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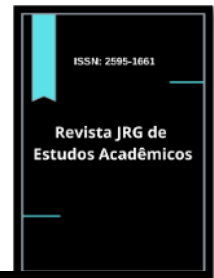
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Micronutrient adequacy of pediatric patients on enteral nutritional therapy during hospitalization

Adequação de micronutrientes dos pacientes pediátricos em terapia nutricional enteral no curso na internação hospitalar

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Abstract

Background: Childhood is a critical step in developing and growing, not yet physically but mentally and immunologically. In the hospitalization context, a correct, adequate, and complete nutritional support is extremely important for optimization of treatment. In this context, this research aims to evaluate the nutritional adequacy of patients admitted to the Maternal and Child Hospital of Brasília who are on full enteral exclusive nutritional therapy. **Methods:** That's a quantitative research in which the participants were patients between 0 and 14 years of age during the medical hospitalization and that were using an exclusive enteral feeding tube with the diet equal to the final

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nutritional goal planned. The data were taken from the electronic medical record and the prevalence of each micronutrient was calculated and for adequation was considered a percentage between 90% to 110%. This research was approved by the research ethics committee. **Results:** 117 patients were chosen, most are male, between 0 to 6 months, and have the principal hospitalization diagnostic of a respiratory disease. The prevalence of adequacy of micronutrients shows that sodium and potassium are nutrients with lower adequacy, vitamin A is the most adequate, and the upper limit recommended for some nutrients was surpassed. **Conclusion:** This research showed that dietary recommendations for micronutrients are not completely respected for pediatric patients who are on full enteral exclusive nutritional therapy with the diet equal to the final nutritional goal planned. This intake out of references to micronutrients may be posing health risks for this group and this demonstrates the need to investigate the cause and the consequence of this intaking profile. To transform this, a law revision is necessary, supported by more studies and researches about the micronutrients adequation in the pediatric context, finding to establish the Brazilian child's micronutrients recommendations.

Keywords: pediatrics; child nutrition; enteral nutrition; infant formulas; micronutrients.

Resumo

Introdução: A infância é uma etapa crítica para o desenvolvimento e crescimento, não apenas físico, mas também mental e imunológico. No contexto da hospitalização, um aporte nutricional correto, adequado e completo é extremamente importante para a otimização do tratamento. Diante desse contexto, esta pesquisa tem como objetivo avaliar a adequação nutricional de pacientes internados no Hospital Materno Infantil de Brasília que estão em terapia nutricional enteral exclusiva e completa. **Métodos:** Trata-se de uma pesquisa quantitativa cujos participantes foram pacientes entre 0 e 14 anos de idade durante a internação hospitalar, utilizando uma sonda de alimentação enteral exclusiva com dieta correspondente à meta nutricional final planejada. Os dados foram extraídos do prontuário eletrônico, e a prevalência de adequação de cada micronutriente foi calculada. Considerou-se adequada a ingestão entre 90% e 110% da recomendação. Esta pesquisa foi aprovada pelo Comitê de Ética em Pesquisa. **Resultados:** Foram avaliados 117 pacientes, em sua maioria do sexo masculino, com idade entre 0 e 6 meses, sendo a principal causa de internação uma doença respiratória. A prevalência de adequação de micronutrientes mostrou que sódio e potássio apresentaram os menores índices de adequação, enquanto a vitamina A foi o nutriente mais adequado. Alguns nutrientes ultrapassaram o limite superior recomendado. **Conclusão:** Esta pesquisa revelou que as recomendações dietéticas para micronutrientes não são completamente respeitadas em pacientes pediátricos em terapia nutricional enteral exclusiva e completa, mesmo com dieta planejada para atender à meta nutricional final. Esse consumo fora dos padrões de referência pode representar riscos à saúde desse grupo, demonstrando a necessidade de investigar as causas e as consequências desse perfil de ingestão. Para transformar essa realidade, é necessária uma revisão das diretrizes legais, apoiada por mais estudos e pesquisas sobre a adequação de micronutrientes no contexto pediátrico, buscando estabelecer recomendações específicas para crianças brasileiras.

Palavras-chave: pediatria; nutrição infantil; nutrição enteral; fórmulas infantis; micronutrientes

1. Introduction

Childhood is a critical step in developing and growing, not yet physically but mentally and immunologically. Especially in the first 1,000 days of life, but not yet in this period, and yes, for all childhood, an inadequate provision of nutrients may lead to deficient physical and cerebral development, possibly irreversible, and this is proportional to time in a nutritionally inadequate diet(1,2).

Beyond the late stages of growth and development, nutritional deficiencies in childhood are associated with learning difficulties, a decrease in academic performance and immunological damage. In addition, children with growth issues due to lower amounts of macronutrients and micronutrients are more likely to develop illness and contract infections(2).

It is estimated that in the year 2020, 149 million children age less than 5 years worldwide showed late development as a result of a chronic malnutrition state(3). In Brazil, hospitalizations for malnutrition, malnutrition sequelae and nutritional deficiencies in the Unified Health System (SUS) are equal to 2,754 records of patients younger than 1 year(4).

Additionally, to avoid nutritional deficits, all nutrients need to be consumed in an amount that the supplying organism demands. These amounts are distinct for different ages and genders too. With this in focus, a revision, done and frequently updated, for the Institute of Medicine of the United States in partnership with Health Canada establish the intake recommendations for macronutrients, micronutrients and food components adequate for nutritional apport(5).

In the hospitalization context, a correct, adequate and complete nutritional apport is extremely important for optimization of treatment, however, attention points need to be respected by taking into focus reserves reduction, nutritional necessities increase caused by metabolic stress and disease or health conditions that can turn the oral feeding unavailable(6). Nevertheless, an adequate dietary apport contributes to adequate nutrition state maintenance and, in addition, directly relates to patient prognosis, which relates to higher costs with health and higher periods of hospitalizations and treatment(7).

Nutritional therapy is essential and needs to be initiated as soon as possible and oral feeding is always preferable. Although, especially in critical patients, but also for some specific pathologies, oral feeding is impossible or contraindicated, this form becomes preferable, in front of the absence of contraindications like not resolvable chock, decompensation, intestinal ischemic or stenosis, use of enteral nutrition via tube, using specific formulas or human milk, and, lastly, parenteral nutrition(6).

In this context, this research aims to evaluate the nutritional adequacy of patients admitted to the Maternal and Child Hospital of Brasília who are on full enteral exclusive nutritional therapy.

2. Methods

That is a quantitative research in which the participants were patients between 0 and 14 years old, during medical hospitalization at the Maternal and Child Hospital of Brasília – HMIB, a tertiary attention in infant care reference, in the Pediatric Intensive Care Unit or one of the pediatric infirmaries and that were using an exclusive enteral feeding tube with the diet equal the final nutritional goal planned during months March to June of 2024. In addition, the patients who were using non mandatory vitamin supplementations considering their age and the patients who received human milk as a diet.

The targeted sample was 60 (sixty) patients using like reference a sampled calculation considering that the hospital has 65 (sixty-five) pediatric beds in the infirmaries and 16 (sixteen) beds in the Pediatric Intensive Care United and a cofinance degree equal 95% and an error equal 11%.

The hospital protocol was used to establish nutritional goals considering age, gender, nutritional level/classification, older injuries/pathologies and current hospitalization principal diagnostic and all nutritional goals were revised by the principal researcher for a more standardized analysis. This protocol was formulated for the dietitian team of the hospital using important scientific studies about nutritional intake necessary for different groups as reference (8–11).

The data were taken from the electronic medical record for uniquely the principal research, aiming to reduce the confounding error, and for each patient in the data analysis one code was established. Data was tabulated using the Excel program for Microsoft 365.

Like variables for analysis were used: age, gender, nutritional level/classification, oldest injuries/pathologies, actual hospitalization principal diagnostic, final nutritional goal, amount of micronutrients received and recommended (vitamin A, C, E, thiamine, riboflavin, vitamin B12, vitamin K, calcium, iron, zinc, potassium, sodium, magnesium, selenium, and phosphorus) and adequation of micronutrients percentage. For the number of micronutrients received, a nutritional label of each formula was used for the patients in the hospital and the Dietary Reference Intakes (DRI) was used to analyze the adequation of micronutrients, looking for a patronization analysis (5).

In the hospital, infant's formulas are separated by age and by protein hydrolysis. With this in focus, infant formulas with polymetric protein are first infant formula for children aged 0 to 6 months; follow-on formula for 6 months to 1 year; high-energy formula for 0 to 3 years that needs a high-energy diet; and growing-up formula for children age up to 1 year. In addition, infant formulas with protein hydrolysis offered are partially hydrolyzed formula with a partial protein hydrolysis; extensively hydrolyzed formula with an extensive protein hydrolysis; and amino acid-based formula with complete protein hydrolysis.

Using this data, the prevalence of each micronutrient was calculated and for adequation there was considered a percentage between 90% to 110%. Additionally, a prevalence analysis for characteristics data was realized using the software Stata® version 16.1 with $p < 0,05$, and a graphic plotting for the micronutrient adequation distribution.

This research was approved by the research ethics committee of the Foundation for Teaching and Research in Health Sciences - FEPECS/SES/DF, under Certificate of Presentation for Ethical Appreciation number 77405124.0.0000.5553 that permitted a not presentation of written informed consent.

3. Results

After inclusion and exclusion criteria have been applied, over 117 patients will be analyzed in this research. The characteristics of this are concentrated in Table 1 and it's possible to observe that most parts are male between 0 to 6 months and have the main hospitalization diagnostic as a respiratory disease.

Table 1: Social and clinical characteristics of patients who are on full enteral exclusive nutritional therapy during the medical hospitalization patients on the Maternal and Child Hospital of Brasília, Brasília, Brazil, n=117 (March to June of 2024)

	Prevalence (%)	95% Confidence Interval
Female	42.74	34.01 - 51.93
Male	57.26	48.06 - 65.98
0 to 6m	50.43	41.35 - 59.46
6m to 1y	10.26	05.88 - 17.28
1y to 3y	20.51	14.08 - 28.88
4y to 8y	14.53	09.18 - 22.22
9y to 13y	4.27	01.77 - 09.94
Respiratory	69.23	60.20 - 76.98
Neurological	5.98	02.85 - 12.10
Dengue	5.98	02.85 - 12.10
Gastrointestinal	4.27	01.77 - 09.94
Others	14.53	09.18 - 22.22

Table 2: Diet intake for patients who are on full enteral exclusive nutritional therapy during the medical hospitalization patients on the Maternal and Child Hospital of Brasília, Brasília, Brazil, n=117 (March to June of 2024)

	Prevalence (%)	95% Confidence Interval
First infant formula (1)	28.21	20.73 - 37.11
First infant formula (2)	4.27	01.77 - 09.94
Follow-on formula	4.27	01.77 - 09.94
High-energy formula	8.55	04.63 - 15.24
Partially hydrolyzed formula	3.42	01.27 - 08.83
Extensively hydrolyzed formula	12.82	07.83 - 20.27
Amino acid-based formula	5.13	02.30 - 11.03
Growing-up formula	33.33	25.32 - 42.44

In addition, the prevalence of adequacy of micronutrients is concentrated in Table 2 and their detailed distribution is exemplified in Image 1. Observing this, it is seen that sodium and potassium are nutrients with lower adequacy, vitamin A is the nutrient with the most part adequate, and for all samples, the adequacy of vitamin B12 is higher to recommendation.



Table 3: Prevalence of adequacy of micronutrients in the diet of patients who are on full enteral exclusive nutritional therapy during the medical hospitalization patients on the Maternal and Child Hospital of Brasília, Brasília, Brazil, n=117 (March to June of 2024)

	Adequacy down 90%		Adequacy between 90% to 110%		Adequacy upper 110%	
	%	95% CI	%	95% CI	%	95% CI
Vitamin A	14.53	09.18 - 22.22	27.35	19.97 - 36.21	58.12	48.91 - 66.79
Vitamin C	0.85	00.11 - 05.92	3.42	01.27 - 08.83	95.73	90.05 - 98.22
Vitamin E	1.71	00.42 - 06.66	4.27	01.77 - 09.94	94.02	87.89 - 97.14
Vitamin B1	0.00	-	2.56	00.81 - 07.73	97.44	92.26 - 99.18
Vitamin B2	0.00	-	0.00	-	100.00	-
Vitamin B12	0.85	00.11 - 05.92	0.85	00.11 - 05.92	98.29	93.33 - 99.57
Vitamin K	4.27	01.77 - 09.94	8.55	04.63 - 15.24	87.18	79.72 - 92.16
Calcium	29.06	21.48 - 38.00	6.84	03.43 - 13.16	64.10	54.93 - 72.34
Iron	9.40	05.25 - 16.27	6.84	03.43 - 13.16	83.76	75.84 - 89.44
Zinc	1.71	00.42 - 06.66	1.71	00.42 - 06.66	96.58	91.16 - 98.72
Potassium	47.86	38.88 - 56.97	12.82	07.83 - 20.27	39.32	30.81 - 48.52
Sodium	47.01	38.06 - 56.14	7.69	04.02 - 14.21	45.30	36.43 - 54.46
Magnesium	22.22	15.53 - 30.73	24.79	17.73 - 33.49	52.99	43.85 - 61.93
Selenium	31.62	23.77 - 40.67	15.38	09.86 - 23.19	52.99	43.85 - 61.93
Phosphorus	8.55	04.63 - 15.24	14.53	09.18 - 22.22	76.92	68.33 - 83.73

Like an adequation intake was considered a percentage between 90% to 110%.

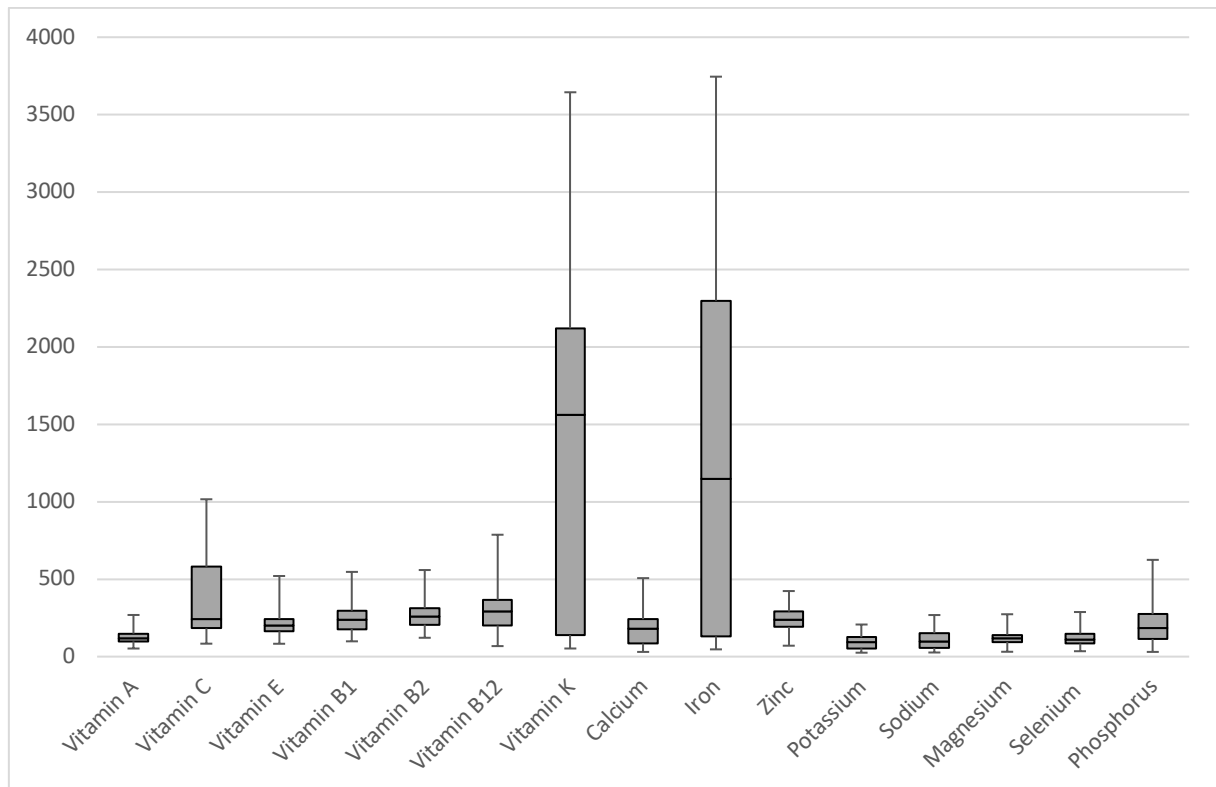


Image 1: Graphic plotting of quantity of micronutrients in the diet of patients who are on full enteral exclusive nutritional therapy during the medical hospitalization patients on the Maternal and Child Hospital of Brasília, Brasília, Brazil, n=117 (March to June of 2024)

Moreover, an analysis of these micronutrients revealed that the upper limit recommended from Dietary Reference Intakes (DRI) for some nutrients was surpassed(5). Magnesium was surpassed for some patients in the age group of 1 and 3 years, and 4 and 8 years. Zinc was surpassed for some patients between 0 and 6 months, 6 months and 1 year, 1 and 3 years, and for the patients between 4 and 8 years. Calcium for some patients in the age group of 0 to 6 months, and 6 months to 1 year. Vitamin A was surpassed for some patients in the age group of 0 to 6 months, 6 months to 1 year, and 1 to 3 years.

4. Discussion

The results show a similar distribution about gender of patients. This aligns with data before research that when investigated different contexts behind hospitalization in pediatric patients also show a similar distribution with a little or no-one difference between females and males patients(12–14).

On the other hand, the present study found a high prevalence of patients aged 0 to 6 months that differs when compared with the study realized for Lima et al., that showed a high prevalence of children aged between 1 and 4 years(12). Although, this difference could be related to the period that data was collected and, for consequence, related to results shown with a high prevalence of respiratory diseases. The period between March and July corresponds to seasonality of respiratory syncytial virus (RSV) and hospitalization of children under 4 years old increases and still more for under six months of age children(15,16).

Respiratory syncytial virus (RSV) is one of the main contributors to respiratory infections in younger children, often leading to outpatient visits, emergency department

utilization and hospitalization(17). It can have difficult prognostics still considering its inverse proportional relation with the patient age. In this context, it is important considering that RSV incidence and its prognostic was associated with perinatal and sociodemographic characteristics, and factors associated with others medical conditions including congenital heart disease, tracheostomy, bronchopulmonary dysplasia, chronic lung disease, Down syndrome or preterm birth(18).

One important part of the treatment and the recuperation is a nutritionally adequate diet. For that, choosing an enteral nutrition on detriment of parenteral nutrition is a best practice considering that this is more physiological and has more benefits for intestinal mucosa and its integrity and function. In addition, this choice is associated with better prognosis for critical patients(19).

The first point that guides the choice of formulas for the kid's diet is the age because each of these is planned for one age group. In this context, the results demonstrate a higher prevalence of first infant formula uses and this formula intended for ages between 0 and 6 months concords with the age prevalence found in this research(19–21).

Beyond that, for choosing a more adequate formula it is important to consider the patient's illness and formula composition and indication. This is necessary because different formulas have different specificities and compositions and indications, and its classification can consider its protein composition beyond age indications. In addition, this choice needs to consider that medicine therapy can affect nutritional metabolism(19).

A polymeric formula has an intact protein while a hydrolyzed has broken protein in different levels of hydrolysis and an amino acid-based formula has only peptides in its composition(19). The results of this research show an expressive prevalence of the use of hydrolyzed formulas. However, unfortunately, these hydrolyzed formulas are produced for englobe children with different ages, between 0 and 36 months, having focus on the dietetic protein needed(22). This fact ignores different nutritional demands, specifically for micronutrients, for different age groups like for example a calcium demand that is triple for children that are 36 months old when compared with children that are 6 months old(23).

Additionally, beyond the formula's choice, in the nutritional offer is necessary an adequate nutritional goal to supply all metabolic demands that are increased for growing and injury stress specially on the pediatric public. In this context, to use of predictive formulas is common to stipulate the energy and protein goal, but these formulas do not embrace micronutrients(19,24).

It is known that the Dietary Reference Intakes (DRI) was delimited for a healthy population and for this does not consider illness augments in nutritional demands, but this is the only reference for enteral nutrition for pediatric patients that englobe micronutrients. Still, it is important to consider that the pediatric formulas were also developed for healthy children and for this fact the better way is to follow clinical signs and exams for each patient during the illness course to determine the success of the feeding strategy(5,19,24).

This study found an irregular micronutrients' adequacy profile where some have a higher prevalence down 90% of adequacy like sodium and potassium, and some have a higher prevalence upper 110% of adequacy like vitamin C, E, B1, B2, B12, iron, zinc, calcium and others when compared to DRI's recommendations. This fact demonstrates a probability that the infants' formulas are not completely adequate for supplying your nutritional necessity for micronutrients and can expose this population group to risk.

For formulas control and rules for your compositions and manufacturing are determined for Brazil National Health Surveillance Agency (ANVISA). Furthermore, rules established limits are calculated with reference to diet calories besides what these are down or upper that DRI's references and established limits and the law permits formulas out for your limits in front of some manufacturing conditions(5,25–27).

In addition, other ANVISA's laws establish rules for foods labeling including infants' formulas, but these permit a composition with until 20% of difference for down or for upper from label to composition(28,29). This difference would mean that there is not a real inadequate consumption of micronutrients and, for consequence, there is a lower risk to the health of this group.

In front of age characteristic of our sample, for children down 6 months of age the recommendation is consumption of maternal human milk only and formulas for these groups aims a similar composition like this, but maternal human milk have a capacity of turn different composition for macronutrients and micronutrients and for non-nutritional compounds. This fact turns difficult a formula with equal composition and still difficult the use of human milk composition like reference for adequate supply for this group(30,31).

The concentration for iron, calcium, magnesium, zinc, vitamin A, C, E and B complex and more other components, despite low research about these apports, in the human milk change influenced for maternal food habits, maternal body composition, maternal age, birth conditions, breastfeeding status, and infant's age, and even for maternal circadian cycle(30–32).

For all ages, adequate micronutrients apport are important for growth and development. Still, the results show that the patients are receiving a lower apport of sodium and potassium and if the permanency of this non-adequation develops hyponatremia and hypopotassemia becomes a possibility(33).

Sodium is an important nutrient for neuromuscular function and for osmotic and acid-base balance in the body and its lower consumption can lead to headache, lethargy, decreased reflexes, convulsion and coma. For children, sodium needs are increased owing to growing. Potassium is a nutrient important for the acid-base balance and that has its levels turning facility due its presence in body tissues can start an overload even with low consumption(33).

A lower apport of these nutrients is contributed to diuretic therapy, therapy that is an important part of treatment for various respiratory diseases. For hospitalization patients, electrolytics disturbances are common and hyponatremia is the most common(33). These disturbances can leave serious cardiac illness(19,33). In a similar context, upper apport of magnesium shown in results can influence diuretic therapy and can be associated with heart failure(33,34).

Other nutrients that the results showed with an upper apparent appliance were vitamin A, calcium and zinc. In the context of vitamin A, oxidative stress for surgeries and diseases can interfere in absorption, but even with stress context, for a non-pediatric patient a consumption upper recommendation, non-necessarily upper tolerated limit, leaves hypervitaminosis and it can leaves to fragile hair, dry mucous, rough skin and bones fractures(33).

For the calcium, an excessive apport can lead to lethargy, nausea, vomiting, and muscle weakness, but in hospitalization context a diuretic therapy contributes for augment of excretion and, for consequence, controls of excessive apport. Reaffirms that hypercalcemia can be a fatal illness and can contribute to development of Milk-Alkali Syndrome and pancreatitis(33).

Zinc is a fundamental nutrient for growth and development due to being a cofactor to hundreds of enzymes, especially for macronutrients and defense metabolisms, and having a structural function for body tissues. Its deficiency causes immunological illness, but its excess can be not good because it is not proportional to the immunological efficiency. It is important to see that blood level about zinc is not reliable for available deficiency or excess and the risk for this is evaluated for consumption. With an excessive consumption due to formula composition this evaluation is harmed(33).

An important fact is that formula composition is estimated and to measure really what micronutrients apport that each child receives is impossible. Vitamins A, D, E, C, B complex, calcium and folate, for example, have their compositions affected by heat treatment and the water temperature chosen for preparation. The vitamin loss is variable and depends on the time/temperature binomial to which the product is subjected and for this the preparation process would be more important than the formula choice(35).

4. Conclusion

This research showed that dietary recommendations for micronutrients are not completely respected for pediatric patients admitted to the Maternal and Child Hospital of Brasília whom are on full enteral exclusive nutritional therapy with the diet equal to the final nutritional goal planned. This intake out of references to micronutrients may be posing health risks for this group and this demonstrates the need to investigate the cause and the consequence of this intaking profile.

A law revision is necessary, supported by more studies and researches about the micronutrients adequation in the pediatric context, to establish the Brazilian child's micronutrients recommendations. This needs to be an urgent goal because inadequate intake of micronutrients in infancy could have losses for growth and development. For this, researches using blood investigations, that wasn't possible to be made in this research because of the high cost and unavailability of micronutrients blood investigations on the Brazilian health public system, can be important and as an comparison of values for micronutrient apport during an health and in illness context for this society group.

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