J Diet Suppl. Author manuscript; available in PMC 2019 March 04.

Published in final edited form as:
J Diet Suppl. 2018 March 04; 15(2): 129–139. doi:10.1080/19390211.2017.1330300.

Micronutrient intake and the contribution of dietary supplements in Hispanic Infants

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Abstract

Objective—To calculate micronutrient adequacy among infants and toddlers and to determine the contribution of dietary supplements to this adequacy.

Methods—Micronutrient intake was assessed using two non-consecutive 24-hour recalls in a sample of 296 infants aged 0-24 m. Micronutrient intake was calculated from foods and beverages and from supplements and compared between non-users and users of supplements. Percentage of children below the DRI and above the UL was also compared between groups.

Results—A total of 241 participants had complete data. The prevalence of dietary supplement use among the sample was 15%. Mean intake of all micronutrient from foods and beverages was similar between non-users and users of supplements ($p>0.05$) but significantly higher for the following vitamins when supplements were included: D, E, B1, B2, B3, and B6 ($p<0.05$). From foods only, the nutrients with highest percentage of children below the DRI were vitamins D and E and potassium. When supplements were included, this percentage significantly decreased among users compared to non-users ($p<0.05$) for vitamins D and E. From foods, the UL was exceeded for magnesium, zinc, and vitamin B3. These were similar when supplements were added.

Conclusion—Supplements significantly increased the intake of some vitamins. Vitamins D and E had the highest percentage of children below the DRI; which was partly corrected with the use of supplements. The UL was exceeded for magnesium, zinc and vitamin B3 in many children. It is important to understand these patterns, as it may be indicative of future nutritional deficiencies and excesses.

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There is no conflict of interest to disclose.

Keywords

dietary supplements; micronutrient intake; adequacy; infants; Hispanic

Introduction

Dietary supplement use among the U.S. population has increased over time [1,2]. According to data obtained in the 2007-2010 National Health and Nutrition Examination Survey (NHANES), 31% of children and adolescents aged 0-19 years reported the use of dietary supplements, with the lowest use among infants <2 years (17%) [3]. In terms of race/ethnicity, it has been found that non-Hispanic white children are more likely to use dietary supplements than Hispanic or non-Hispanic black children [3,4]. Yet in most cases, dietary supplements are not necessary if children are healthy and meeting all the nutritional requirements through diet.

Nevertheless, for infants and toddlers who are at risk of a nutrient deficiency because of lifestyle or environmental factors, diseases, or any other specific reason, dietary supplements are recommended [5–7]. For instance, the Institute of Medicine (IOM) and the American Academy of Pediatrics (AAP) recommend 400 IU/d of vitamin D supplementation for partially or fully breastfed infants to prevent vitamin D deficiency, as breast milk does not provide enough vitamin D [6,8]. The AAP also recommends iron supplements for breastfed infants from 4 months old until iron-rich complementary foods are introduced to prevent iron-deficiency complications [7] and fluoride supplements for those children living in low fluoride areas to prevent dental caries [9].

However, recent studies have shown high intakes of some micronutrients in small children, well above the Dietary Reference Intakes (DRI), particularly among users of dietary supplements [10–12]. For example, the Feeding Infants and Toddlers Study (FITS) reported that children aged 6-47 months had intakes above the Tolerable Upper Intake Level (UL) for folate, vitamin A, zinc, and sodium from diet alone, and intake of vitamin A and zinc was well above the UL in users of dietary supplements [10]. The potential health consequences of such high intakes of some of these micronutrients include skeletal abnormalities (vitamin A), vitamin B12 deficiency masking (folate), and suppression of the immune function (zinc) [13,14].

On the other hand, some studies have found that several micronutrients are consumed below the recommendations, in particular, vitamin D, for which the recommended intake was recently increased to 400 IU/d [8]. For example, the Infant Feeding Practices Study II found that in children 1-10.5 months vitamin D intake was below the recommendation, regardless if infants were breastfed, mixed-fed or formula-fed [15]. Similar results were found among children aged 1-3 years in Canada [12]. Others studies have also reported inadequate intakes of iron, zinc, vitamin E, and potassium among children under 5 years old [10,16]. Important health consequences associated with deficiencies in some of these micronutrients include rickets (vitamin D and calcium), anemia (iron), growth retardation (zinc), and impaired immune function (zinc and vitamin E) [8,14].

There are scarce studies assessing nutrient intake from foods and supplements among infants and toddlers [11], a very important age for the development of the brain, linear growth, bone mass acquisition, and adipose tissue development. Most studies have been done among children 2 years and older. Also, this has been understudied among Hispanics, a population with many health disparities. Additionally, to our knowledge, this has not been evaluated among WIC participants. This is important because a total of 8.3 million US children and pregnant women participate in the WIC program [17], which is about 50% in the US and 79% in Puerto Rico, with a total annual cost of $6.3 billion in 2014 [18]. Therefore, it is critical to understand if participants of the WIC program are meeting the recommendations for important micronutrients essential in their development. This could help improve their interventions to ensure that children in their program meet the recommended amounts for these micronutrients. Thus, the objective of this study was to assess micronutrient intake adequacy among infants based on the DRI and to determine the contribution of supplements to this adequacy. We hypothesize that some micronutrients are consumed in excess, while others, such as vitamin D, are consumed below the recommended intakes in this sample of infants and toddlers.

Methods

Study design

This was a cross-sectional analysis that used a non-probabilistic convenience sample of caregivers of infants aged 0-24 months. Caregivers completed a battery of questionnaires (i.e., demographics, feeding practices) and anthropometrics in infants were taken. Written consent was obtained before participating in the study. The Institutional Review Board of the University of Puerto Rico, Medical Science Campus approved this study.

Study population

Originally, 296 infants were included in our study according to our criteria. We recruited caregivers of singleton infants, who were 21 years or older, participants of the Women, Infant's and Children (WIC) Program and with infants aged 0-24 months without disabilities that could impede regular infant feeding practices. The following disabilities were specifically excluded: autism, celiac disease, Chron's disease, innate errors of metabolism, cancer, cleft palate, and dysphagia. Additional criterion to be included in the analyses was to have complete data (two 24-hour recalls); 55 did not meet this criterion. Therefore, our final sample was 241 infants and toddlers. Recruitment occurred daily from November 2014 – March 2015 in the only WIC clinic in the municipality of Trujillo Alto in Puerto Rico in order to ensure participation of all active participants.

Dietary intake

Trained nutritionists administered two 24-hour recalls by phone on non-consecutive days using the multi-pass method of the Program Nutrition Data System for Research (version 25, Nutrition Coordinating Center, University of Minnesota) [19]. The 24-hour recall is a nutritional assessment in which participants are asked to recall the foods and beverages they consumed in the past twenty-four hours before the interview. Micronutrient intake was first calculated from foods and beverages using the average of the two 24-hour recalls, after adjust these for within- and between-person variability. Second, adequacy was assessed using the DRI values as established by the IOM by age groups: 0 to <6 months, 6 to <12 months and 12 to 24 months. Adequacy was defined as meeting or not the Estimated Adequate Requirements or Adequate Intake, as appropriate. Third, adequacy was also assessed among supplements users after adding the contribution of micronutrients from dietary supplements. We also calculated the % of infants with intakes above the UL, for nutrients that have this level established (vitamin A, D, calcium, iron, zinc for infants and toddlers 0-24 months and vitamin C, E, B6, B3, folate, and copper for toddlers 12-24 months).

Statistical analysis

Mean and standard errors were computed for continuous variables and frequencies for categorical values. We estimated group difference of micronutrient intakes using the SAS macro created by National Cancer Institute (NCI) which allows to adjust the 24-hour dietary recall data for within- and between-person variability and other covariates, and thereby to remove the effect of the sequence of the 24-hour dietary recall from the estimated nutrient intake distribution (day 1 or day 2) [20]. Covariates in the model included dichotomized weekend (Friday-Sunday vs. other), age in months, and gender. Within-person variance and covariates-adjusted mean of micronutrient intakes per person were estimated using the method proposed by Willett [21], and the proportion meeting the EAR and exceeding the UL were compared between dietary supplement users and nonusers using T-test or chi-square, as appropriate. All statistical analyses were performed using SAS (v. 9.3, SAS Institute Inc, Cary, North Carolina) software. Statistical significance was set at $p<0.05$.

Results

Characteristics of the sample

A total of 241 participants completed both 24-h recalls. Over half of the participants were boys (55.6%), 39.0% are between 12-24 months old, most parent/caregivers were older than 25 years, and 60% had higher than high school education (Table 1). There was a greater proportion of parent/caregivers among users with an education of higher than high school ($p<0.05$). Overall, 15% of the sample used dietary supplements, mainly from multivitamins/ multiminerals (81.1%), followed by a combination of 2 or 3 nutrients, such as Trivisol (16.2%), and single nutrients, such as vitamin C (2.7%).

Mean intake of micronutrient

Mean intake of all micronutrient from foods only was similar between non-users and users of supplements ($p>0.05$; Table 2). However, when supplements were included in the total micronutrients intake, users had significantly higher intakes of vitamins D, E, B1, B2, B3, and B6 ($p<0.05$). No differences in the intake of minerals were observed between these groups ($p>0.05$). Compared to foods only, micronutrients intake from foods plus supplements was also significantly higher for vitamins D, E, B1, B2, B3, and B6 ($p<0.05$) among users.

Micronutrient adequacy

The percentage of infants and toddlers with intakes below the RDA or AI is shown in Table 3. From foods only, the nutrients with highest percentage of children with intakes below the DRI were vitamin D (85.4% in non-users and 86.1% in users), followed by vitamin E (57.1% in non-users and 52.8% in users) and potassium (26.8% in non-users and 50.0% in users). In addition, there were a significantly higher proportion of infants and toddlers below the DRI for vitamin B1 (8.3%) and calcium (19.4%) in users compared to non-users (2.0% for B1 and 7.8% for calcium; $p<0.05$). When supplements are included, the percentage of children with intakes below the DRI for vitamin D is significantly decreased from 86.1% to 36.1% and for vitamin E is significantly decreased from 52.8% to 27.8% among users compared to foods only and it is also significantly lower compared to non-users ($p<0.05$). In addition, when supplements are included, the percentage of children with intakes below the DRI is not significantly different between users and non-users for vitamin B1, although it is still significantly higher for calcium among users compared to non-users ($p<0.05$).

Tolerable Upper Intake Level

The percentage of infants and toddlers with intakes above the UL is shown in Table 4. Not all micronutrients have an UL available for all age groups. From foods only, the UL was exceeded for magnesium (92.7% in non-users and 94.4% in users) in toddlers aged 13-24 months (there is no UL for younger infants). Zinc intake also was above the UL from foods only in infants aged 0-6 months (63.4% in non-users and 60.0% in users) and in infants aged 7-12 months (63.2% in non-users and 50.0% in users). Vitamin B3 intake was above the UL from foods only in toddlers aged 13-24 months (40% in non-users and 38.9% in users). These percentages did not change when supplements were added to total intake, except for vitamin B3, which increased to 61.1%.

Discussion

In this sample of Hispanic infants and toddlers' participants of the WIC program, overall dietary supplements use was 15%. Mean intake of all micronutrients from foods only was similar between non-users and users of supplements but in general, most children had inadequate intakes of vitamins D and E. When supplements were included, this significantly increased the intakes of vitamins D, E, B1, B2, B3, and B6, which significantly improved the percentage of children falling short for vitamins D and E. The ULs were exceeded in most for magnesium and zinc, irrespective of supplement use.

Similar to the present study, others have found similar mean intake of micronutrients from foods only between non-users and users, such as in the Infant Feeding Practices Study II [15]. Also, others have found similar nutrient adequacy between non-users and users in toddlers aged 1-3 years from the Canadian Community Health Survey 2.2, except for vitamin D [12] (SHAKUR). In fact, for vitamin D, both the Infant Feeding Practices Study II [15] and the study in Canada reported that children's diets fell short for vitamin D. Older studies assessing intake of vitamin D in US infants found adequate intake [10,22], but this was compared against the previous vitamin D recommendation of 200 IU/day [5]. This recommendation was revised by the Institute of Medicine in 2011 and based on the available data it was increased to 400 IU/day for infants and toddlers. In addition, vitamin D has only a few dietary sources other than sun exposure. This combination of factors may be related to the results. It may take a several years for the food industry to catch up with this new recommendation. Similar results have been found in other age groups with vitamin D [23]. However, the present study and the study among Canadian toddlers demonstrated that when supplements are used, vitamin D adequacy significantly increases, indicating that supplements may be needed to achieve vitamin D recommendations.

Two other micronutrients in which most infants and toddlers fell short compared to the recommendation were vitamin E and potassium. Similar results were found in the FIT study among toddlers and preschoolers [10]. Also, data from NHANES 2003–2010 also showed that potassium intake was below the recommendation in infants [16]. Vitamin E is usually found mainly in nuts, seeds, and vegetable oils, while potassium is usually found in fresh fruits and vegetables. However, in the present sample, the main contributors for vitamin E were infant formula, almond milk and some starchy vegetables, while for potassium were milk, and some fruits and vegetables, such as bananas, potatoes and sweet potatoes. Supplements significantly increased the intake of vitamin E among this sample, which reduced inadequacy. In the case of potassium, inadequacy did not change with supplement use, as potassium is usually not included in dietary supplements. Therefore, for meeting potassium recommendation, an increase in fruits and vegetables is probably needed.

The ULs were exceeded in most for magnesium and zinc, irrespective of supplement use. Similarly, the FIT study also found that intake of zinc, as well as vitamin A, exceeded the UL [10,22]. In our sample, the main food sources of magnesium were fortified instant oatmeal, ready-to-eat cereals and some fruits and vegetables and for zinc were meat, ready-to-eat cereals and infant formula. For healthy individuals, excessive intake of magnesium from food does not result in the long-term health effects because excess of magnesium can be eliminated through the urine, while supplemental magnesium can cause diarrhea or gastrointestinal disturbance [24]. On the other hand, zinc intake exceeding the UL can increase the risk of adverse health effects by altering copper status and affecting the immune function [25]. Thus, as proposed by Briefel and colleagues [22], some fortified processed foods are the main contributors for several of these micronutrients. It is also important to note that most micronutrients evaluated in the present study do not have an UL in infants, therefore, it was not possible to calculate if other micronutrients are consumed in excess. Therefore, given the potential adverse effects of excessive intake of some of these micronutrients and the lack of information on excessive intakes of others in infants and toddlers, it is important to monitor micronutrient intake among young children to prevent potential negative health outcomes in the long-term.

This study has some limitations that should be addressed. Because of limitations in our design, we were not able to distinguish between fortified and non-fortified foods. Therefore, our results took into consideration intake of all micronutrients regardless if they were from fortified foods or not. This may have resulted in an overestimation in the values used for the UL analysis. Second, causality cannot be inferred due to the cross-sectional design of the study and the total number of participants. Third, the study could have some bias in the information collected in the 24-hour recalls, as the data was self-reported by the participants.

Also, the results cannot be generalized, as the participants were selected from a single WIC clinic. However, the municipality in which the study was conducted has only that one specific WIC clinic and in order to ensure enrollment of all active participants, recruitment was done daily for three months. Additionally, one of the advantages of our study is that the sample recruited was from an underrepresented population, giving good insights of micronutrient status and supplement use among Hispanic infants and toddlers participants of the WIC program.

In conclusion, in this sample of socially disadvantage background Hispanic infants and toddlers' participants of the WIC program, most had diets deficient of vitamins D and E. However, supplement use significantly decreased the proportion of infants with vitamin D and E intakes below the DRI. This indicates that supplements are important sources of these nutrients for meeting the recommended levels. Magnesium and zinc were consumed excessively by most, which may have long-term health consequences. It is important to understand these patterns, as it may be indicative of future nutritional deficiencies and excesses.

Acknowledgments

This study was conducted with support from University of Puerto Rico Central Administration Grant, Capacity Advancement in Research Infrastructure, UPR-MFP 6251123 and in part by Awards 8G12MD007600, 2U54MD007587 and U54MD008149 from the National Institute on Minority Health and Health Disparities. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

We thank the Puerto Rico WIC Program for their support, in particular to Dana Miró (Executive Director), Blanca Sastre (Interim supervisor of Nutrition and Lactation Division), and Marta Meaux, Nutrition Supervisor of the Trujillo Alto Clinic and her team.

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List of Abbreviations

WIC	Women, Infant, and Children program
DRI	Dietary Recommended Intakes
IOM	Institute of Medicine

RDA	Recommended Dietary Intake
AI	Adequate Intake
UL	Tolerable Upper Intake Level
NHANES	National Health and Nutrition Examination Survey
FITS	Feeding Infants and Toddlers Study
AAP	American Academy of Pediatrics
CDC	Center for Disease Control

Table 1
Study participants' characteristics (N=241)

Characteristics of the sample	Users of supplements	Non-users of supplements	Total participants
		N (%)	
Total sample	35 (14.5)	206 (85.5)	241 (100)
Gender			
Boy	21 (8.7)	113 (46.9)	134 (55.6)
Girl	14 (5.8)	95 (38.6)	107 (44.4)
Ages (months)			
0-5	8 (3.3)	77 (32.0)	85 (35.3)
6-11	7 (2.9)	55 (22.8)	62 (25.7)
12-24	20 (8.3)	74 (30.7)	94 (39.0)
Parents/Caregivers ages (years)[b]			
<25	13 (5.4)	60 (24.9)	73 (30.3)
25-30	11 (4.6)	66 (27.4)	42 (17.4)
>30	11 (4.6)	80 (33.2)	91 (37.8)
Parents/Caregivers education *			
≤ High School	9 (3.7)	87 (36.1)	96 (39.8)
> High School	26 (10.8)	119 (49.4)	145 (60.2)

*Significantly different between non-users and users of supplements, P<0.05.

Table 2

Mean intake of micronutrients infants and toddlers 0-24 months (n=241)

Micronutrient	Non-users (foods only) N=206		Users (foods only) N=35		Users (foods + supplements) N=35		Difference between non-users and users (foods only)[1]	Difference between non-users and users (foods + supplements)[1]	Difference between users (foods only vs foods + supplements)[1]
	Mean	S.E.	Mean	S.E.	Mean	S.E.			
Vitamins									
Vitamin A (Retinol; mcg)	535	157	523	150	541	158	0.28	0.24	0.85
Vitamin D (mcg)	6.6	4.5	8.6	5.4	10.9	6.6	0.42	<0.0001	<0.0001
Vitamin E (mg)	5.3	4.3	6.4	4.8	8.3	6.8	0.49	<0.0001	0.01
Vitamin K (mg)	38.8	28.6	31.8	23.5	28.3	22.7	0.27	0.28	0.99
Vitamin C (mg)	84.0	28.9	90.7	31.1	107	35.4	0.07	0.54	0.16
Vitamin B1 (mg)	0.7	0.2	0.8	0.2	0.9	0.3	0.49	0.00	0.00
Vitamin B2 (mg)	1.0	0.3	1.1	0.3	1.2	0.3	0.55	0.00	0.00
Vitamin B3 (mg)	8.6	2.8	9.9	3.0	11.1	3.3	0.72	0.00	0.01
Vitamin B5 (mg)	3.5	0.9	3.4	0.8	3.4	0.8	0.41	0.70	0.33
Vitamin B6 (mg)	0.7	0.2	0.9	0.2	1.0	0.2	0.19	<0.0001	0.00
Vitamin B9 (mcg)	146	36.7	160	38.8	167	41.1	0.28	0.13	0.52
Vitamin B12 (mcg)	2.3	1.0	2.4	1.0	2.4	1.0	0.22	0.45	0.13
Minerals									
Calcium (mg)	628	178	620	173	603	173	0.63	0.62	0.96
Phosphorus (mg)	517	145	545	145	535	145	0.80	0.79	1.00
Magnesium (mg)	108	26.1	117	26.0	121	26.3	0.24	0.24	0.99
Iron (mg)	9.6	5.6	10.0	5.6	10.5	6.1	0.89	0.16	0.30
Zinc (mg)	5.1	1.4	4.9	1.3	4.7	1.3	0.30	0.68	0.60
Copper (mg)	0.7	0.1	0.7	0.1	0.7	0.1	0.50	0.50	0.99
Potassium (mg)	1197	235	1270	235	1318	240	0.22	0.25	0.96

[1] T-test

Table 3

Percentage of infants and toddlers 0-24 months with micronutrient intakes below the Estimated Average Requirements (EARs) or Adequate Intakes (AIs)

Micronutrient	Non-users (foods only) N=206		Users (foods only) N=35		Users (foods & supplements) N=35		Difference between non-users and users (foods only)[1]	Difference between non-users and users (foods +supplements)[1]	Difference between users (foods only vs foods +supplements)[1]
	n	%	n	%	n	%			
Vitamins									
Vitamin A (Retinol; mcg)	33	16.1	5	13.9	5	13.9	0.74	0.74	1.00
Vitamin D (mcg)	175	85.4	31	86.1	13	36.1	0.91	<0.0001	<0.0001
Vitamin E (mg)	117	57.1	19	52.8	10	27.8	0.63	0.00	0.03
Vitamin K (mg)	55	26.8	14	38.9	14	38.9	0.14	0.14	1.00
Vitamin C (mg)	26	12.7	4	11.1	2	5.6	0.79	0.22	0.39
Vitamin B1 (mg)	4	2.0	3	8.3	1	2.8	0.04	0.75	0.30
Vitamin B2 (mg)	4	2.0	0	0.0	0	0.0	0.40	0.40	-
Vitamin B3 (mg)	17	8.3	4	11.1	2	5.6	0.58	0.57	0.39
Vitamin B5 (mg)	3	1.5	1	2.8	1	2.8	0.57	0.57	1.00
Vitamin B6 (mg)	7	3.4	1	2.8	0	0.0	0.84	0.26	0.31
Vitamin B9 (mcg)	21	10.2	1	2.8	1	2.8	0.15	0.15	1.00
Vitamin B12 (mcg)	7	3.4	3	8.3	2	5.6	0.17	0.53	0.64
Minerals									
Calcium (mg)	16	7.8	7	19.4	7	19.4	0.03	0.03	1.00
Phosphorus (mg)	13	6.3	4	11.1	4	11.1	0.30	0.30	1.00
Magnesium (mg)	8	3.9	1	2.8	1	2.8	0.74	0.74	1.00
Iron (mg)	22	10.7	2	5.6	1	2.8	0.34	0.13	0.56
Zinc (mg)	3	1.5	2	5.6	1	2.8	0.11	0.57	0.56
Copper (mg)	2	1.0	2	5.6	2	5.6	0.05	0.05	1.00
Potassium (mg)	55	26.8	18	50.0	18	50.0	0.01	0.01	1.00

[1] T-test

Table 4

Percentage of infants and toddlers 0-24 months with micronutrient intakes above the Tolerable Upper Intake Levels (ULs)[1]

Micronutrient	UL	Non-users (foods only)		Users (foods only)		Users (foods + supplements)	
		n	%	n	%	n	%
0-6 months							
Vitamin D (mcg)	25	2	2.2	0	0.0	0	0.0
Calcium (mg)	1000	4	4.3	0	0.0	0	0.0
Zinc (mg)	4	59	63.4	6	60.0	6	60.0
7-12 months							
Vitamin D (mcg)	38	1	1.8	0	0.0	0	0.0
Calcium (mg)	1500	0	0.0	1	12.5	1	12.5
Zinc (mg)	5	36	63.2	4	50.0	4	50.0
13-24 months							
Vitamin D (mcg)	63	0	0.0	0	0.0	1	5.6
Vitamin E (mg)	200	0	0.0	0	0.0	0	0.0
Vitamin C (mg)	400	1	1.8	1	5.6	1	5.6
Vitamin B3 (mg)	10	22	40.0	7	38.9	11	61.1
Vitamin B6 (mg)	30	0	0.0	0	0.0	0	0.0
Vitamin B9 (mcg)	300	3	5.5	1	5.6	4	22.2
Calcium (mg)	2500	0	0.0	0	0.0	0	0.0
Phosphorus (mg)	3000	0	0.0	0	0.0	0	0.0
Magnesium (mg)	65	51	92.7	17	94.4	17	94.4
Zinc (mg)	7	6	10.9	1	5.6	1	5.6
Copper (mg)	1	1	1.8	0	0.0	0	0.0
0-24 months							
Vitamin A (Retinol; mcg)	600	46	22.4	7	19.4	7	19.4
Iron (mg)	40	0	0.0	0	0.0	1	2.8

[1] UL for certain micronutrients are not available in infants