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SCN 2003 Report from University of Brasilia

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1. **Advocacy**: Community micromineral fortification projects targeting the poor; nutrition educational programs targeting young adolescent girls, adult women and pregnant mothers.
2. **Fortification**: Working under limited, available resources, while adapting to local, cultural customs, the fortification of drinking water to reduce and prevent ID and/or IDA in preschool children attending daycare facilities has been underway for the past two years, and positive and significant results have been gathered under controlled methodological conditions (see article and tables below for a detailed analysis).
3. **Research:** Effect of iron-fortified drinking water on the iron status of children aged 6 to 59 m attending daycare in Brazil. See below.

Experiences or lessons learned: Please see Discussion from the Fe-fortification of drinking water article by Beinner et al.

What partners or organizations have helped make your projects successful?

We have encountered constraints from municipal authorities. We are working on the formation of local, community leaders and volunteer groups. More emphasis must be placed on educating teens and women, motivating them to assist others in need.

Future plans and goals:

Plans are already underway to multiply Fe-fortified drinking water in more than 36 small cities targeting some 15,000 preschoolers attending daycare facilities. We are optimistic, as the newly elected Brazilian government has given priority to combating hunger in regions whose populations are poor, particularly in the Northeastern regions.

What else do you need? Is there any specific information that would be useful?

We would appreciate receiving any and all literature (textbooks, manuals, ect.) on preventing malnutrition. Would greatly appreciate if you would kindly place us on your mailing list using the address above. Thank you for your time, consideration and reply.

Effect of iron-fortified drinking water on the iron status of children aged 6 to 59 m attending daycare in Brazil

Mark Anthony Beinner, Joel Alves Lamounier, José Garrofe Dórea

ABSTRACT

Background: Iron deficiency anemia (IDA) is the most prevalent nutrition problem in young children. One possible strategy to prevent IDA is the fortification of affordable foods.
Objective: The aim of this study was to evaluate the impact of iron-fortified drinking water on the hemoglobin and anthropometric status of pre-school children.
Design: Hemoglobin status, weight and height measurements were assessed in 160 pre-school children aged 6 to 59 m before and after daily consumption of iron- (12 mg/L) and vitamin C- (90 mg/L) fortified drinking water during 8 m.
Results: Initially, 43.2% (69) were evaluated as being iron-deficient. After study, prevalence decreased to 21% (37). The average increase in Hb at 8 m was significant (*p*<0.001). Iron deficiency anemia was virtually

eliminated; at baseline, 42 (26.3%) children suffered from ID and 27 (16.9%) suffered from IDA. At 8 m, total number of children suffering from ID and IDA had decreased to 32 (20.7%) and 5 (0.03%), respectively. There were no significant gender differences for Hb. Weight-for-age (WAZ), height-for-age (HAZ) and weight-for-height (WHZ) *Z*-scores increased significantly from –0.84 ± 1.03 to 0.06 ± 1.10, –0.84 ± 1.11 to 0.54 ±1.10 and –0.39 ± 0.94 to –0.18 ± 1.14, respectively ($p<0.05$). Enhanced growth after iron fortification was attributed to improved appetite and decreased absenteeism.

Conclusion: Daily consumption of iron-fortified drinking water is an effective, simple and inexpensive means of reducing and controlling for iron deficiency and iron deficiency anemia in pre-school children attending daycare.

Key words: iron deficiency, anemia, vitamin C, foods, fortification, antropometry, *Z*-score, children

Introduction

Iron deficiency anemia (IDA) has been the center of numerous studies worldwide. Globally, it is estimated that 46% of school-aged children in developing countries succumb to IDA (UNICEF/UNU/WHO/MI, 1998). There have been calls from international conferences endorsing ambitious goals to reduce malnutrition by the year 2000. However, many of these goals have not been achieved. In 1992, the International Conference on Nutrition met with the objective among others, to endorse the 1990 World Summit for Children goal of halving the 1990 prevalence of underweight in young children and substantially reducing anemia by the year 2000 (Latham, et al., 2001). Unfortunately too little progress has been made toward the global elimination of iron deficiency. It has often been reported that iodine and vitamin A deficiency receive far greater attention and support (ACC/SCN, 1998).

Iron deficiency (ID) and anemia have few overt symptoms, this being partly a reason for a lack of action. There is a shortcoming of knowledge of its serious and often permanent consequences to the cognitive developments of young children, and its negative impact on the health of all people (UNICEF/UNU/WHO/MI, 1998). To achieve results, current thinking must be directed at prevention measures that entail simple and low cost fortification models, easily adaptable to cultural environments targeting all children anemic or not. A prevention model must be maintained permanently, the public at large be informed, the object being to control and prevent ID and IDA in children.

Therapeutic supplementation is considered a direct measure, while nutrition education, iron fortification and public health measures are indirect measures and may be applied to prevent iron deficiency. Ideally the fortification of widely consumed and centrally processed food staples with iron should be the priority by most developing country governments if iron intake levels are to improve in children (Dutra-de-Oliveira, et al., 1996).

To seriously confront the problem of iron deficiency anemia in developing countries requires commitment, principally innovative “user-friendly” approaches which are appropriate to their socioeconomic and cultural environments and are simple and sustainable. One such approach to fortification is to use potable drinking water as a vehicle for iron fortification to prevent iron deficiency anemia among the low socioeconomic population in Brazil. The use of drinking water as a vehicle for fluoridation (MMWR, 2001) and iodization (Pandav, et al., 2000) in large scale has resulted in positive gains for control and elimination of goiter and dental caries in many parts of the world.

During the 1990s, the fortification of drinking water with iron and ascorbic acid to control for iron deficiency anemia was tested in rats, and later in humans (Ferreira et al., 1991). Results from Dutra-de-Oliveira and colleagues (1996 & 1994) in Brazil demonstrated that drinking water fortified with iron sulfate and ascorbic acid contributed to reducing ID and anemia in daycare children after 8 months of careful evaluation. In this study, we examined the effects of long-term oral iron fortification in drinking water in preschool children in a socioeconomic deprived region in southeast Brazil.

Subjects and methods

Study site and subjects

Initially, an investigation was carried out in December of 2000 to assess ID, IDA prevalence and growth of 241 children 6 to 59 months of age, using same Hb and anthropometry data collection procedures as outlined in current methods. In 2001, from March to November, we studied the feasibility and long-term effects of iron fortification of drinking water on the control and prevention of an iron-deficiency with and without anemia, as well as on child's growth in daycare children. The study was conducted in the town of Diamantina (pop. 43,000), located at an altitude of 1,300 meters above sea level, in the Jequitinhonha Valley region of the state of Minas Gerais, Brazil. This area is characterized as having a low socio-economic population, with poor hygienic conditions, the principle occupation being diamond extraction. The estimated population of pre-school children attending daycare was 400. At enrollment, 221 pre-school children aged 6-59 months from 8 municipal daycare centers; São Vicente de Paulo (SVP), Bela Vista (BV), Pequeno Príncipe (PP), Creche Cazuza (CC), Bom Jesus (BJ), Rio Grande (RG), Creche Nazaré (CN) and Maria Antônia (MA), were selected to participate in study during 8 months of intervention. Children attended daycare Monday thru Friday from 7 a.m. to 5 p.m. Daily attendance was recorded, and average number of days absent per child during 8 m intervention period was compared to absenteeism rate of children during 8 m from year before (2000). An invitation letter and consent form were sent to parents whose children were enrolled in any one of the eight-daycare. All children who received parental consent had their baseline data measured. During this study, 61 (27.6%) children left the study: because of family migration in the case of 33 (14.9%) children; 26 (11.8%) were excluded from study due to chronic disease such as pneumonia, infection or absent from daycare more than 10 d and 2 (0.01%) were diagnosed com severe anemia (<9.8 g/dl) and referred to the community hospital for further evaluation and treatment. Therefore, 160 children participated during the 8 m intervention study. Socioeconomic status data (mother's education, monthly income and living situation) were collected via a questionnaire administered to mothers by trained nurses before the intervention began. A research protocol was approved by the Human Ethics Committee at the University of Brasília (UnB).

Stool samples were examined to determine the worm burden of 109 pre-school children by using Stoll's dilution egg-count technique (Melvin & Brook, 1982). A 2 ml sample of feces was added to 60 ml of 0.1 N NaOH and the flask was mixed during 1 minute. An aliquot of 0.20 ml was then put onto a clean slide upon which a cover slip was placed. Total number of eggs were counted microscopically and expressed as the number of eggs per gram of stool by multiplying by a factor of 200. Subjects testing positive for parasites were treated with 100 mg of mebendazole (Pluriverm®) twice daily during 3 days as to remove helminthiasis as a confounder of both growth and hematological status. This was carried out by trained supervisors from each daycare. Mothers, whose children tested positive for *G. lamblia*, were encouraged to seek treatment at local health clinics. After children participated during the first four months of intervention, fecal exams were once again evaluated.

Measurement of variables

Anthropometric measurements (weight and height) were obtained at baseline, 4 m, and 8 m by four examiners who followed standard procedures according to World Health Organization (WHO, 1968). Infants were weighed naked (to nearest 100 g) on a digital infant scale (Seca Inc., Australia). Recumbent length was measured to the nearest 0.1 cm on a portable infant measuring tape (Raven Equipment Limited). The hemoglobin (Hb) level of 160 children was determined on site by fingerprick blood samples at baseline, 4 m and 8 m of intervention using the HemoCue® (Hemo®Cue, Inc, Ängelholm, Sweden). Cut-off for iron deficiency (ID) was established at <11.8 g/dl, and IDA at <10.8 g/dl, after compensating for altitude. Three return visits were made to record data of children who were previously absent.

Intervention

Six hundred milliliters of deionized water was placed in a 1L erlenmeyer flask to prepare the concentrated iron and vitamin C solution. Thirty-six grams of iron sulfate (12 g element iron) and 54 g of ascorbic acid were added and mixed with the 600 mL deionized water. From the concentrated iron and ascorbic acid solution, 1 milliliter was added to each 1 liter of drinking water consumed at each daycare. Amber 20 ml vials were used to store the concentrated solution during daily fortification of drinking water. New solution was delivered each Monday and stored in refrigerators at each daycare until use. Daycare did not operate on weekends. The concentration depended on the number of liters of drinking water per day consumed at each daycare. To facilitate consumption, iron-concentrated solution was added to plastic mineral water jugs (20L) containing the appropriate quantity of drinking water in liters. Daycare workers were instructed how to add the iron solution to drinking water. Supervision occurred twice weekly on randomly chosen days to insure adherence and quality control. Children had *ad labium* to drinking water during the entire day (7 a.m. to 5 p.m.). The plastic jugs were washed with water and dish detergent each morning.

Color and turbidity analysis

Color and turbidity of iron-fortified drinking water with and without ascorbic acid were initially studied using the model according to Dutra-de-Oliveira et al. (1996). Briefly, 25 mL of iron-fortified water sample was analyzed immediately after preparation, and 3 vials containing same quantity solution were stored for a period of 1, 3 and 7 d at room temperature (27°C). Water color was quantitatively determined by a Hellige Water Tester (Hellige Inc., Garden City, NY). Results were expressed in mg Pt/L. Turbidity measures were quantitatively determined using same quantity and days as were used for color, but analyzed using a Micronal Turbidometer-B250 (Micronal FA, São Paulo, Brazil). Results were expressed in mg SiO_2/L. At the start of the intervention, all fonts of drinking water were substituted for plastic 20 L jugs containing iron-fortified drinking water. Children were told that a new, more hygienic water storage and *ad labium* system was substituted for the old clay, water filter system, typical in Brazil. They were also told to drink water as much as they would like, that it would make them strong and healthy (*forte* and *saudável*).

Evaluation of the quantity of nutrients served

An estimation of the quantity of foods and their recommended daily allowance (RDA) of nutrients offered to pre-school children were studied and expressed in grams and milliliters. Five of 8-daycare were randomly sampled. Aliments were weighed separately using a digital balance (Instrutherm BD-140, São Paulo, Brazil) to the nearest 1 g. Three plates were weighed and mean weight was subtracted from total weight of each aliment. Each aliment was weighed three times, and liquids were measured to the nearest 10 ml using a standardized measuring cup (Quality Injetemp Ind., Brazil). Means were then calculated from each aliment. Average daily water consumption (ml/d) was measured in 10 randomly selected children from each daycare (n=80). Data were recorded on a food evaluation form and later analyzed with Virtual Nutri 1.0 software for Windows (Philippi et al., 1996).

Statistical analyses

The distribution of each variable was tested for normality before analyses, using the Kolmogorov-Smirnov goodness of fit test. Where necessary, data were normalized using appropriate transformations. Data are presented as means ± standard deviations when normally distributed. Pearson's correlation test was used to examine the association between Hb and weight and height. Weight-for-age, height-for-age and Height-for-weight *Z*-scores were calculated by using National Center for Health Statistics reference data using the EPI-INFO software, version 6 (Centers for Disease Control, Atlanta, GA). Weight and height gains were calculated by adjusting for the actual length of the interval between measurements. The change of Hb from pre- and post-treatment was examined and compared across the intervention using Student's *t* test and ANOVA with Bonferroni's multiple comparison tests. Differences between pre- and post-treatment of parasitic infection were expressed as percentage. The acceptable level of statistical significance for all tests was $p<0.05$. Results are expressed as geometric means (± SDs) and ranges. Analyses were performed with SPSS software program (version 10.0; SPSS Inc., Chicago).

Results

Baseline data analyses are presented in **Table 1** based on the interviews of 144 mothers whose children participated in study. According to one-way ANOVA, there were no statistically significant differences between socio-economic indicators when compared to 69 iron-deficient or anemic children of mothers who responded to the questionnaire. Absenteeism from daycare was greater in children before (3.5 ± 1.6 days) participating in study than after 8 m of intervention (2.5 ± 1.1 days) (**Table 2**).

Color and Turbidity analysis

An analysis of water behavior fortified with ferrous sulfate, ferrous sulfate and ascorbic acid are presented in **Table 3**. When 12 mg Fe/L as ferrous sulfate was added to water, presence of metallic iron was visible immediately, and color increase on 0, 1, 3 and 7 d. Color presence, measured in mg Pt/L using the Hellige Water Analyzer, resulted in the highest reading, 70 mg Pt/L for Fe only. When same concentration of

Fe/L and 90 mg/L of ascorbic acid were added to drinking water, presence of color was absent during 0, 1, 3 and 7 d. Turbidity was also markedly present in water fortified with Fe only, according to mg SiO_2/L, and insignificant when 90 mg/L of ascorbic acid was added with Fe. Measurements of pH during 0, 1, 3 and 7 d were 6.9, 6.9, 6.4 and 6.7 for Fe only (mean pH 6.7) and 5.0, 4.6, 4.0 and 4.8 (mean pH 4.6) for Fe + ascorbic acid respectively. Supervisors from the 8 daycare reported that all children consumed the fortified drinking water without any complaints and/or negative side effects during the 8 m evaluation period. Adhesion was therefore 100%. Any remaining iron-fortified drinking water from the day before was used for cooking rice, noodles, beans or preparing corn meal for breakfast.

Anthropometry

Mean and standard deviation of WAZ, HAZ and WHZ from pilot study were –0.63 ± 1.19, –0.80 ± 1.30 and –0.13 ± 1.0, respectively. From current study, mean weight-for-age (WAZ) *Z*-score at baseline was –0.84 ± 1.03. There was a significant difference between at baseline and 8 m post-intervention ($p<0.05$). Mean SD height-for-age (HAZ) and weight-for-height (WHZ) *Z*-score at baseline were -0.84 ± 1.11 and –0.40 ± 0.94, respectively. These were also significant at $p<0.05$. When comparing Hb levels with anthropometry before and after intervention, no statistically significant differences were observed in relation to WAZ and/or HAZ *Z*-scores. However, there was a significant positive mean *Z*-score increase in WAZ, HAZ and WHZ at 8 m to 0.06 ± 1.10, 0.54 ± 1.10 and –0.18 ± 1.14, respectively. This translated to an overall increased difference in Z-score of 0.90 ± 0.50, 1.38 ± 0.64 and 0.21 ± 1.0 for WAZ, HAZ and WHZ, respectively (**Table 2**).

Hematology

According to results from an ID and IDA prevalence study conducted 4 m before in 2000, 53 (22%) children suffered from iron deficiency and 40 (16.6%) were anemic. At baseline from current study analysis, the overall prevalence of ID (Hb < 11.8 g/dl) and IDA (Hb < 10.8 g/dl) were measured as the percentage of individuals responding to iron-fortification during 8 m. Initially, 43.2% (n=69) were evaluated as being iron-deficient and/or anemic. At the end of study, prevalence decreased to 21%. Iron deficiency was twice as high in children 7 to 23 m old compared to those aged 24 to 59 m, which has also been shown by others. At baseline, mean Hb was 11.8 ± 1.3 g/dl. At 8 months, mean Hb increased to 12.4 ± 0.93 g/dl ($p<0.01$). There were no significant gender differences for hemoglobin (Hb). Before intervention began, 26.3% (42) of the children suffered from ID and 16.9% (27) suffered from an IDA. At 8 m, 20.7% (32) and 0.03% (5) continued to suffer from ID and IDA, respectively (**Table 4**). The number of non-iron-deficient and non-anemic had risen from 91 (56.9%) at baseline, to 126 (78.8%) at the end of study. Hemoglobin levels were also grouped according to age during 8 m (**Table 5**). There were statistically significant increases in Hb levels in 7 to 23.9 m ($p=0.02$), 24 to 35.9 m ($p<0.01$) and 36 to 47.9 m of age groups ($p<0.01$). Hemoglobin levels in children older than 48 m increased (0.05 g/dl), but this increase was no longer significant ($p=0.45$).

Parasitology

Upon analysis of feces, 55.5% of the 109 subjects examined were infected with one or more parasites. Baseline fecal examination showed that 39.1% (68) were infected with *Ascaris lumbricoides*, 16.1% infected with *Entamoeba histolytica* (28), 13.8% infected with *Entamoeba coli* (24) and 39.1% (68) tested positive for *Giardia lamblia*. After 4 months, subjects were once again reevaluated for parasites. According to results, treatment was poorly effective and re-infection was a common problem. Specifically, infection by *Ascaris* decreased to 24.1% (43), infection of *E. histolytica* increased to 20.1% (35) and remained virtually unchanged for *E. coli* and *G. lamblia*, 12.1% (24) and 37.4% (65), respectively. Overall parasitic infection decreased to only 50% upon reexamination. There was no statistical association between hemoglobin levels and parasite infection after the second exam during the 4-month intervention (baseline $p=0.82$, post-exam $p=0.62$).

Evaluation of quantity of foods

A 24-hour dietary evaluation of the quantity of foods offered to children in 5 daycare is shown in second part of **Table 2**. Mean total energy, protein, and iron consumption were below the RDA recommendations. Mean energy available from diet was 943.5 ± 173.5 Kcal/d. Food source proteins and vitamin C were 97% and 52% above RDA recommendations respectively. Vegetable source iron, or non-heme iron, was greater (5 ± 1.4 mg/d) than animal source iron, or heme-iron (2.0 ± 1.4 mg/d). Mean daily-intake of iron offered from breakfast, lunch, a snack and dinner was 7.0 ± 1.9 mg/d, which was 70% of RDA. Total percentages of energy from foods were 19.8%, 48.6% and 31.6% of proteins, carbohydrates and fats, respectively. Children at daycare took their meals in the home place on weekends and holidays. Finally, mean total consumption of iron-fortified drinking water, measured in milliliters per day, taken from 80 pre-school children, was 503.3 ± 64.8 ml/d. This would translate to an additional Fe consumption of approximately 6.04 mg Fe/d.

Discussion

The results of the present study indicate that iron-fortified drinking water was highly acceptable to children aged 6 to 59 m, and significantly improved their iron status by decreasing ID and/or IDA in 48%. Iron-fortified drinking water provided 120% of RDA allowance of Fe if one liter of water were consumed daily. The relatively simple method of adding concentrated iron solution to drinking water on a daily basis was also a plus for daycare workers, many of whom possess less than five years of school instruction. Additional advantages are that this method requires less then one hour each week to prepare the iron-concentrate, however, this may depend on the number of daycare and children to be targeted. Other then adding iron-concentrate to the appropriate number of liters of drinking water consumed by children in daycare, it is easy to distribute and can be easily monitored.

For an iron-fortification program to be successful, it is important to select food vehicles that are consumed daily, to select an iron compound that is well absorbed, and to have the ability to control enrichment (WHO, 1968, Mora, 2002). Food fortification and supplementation are generally considered the best approaches for combating iron deficiency in a population. However, fortified foods do not always reach the intended target groups, and in the case of pre-school children, consumption of fortified foods may not be large enough to significantly increase their intake of key elements (Mora, 2002; Uauy, 2002). Therefore, the effect of iron-fortified drinking water on pre-school children in municipally funded daycare was studied as a form for guaranteeing the RDA allowance of iron in children.

According to guidelines for approaches to fortification of foods, pre-requisites for effective fortification will include: a long-term commitment; a bioavailable iron source compatible with suitable food vehicles which conforms to existing regulations; a suitable food vehicle, i.e. one that is centrally processed, technologically and economically fortifiable with no change to taste, texture, appearance and acceptable and frequently used by the target group, in this case, children (Gillespie et al., 1991). Contrary to criticism against iron-fortified drinking water, the relatively minor metallic taste is not an inhibiting factor, as pre-school children adapt amazingly well to novel situations. Advocacy and national programs have been constrained by erroneous perceptions that effective, practical interventions are not available (ACC/SCN, 1999). Should a program such as iron-fortified drinking water be implemented in school feeding, it is strongly recommended that it be accompanied by a relevant nutritional message, which would put fortified drinking water into perspective.

There are fortunately just two studies published in the literature on iron-fortified drinking water, which were shown to substantially reduced ID and/or IDA prevalence in social-economically poor populations whose initial prevalence of iron deficiency was greater than 40%. It was demonstrated that incorporating 20 mg of element iron per liter of drinking water during 8 m in a daycare reduced the incidence of IDA from 48% to as little as 3% in 31 children at a cost-benefit of US$0.05 cents per child (Dutra-de-Oliveira et al., 1994). Mean hemoglobin (Hb) level at baseline was 10.7 ± 0.7 g/dl and 13.0 ± 1.1 g/dl at 8 m (baseline serum ferritin (SF), 13.7 ± 8.9 µg/L and 25.6 ± 10.5 µg/L at 8 m). The second study on iron-fortified drinking was also conducted by Dutra-de-Oliveira et al. (1996). During 4 m, 10 mg of element iron (ferrous sulfate) and 100 mg vitamin C were added to each liter of drinking water consumed by 44 family members. An additional 44 family members served as a control group and did not receive iron in their drinking water. Mean Hb levels at baseline in adults (12.9 g/dl) and in children (10.9 g/dl) increased significantly ($p<0.01$) to 13.7 g/dl and 11.7 g/dl, respectively. Increase in SF was significant in adults (94.4 ± 38.3 µg/L to 162.2 ± 113.8 µg/L), and not in children (27.6 ± 21.6 µg/L to 33.8 ± 22.1 µg/L) at 4 m. Hemoglobin levels in control group families decreased, contrary to experimental group families.

In many developing countries, iron deficiency is common largely in part due to a high cereal-based diet and one that contains little animal protein, as the latter is generally too costly for the poor. In this study, an evaluation of the quantity and quality of foods offered to daycare children revealed that non-hem Fe sources consisted of 5 mg Fe/d, and only 2 mg Fe/d was in the from of heme Fe, for a total daily iron-intake of 7 mg Fe/d. This would amount to 70% of RDA allowances. Available total vitamin C offered in foods was high, which is a plus, as it will increase absorption of non-heme iron foods (Hallberg, 1989 & 1981). An increased consumption of iron-rich animal foods will require overall economic improvements which are unlikely to occur on a short-term basis.

When iron soluble inorganic salts are given together with water, absorption is higher than when given with foods (Hurrell, 1984). Consumed together with foods, several dietary aliments, such as calcium, phytates, polyphynols and alcohol, inhibit iron absorption at the cellular level (Hallberg & Hulthen, 2000). According to nutrition studies on inhibitory dietary aliments, it has been estimated that daily iron absorption is roughly 40%, but this however, will depend on ones dietary habits (Hallberg et al., 1998 & 1997). Children chronically anemic will possibly absorb a greater percentage of iron, for example, 60% or more, in an attempt to restore iron stocks, and in turn, restore hemoglobin levels (Hallberg, 1998). Children in this study would possibly consume 3.6 mg Fe/d more given mean daily water consumption was 503 ml/d, increasing iron intake from 7 mg Fe/d to 10.6 mg Fe/d. On the other hand, the risks of iron overload from iron-fortified drinking water are very remote, as the quantity of Fe/L (12 mg Fe/L) is small, and iron overload disorders and hemochromatosis are mostly prevalent in European populations (Gillespie, 1998). Importantly was that children attending daycare, especially at-risk of iron deficiency, had *ad labium* to iron-fortified drinking water five days per week.

During the fortification period, weight and height increased as would be expected for growing children. Effects of iron-fortified drinking water may have positively influenced this increase, however, no statistically significant results could be presented, as there was no control group in this study. Although there were expressive increases seen in *Z*-score values, it is believed that these results could not have happened by chance alone. Daycare workers reported increased appetite in children during study, but the extent to which this may be true was not measured in this study. Children were less absent at daycare than before intervention, which may indicate that they were less prone to disease. Many children who were stunted (11.3%) or severely underweight (8.1%) at baseline were less so to be after 8 m of intervention as percentage of children with a *Z*-score of <-2 for HAZ and WAZ decreased from 11.3% and 8.1% to 1.3% and 1.9% respectively.

Deworming treatment was largely ineffective and apparently had not negatively influenced growth. Parasitic infection, as demonstrated from fecal exams in 109 of the 160 children participating in the intervention study, brings forth the urgent need to improve overall hygienic conditions in areas were the poor inhabit. This region possess one of the lowest Human Develop Indexes (0.49) according to UNICEF (2001) and lacks proper sewage disposal and treatment systems. The relatively high percentage of children infected with parasites can be attributed to the contaminated nearby streams and springs that often receive discharged human feces. The insignificant decrease (39.1% to 37.4%) in *G. lamblia* cases after reevaluation was mostly due to the mother's inability to afford anti-*Giardia* medication. Although *G. lamblia* is the most prevalent parasite infection in the region, municipal health centers do not distribute free medication, which is otherwise unaffordable by most.

Two shortcomings of the method of our data collection included the use of one hematological indicator and the absence of a control group. Since hemoglobin is the most readily measured essential iron compound, an increase in Hb concentration in response to iron administration can be regarded as presumptive evidence of prior iron deficiency (Dallman et al., 1980). Hemoglobin measurement to detect iron-deficiency anemia is suitable in field circumstances where other methods are less suitable and make analysis complex. Furthermore, hemoglobin measurements give a satisfactory estimate of the prevalence of iron deficiency when prevalence is high (Schultink et al., 1993 & Freire, 1989).

Despite the difficulties in assessing ID and IDA, we feel confident that the high prevalence of iron-deficiency and anemia from this child population was real, and thus justified a creative, low-cost, effective intervention model. In fact, the daily quantity of foods available to children was far below RDA requirements; especially aliments high in energy (Kcal/d) and animal source Fe (mg/d). Total daily milligrams of Fe in foods served to children were 7.0 mg Fe/d (70% RDA). The recommended daily allowance is 10 mg/d for pre-school children (NRC, 1989).

In summary, there is a great need for alternative, feasible, effective and practical ways to distribute iron and seriously increase compliance. The role of nutrition education as a long-term solution should, however, not be overlooked. We conclude that consumption of drinking water fortified with iron contributed to increasing iron-intake to meet minimal daily-recommended allowance of bioavailable iron acceptable to pre-school children aged 6 to 59 m attending daycare. This intervention program was offered to all children (≈ 400) attending daycare and will continue on a permanent daily basis, and plans are to multiply it to other regions with a high prevalence of a deficiency of iron. Total cost-benefit was approximately US$0.08 cents per child during 8 m. Apparent mild metallic Fe taste was not an inhibiting factor to consumption.

Acknowledgments

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See Below for Tables

Table 1. Hematological and anthropometric measurements from prevalence study of children enrolled in daycare facilities (Beinner Personal Communication).

Variables	n = 241
Hemoglobin, *g/dl*[*]	12.2 ± 1.6
Iron deficiency, *%*	22
Iron deficiency anemia, *%*	16.6
Weight-for-age, *Z-score*[*]	-0.63 ± 1.19
Heigtht-for-age, *Z-score*[*]	-0.80 ± 1.3
Weight-for-height, *Z-score*[*]	-0.13 ± 1.0

[*] Values are mean ± SD.

Table 2

Baseline characteristics of pre-school children .[1,2]

Variables	**Intervention**
Biological characteristics, *n*	160
Hemoglobin, g/dL	11. ± 1.3
Anemic, *n*	69
Nonanemic, *n*	91
Sex (male: female)	67:93
Age, *y*	3.4 ± 1.1
Weight, *kg*	13.6 ± 2.6
Height, *cm*	94.0 ± 10.7
Socioeconomic characteristics	
Mother's education, *y*	4 ± 2
Sleeping arrangement, *n*	
1 bed ≤2 members	57
1 bed >2 members	87
Safe water, *n*	117
Sanitation, *n*	
Toilet in home	116
Latrine	11
Use open camp	17
Electricity, *n*	
Own meter	108
Share meter	19
No electricity	17
Mother's monthly income, *n*	
≤200 reais[3]	113
>200 reais	31

[1] Values are means ± SD or numbers of children.

[2] Total number of mothers interviewed = 144.

[3] 1 real = 0.40 US $ at the time of data collection.

Table 4. Change in variables before and 8 m post-intervention, including an evaluation of quantity of foods offered to preschool children attending daycare.

Variables[1]	**Before**	**After**	**Difference**	***p***
Hemoglobin, *g/dl*	11.8 ± 1.3	12.4 ± 0.93	0.60 ± 1.3	<0.01
Absenteeism[2]	3.5 ± 1.6	2.5 ± 1.1	1 ± 2.7	<0.01
Anthropometry measurements (*z*-score)				
W/A	-0.84 ± 1.03	0.06 ± 1.10	0.90 ± 0.50	<0.05
H/A	-0.84 ± 1.11	0.54 ± 1.10	1.38 ± 0.64	<0.05
W/H	-0.39 ± 0.94	-0.18 ± 1.14	0.21 ± 1.0	<0.05
Intestinal parasites [3] (%), *n = 109*	55	50.6	4.4	0.62

Food composition[4]		**% RDA**[5]
Energy, *Kcal/d*	943.47 ± 173.42	67
Protein, *g/d*	47.56 ± 12.77	297
Vitamin C, *mg/d*	60.96 ± 32.78	152
Fe (animal source), *mg/d*	1.99 ± 1.29	-
Fe (vegetable source), *mg/d*	5.00 ± 1.44	-
Total Fe, *mg/d*	7.0 ± 1.9	70

[1] Values are means ± SD in 160 children; [2] Mean ± SD of child/days absent per month before intervention and after 8 m post-intervention; [3] Children testing positive for parasites were treated with 100 mg mebendazole (Pluriverm®) before and retested 4 m during intervention; [4] Evaluation of quality and quantity of foods offered to children in 5 daycare centers; [5] RDA-Recommended Daily Allowances.

Table 5. Classification of iron status of pre-school children aged 6 to 59 m participating in 8 m of iron-fortified drinking water in daycare centers.

	Before		After	
	n	%	n	%
Normal	91	56.9	126	78.8
Iron deficiency	42	26.3	32	20.7
Iron deficiency anemia	27	16.9	5	0.03
Total	160	100	160	100

Table 6. Mean and SD of hemoglobin (Hb) levels at baseline and 8 m post-intervention according to age group in children attending daycare.

Age group (m)	n	Hemoglobin (g/dl) Before	 After	p*
7 to 23.9	18	11.0 ± 1.4	11.7 ± 1.0	0.02
24 to 35.9	42	11.5 ± 1.5	12.5 ± 1.0	0.01
36 to 47.9	39	12.3 ± 1.2	12.8 ± 0.9	0.01
> 48	61	12.5 ± 1.2	12.6 ± 0.8	0.45
Total	160	11.8 ± 1.3	12.4 ± 0.9	0.01

* $p<0.05$.

Table 3. Analysis of iron-fortified drinking water: color and turbidity.

	Concentration (mg/L)		Color (mg Pt/L) Days after preparation				Turbidity (mg SiO_2) Days after preparation			
Solutions	Iron	Ascorbic acid	0	1	3	7	0	1	3	7
Ferrous sulfate	12	-	70	70	70	70	9.3	24.0	26.0	27.0
Ferrous sulfate + ascorbic acid	12	90	5	5	30	55	0.6	0.5	0.4	11.0