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ORIGINAL ARTICLE

Multivitamin and mineral supplements for pediatric use. How much of the nutritional recommendations do they cover?

Suplementos multivitamínicos y minerales de uso pediátrico ¿Cuánto cubren de las recomendaciones nutricionales?

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What do we know about the subject matter of this study?

The growing interest in improving health has led to the expansion of the dietary supplement industry, including multivitamin/mineral (MVM) supplements used to complement dietary intake. These supplements lack a regulated or standardized definition, resulting in variability in their composition.

What does this study contribute to what is already known?

The MVMs available for the pediatric population show significant variability in what is labeled as MVM, in the number of micronutrients they contain, and in their concentrations. When analyzing how much they cover nutritional requirements, it becomes evident that they are insufficient for certain micronutrients known to be commonly deficient, while for others that are not a health concern in pediatrics, their content exceeds recommended levels.

Abstract

Multivitamin/mineral (MVM) supplements are widely available and promoted to complete nutritional intake. There is no standard definition and their compositions vary. **Objective:** To evaluate the percentage of adequacy (PA) of the content according to the micronutrient intake requirement of MVM for pediatric age. **Materials and Method:** Descriptive study. Data was obtained from publicly available information by reviewing the websites of the four pharmacies with the highest sales, selecting those labeled for pediatric age, and excluding those with only one component, indicated for specific groups or purposes. For those available in 2 or more pharmacies and with > 10 components, the PA (amount of micronutrient/recommended dietary intake) *100 was calculated, according to sex, and divided into two age groups: 9-13 and 14-18 years. **Results:** A total of 164 MVM were found, 44 (26.8%) for pediatric age, resulting in 9 for PA analysis, and 7 for the 9-13 years group. They had a minimum total of 15 components and a maximum of 21, with >19 in 7/9 (77.8%). 12 vitamins in 7/9

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Vitamins;
Minerals;
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(77.8%) MVM and > 7 minerals in 7/9 (77.8%). The micronutrients with PA < 25% were vitamin D, K, calcium, magnesium, fluoride, zinc, phosphate, potassium, and sodium; between 76-99% vitamin A, iodine, copper, chromium for males and PA > 100% vitamin C, B1, B2, niacin, pantothenic acid, biotin, pyridoxine, molybdenum, selenium, and chromium for females. There were no significant differences in PA for each of the micronutrients according to the ages compared. **Conclusions:** There is a varied offer of MVM and with different formulations, presenting low coverage for micronutrients that are in deficiency such as calcium, zinc, and vitamin D, contrary to full coverage in micronutrients not studied as deficient in the pediatric population.

Introduction

Worldwide, the growing interest in improving health has led to the expansion of the dietary supplement (DS) industry[1]. Vitamin supplements are included in the general field of DS, and an expanding segment of this market is vitamins and minerals targeted at children and adolescents.

Professional medical organizations do not recommend its use in healthy children[2]. Despite this, a recent study found that 18% of U.S. children and adolescents who take DS did so based on the recommendation of a healthcare professional[3]. As socioeconomic status improves, the use of DS is becoming increasingly prevalent among children and adolescents in developed countries to compensate for nutritional deficits, improving health conditions, or preventing disease[4].

Multivitamin/mineral (MVM) products are considered DS. The first recommendation is to consume a wide variety of foods to meet nutrient needs and take MVMs to fill the remaining gaps[5]. A balanced diet delivers a variety of important nutrients in optimal proportions rather than isolated compounds in highly concentrated forms that may not meet all nutritional requirements. Positive health outcomes are more strongly related to dietary patterns and specific food types than to individual intake of micro- or macronutrients[6].

Supplements are effective only when individuals are nutritionally vulnerable. From a public health perspective, it is important to know what deficiencies exist in children and adolescents through national population-based surveys to evaluate how the formulations of the DSs are adjusted to the needs of these micronutrients[5]. There are also other strategies such as food fortification, a very important measure when nutritional deficiencies exist at the population level and have the advantage of providing nutrients to large segments of the population without requiring significant changes in food consumption patterns or supplement intake[7].

Meeting micronutrient needs is only one of many factors that influence MVM formulations. Other factors include marketing considerations, such as meeting consumer perceptions of the benefits of individual nutrients by displaying a large percentage of daily values on labels[5].

MVM supplements contain a combination of vitamins, minerals, and sometimes other ingredients. There is no standard or regulatory definition for their content. Manufacturers are free to choose the ingredients and amounts to include in their products, varying widely in composition and characteristics[5].

In Latin America, the designation of these products is not standardized, with legal documents referring to them as either food supplements (FS) or DS. In most countries, since DS are considered food products, their regulation is governed by the legal frameworks applicable to food. Panama is an exception, as in 2019 it approved a regulation for the sanitary registration process of vitamin, dietary, and food supplements with therapeutic properties, granting them the category of medicines intended to prevent, treat, or cure any disease[8]. In Chile, they are called FSs and it is the Ministry of Health the organism that determines the allowed ingredients, as well as the concentrations and characteristics required to classify a food as FS[9].

DS or FS can contribute significantly to total nutrient intakes[10], with the potential to both mitigate nutrient deficiencies and lead to nutrient intakes above recommended upper limits[3]. Despite the growing number of vitamins, minerals, and supplements targeting children and adolescents, few studies examine their risks[2]. Studies on prevalence and factors related to pediatric DS use are scarce around the world[4].

Considering the increasing number of supplements marketed and the fact that the consumption of DS intended for children and adolescents is increasing, the objective of this study was to evaluate the percentage of adequacy (PA) of the content according to the micronutrient intake requirement of MVM in pediatrics.

Material and Method

Descriptive study of data obtained from publicly available information on MVM in Chile in 2023.

The websites of the four top-selling pharmacies in the country were reviewed: *Farmacias Cruz Verde*, *Farmacias Salcobrand*, *Farmacias Ahumada*, and *Doctor Simi*. Notably, the first three account for 80% of national sales[11,12]. The search terms used were "multivitamins" and "polyvitamins."

The total number of products was recorded, excluding those containing a single component or those intended for specific groups such as women, pregnancy, and older adults or for specific uses, such as vegetarian diets, malabsorptive disorders, bone health, appetite stimulation, sports, or any purpose other than supplementation in healthy children and adolescents. From the selected MVMs labeled for pediatric age, data were collected on the pharmaceutical form (drops, syrup, injectable solution, pills, tablets, capsules), number of vitamins and minerals, concentration (mg, mcg, or UI) or dosage, recommended age, and the presence of other compounds (such as amino acids, probiotics, prebiotics, etc.).

PA was calculated using the formula: PA = (amount of the micronutrient [vitamin or mineral] in the MVM / recommended dietary intake)* 100, according to sex and age indicated by the manufacturer. This analysis included MVMs available in 2 or more pharmacies, representing 50% of the pharmacies studied, and containing ≥ 10 components, which are close to half of the micronutrients analyzed (10/26, 38.5%). Both criteria were defined by the research team. In addition, the UL (Tolerable Upper Intake Level) was evaluated for micronutrients that exceeded 100% of the recommended intake. Nutritional requirement recommendations for children and adolescents were based on the 2006 DRI[13], and for vitamin D, on the 2011 DRI[14].

The following vitamins were included in the study: vitamins A, C, D, K, thiamine, riboflavin, niacin, vitamin B12, folic acid, pantothenic acid, biotin, and pyridoxine; and the following minerals: calcium, iodine, iron, zinc, phosphorus, copper, manganese, potassium, sodium, molybdenum, fluoride, cobalt, selenium, and chromium. Vitamin E was not included in the analysis due to the difficulty in converting the milliequivalents (mEq) of synthetic (pharmaceutical) active tocopherol to the recommended intake values, which are based on natural sources[15].

Statistical analysis

Data was analyzed using STATA 16. Descriptive statistics were performed, including absolute and relative frequency, as well as minimum and maximum values for the number of components (total, vitamins, and minerals). Medians and their interquartile range (IQR: p25-p75) were calculated for the PAs and compared according to age groups using the Wilcoxon test. A $p < 0.05$ value was considered statistically significant.

Ethical considerations

This protocol was submitted to the Scientific Ethics Committee of the Central Metropolitan Health Service, which issued a certificate stating that ethical approval was not required since there was no human being involvement or collection of sensitive data.

Results

Figure 1 outlines the results of the search process, showing how MVMs were progressively excluded until reaching the 9 selected for PA analysis. Of the 288 products identified in the initial search, 124 corresponded to other types of items such as collagen, berries, shampoo, creams, shakes, sports drinks, and plant-based beverages, among others.

Of the 164 MVMs, 149 (90.8%) were found in the country's three major pharmacy chains, and 15 (9.2%) in Dr. Simi pharmacy. Table 1 details the MVMs excluded due to product duplication, target group, or specific purposes, resulting in 27 (16.4%) MVMs intended for the pediatric population. Of these, 18 were excluded for having fewer than 10 components and/or being available in fewer than two pharmacies. This left 9 MVMs for PA analysis: 7 intended for ages 9–13, and 2 for ages ≥14 (Figure 1).

Table 2 describes the characteristics of the MVMs analyzed. In relation to the total number of micronutrients, they had a minimum of 15 and a maximum of 21 components, with ≥ 19 in most of them. The highest number of vitamins was 12 in 7/9 (77.8%) and most had ≥ 7 minerals corresponding to 7/9 (77.8%). As for other compounds found in the MVM analyzed, trace elements were found in 4/9 (44.4%) and probiotics in 3/9 (33.3%). Supplementary table (available online) details the composition of the selected MVMs.

Table 3 shows the mineral content of the analyzed MVMs according to the age groups indicated by the manufacturer, along with the median PA calculated for all MVMs containing each mineral. Table 4 presents the same information for vitamins; vitamin K is not included, as it was not present in any of the MVMs.

Micronutrients with median PA< 25% were vitamin K, D, calcium, magnesium, fluoride, zinc, phosphorus, potassium, and sodium; PA 26-50% were folic acid, manganese; PA 51-75% were vitamin B12, iron; PA 76-99% were vitamin A for men, iodine, copper, chromium for men, and PA >100% were vitamin A for women, vitamin C, vitamin B1, vitamin B2, niacin, pantothenic acid, biotin, pyridoxine, molybdenum, selenium, and chromium for women. There were no significant differences in PA for each of the micronutrients according to age groups.

With respect to UL, it was found that only niacin exceeded it. For thiamine, riboflavin, pantothenic acid, biotin, and chromium, it was not possible to perform this analysis because it does not have a defined UL.

Discussion

We analyzed the MVMs currently marketed for the pediatric population, available on the websites of the four main pharmacies in the country. We describe the components of the MVMs for the pediatric population that are not directed to populations with specific needs or other objectives different from supplementation in healthy children and adolescents. This would be the first study that collects this type of information in Chile and evaluates them in relation to nutritional intake recommendations according to age and sex. We found that there is a wide range of MVM with very varied compositions, which could be because there is no established definition of what the characteristics of this type of product should be, nor are they aimed at completing known nutritional deficiencies for the national pediatric population[5].

In Chile, article 534 of the food sanitary regulations of 1996 establishes that "FS are those products elaborated or prepared especially to supplement the diet with healthy purposes and contribute to maintain or protect characteristic physiological states such as adolescence, adulthood, or old age. Their composition may be a nutrient, mixture of nutrients, and other components naturally present in food, including compounds such as vitamins, minerals, amino acids, lipids, dietary fiber, or their fractions..."[9]. The maximum and minimum levels of vitamins, minerals, and other components are established by a resolution issued by the Ministry of Health under its legal and technical regulatory authority, with the most recent being Resolution No. 394 from the year 2002[16].

This allows different presentations to be offered with a wide range of variety of components, and great differences between them such as the age at which they are aimed, the content, the number of micronutrients, and other types of added components, so it is important to know each of the products, their content and especially the reason for indication, whether supplementation or treatment.

Regarding the MVMs recommended according to specific age groups, for children under 1 year of age, we found vitamin drops composed of vitamins A, C, and D. For children over 1 year of age, MVMs composed of different vitamins and minerals are becoming available. Most of them were aimed at the population over 8 years of age and the products aimed at those over 15

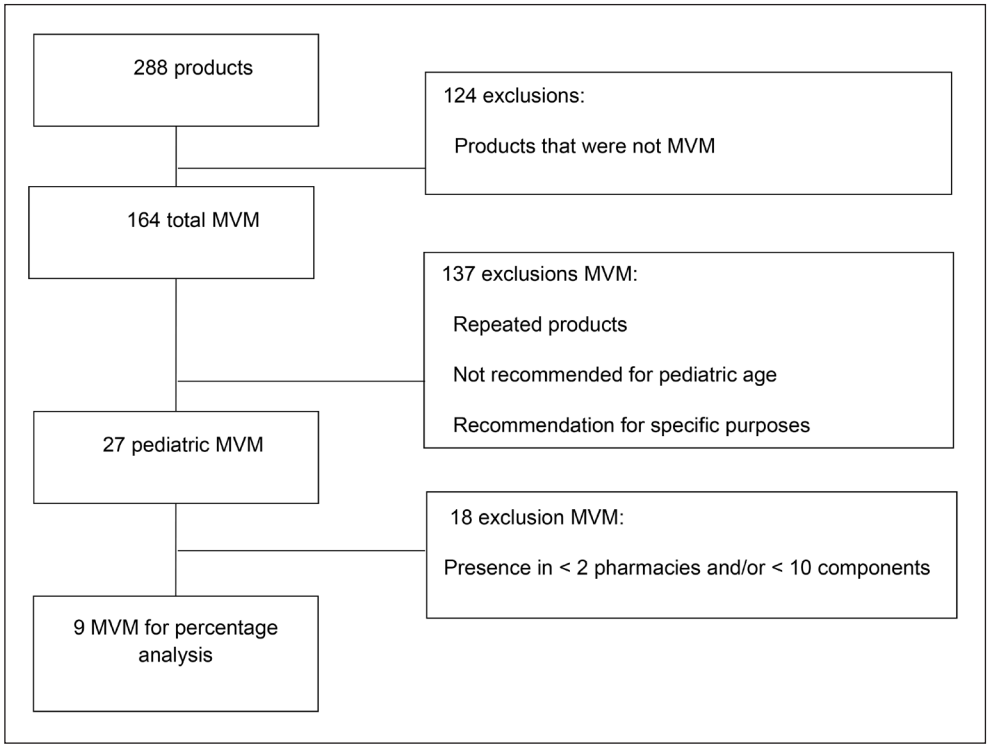

Figure 1. Search diagram Multivitamin/Mineral (MVM).

Table 1. Selection of Multivitamin/Mineral (MVM)

Variable	Multivitamins and Minerals
Number of MVM in initial search, n	164
Number of MVM by pharmacy, n (%)	
Ahumada	55 (33.5)
Salcobrand	49 (29.9)
Cruz Verde	45 (27.4)
Doctor Simi	15 (9.2)
MVM exclusion for repeated products, n (%)	54 (32.9)
MVM exclusion by target group, n (%)	83 (50.6)
No recommendation for pediatrics	33 (39.8)
Women	11 (13.3)
Seniors	10 (12.1)
Sports	9 (10.8)
Man	6 (7.2)
Pregnant, breastfeeding, menopause	5 (6.0)
More than 1 exclusion group	5 (6.0)
Vegan, vegetarian	3 (3.6)
Students	1 (1.2)

MVM: Multivitamin/Mineral.

Table 2. Characteristics of Multivitamin/Mineral (MVM) selected for percentage adequacy analysis (n = 9)

Recommended age, n/ N (%)	
9-13 years	7/9 (77.8)
14-18 years	2/9 (22.2)
Pharmacological presentation, n/N (%)	
Chewable	4/9 (44.4)
Capsule	3/9 (33.3)
Pill	1/9 (11.1)
Tablet	1/9 (11.1)
Number of pharmacies for sale, n/N (%)	
2	4/9 (44.4)
3	4/9 (44.4)
4	1/9 (11.1)
Number of micronutrients per MVM, n/N (%)	
15	1/9 (11.1)
17	1/9 (11.1)
19	3/9 (33.3)
20	2/9 (22.2)
21	2/9 (22.2)
Number of vitamins per MVM, n/N (%)	
11	2/9 (22.2)
12	7/9 (77.8)
Number of minerals per MVM, n/N (%)	
3	1/9 (11.1)
5	1/9 (11.1)
7	3/9 (33.3)
8	2/9 (22.2)
10	2/9 (22.2)
Other components in MVM, n/N (%)	
Trace elements	4/9 (44.4)
Probiotics	3/9 (33.3)
Ginseng	2/9 (22.2)
Coenzyme Q10	2/9 (22.2)

MVM: Multivitamin/Mineral.{

years of age were mainly for sports purposes. It is interesting to note that many MVMs state in their labeling that their use is not recommended for children under 8 years of age, pregnant women, and wet nurses; however, they do not specify from what age they can be used, and we must consider that the requirements are changing according to age range.

In population-based studies on the consumption of these products, more than 33% of american children took vitamins[5] and 45% of canadians aged 1 to 8 years received nutritional supplements[2]. Korean data from a 24-hour dietary recall survey in a population of 4,380 children and adolescents aged 1-18 years showed that 20.3% of them used DS, including in its definition the use of probiotics/prebiotics, which corresponded to the highest intake (26.9%), followed by MVMs (25.9%)[4]. In Puerto Rico, the use of MVM was reported by 9.3% of 12-year-old children[17]. In Chile, there are no recent national surveys estimating the use of MVM in the pediatric population. The most recent data on this matter comes from the National Health Surveys (ENS) 2009-2010 and 2016-2017, which showed that vitamin use in the general population aged 15 and older in Chile increased from 3.7% to 5.3%[18].

We studied the content for each of the micronutrients as a PA. This information will be important considering national dietary intake studies.

The last chilean national food consumption survey was carried out in 2010 and included a population from 2 years of age onwards, estimating micronutrient deficiencies according to food intake. Vitamin B12 stood out, with 24% of males and 20% of females aged 9 and older not meeting the estimated average requirement (EAR), with the deficiency increasing with age. As for vitamin A, a decrease in the reported intake of foods with higher content was observed starting at age 9 in females (56.7%) and age 14 in males (40.3%). Zinc shows a high prevalence of values below the EAR starting at age 9, with 20.6% in males and 51.5% in females. Notably, among children aged 1-3 years, there is a difference between sexes with 18.8% in males and 3.7% in females. Iron intake does not meet the requirement in 90% of individuals over 4 years of age, and as for folic acid, the

Table 3. Mineral content in Multivitamin/Mineral (MVM) and the percentage of adequacy (PA)

Micronutrient	Total MVM n = 9	MVM according to age		PAa median (IQRb)*
		9-13 y n = 7	14-18 y n = 2	
Sodium	1	0	1	0.08
Potassium	2	1	1	0.2 (0.2-0.2)
Phosphorus	4	4	0	2.5 (2.2-3.8)
Fluorine	2	1	1	3.8 (3-4.5)
Calcium	8	7	1	5.3 (3.3-6.9)
Magnesium				
Males	8	6	2	10.4 (7.4-17.3)
Females	8	6	2	10.4 (7.4-18.2)
Zinc	9	7	2	23.5 (6.3-46.3)
Manganese				
Males	7	5	2	26.3 (9.5-45.8)
Females	7	5	2	31.3 (11.3-63)
Iron				
Males	9	7	2	56.3 (43.8-98.5)
Females	9	7	2	56.3 (33.3-72.3)
Chromium				
Males	1	0	1	71.4
Females	1	0	1	104.2
Iodine	2	1	1	95.8 (66.7-125)
Copper	6	5	1	98.4 (35.7-142.9)
Selenium	1	0	1	100
Molybdenum	3	2	1	150 (141.9-294.1)

[a]Formula to calculate PA: percentage of adequacy (PA) = (amount of micronutrient [vitamin or mineral] in the MVM /recommended dietary intake) *100. [b]IQR: interquartile range (p25-p75). *For chromium, sodium and selenium, the median was not calculated because only one MVM contained these minerals.

UL is moderately exceeded due to folic acid supplementation of flour implemented since 2000. Regarding calcium, except for children under 4 years of age, the other age groups report diets with very low calcium content, therefore, more than 90% of all groups do not meet the requirement[19].

Regarding vitamin D, studies have found a 61% deficiency rate in preschool children in Coyhaique[20], and 97% in school-aged children in Punta Arenas[21].

Thus, it should be noted that, according to existing national studies, there is no relationship between the micronutrient content of this MVM supply and the state of sufficiency or deficiency of micronutrients. Relying on these "multi- or poly-vitamin and mineral" supplements may create a false sense of improving the nutrition of children and adolescents, assuming they provide complete coverage. However, the results of this study suggest that this is not the case, at least not for those micronutrients known to be deficient in the chilean population.

The national information on deficient intakes of these micronutrients contrasts with the contents of the MVMs analyzed; the most deficient minerals being calcium, zinc, and iron, and vitamins B12 and D.

Analyzing the micronutrients that are above the recommendations in women are vitamins A, C, B1, B2, niacin, pantothenic acid, biotin, pyridoxine, molybdenum, selenium, and chromium. The UL is used at both the individual and group levels to estimate the risk of excessive micronutrient intake, and among the MVMs analyzed, only one product was found that exceeds it for niacin. Potential adverse effects of chronic, excessive niacin intake include flushing, nausea and vomiting, liver toxicity, blurred vision, and glucose intolerance[13]. Evidence suggests that the increased insulin release induced by niacin may be a compensation of pancreatic islet β-cells in response to insulin resistance and could play a role in obesity[22]. The UL is based on flushing as a critical adverse effect[13]. The rest of the micronutrients do not exceed UL or do not have a defined one.

There were no significant differences in PA for each

Table 4. Vitamin content in Multivitamin/Mineral (MVM) and the percentage of adequacy (PA)

Vitamin	Total MVM	MVM según edad		PA[a] mediana (RIC[b])
	n = 9	9-13 años n = 7	14-18 años n = 2	
Vitamin D	9	7	2	25 (20-50)
Folic acid	9	7	2	33.3 (31.7-250)
Vitamin B12	9	7	2	63.9 (55.6-111.1)
Vitamin A				
Males	9	7	2	88.9 (83.3-166.7)
Females	9	7	2	144.3 (83.3-166.7)
Niacin	9	7	2	100 (83.3-158.3)
Vitamin B6				
Males	9	7	2	110 (100-153.8)
Females	9	7	2	110 (100-166.7)
Vit B1				
Males	9	7	2	111 (100-208.3)
Females	9	7	2	130 (100-250)
Vitamin C				
Males	9	7	2	133.3 (66.7-144)
Females	9	7	2	133.3 (66.7-166.2)
Pantothenic acid	9	7	2	125 (87.5-290)
Biotin	7	6	1	150 (125-1000)
Vitamin B2				
Males	9	7	2	155.6 (111.1-188.9)
Females	9	7	2	155.6 (144-220)

[a]Fórmula para cálculo de PA: Porcentaje de adecuación (PA) = (cantidad del micronutriente (vitamina o mineral) en MVM/aportes dietéticos recomendados)*100.
[b]RIC: rango intercuartil (p25-p75).

of the micronutrients according to the age indicated by the pharmaceutical laboratory. There was a greater presence of vitamins than minerals in the MVM as well as a better PA for the former.

In studies from developed countries such as the USA, MVMs contributed half or more of the requirement for vitamin D, and folate, and were high in iron, but low in calcium and potassium[5]. In Canada, MVMs were also low in calcium, choline, iron, and phosphorus and high in biotin, pantothenic acid, riboflavin, thiamin, vitamin A, pyridoxine, vitamin B12, and vitamin C[2]. The finding of low calcium content in developed countries is concordant with that found in our study. This is of concern in the context of the reported low consumption of dairy foods in our country, affecting the population from early school age, which could be influenced by the mealtimes in Chile which are mainly three, and dinner is consumed by only about 27% of the general population[19].

On the other hand, in developing countries such as Puerto Rico, in a 24-hour oral health and recall study they found that the average intake of calcium and magnesium was below the recommended levels, while the intake of copper, iron, and zinc was above these levels. Non-users and MVM users reached the recommended levels of all these vitamins from food and beverage sources, except pantothenic acid, which was only reached by users with the help of supplements. These findings support that MVM use has the potential to improve micronutrient intake among children with poor-nutrient diets[17]. Thus, data from national surveys and nutritionally at-risk populations could serve as a basis for establishing reasonable ranges of these micronutrients in products that aim to fill key micronutrient gaps and prevent excess intake.

Many times, the MVMs are prescribed by the health team, and other times it is the same population that self-prescribed because they are over-the-counter products, thinking that they complete the nutrition of children and adolescents. According to data from the ENS 2016-2017 when describing where they obtained the medication from, it was self-prescribed in 6.2%, where the age group from 15 to 24 years had the highest percentage[18].

If a micronutrient deficiency is suspected due to some type of dietary restriction, it would be better to

provide specific or isolated supplementation of each one of them with the appropriate doses according to age and sex, if the nutritional intervention has not been sufficient or adequate. Education on dietary intake should be carried out, which could cover all the requirements of a healthy child or adolescent, except for vitamin D and iron in the first year of life.

Some MVMs contained additional dietary ingredients, which were not analyzed in this study and may also have health implications, requiring further research into the synergistic or antagonistic actions of the multiple nutrients and other bioactive components contained in MVMs.

This work contributes to the health of children and adolescents as it is the first to analyze the availability of MVM for the pediatric population in the national market. The strengths of the study include the analysis of a comprehensive dataset of products targeted at children and adolescents, as well as the calculation of the percentage of adequacy according to our current daily intake recommendations. This study offers insight into the availability of components and provides greater certainty when making decisions about supplementation or treatment. Its importance also lies in the fact that it gives rise to further knowledge of this growing industry targeted at our children. Another strength is that it is reproducible in other populations to continue expanding knowledge in this regard.

In terms of limitations, this study analyzes the online availability of MVMs in the pharmacies with the highest sales but does not have information on the products most sold or consumed by the population. It should be noted that selecting the MVMs available in more than 2 pharmacies does not necessarily mean they are the most consumed.

In conclusion, there is a wide range of MVM with a varied formulation in terms of their components. Those selected for PA analysis had a low coverage for micronutrients that are deficient in our population such as calcium, zinc, and vitamin D, and, on the contrary, total coverage of the requirement in micronutrients that are not studied as deficient in the general pediatric population. If a micronutrient deficiency is suspected due to some type of dietary restriction, it will be better to supplement each of them specifically or in isolation, always after evaluating the nutritional intervention.

There is a need for greater standardization of these products to provide clearer guidance when recommended by health professionals. Reformulating the amounts and types of micronutrients in MVMs could better address critical gaps in population intakes and, at the same time, help prevent excessive consumption.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Right to Privacy and Informed Consent: The study is based on data obtained from publicly available information from MVM in Chile in 2023.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

Financial Disclosure

Authors state that no economic support has been associated with the present study.

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