children in Argentina.

KEYWORDS

Breast feeding, child malnutrition, community health services, inpatient recovery centre, outpatient preventive centre

KEY NOTES

- We retrospectively studied 300 children up to five years of age with primary malnutrition, who were treated by an inpatient recovery centre and outpatient prevention centre.
- The children's weight-for-age, height-for-age and weight-for-height z-scores improved significantly when we compared data at admission, discharge and after one-year of outpatient treatment.
- Higher age at admission, sub-optimal breastfeeding, low birth weight, longer hospital stays, younger maternal age and overcrowded housing negatively impacted nutritional recovery.

INTRODUCTION

Child malnutrition has been associated with high morbidity and mortality worldwide.[1] It causes immune and cognitive deficiencies, loss of academic performance and lower productivity in adult life.[2–4] In addition, malnutrition has been associated with a lifetime of medical and psychosocial problems, as well as possible effects on offspring.[4] These effects cost society more than preventing them.[2]

A World Health Organization (WHO) study published in 2011 showed that the growth of children under five years of age was similar throughout the world, regardless of ethnicity.[5] However, it could be influenced by inequalities in dietary intake, socioeconomic status and living conditions. In 2021 the United Nations stated that the prevalence of hunger in Latin America had risen exponentially and had reached the highest point in the last 15 years.[6] Latin America faces a critical food security situation. These facts highlight the need to unify and strengthen the criteria for national nutritional assistance and evaluate their effectiveness. The Cooperative Foundation for Infant Nutrition (the Foundation, known as CONIN) provides detection, diagnosis and treatment services to children with malnutrition. There are now more than 100 Centres for the Prevention of Child Malnutrition and Human Promotion (prevention centres) run by the Foundation in Argentina, but Foundation centres also exist in Paraguay, Perú and The Gambia. The Argentinian prevention centres provide outpatient support, and home visits, for malnourished children who were previously hospitalised and/or have been referred for follow up. There is also a Nutritional Recovery Centre (recovery centre) in the province of Mendoza that provides inpatient treatment for malnourished children under five years of age when outpatient treatment has failed or cannot be provided for social reasons. The treatment provided by the Foundation includes paediatric, nutritional and psychomotor stimulation assistance. In addition, it works with families to minimise the risk factors related to the child's environment. The Foundation provides food, material resources, literacy programmes, job training, and health education. It also improves housing conditions and makes safe water and sanitation available.

An earlier study aimed to quantify the impact of the Foundation's integrated strategy to prevent infant undernutrition and determine its causes, Ortiz-Andrellucchi et al compared 186 children aged 5-17 years who had been admitted to the Foundation's recovery centre in Mendoza with 292 controls from the same school who had never had attended the centre.[7] This retrospective, cross-sectional study was useful, as it

identified the main variables that led to admission to the Foundation programme and those that could be modified by the integrated strategy. Based on this earlier study, we aimed to evaluate if the nutritional intervention at the Foundation centre in Mendoza was effective in overcoming barriers to recovery. We carried out a longitudinal study of children up to five years of age who had primary undernutrition and required hospitalisation. We assessed them on admission, at discharge and after one year of outpatient treatment following their discharge. Our aim was also to measure the effect of the intervention and identify the barriers to recovery. We hope this will provide relevant information that can contribute to optimising the nutritional recovery of children in Argentina.

PATIENTS AND METHODS

This study evaluated the impact of the hospital and outpatient interventions offered by the Foundation's inpatient recovery centre and outpatient preventive centre in Las Heras, Mendoza, Argentina. It also identified the factors that influenced the children's nutritional recovery. We developed a retrospective study, based on the records of 300 children up to five years of age with primary nutritional deficiencies who were admitted to the recovery centre between January 1st 2010 and December 31st 2018. Patients who received outpatient treatment at the prevention centre for at least one year after their discharge from the recovery centre were included. Children with chronic diseases or pathologies that could have affected their nutritional status were excluded.

We analysed the children's anthropometric information, namely height, weight, head circumference and z-score values, at three cut-off points: when they were hospitalised in the recovery centre (admission), when they were discharged from the recovery centre (discharged) and after one year of outpatient treatment at the prevention centre (follow up). We also analysed the psychomotor development on admission and discharge and recorded data related to their birth: date of birth, age, gender, gestational age, birth weight and breastfeeding. Social information was also recorded, namely maternal educational level, maternal age, the child's social risk and housing data related to precarious living conditions, toilet facilities, overcrowding, gas, electricity, drinking water and sewers. We found that 241 of the 300 patients had their annual check-up after one year of outpatient treatment. The other 59 patients had their last outpatient follow

up before one year and in these cases we only use to compare data at the admission and discharge time-points (Fig.1).

We assessed the children using the Psychomotor Development Assessment Scale for children under two years of age (Rodriguez test),[8] and the TEPSI Psychomotor Development Test for children from two to five years of age.[9] The nutritional treatment consisted of 100-120 Kcal/kg/day and 1-1.5g/kg/day of protein for moderate malnutrition and 80-100 Kcal/kg/day and 1g/kg/day of protein for severe malnutrition. Diet formulas were adapted to the requirements of the patients.

Anthropometric measurements were performed by health professionals at the recovery centre based on WHO training. [10] The weight-for-age, height-for-age and weight-for-height z-scores were calculated with Anthro software, version 3.2.2 (WHO, Geneva, Switzerland), which uses the WHO reference values. Malnutrition was defined as a z-score of less than two, which indicated low weight-for-age, height-for-age and weight-for-height.[11]. We used the weight-for-height reference values in The Sphere Handbook (The Humanitarian Standards Partnership, Geneva, Switzerland) to define recovery from moderate and severe acute malnutrition. These were a recovery rate of more than 75%, a non-compliance rate of less than 15% and a mortality rate of less than 3%.[12]

Statistical analyses were performed using R programming language (R Foundation, Vienna, Austria). To compare the difference in the z-score means we used the Wilcoxon test, according to the distribution of the variables. In addition, simple and multiple linear regression techniques were applied to the data set to determine the influence of several variables on the patients' improvements. A minimum level of significance of $p \leq 0.05$ was used in all cases. Outliers were detected using Cook's distance. Finally, we use a backward stepwise regression method to fit the best model with the most relevant predicting variables.

This project was approved by the Scientific Research Ethics Committee of the Dr Humberto Notti Pediatric Hospital, Mendoza, Argentina (act number 24/2019). The research was conducted in line with ethical guidelines set by The National Committee for Research Ethics in the Social Sciences and the Humanities and with the Declaration of Helsinki or comparable ethical standards.

RESULTS

The mean age of the 300 children (51.0% male) on admission was 14.8 ± 12.4 months and their mean weight was 6.9 ± 2.3kg. They stayed in hospital for a mean of 59.5 ± 49.7 days. Ninety nine patients (33.0%) had a stay longer than the mean because it was not appropriate for the children be at home during their outpatient treatment. Full data, including measurements at the one-year follow up, were available for 241 of the 300 children and just admission and discharge data were available for 59. Only 16.7% of the children were exclusively breastfed until six months of life and only 11.4% were breastfed until the first year of life. In addition, 89.7% patients were admitted with a z-score of less than two for weight-for-age and it was 70.7% for height-for-age and 38.3% for weight-for-height. At the time of their hospital discharge, 41.3% of the patients still had a z-score of less than two for weight-for-age, 55.7% for height-for-age and 8.3% for weight-for-height.

The majority of the study population lived in homes with access to drinking water (89.0%), electricity (98.7%), natural or bottled gas (99.3%) and their own internal or external toilets (87.3%). However, about two-thirds (66.4%) of the patients did not have a sewer system at home, nearly three-quarters (73.6%) lived in overcrowded conditions and 78.2% were at high social risk. In more than a fifth of cases (21.2%) their homes were built with materials of insufficient quality. Only 35.6% of the mothers or people in charge of the children had completed their primary education and 7.5% had finished high school. None of the parents had a university degree. Recovery from moderate and severe acute malnutrition was assessed with the weight-for-height parameter. The recovery rate was 83.5% and the non-compliance rate was 7.1%. No deaths was reported during the study period.

We compared the z-scores for weight-for-age, height-for-age and weight-for-height on admission, discharge and at follow up, after one year of outpatient treatment (Fig. 2). The results showed significant differences ($p < 0.001$) in the recovery of the all the three z-scores at all three time points.

The children's psychomotor development showed favourable development in children under two years of age ($p < 0.001$) and older than two years ($p < 0.01$) during their hospital stay in the recovery centre (Fig. 3). About a fifth (19.8%) of the patients who were evaluated was over two years of age. On admission, 42.3% of this age group had delayed psychomotor development, 9.6% were at risk and 48.1% had normal development. At discharge, only 28.3% of the patients were delayed, 15.1% were still at risk and 56.6% had achieved normal psychomotor development. Nearly a third (30.3%) of the patients under two years of

age at the time of admission had delayed psychomotor development, 16.1% were at risk and 53.6% had achieved normal psychomotor development. At the time of discharge the figures were 16.2% delayed, 15.7% at risk and 68.1% normal.

In order to identify factors that may have affected their nutritional recovery, we used linear regression to evaluate the relationships between different variables and their z-scores (Table 1). We saw that when the age of admission to the Centre was higher, there was a lower recovery. This was indicated by the z- scores for weight-for-age at the one-year follow up and also height-for-age at discharge and weight-for-height at discharge and the one-year follow up. In addition, we noted that infants who were breastfed for three or more months had lower weight-for-age and weight-for-height z-scores for recovery at the one-year follow up. On the other hand, patients with higher birth weights showed greater recovery, at discharge and follow up, of the weight-for-age and height-for-age z-scores during hospitalisation and outpatient treatment. We also saw that longer hospital stays were associated with lower height-for-age recovery z-scores at discharge. There were higher height-for-age and weight-for-height z-scores between discharge and the one-year-follow up for infants born to older mothers. Furthermore, height-for-age z-scores tended to have improved at follow up if children did not live in overcrowded homes. The children's nutritional status was not significantly influenced by variables such as gestational age at birth, mother's education, social risk, characteristics of the home, access to toilets, electricity and drinking water.

Multiple linear regression model showed that the main factors that influenced weight recovery were birth weight and age at admission to the recovery centre (Table 2). Weight-for-height recovery one year after outpatient treatment decreased in children who were more than two years of age at the time of admission. In contrast, the height-for-weight recovery was better in children with a higher birth weight.

DISCUSSION

There are several food aid programmes that tackle malnutrition in Argentina, but no studies have been published on their shortcomings and/or efficacy.[13] Our study provides evidence of the nutritional evolution of primary malnourished patients who required hospitalisation at the recovery centre, followed by outpatient treatment at the prevention centre. The variables that affected the nutritional recovery of the

children were also identified. The Foundation's treatment was mainly providing nutritional assistance for the child and training the mothers.

The nutritional recovery of the 300 patients was evaluated during hospitalisation and we observed a significant improvement in weight-for-age, height-for-age and weight-for-height z-scores. The overall recovery rate of 83.5% was within the international Sphere standard of >75% for managing severe acute malnutrition.[12] Undernourishment and inadequate stimulation have been reported to be the major risk factors responsible for developmental deficits in psychomotor development.[14,15] The prevalence of developmental delay observed on admission to the recovery centre was higher (32.7%) than an American centre for children aged 9-24 months (13%).[16] It was also similar to pre-school children in Nigeria (35.4%)[17] and lower than children under five years of age in Ghana (44.6%).[18] At the time of discharge, only 18.6% of the children were still developmentally delayed, which highlights the importance of the comprehensive treatment carried out by the Foundation.

The mean hospital stay was 8.5 weeks (59.5 days), which exceeds the Sphere standard of less than four weeks.[12]This was because some patients had social problems that prevented them from returning to their homes during outpatient treatment. Foundation centres in eastern Ethiopia[19] and India[20], recorded longer mean hospital stays of 72.0 and 60.9 days respectively. Our results show that children with longer hospital stays had lower height-for-age z-score recoveries at discharge.

The mean weight gain during hospitalisation was 5g/kg/day, which is less than the Sphere standards of 8 g/kg/day.[12] This could explain why longer hospital stays were required to meet the discharge criteria. Similar lower weight gains have been reported by Foundation centres in Kenya (5.1g/kg/day)[21], India (4.7g/kg/day)[20] and southern Ethiopia. (3.8g/kg/day).[22]

These variations in hospital stays and weight gain could be due to differences in treatment to what is stipulated by the WHO, as well as different contexts of medical care and socioeconomic factors in the countries that were studied. The United Nations Children´s Fund has reported that areas with vulnerability indicators, such low educational attainment and living below the poverty threshold, had a higher prevalence of malnutrition and stunted growth.[23] Therefore it is important to consider that 78% of patients presented with high social risk, where quickly returning them to an inappropriate environment can generate relapses.

In such cases the Foundation treatment prioritises establishing a bond with the family that allows them to assess the child's environment and tackle unfavourable conditions.

During outpatient treatment, patients showed marked recovery in their weight-for-age, height-for-age and weight-for-height z-scores. Height recovery was negatively influenced by high overcrowding rates, low birth weight and younger mothers.

Exclusive breastfeeding and its long-term maintenance is one of the most effective ways of improving global child health and survival.[24] Sub-optimal breastfeeding practices cause more than 11% of global deaths and 10% of disability-adjusted life-years in children under five years of age.[25,26] Our results show that those children who sustained breastfeeding for three months or longer had a lower recovery of weight-for-age and weight-for-height during outpatient treatment, compared to those who were not breastfed. Fawzi et al showed that breastfed children aged 6-12 months gained significantly less weight than fully weaned children and suggested this was due to poorer complementary feeding among breastfed than weaned children.[27] Other non-exclusive explanation could be that breastfeeding practices were sub-optimal, so maternal training in this area should be strengthened.

Both weight and height were affected by the age when the treatment stated. Children who were over two years of age on admission had lower height and weight recovery. This highlights the importance of detecting nutritional deficits early.[28] We noted that 80.2% of the admissions to the Foundation centre were under two years of age, which has important implications for the prevention and recovery of growth deficits and impacts the population's public health.

We also identified that weight recovery at all three time points, namely admission, discharge and one-year follow up, improved in children with a higher birth weight. Low birth weight has been identified as a strong predictor of malnutrition during the first years of life, even after controlling for risk factors for child malnutrition.[29] Taken together, these data suggest that efforts to prevent nutritional deficiencies in childhood should start during pregnancy. It is important to note that the Foundation centre that was studied didn't just provide nutritional treatment for the child. It also provided community tools that contributed to improving the nutritional and health conditions of the child's family, including pregnant women, and their environment.[7]

We noted that the literature discussed the advantages of outpatient treatment compared to a short-stay residential nutrition centre.[30] Our decision was to analyse data from children who received both hospital recovery care and outpatient preventive care. This enabled us to identify some advantages during their short stay at the centre. They included: supervised feeding, the chance to teach mothers, the potential for preventing long-term malnutrition and avoiding poor primary health care systems. However, the intervention had several disadvantages compared with home treatment, such as: the need for a complex facility or centre attached to a clinic, the high institutional cost for a stand-alone centre and the low coverage due to the limitation on centres. Nevertheless, the recovery centre may be considered as a half-way step between a primary health care system and home. The prevention centre provides all the benefits of an outpatient facility, such as monitoring progress during home rehabilitation, by home visits or follow-up visits to the centre.

One of the most important features of the Foundation´s intervention is the frequent post-discharge follow up. The one-year follow up involves important work with families to provide material resources and food, as well as training on health and nutritional issues. In fact, our most interesting finding was the significant increase in all the three z-scores at the one-year follow up. This improvement showed good adherence by the families to the post-discharge treatment and the effectiveness of this treatment beyond the inpatient intervention.

This was a retrospective study and that meant there were some limitations. These included the lack of complete records in some areas of interest and the inability to collect more information on the socioeconomic characteristics of the patient's immediate family. The sample size was relatively small, but it represented 67.4% percent of all children up to five years of age admitted to the recovery centre during the study period with primary nutritional deficiencies.

CONCLUSION

The comprehensive intervention provided by the Foundation in this area of Argentina comprised a relatively short stay in a recovery centre followed by an outpatient prevention centre. It proved effective for preventing and treating child malnutrition and contributed to reduced mortality from acute malnutrition in Argentina. Some of the children faced high social risks, and had to stay in the recovery centre during the

preventive outpatient phase rather than be discharged home. Efforts to facilitate the early nutritional recovery of patients should be strengthened, by considering the barriers that our study revealed. Our results show that social work would be the key to preventing childhood malnutrition, by tackling overcrowding, young pregnancies, inadequate feeding during pregnancy, incorrect breastfeeding practices and late diagnoses. They also showed that following up preventive outpatient treatment, after being discharged from inpatient recovery care, can optimise the results that are achieved.

FUNDING

This study did not receive any external funding.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

Abbreviations

WHO - World Health Organization

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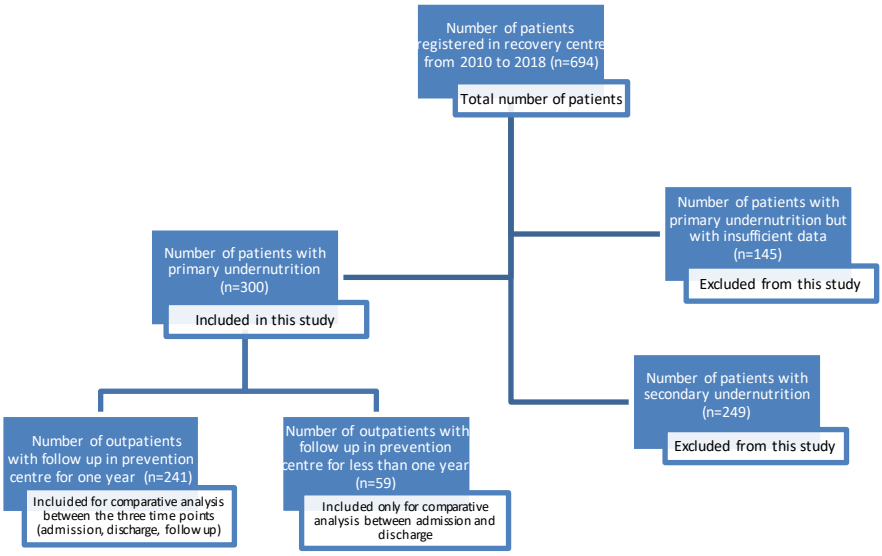
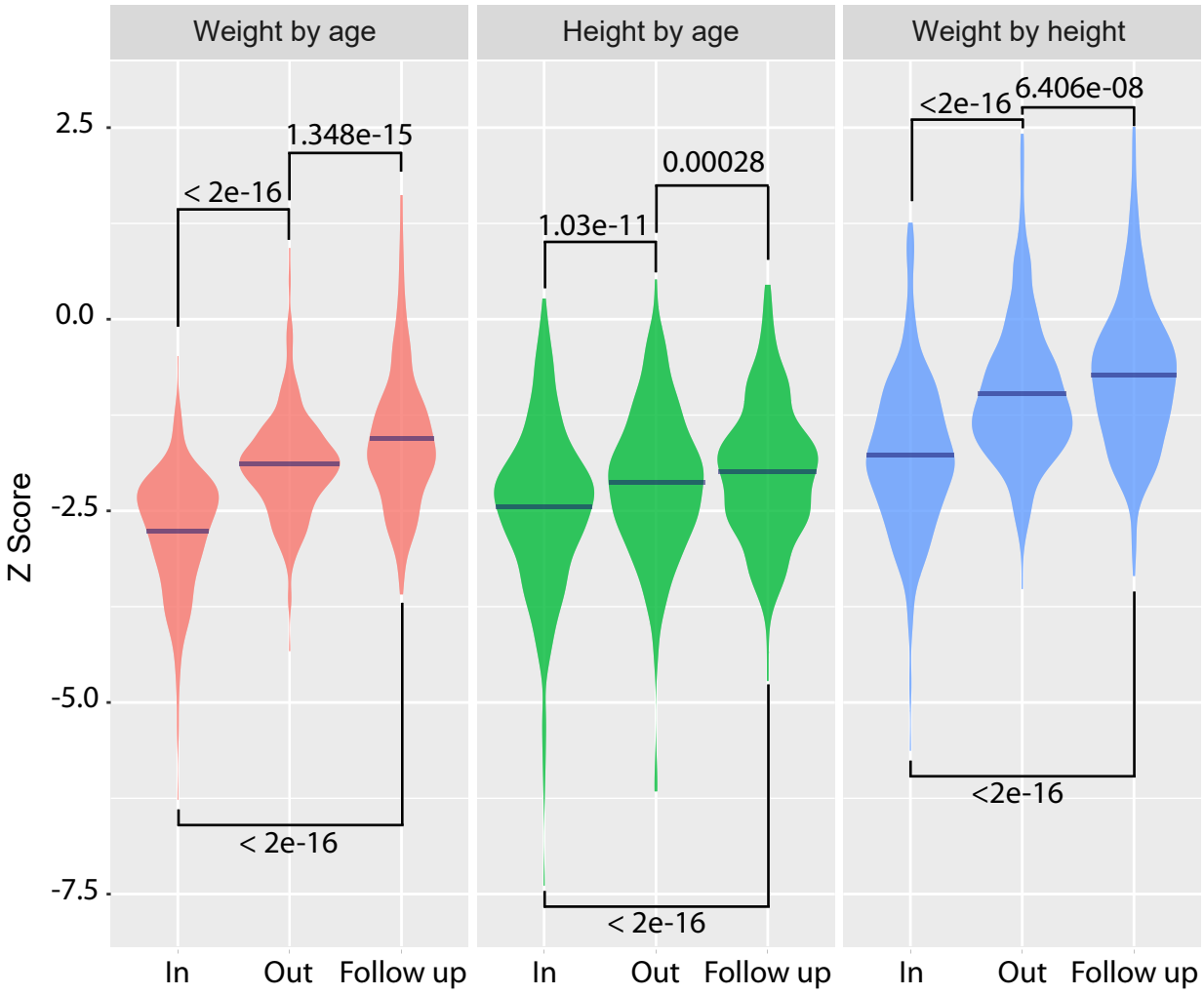
FIGURE LEGENDS

Fig. 1 Flow chart illustrating the inclusion and exclusion criteria of participants into the study.

Fig. 2 Comparison of z-scores of weight-for-age, weight-for-height and height-for-age on admission to the recovery centre (in), discharge from the recovery centre (out) and one year of outpatient treatment at the prevention centre (one-year follow up). The p values shown were obtained by the Wilcoxon test.

Fig. 3 Comparison of psychomotor development on admission to, and discharge from, the recovery centre. We used the Rodríguez test for children under two years of age or the TEPSI test for children over two years of age. The p values shown were obtained by the Wilcoxon test.





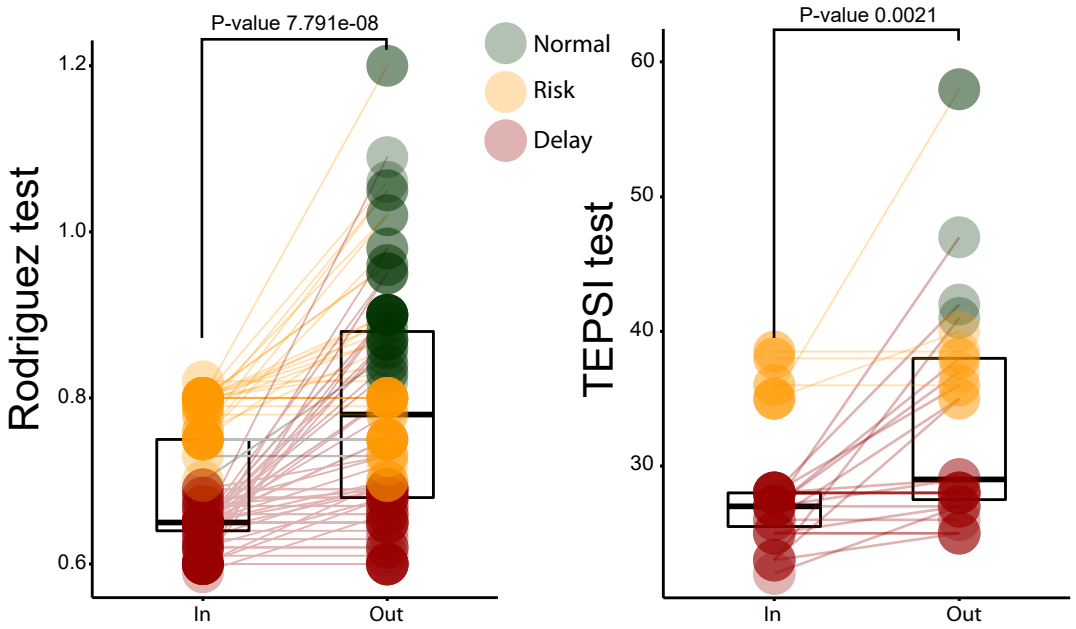


Table 1. Linear regression analysis between different variables and z score for weight-for-age, height-for-age and weight-for-height at discharge and follow up

Variable	Adjusted R-squared	Coefficients	P
z score W/A discharged			
birth weight (kg)	0,125	0.3598	$6.16^{e-0.9}$ ***
z score W/A follow up			
admission age (months)	0,0992	-0.02257	2.39^{e-06} ***
lactation (months)	0,05354	-0.3528	0.000684 ***
birth weight (kg)	0,0661	0.3556	0.000162 ***
z score H/A discharged			
admission age (months)	0,01248	-0.009608	0.0403 *
birth weight (kg)	0,0611	0.3995	4.77^{e-05} ***
hospital stay	0,01387	-0.002095	0.0326 *
z score H/A follow up			
birth weight (kg)	0,02442	0.2507	0.0151 *
mother's age	0,04799	0.3071	0.00122 **
z score W/H discharged			
admission age (months)	0,01754	-0.01092	0.02021 *
mother's age	0,02039	0.02014	0.0151 *
z score W/H follow up			
admission age (months)	0,1548	-0.0348	6.38^{e-09} ***
lactation (months)	0,03872	-0.3208	0.00367 **

Table 2. Multiple linear regression analysis between different variables and z score for weight-for-age and weight-for-height at admitted, discharge and follow up

Variable	Adjusted R-squared	Coefficients	P
z score W/A admitted	**0,2617**		
birth weight		0.5619	0.000236 ***
lactation		0.3838	0.028731 *
z score W/A discharge	**0,1422**		
birth weight		0.5985	0.000715 ***
z score W/A follow up	**0,1894**		
Birth weight		0.4968	0.00158 **
entry age		-0.02745	0.00103 **
z score W/H follow up	**0,09634**		
birth weight		0.5582	0.0285 *
entry age		-0.02095	0.0261 *