



Original/*Pediatría*

Risk factors associated with iron depletion and parasites in preschool and school children of Arandas, Jalisco, México

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Abstract

Objective: The objective of this study is to explore factors associated with iron depletion and parasites in preschool and school children attending the Instituto Alteño para el Desarrollo de Jalisco (INADEJ) and children who attend preschools and schools in Arandas, Jalisco.

Methods: This cross sectional study assessed two groups of children. In the INADEJ group, 102 children aged 60 to 144 months old were included, and in the School group of Arandas, Jalisco, 206 children were randomly selected from schools and preschools in the same municipality. **Variables:** Ferritin concentration ($\mu\text{g/ml}$), parasites, demographic, socioeconomic, educational and dietary data were collected. The Student's t test, U Mann Whitney, chi square, odds ratio and logistic regressions were estimated.

Results: Family income in the Schools group was \$5,707 Mexican pesos (MP), which was higher than the family income in the INADEJ group (\$4,311 MP), $p = 0.031$. The proportion of parents with incomplete primary education was higher in the INADEJ group (41.3%) than in the Schools group (35.4%) [OR = 1.88 (1.0-3.55)]. Unstable work was more frequent in the INADEJ group than in the Schools group [OR = 5.6 (3.26-9.62)]. The ferritin concentration was lower in the INADEJ group than in the Schools group (25 $\mu\text{g/L}$ vs. 60 $\mu\text{g/mL}$, respectively), $p < 0.001$. Having giardiasis and two or more parasites was more common in the INADEJ group compared with the Schools group [OR = 7.2 (2.25-23.0)] and [RM 3.86 (1.35-10.98)]. Heme iron intake was lower in the INADEJ group.

Conclusion: Low family income, father's job instability, lower levels of education, overcrowding, living with animals and lower consumption of heme iron were associated with parasites and iron depletion.

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FACTORES DE RIESGO ASOCIADOS CON LA DEPLECIÓN DE HIERRO Y PARASITOSIS EN NIÑOS PREESCOLARES Y ESCOLARES DE ARANDAS, JALISCO, MÉXICO

Resumen

Objetivo: Explorar factores asociados con depleción de hierro y parasitosis en preescolares y escolares que asisten al Instituto Alteño para el Desarrollo de Jalisco (INADEJ) y los niños que asisten a escuelas en Arandas, Jalisco.

Métodos: Este estudio transversal evaluó dos grupos de niños. En el grupo INADEJ, fueron incluidos 102 niños de 60 a 144 meses de edad; en el grupo Escuelas fueron seleccionados 206 niños al azar de las escuelas del mismo municipio. Se obtuvieron las variables: ferritina (g/mL), parasitosis, variables demográficas, socioeconómicas, educativas y datos dietéticos. Se realizaron pruebas t de Student, U de Mann-Whitney, ji cuadrada; odds ratio y regresiones logísticas.

Resultados: El ingreso familiar en el grupo escuelas era \$ 5,707 pesos mexicanos (pm), más alto que el grupo INADEJ (\$ 4,311 pm), $p=0,031$. La proporción de padres con educación primaria incompleta fue mayor en el grupo INADEJ (41,3%) que en el grupo escuelas (35,4%) [OR = 1,88 (1,0-3,55)]. Trabajo inestable del padre fue más frecuente en el grupo INADEJ [OR = 5,6 (3,26-9,62)]. La concentración de ferritina fue menor en el grupo INADEJ que en el grupo Escuelas (25 $\mu\text{g/L}$ vs. 60 $\mu\text{g/ml}$, respectivamente), $p < 0,001$. Tener giardiasis y dos o más parásitos fue más frecuente en el grupo INADEJ [OR = 7,2 (2,25 a 23,0)] y [RM 3,86 (1,35-10,98)]. La ingestión de hierro hemo fue menor en el grupo INADEJ.

Conclusion: Los bajos ingresos familiares, inestabilidad laboral de su padre, pobre educación, hacinamiento, convivencia con animales y menor consumo de hierro hemo se asociaron a parasitosis y depleción de hierro de hierro.

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Palabras clave: *Parasitosis. Depleción de hierro. Preescolares y escolares.*

Introduction

Iron deficiency is the most prevalent nutritional disorder in the world and is related to a low iron diet, gastrointestinal problems and bacterial and parasitic infections¹⁻³. Globally, iron deficiency and iron deficiency anemia afflicts more than 3500 million people, mainly in less developed countries⁴. In México, the last national survey of health and nutrition⁵ showed that the national prevalence of anemia in preschool children was 23.3% and was 10.1% in school children.

A previous study in the Instituto Alteño para el Desarrollo de Jalisco (INADEJ) in Arandas, Jalisco, a non-governmental institution dedicated to food aid programs and orientation, showed that the combination of depletion and iron deficiency occurred in 61% of preschoolers and 44% of school children⁶. The deleterious effects of iron deficiency anemia on cognitive function have been extensively described⁷; however, fewer studies have explored the deleterious effects of iron deficiency without anemia⁸. Some studies suggest that even in school children, depletion and iron deficiency without anemia may affect cognitive development⁹⁻¹¹.

An estimated 3.5 billion people (mostly children) are affected by parasites and disease is manifested in 450 million people¹². Giardiasis is the most common intestinal protozoa parasite in the world and an estimated 280 million cases occur each year¹³. In poor countries, this parasite alone represents 2.5 million cases of diarrhea each year¹⁴. Therefore, given its high prevalence in poor and underdeveloped communities, in 2004 the WHO included giardiasis as a "neglected diseases"¹⁵. Giardia infection is acquired in early childhood and the prevalence peaks at 30% in children under 10 years of age. Others have described the effects of giardia infection in children, including growth failure and the long-term impairment of cognitive function^{16, 17}.

Therefore, the purpose of this study was to explore the association between parasites and iron depletion and the risk factors associated with iron depletion and parasitism in preschool and school children in the municipality of Arandas, Jalisco.

Methods

Two groups were included in this comparative cross sectional study: a) a group of 102 children (INADEJ group) of both sexes from 60 to 144 months old, apparently healthy, with no apparent infection in the last two weeks, diarrhea or other pathology attending the food aid program. Ten subjects were excluded due to incomplete records or errors in laboratory techniques; b) a group of 206 children (Schools group) with similar characteristics and the same age as the INADEJ group who attended the preschool and primary schools in the municipality of Arandas education during the years 2010 and 2011; of these, 16 participants were ex-

cluded for similar reasons. Children who had chronic diseases, genetic or congenital apparent, rejection of the child and/or a parent or person legally authorized to participate in the study, or children who consumed multivitamins or iron supplements were not included.

The calculation of the sample size for the group of children attending preschools and primary schools in the municipality of the Arandas education system was based on the prevalence of iron deficiency with ferritin <10 ng/mL in the municipality (INADEJ 2002) for children 12 to 71 months (20%) and children aged 72 to 120 months (15%)⁶ Old, with an alpha error of 0.05 and a power of 80%.

Sampling System

From the complete list of all children enrolled in the outpatient INADEJ, children whose ages ranged between 60 and 144 months were selected. Once identified, these children were stratified into two subgroups: a) preschoolers aged 60-71 months; and b) school children aged 72 to 144 months. Then, a complete list of all preschools and primary schools in the rural area and the head of the municipality registered in the Ministry of Education of the State of Jalisco in the town of Arandas were obtained. Preschool children aged 60 to 71 months and children from elementary schools aged 72 to 144 months were selected. A random cluster sampling (schools) was stratified into two groups: a) preschool education and b) primary education. Next, a complete list of the subjects in each selected cluster was obtained and simple at random sampling was performed.

The dependent variables included: ferritin ($\mu\text{g/L}$); iron depletion (ferritin <20 $\mu\text{g/L}$); and parasitism: the presence of parasites (dichotomous yes/no) and the type of parasites. The independent variables included: age (years), age group (years), sex; membership, family composition, marital status; mother's age, father's age (years); father's education, mother's education; employment status (unstable vs. permanent); occupation of the father and mother; and the combined monthly family income, spending on food per month, amount allocated to each member for food, food expenditure per capita (percentage of Mexican pesos of minimum salary), the average consumption of iron and the frequency of consumption of iron in the week.

Criteria and fieldwork strategies

Once support of the authorities and staff of INADEJ was obtained, the families of the children selected for the study were invited. From the selected schools, an interview was conducted with the principals, teachers and parents to explain the project, its purpose and benefits and to ensure their participation in the study once was concluded. In cases where iron deficiency

or parasites were found, the participants were given proper treatment and/or dietary guidance necessary to prevent deficiencies. On average, 10 participants were cited weekly on Fridays. Analyses of the biological samples (ferritin and coproparasitology) were conducted in the Clinical Pathology Laboratory of the Hospital Civil de Guadalajara Dr. Juan I. Menchaca

Measuring instruments and techniques

Ferritin ($\mu\text{g/L}$) was determined by a chemiluminescence immunoassay of paramagnetic particles for the quantitative determination of ferritin levels in the serum and plasma (Beckman Coulter, Inc. Access Immunoassay Systems, Brea, CA, USA). To determine the type of parasite (protozoa and helminths), Faust's flotation technique was used. Additionally, two dietary surveys were conducted to assess 24 h recall and food consumption frequency.

Methods of data collection, databases and computer programs

Information on general demographic, socioeconomic and educational variables and laboratory data were captured in Excel with collection sheets specially designed for the protocol. Once the information in the database was obtained, statistical analysis was performed with the SPSS v 18 program.

Statistical analysis

The analysis included descriptive statistics of the parametric and nonparametric variables; ANOVA for comparison of variances between groups; Student's t test for unpaired comparisons between two independent samples with normal distribution and the U test Mann Whitney for data with nonparametric distributions. The Kruskal Wallis test was used to identify the association between variables of various proportions and the chi square test, in tetra choric 2 x 2 tables, was used to identify the epidemiological significance of the independent variables, and the odds ratio (OR) was used in bivariate models. Finally, a logistic regression model was designed with those variables significantly associated with iron depletion.

Ethical considerations

Each of the participants who met the inclusion criteria and whose parents or legal guardians gave their consent by signing the informed consent form were included in the protocol activities. The protocol was approved by the Bioethics Committees and Research at the University of Guadalajara, Opinion CI-13609.

Results

From the INADEJ group ($n = 92$), 48% were male, of which there were 13 pairs of siblings (26), three families with three siblings each and a family of four children; from the Schools group ($n = 190$), the frequency of males (58%) was higher than in the INADEJ group ($p = 0.053$). The mean age was similar (96.7 months), while maternal age was significantly lower in the INADEJ group (34.5 years) than in the Schools group (38 years), $p < 0.001$. The real or functional illiteracy (\leq three years of elementary school) in mothers was slightly higher in the INADEJ group (21% vs. 17%), $p = 0.118$; while the fathers' illiteracy rates were similar in both groups (22%). The proportion of fathers with incomplete elementary school education was significantly higher in the INADEJ group than in the Schools group (41.3 vs. 35.4%, respectively) [OR = 1.88 (1.0-3.55), $p = 0.05$]. Most mothers in both groups were dedicated to the home (78%; in INADEJ group and 74% in the Schools group).

Parents were mainly engaged workers, masons, drivers, employees and peasants. Fathers' unstable work situations were significantly more frequent in the INADEJ group (65%) than in the Schools group (25%) [OR = 5.6 (3.26-9.62), $p < 0.001$]. Seventy mothers worked outside the home (22% of the INADEJ group and 24% of the Schools group). In the Schools group, mothers who had casual work predominated [RM 5.2 (1.72-15.8), $p = 0.002$]. The family income of the Schools group (\$5,707 Mexican pesos) was equivalent to 3.2 times the minimum wage (MW) and was significantly higher than the INADEJ group (\$43100, Mexican pesos), which was equivalent to 2.5 times the MW, $p = 0.031$. The daily MW (2010-2011) was \$57.85 (4.45 U.S. dollars). The peso: dollar ratio was 13:1, and spending per capita supply was \$15.6/d in the INADEJ group and \$16.3/d Mexican pesos in the Schools group (equivalent to \approx \$1.28 USD/d).

Most families lived in houses with two or three rooms plus a kitchen. Families that slept two or three persons per room were the most frequent; 56 families (approximately 18%) slept four or more persons per room. The frequency of families where three or more members slept in the same room was higher in the INADEJ group (54%) than in the Schools group (44.5%), $p = 0.06$. A large percentage of the houses were built of brick (walls and ceilings) and almost all had floor tile or cement.

Families in the Schools group used blocks instead of bricks for building the roofs of their houses ($p = 0.006$). That material is more expensive and coincided with higher family income. The vast majority of families in the INADEJ group (89.2%) had intra-household water, while 30.3% of families in the Schools group lacked this service ($p < 0.001$). The majority of families had a container water tank or cistern. Garbage was placed in garbage bags in more than half of the households in both groups. In most homes of both

groups, the collector was responsible for disposing of garbage; excreta disposal was carried out through the drain and approximately 15% had a septic tank. Almost all households had electricity and gas used as fuel. Half of the study population lived in their home with pets, mostly dogs, birds, cats and rabbits. This trait was significantly more common in the INADEJ group ($p = 0.039$).

A 24 h recall dietary survey (RDS 24 h) taken over the weekend showed a lower intake of iron (10.5 mg/d) in the INADEJ group than in the Schools group (13.1 mg/d), $p = 0.058$. The RDS-24h showed a similar average weekday iron intake in both groups (12.6 mg/d); while the consumption of processed foods of animal origin (≥ 3 -5 times/week vs. <1 times/week) was more common in the Schools group than in the INADEJ group (67% vs. 51%, respectively) [RM 2.09 (1.13-3.88), $p = 0.009$].

Ferritin concentration was significantly lower in the INADEJ group (25 $\mu\text{g/L}$) than in the Schools group (60 $\mu\text{g/L}$), $p < 0.001$. The frequency of parasitism was higher in the INADEJ group than in the Schools group (32% vs. 22%, respectively). Giardiasis frequency and the presence of two or more parasites were higher in the INADEJ group [OR = 7.2 (2.25-23.0), $p < 0.001$ and OR 3.86 (1.35-10.98), $p = 0.007$]. Table I shows the risk factors associated with parasites in the INADEJ group and the Schools group. In an analysis of both groups combined, families with lower income,

fathers with unstable employment, low education, and more persons sleeping in the same room and living with animals inside the house were identified as risk factors associated with parasites and iron depletion, Tables II and III. Only one variable was found to be significantly associated with iron depletion in the logistic regression model, and two variables were found to be potentially associated with iron depletion, Table IV.

Discussion

Unlike the balanced ratio between boys and girls in the INADEJ group, in the Schools group, an almost significant predominance in the ratio of boys to girls was observed. The INADEJ group belonged mostly to the urban area of the municipality, whereas the population in the Schools group had a greater number of preschool and school children from rural areas that were distant from the urban area. It is not difficult to assume that the parents of the participants in this mainly rural area more frequently leave girls at home to support their mothers in household chores or other tasks. In a study of the FAO, Lakin and Gasperini¹⁸ analyzed this situation around the world and noted that "local traditions can promote the education of males and assign little value or even negative value to the schooling for girls" and point to many "determinants of inadequa-

Table I
Risk factors associated with parasites in children of Arandas, Jalisco by group

Variable	Parasites		No parasites		OR	CI (95%)	P
	n/N	%	n/N	%			
Father's employment status ^{a*}	16/41	39	24/129	18.6	2.8	1.3-6.04	0.007
Father's schooling ^{b†}	11/21	52.4	7/34	20.6	4.2	1.29-14.0	0.015
Persons per room ^{c*}	13/34	38.2	8/91	8.8	6.4	2.36-17.5	0.001
Living with animals in the home ^{d*}	27/92	29.3	16/98	16.3	2.1	1.06-4.28	0.03

^aInstable vs. Permanent; ^b ≤ 3 years vs. high school; ^c ≥ 4 vs. < 3 ; ^dYes vs. No; *Schools group (n=190); †INADEJ group (n=92).

Table II
Risk factors associated with parasites in children of Arandas, Jalisco. Whole sample (n=282)

Variable	Parasites		No parasites		OR	CI (95%)	P
	n/N	%	n/N	%			
Persons per room*	24/55	43.6	31/149	20.8	3.04	1.56-5.9	0.001
Father's employment status ²	35/95	36.8	31/161	19.3	2.45	1.38-4.33	0.002
Monthly family income ^d	24/71	33.8	21/106	19	2.1	1.04-4.1	0.037
Father's schooling [§]	21/61	34.4	20/103	19.4	2.18	1.06-4.47	0.032
Living with animals in the home ^{**}	46/147	31.3	26/134	19.4	1.89	1.09-3.3	0.023

* ≥ 4 vs. < 3 ; ²Unstable vs. Permanent [§] < 2 Minimum wage (MW) vs. > 3 MS; [§] ≤ 3 years vs. High school or more; **Yes vs. No.

Table III
Risk factors associated with iron depletion (<20 µg/L) in children in Arandas, Jalisco (n = 282)

Variable	Iron depletion		No iron depletion		OR	CI (95%)	P
	n/N	%	n/N	%			
Father's employment status *	22/107	20.6	15/167	9	2.6	1.29-5.32	0.006
Persons per room?	14/67	24.6	17/158	10.8	2.7	1.23-5.9	0.011
Amebiasis (E. Histolytica) †	9/33	27.3	29/255	11.4	2.9	1.24-6.89	0.01
Giardiasis ‡	5/16	31.2	33/279	11.8	3.3	1.01-10.0	0.028
Two or more parasites ‡	5/16	31.3	33/272	12.1	3.3	1.1-10.1	0.028

*Unstable vs. Permanent; †≥ 4 vs. < 3; ‡Yes vs. No.

Table IV
Factors associated with iron depletion (<20 µg/L) in children in Arandas, Jalisco; a logistic regression model (n = 282)

Variable	β	SE	OR	CI (95%)	P
Father's employment status*	0.80	0.38	2.24	1.061 – 4.711	0.03
Persons per room?	0.79	0.41	2.21	0.995 – 4.922	0.051
Amebiasis (E. Histolytica)†	0.91	0.47	2.48	0.985 – 6.27	0.054

SE: Standard error; *Unstable vs. Stable; †≥ 4 vs. < 3; ‡Yes vs. No.

te education of girls". It is an interesting finding that would require a separate study, as the populations in the region of Los Altos de Jalisco in general, and the town of Arandas in particular, hold conservative beliefs about family, religious and cultural traditions.

We do not know why the average age of the mothers was significantly lower in the INADEJ group than in the Schools group. It was evident that these populations were different in respect to socioeconomic, demographic and educational aspects. For example, the probability of parents with incomplete elementary education was 88% higher in the INADEJ group, despite belonging to the most urbanized area of the municipality. Similarly, the probability of having an unstable job was 5.6 times higher in the INADEJ group than in the Schools group. Additionally, the probability of mothers who supported the family income with some casual labor was 5.2 times higher in the Schools group. These findings mean that factors such as parents with incomplete elementary education, minor monthly family income and unstable working conditions are promoters of suboptimal conditions at home and probably have consequences including stress and food insecurity in the family. It is noteworthy that although the monthly family income was significantly lower in the INADEJ group, food expenditure per capita was very similar to the Schools group, which was very low in both groups.

Other factors that tend to be relevant in the prevalence of parasites such as housing conditions, draina-

ge and garbage disposal were similar in both groups. Only the intra-household water variable was significantly more common in the INADEJ group. This finding is understandable because, as mentioned earlier, most of the children in the INADEJ group lived in the most urbanized area of the municipality, unlike the children in the Schools group. However, the frequency of overcrowding and coexistence with animals at home were more frequent in the Schools group.

These differences in socioeconomic, demographic and educational status may explain why ferritin concentration was significantly lower in the INADEJ group, that the prevalence of iron depletion (ferritin <20 µg/l) was 40.5% in the INADEJ group and that there has been no case of iron depletion in the Schools group. As mentioned earlier, the 24 h dietetic recall taken on the weekend showed a lower intake of iron in the INADEJ group than in the Schools group; while the probability of consumption of processed foods of animal sources was twice as high in the Schools group as in the INADEJ group. These dietary backgrounds have likely influenced the markedly different results in the frequency of iron depletion.

The frequency of parasitism was higher in the INADEJ group than in the Schools group. Additionally, the probability of having giardiasis or two or more parasites were 7.2 and 3.86 times higher, respectively, in the INADEJ group than in the Schools group. The variable of greatest risk for the presence of parasites

in the INADEJ group was low education of the father, while unstable work, the highest number of persons per room and living with animals in the home were variables that increased the risk of parasitism in the Schools group.

By combining the groups (INADEJ and Schools), we observed that lower family income, unstable employment status of the fathers with less education, the largest number of persons per room and living with animals appeared as variables that increased the risk of parasites. Additionally, the unstable condition of the fathers' employment, the greatest number of persons per room, giardiasis, amebiasis and the presence of two or more parasites appear as variables that increased the risk of iron depletion. Apparently, the most important variable was the instability in employment, as this is the only significant variable in the logistic regression model. However, the number of persons per room (overcrowding) and amebiasis had a potentially significant trend.

Although the health conditions and socioeconomic status of these families appear to be better than those observed 10 to 12 years ago⁶, it is clear that the risk of parasites remains, especially when the impoverished socioeconomic conditions persist, fathers have low education levels and employment is unstable.

This findings are important because, as it has been noted¹⁰, iron depletion and parasitic diseases, particularly giardiasis, are pathological diseases that must be identified promptly because regardless of the impact that both have on the cognitive development of the individual^{8, 9, 15, 16, 19}, there is a likelihood that iron depletion becomes deficient due to the high vulnerability and food insecurity conditions in which these children live.

Study limitations are related to sample size and the fact that they refer to a single municipality in the region of Los Altos de Jalisco, México; although inferences regarding similar situations are found in other parts of the country, especially the center, are relatively valid because it is a population with socio-economic, educational and cultural similar features.

In short, if we were to extrapolate the data found in the town of Arandas, Jalisco to other populations of Mexican children living in similar conditions of poverty, overcrowding, poor schooling, job instability and coexistence with animals in the home, we could infer that iron depletion and parasites, especially giardiasis, continue to be public health problems in México. Furthermore, the impact on physical growth and cognitive development of children with these two linked pathological entities has yet to be adequately evaluated.

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Conflict of interest

None.

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