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Vitamin A deficiency and associated factors in preschoolers from the outskirts of La Plata, Buenos Aires

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ABSTRACT

Introduction. Vitamin A deficiency (VAD) has been recognized as an important public health problem in developing countries. Preschoolers account for risk groups within vulnerable populations. The objective of this study was to determine the prevalence of VAD and associated factors in a sample of preschoolers.

Material and methods. Cross-sectional study with children aged 1-6 years receiving social assistance and seen at primary health care centers in the outskirts of the city of La Plata, Buenos Aires. Vitamin A levels were determined by measuring serum retinol with a liquid chromatography; anthropometric parameters and dietary intake were recorded. A multinomial logistic regression model was used to assess the association among outcome measures.

Results. Data from 624 children were analyzed. The geometric mean of retinol was 23.8 μg/dL (95 % CI: 23.3-24.3). The prevalence of VAD and the risk for VAD were 24.3 % and 57.4 %, respectively. Retinol levels were significantly lower among boys, low-weight children, and those with low intake (below the first tertile of distribution). The multivariate analysis showed a significant association between VAD and male sex (odds ratio: 1.93; 95 % CI: 1.15-3.24) and between VAD and low intake (odds ratio: 1.48; 95 % CI: 1.15-2.62).

Conclusion. The prevalence of VAD (24.3 %) is a major public health problem in this population. VAD-associated factors were male sex and low vitamin A intake.

Key words: *retinol, vitamin A deficiency, preschooler, risk factors.*

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INTRODUCTION

Vitamin A (retinol) is an essential nutrient that, in small amounts, is necessary for a normal functioning of the visual system, adequate growth and development, epithelial cell integrity, red blood cell production, immunity, and reproduction.[1]

The groups that are most vulnerable to vitamin A deficiency (VAD) include infants, preschoolers, and pregnant women.[2] VAD is the leading cause of preventable blindness in children and contributes greatly to increased morbidity and mortality from infections.[3]

VAD has been recognized as an important public health problem in developing countries. In 2009, the World Health Organization (WHO) estimated that 33 % of the world population had VAD, with a prevalence of 15.4 % in the Americas.[1]

The primary cause of VAD is an inadequate dietary intake, especially with low-quality or poorly diverse diets. However, it may also occur as a result of other factors, such as the presence of frequent infections, socioeconomic conditions, and accelerated growth and development, like what happens in certain stages in life.[4] In this context, low-income populations receiving social assistance with limited access to healthy food and a low consumption of fruits and vegetables may be at a higher risk for VAD.[5]

In Argentina, there is little information about the nutritional status of vitamin A. The National Survey on Nutrition and Health (Encuesta Nacional de Nutrición y Salud, ENNyS), which covered all socioeconomic strata of Argentina, showed that the prevalence of VAD in children aged 2-5 years was 14.3 %, with variations among the different regions.[6]

The objective of this study was to determine the prevalence of VAD and the associated factors in a sample of preschoolers seen at primary health care centers in the outskirts of the city of La Plata, province of Buenos Aires, Argentina.

MATERIAL AND METHODS

This was a cross-sectional study that was part of a larger intervention called "Comprehensive intervention in management and harmonization of dietary programs aimed at improving the population's nutritional status."[7] This study describes the baseline results.

The sample was selected by convenience, in a non-probabilistic fashion. Participants were clinically healthy children aged 1-6 years whose families were receiving social assistance, seen at primary health care centers located in the outskirts of the city of La Plata, province of Buenos Aires, during 2010 and 2011. Children diagnosed with chronic, acute or infectious diseases at the time of the study and those whose parents or adult caregivers refused to participate were excluded.

Health care centers were selected based on the availability of a pediatrician interested in collaborating with the project. Pediatricians and health care promoters from each center invited all families who had regular health checkups there, and children who attended on the day of the assessment were included.

Sample size calculation

Considering that the sample was not estimated for the purpose of this study, the sample error was retrospectively calculated. In these circumstances, and based on the prevalence of VAD observed in this study (24.3 %), the sample size allowed to determine observed results with a 3.4 % error, considering a 95 % confidence interval (CI).

Ethical considerations

The study was carried out in accordance with the guidelines established by the Declaration of Helsinki, and a written informed consent was obtained from all participating children's parents or legal guardians. The protocol was approved by the Institutional Research Protocol Review Committee (Comité Institucional de Revisión de Protocolos de Investigación, CIRPI) of the Pediatric Research and Development Institute of Hospital de Niños "Sor María Ludovica" of La Plata.

Data collection instruments and techniques

Biochemical indicators

Fasting blood samples were collected by venipuncture in all children to measure vitamin A and serum retinol levels. Once collected, blood samples were protected from light and stored at -70 °C until processing.

Serum retinol was measured using the procedure recommended by the Spanish Society of Clinical Biochemistry and Molecular Pathology (Sociedad Española de Bioquímica Clínica y Patología Molecular, SEQC).[8] The samples were analyzed by ultrafast liquid chromatography (UFLC) in a Shimadzu Prominence equipment with diode array detector, wavelength of maximum absorption, Lamba max. = 325 nm, and a Shim-Pack ODS II 3.0 mm x 75 mm chromatographic column (particle size: 2.2 μm). The identification and measurement of retinol in blood samples were established by comparison with the retention times and areas of an all-trans-retinol standard (SIGMA).

Serum retinol levels were classified into three categories: VAD (< 20 μg/dL), at risk for VAD (≥ 20 μg/dL and < 30 μg/dL), and adequate (≥ 30 μg/dL).[9]

Anthropometric indicators

Weight and height were measured using standard techniques by nutritionists who were trained in advance.[10] Weight was measured using a digital electronic scale (Tanita UM-061, precision 0.1 g, Tanita Corporation of America Inc., Illinois, USA). Height was measured using a portable stadiometer (precision 0.5 cm, SECA, United Kingdom). Weight-for-age (WA), height-for-age (HA), and body mass index (BMI) indicators were developed and assessed using the tables proposed by the WHO.[11] The following indicators were used for nutritional classification: stunting: < -2 HA Z, underweight < -2 WA Z, overweight > +1 BMI Z-score, and obesity > +2.0 BMI Z-score.

Dietary intake

Vitamin A dietary intake (μg of retinol equivalent [RE]) was assessed by means of a 24-hour recall interview with the adult caregiver of each child conducted by trained nutritionists using the multi-step technique.[12]

The recall interview was done so that all week days were represented, except when the child's intake on the previous day had been affected by a disease. Quantities and servings were standardized using food replica kits and visual aids.[13] Reported food, beverage, and supplement quantities were translated into nutrients using the chemical composition tables by the United States Department of Agriculture (USDA).[14] Vitamin A intake was stratified according to distribution tertiles; the first tertile was considered low intake and the rest, a reference intake.

Statistical analysis

The R statistical package, version 3.3.2, was used for statistical analysis. The Kolmogorov-Smirnov test was used to analyze outcome measure normality. Vitamin A levels were described as geometric mean (GM) and 95 % CI, due to their lognormal distribution. Vitamin A intake was reported as median and interquartile range (IQR); the other outcome measures were described as mean ± standard deviation due to their normal distribution. Qualitative outcome measures were expressed as frequency (%). Student's test was used to compare the mean between two groups and the analysis of variance (ANOVA), for more than two groups.

A multinomial logistic regression was done to determine VAD-associated factors. The strength of the association was described using odds ratio (OR) (95 % CI).

The first stage of the analysis was done using a bivariate multinomial logistic regression to study the association of each outcome measure with VAD. VAD-associated outcome measures with a p value < 0.20 in the bivariate analysis were then selected and included in a multivariate analysis. The backward stepwise method was used with the Akaike information criterion (AIC) to select outcome measures in the final explanatory model.

RESULTS

The data of 624 children aged 1-6 years participating in the original study were analyzed. The characteristics of the population are presented in *Table 1*.

The GM of vitamin A was 23.8 µg/dL (95 % CI: 23.3-24.3). The prevalence of VAD and the risk for VAD were 24.4 % and 57,4 %, respectively. Only 2 children (0.3 %) had severe VAD (vitamin A: < 10 µg/dL).

The median vitamin A intake was 236.7 µg/day (105.6-436.9); with the stratification of intake into tertiles, values below 148.8 µg/day (first tertile) were considered low intake of vitamin A.

Table 2 shows the comparison of the mean serum retinol levels by studied outcome measures. Statistically significant differences were observed by sex and nutritional status of children based on the WA and BMI indicators.

Factors associated with vitamin A deficiency

The bivariate analysis showed a statistically significant association between VAD and male sex (OR: 1.81; 95 % CI: 1.11-2.95) *(Table 3)*. The prevalence of VAD was 29.5 % in boys and 19.6 % in girls (p = 0.015). No statistically significant differences were observed in relation to the other outcome measures. Since there were no low-weight children with adequate retinol levels, it was not possible to estimate the OR as per the WA Z-score indicator.

The multivariate analysis included the following outcome measures: sex, age category, overweight/obesity, and vitamin A intake. After the selection of outcome measures, the final model included sex and vitamin A intake below the first tertile. This analysis confirmed the association between VAD and male sex (OR: 1.93; 95 % CI: 1.15-3.24) and between VAD and vitamin A intake below the first tertile (OR: 1.48; 95 % CI: 1.15-2.62) *(Table 4)*.

TABLE 1. *Characteristics of studied children (n= 624)*

Outcome measures	**n (%) Mean ± SD**
Age (years old)	3.41 ± 1.51
Age distribution in years old	
1-1.9	158 (25.3)
2-2.9	114 (18.3)
3-3.9	117 (18.7)
4-4.9	121 (19.4)
5-5.9	114 (18.3)
Sex	
Male	302 (48.4)
Female	322 (51.6)
Anthropometric measures	
WAZ	0.01 ± 1.14
Low weight (n = 618)	17 (2.8)
HAZ	-0.67 ± 1.13
Chronic growth retardation (n = 615)	68 (11.1)
BMIZ	0.61 ± 1.18
Overweight/obesity	209 (33.9)

SD: standard deviation; WAZ: weight-for-age Z-score; HAZ: height-for-age Z-score; BMIZ: body-mass-index Z-score.

DISCUSSION

Our findings show that 24.4 % of children have VAD and that more than 50 % are at risk for developing it. These values exceed the prevalence reference limits established by the WHO[15] (> 20 %), making VAD a serious public health problem.

In Latin America, VAD prevalence in children younger than 5 years ranges from below 2 % in Guatemala and Nicaragua to 32 % in Haiti.[16] Our findings are similar to those of other studies conducted in Colombia and Brazil,[17-18] which reported that 24.3 % and 24.7 % of children aged between 1 and 5 years had VAD, and higher than those reported by other authors in the region.[19-21] Such differences in prevalence are probably a reflection of each country's or region's specific characteristics.

Comparing our findings to the data available in our country, our prevalence was higher than that reported by the ENNyS, which included a population sample of all socioeconomic strata and reported a 14.3 % VAD prevalence in children 2-5 years old.[5] Most likely, such difference is because our results correspond to a sample focused on a vulnerable population. In addition, a study conducted by our research group, which assessed the impact of a dietary program on a population of children with similar characteristics (low-income families receiving food aid), found a similar prevalence.[22] In spite of the 10 years elapsed between both studies, VAD prevalence is still high. In contrast, Guatemala has managed to become the Latin American country with the lowest VAD prevalence through staple food fortification with vitamin A more than 20 years ago.[23]

Among analyzed factors, in this study, VAD was associated with male sex and a low vitamin A intake. Boys had a higher risk for VAD than girls, which is consistent with the findings of Tariku et al.[24] and different from what was observed by other authors who reported a similar deficiency prevalence in both sexes.[25-27]

In addition, as seen with other nutritional deficiencies, a diet that is chronically insufficient

TABLE 2. *Comparison of mean vitamin A (serum retinol) levels as per studied outcome measures*

Outcome measure	n	GM (95 % CI) (µg/dL)	*p* value*
Sex			
F	322	24.43 (23.72-25.15)	0.007
M	302	23.19 (22.48-23.92)	
Age (years old)			
1-1.9	158	23.49 (22.56-24.46)	0.653†
1-2.9	114	24.53 (23.15-25.98)	
3-3.9	117	23.76 (22.62-24.96)	
4-4.9	121	23.40 (22.26-24.60)	
5-5.9	114	24.09 (23.01-25.23)	
WAZ			
LW	17	18.93 (16.06- 22.30)	0.008
Normal	601	23.92 (23.42-24.44)	
HAZ			
CGR	68	23.80 (22.24-25.46)	0.978
Normal	547	23.77 (23.24-24.32)	
BMIZ			
O/O	209	24.32 (23.44-25.23)	0.041
Normal	404	23.46 (22.85-24.09)	
Vitamin A intake‡			
$< T_1$	189	23.32 (22.43-24.24)	0.298
$\geq T_1$	378	23.92 (23.36-24.59)	

* Student's test.
† ANOVA test.
‡ Only 567 24-hour recall interviews were done. T1: first intake tertile = 148.8 µg/day.
LW: low weight; CGR: chronic growth retardation; O/O: overweight/obesity; WAZ: weight-for-age Z-score; HAZ: height-for-age Z-score; BMIZ: body-mass-index Z-score; GM: geometric mean.

in vitamin A can lead to lower liver stores and fail to meet physiologic needs.[1] Peng et al., in a study conducted in children aged 2-7 years, found a significant relationship between vitamin A dietary intake and retinol levels.[28] In this study, although no differences were observed in serum retinol levels by vitamin A intake category, children with a low vitamin A intake, defined as an intake below the first tertile, had a greater risk for VAD than the rest.

In relation to children's age, in our study we did not observe differences in retinol levels when comparing age groups, similar to what has been observed in preschoolers by other authors.[17,27]

The results of the anthropometric assessment of nutritional status showed that, on the one side, low-weight children had significantly lower serum retinol levels than children with a normal weight; moreover, none of the children with a low weight had adequate vitamin A levels. Similarly, in a study carried out in schoolchildren, Ribeiro-Silva et al. found that those with a low weight had twice the risk for VAD than normal weight children.[29] Such analysis was not possible in our study because none of the children with a low weight had adequate vitamin A levels (comparison group). In addition, unlike what has been reported by other authors,[30-31] retinol levels

Table 3. *Association between vitamin A deficiency and studied outcome measures. Bivariate model*

Outcome measures		**Bivariate model**			
		VAD*		**Risk for VAD***	
		OR	**95 % CI**	**OR**	**95 % CI**
Sex	Female	Reference	Reference		
	Male	1.81	(1.11-2.95)	1.07	(0.70-1.64)
Age (years old)	1-1.9	Reference	Reference		
	2-2.9	0.11	(0.25-1.14)	0.23	(0.36-1.28)
	3-3.9	0.63	(0.40-1.75)	0.51	(0.42-1.55)
	4-4.9	0.72	(0.42-1.81)	0.43	(0.40-1.47)
	5-5.9	0.68	(0.39-1.85)	0.84	(0.54-2.12)
Nutritional status†	Normal	Reference	Reference		
	CGR	1.30	(0.62-2.77)	1.14	(0.61-2.15)
	Normal	Reference	Reference		
	O/O	0.66	(0.39-1.11)	0.96	(0.61-1.49)
Vitamin A intake‡	$\geq T_1$	Reference	Reference		
	$< T_1$	1.36	(0.78-2.37)	1.49	(0.91-2.43)

OR: odds ratio; VAD: vitamin A deficiency; CI: confidence interval; O/O: overweight/obesity.
* Adequate vitamin A levels: retinol ≥ 30 μg/dL (comparison group).
† The low/normal weight categories are not included because no child with low weight had adequate retinol levels.
‡ T1: 148.8 μg/day.
Vitamin A intake ≥ T1 (comparison group).

Table 4. *Association between vitamin A deficiency and studied outcome measures. Multivariate model*

Outcome measures		**Multivariate model**			
		VAD*		**Risk for VAD***	
		OR	**95 % CI**	**OR**	**95 % CI**
Sex	Female	Reference	Reference		
	Male	1.93	(1.15-3.24)	1.04	(0.66-1.64)
Vitamin A intake‡	$\geq T_1$	Reference	Reference		
	$< T_1$	1.48	(1.15-2.62)	1.61	(0.97-2.66)

OR: odds ratio; VAD: vitamin A deficiency; IC: confidence interval.
Adjustment outcome measures: sex, age, overweight/obesity, and vitamin A intake.
* Adequate vitamin A levels: retinol ≥ 30 μg/dL (comparison group).
‡ T1: 148.8 μg/day.
Vitamin A intake ≥ T1 (comparison group).

in children with overweight/obesity were mildly higher than in normal weight children, although no association with VAD was observed.

Our findings evidence the magnitude of VAD in preschoolers, a problem that has been scarcely studied in our region. However, this study has limitations. First of all, our findings are only representative of the children seen in the public health system, whose families receive social assistance, and may not be extrapolated to the general population from the outskirts of the city of La Plata. Secondly, the 24-hour recall interview method to study food consumption also has certain limitations, although it is adequate to estimate the average population intake, even if used only once.[32] Finally, since this is a cross-sectional study, it only provides scarce evidence of causality.

Based on the findings, and considering that VAD in children is associated with respiratory and diarrheal diseases and with an increase in their frequency, severity, and mortality,[33] it is necessary to strengthen health interventions to allow the systematic implementation of prevention measures, mostly focused on nutritional education. Although our findings may not be generalized to the entire population, they provide an important piece of evidence for planning public policies.

In order to reduce VAD, besides prevention strategies such as food fortification or supplementation, it is necessary to consider the risk factors for it.

CONCLUSION

The prevalence of VAD (24.3 %) is a major public health problem in this population. VAD-associated factors were male sex and a low vitamin A intake. ■

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