Original Article

Malnutrition and the presence of intestinal parasites in children from the poorest municipalities of Mexico

Javier Gutierrez-Jimenez[1], Maria G. C. Torres-Sanchez[1], Leamsi P. Fajardo-Martinez[1], Maria A. Schlie-Guzman[1], Lorena M. Luna-Cazares[1], Alma R. Gonzalez-Esquinca[1], Salvador Guerrero-Fuentes[1], Jorge E. Vidal[2]

[1]Facultad de Ciencias Biológicas, Universidad de Ciencias y Artes de Chiapas (UNICACH), Tuxtla Gutiérrez, Chiapas, México
[2]Hubert Department of Global Health, Division of Infectious Diseases, Rollins School of Public Health, Emory University, Atlanta GA, United States

Abstract

Background: For many years Chiapas, Mexico's poorest state, has had the highest rate of child mortality due to intestinal infections of unknown etiology in the country. To begin identifying the infectious agents, our work determined the prevalence of intestinal parasites as well as malnutrition in children from Chiapas's three most impoverished municipalities: Pantepec, Chanal, and Larrainzar.

Methodology: In this cross-sectional study, conducted between January and November 2009, we assessed the prevalence of intestinal parasites by means of coproparasitological analysis in children <5 years of age (N=250) from three of the marginalized municipalities: Pantepec, Chanal and Larrainzar. The prevalence of malnutrition was then assessed using the Mexican official norm NOM-031-SSA2-1999 and WHO criteria. We evaluated the association between age (breast-fed and pre-school children) with parasites and nutritional status.

Results: Our analysis revealed the highest prevalence of intestinal parasites in children from Pantepec (62.8 %), followed by Chanal (47.3 %), and then Larrainzar (11.9 %). The nematode *Ascaris lumbricoides* was the most prevalent enteroparasite (33.6%). Anthropometric analysis revealed that >40% of children represented varying degrees of malnutrition and a marked constitutional delay in growth. A very high prevalence of stunting was also recorded in children from Chanal and Larrainzar (70% and 55 %, respectively). An association between infection with intestinal parasites and malnutrition was observed in Pantepec. Preschool-age children were more likely to be infected with intestinal parasites.

Conclusion: Our results indicate the urgent need for interventions in order to 1) improve the nutritional status of children and 2) reduce infection rates of enteric parasites.

Key words: Malnutrition; children; intestinal parasites; *Ascaris*; Chiapas; poverty

J Infect Dev Ctries 2013; 7(10):741-747. doi:10.3855/jidc.2990

(Received 06 September 2012 – Accepted 21 April 2013)

Introduction

Intestinal parasites such as *A. lumbricoides*, also known as hookworms, negatively affect the nutritional status of children. [1-3]. Regions with high prevalence of intestinal parasites (i.e. *A. lumbricoides* or *Trichuris trichiura*) include Asia, Africa and Latin America [2,4]. The state of Chiapas, Mexico, occupies the first place in multidimensional poverty and has had, for almost a decade (2000-2008), the highest rate of child death due to diarrheal diseases [5]. Nearly 76.7% of Chiapas inhabitants live in extreme poverty; this includes severe deficiencies in areas of economic and social well being [6]. The municipalities of Pantepec, Chanal, and Larrainzar are among the lowest on the Human Development Index. In 2005 these municipalities had a child death rate of 35.15, 30.12 and 35.07 deaths per 1000 live births, respectively, above the state and national rates of 23.89 and 16.8 [7].

Given the livings conditions in these municipalities, we hypothesize that the observed deaths could be attributed to malnutrition and infectious processes. Therefore, the aim of this work was to determine the prevalence of intestinal parasites among children up to 5 years of age from those municipalities and the relationship between malnutrition and age. Malnutrition, family and socioeconomic conditions, as well as natural living environments in the municipalities of Pantepec, Chanal, and Larrainzar are discussed.

Methodology

Study area: The Pantepec municipality, originally inhabited by the Zoque people, is located in the northern region of Chiapas; the municipality of Chanal belongs to the Tzotzil-Tzeltal people of the "Altos" region of the state; and the Larrainzar municipality, a region inhabited by Tzotzil people, is also situated in the "Altos" region of Chiapas. Pantepec, Chanal, and Larrainzar are located at altitudes of 1,500, 2,100, and 2,000 meters above sea level. Average rainfall ranges from 100 to 2,600 mm annually [8].

Study population: Before beginning the project, we obtained authorization from administrators at the following healthcare centres: The Mexican Institute of Social Security (IMSS) in Pantepec, the health centre with a hospitalization unit in Chanal, and from the community's basic hospital in Larrainzar. The protocol was approved by the ethics committee at the Universidad de Ciencias y Artes de Chiapas (UNICACH) and was carried out with recommendations from the aforementioned healthcare centres. According to the 2010 Mexican national census, the combined population of children from all three municipalities was 7,830 individuals: 1,695 in Pantepec; 2,309 in Chanal and 3,826 in Larrainzar [9]. The statistically-calculated representative size sample was 366, with a 95% confidence level, a 50% level of expected and failure proportions, and a 5% level of precision; the calculated sub-groups by quota sampling method were 79, 179, and 108 children for Pantepec, Chanal, and Larrainzar, respectively. Total enrolment for the study was 250 children (94 from Pantepec, 55 from Chanal and 101 from Larrainzar.) Enrolment was limited due to extreme poverty and marginalization in the region, and means of transportation to study sites (i.e. clinics, hospitals) were often unavailable or unfeasible. This nevertheless constituted an adequate sample size for an ecologically homogeneous area in order to evaluate the prevalence of soil-transmitted helminthiasis [10].

Collection of anthropometric data: Each municipality has a health centre supported by either the federal or state government. Families regularly attend for medical examinations and to receive social benefits. Upon arrival at each healthcare centre, we approached all parents of children <5 years of age to take part in the study. After agreeing to participate, they signed a written consent form. Refusal was common, due to the lack of transportation to the healthcare centre. In general, mothers brought their children in for testing at the healthcare centres once a month [11]. In order to analyse in detail all possible variables, the age data were stratified into two groups that included 1) breast-fed children ranging from 0 to 1.9 years of age and 2) pre-school children from 2 to 5 years of age. In the three municipalities, most children were of pre-school age (61.7%, 56.4% or 65% for Pantepec, Chanal and Larrainzar, respectively) with a mean of 2.4 years (SD ±1.3). Regarding gender, there was not a statistically significant difference among girls (N=127) and boys (N=123) ($p>0.05$). The children's mean weight and height was 11.2 kg (SD ±3.18) and 0.81 m (SD ±0.11), respectively. Children's nutritional levels were assessed by means of the Mexican Official Norm NOM-031-SSA2-1999 [12] as well as the WHO Anthro software [13], using the weight-for-age (W/A), height-for-age (H/A), and weight-for height (W/H) indices. According to NOM, both W/A and W/H indexes establish a standard deviation (SD) for normal weight of ±1, for obesity from +2 to +3 SD, for overweight +1 to +1.99 SD; for mild malnutrition -1 to -1.99, moderate malnutrition from -2 to -2.99 SD and severe malnutrition -3 or even less SD, with all thresholds related to the median. Regarding the H/A index, children of normal height have plus-minus 1 SD, those of high stature +2 to +3 SD, those of slightly high stature +1 to +1.99 SD, those of slightly low stature from -1 to -1.99 SD and those of low stature at -2 and below SD, all in comparison to the median [12].

According to WHO criteria, children with Z-scores below -2 for W/A, H/A, and W/H were classified as underweight, stunted, and wasted, respectively. Children with Z-scores for W/H above +2 were classified as overweight [14].

Parasitological studies: Stool samples were collected in a clean polypropylene tube of 101 x 16.5 mm, with a screw top and a spoon (Sarstedt, Numbrecht Rommelsdorf, Germany). All samples were received at the facilities of the aforementioned healthcare units and kept at 4□C until same day shipping to the laboratory. The screening for intestinal parasites was performed using the direct coproparasitological exam and the formaldehyde/ethyl acetate concentration method [15]. The preparations were evaluated using an upright light microscope (Leica Microsystems, Wetzlar, Germany).

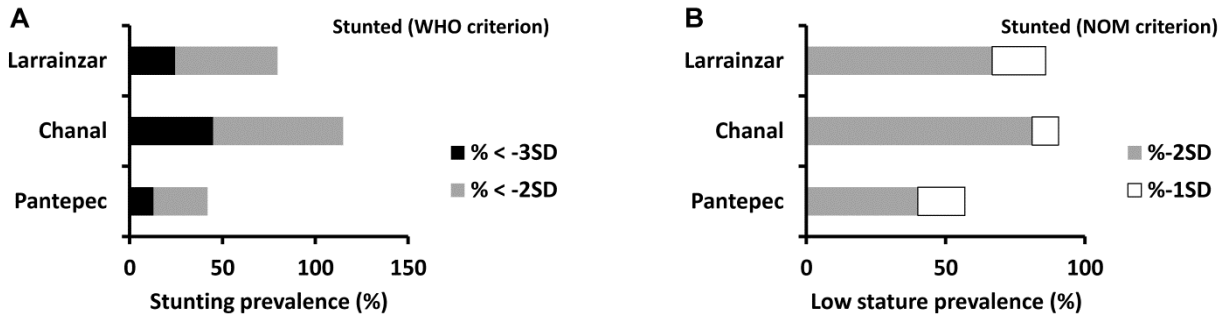
Statistical analysis: Descriptive statistical analyses were utilized in this study to obtain frequencies, means and standard deviation of the independent variables (such as age, weight and gender) and dependent variables (absence or presence of intestinal parasites, absence or presence of malnutrition). The association between nutrition (using the W/A index of the NOM

Table 1. Association between nutritional state and the presence of intestinal parasites

Municipality of Chiapas	Malnutrition			Normal weight	Overweight	Obesity	Total	p
	Severe	Moderate	Light					
Pantepec*								
Enteroparasite	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	
Present	1 (1.1)	6 (6.4)	22 (23.4)	23 (24.5)	7 (7.4)	0 (0.0)	59 (62.8)	0.016
Absent	0 (0.0)	3 (3.2)	7 (7.4)	11 (11.7)	10 (10.6)	4 (4.3)	35 (37.2)	
Total	1 (1.1)	9 (9.6)	29 (30.9)	34 (36.2)	17 (18.1)	4 (4.3)	94 (100.0)	
Chanal**								
Enteroparasite	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	
Present	7 (14.0)	4 (8.0)	6 (12.0)	4 (8.0)	1 (2.0)	0 (0.0)	22 (44.0)	0.088
Absent	13 (26.0)	9 (18.0)	1 (2.0)	5 (10.0)	0 (0.0)	0 (0.0)	28 (56.0)	
Total	20 (40.0)	13 (26.0)	7 (14.0)	9 (18.0)	1 (2.0)	0 (0.0)	50 (100.0)[a]	
Larrainzar**								
Enteroparasite	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	
Present	1 (1.0)	2 (2.0)	4 (4.0)	4 (4.0)	0 (0.0)	0 (0.0)	11 (11.1)	0.862
Absent	5 (5.1)	22 (22.2)	34 (34.3)	22 (22.2)	3 (3.0)	2 (2.0)	88 (88.9)	
Total	6 (6.1)	24 (24.2)	38 (38.4)	26 (26.3)	3 (3.0)	2 (2.0)	99 (100.0)[b]	

*($p<0.05$), indicates statistic differences between the municipalities, based on Fisher's exact Test; **($p>0.05$). [a] Not stated: 5 children (9%), [b] Not stated: 2 children (1.9%).

Figure 1. Prevalence of stunting among children from three municipalities of Chiapas, Mexico**.** A), stunting prevalence, according to WHO criterion B), low stature prevalence, according to NOM criterion; %<-2SD includes %<-3SD in WHO criterion.



standard) and parasite infection or child age and parasite infection were assessed with the Fisher's exact test and the Chi square test at a 5% significance level from the contingency tables. The odds ratio (OR) with a 95% confidence interval was also calculated. All statistical analyses were done using SPSS 15.0 software.

Results

Anthropometric data

According to the W/A index of the NOM criteria, more than half of children [60.5% (N=147)] presented some degree of malnutrition (Table 1). Alarming data revealed that in Chanal up to 80% of children had some degree of malnutrition (Table 1); malnutrition in children from Chanal or Larrainzar was significantly greater than that in children from Pantepec ($p<0.05$). There was also a high prevalence of small stature in children from Chanal (90.5%) and Larrainzar (85.9%) (Fig. 1).

According to the WHO criteria, a high prevalence of stunting (Z-score<-2SD) was recorded in children from Chanal and Larrainzar (70 and 55.1 %, respectively; Figure 1).

Prevalence of intestinal parasites

The overall intestinal parasite prevalence detected in those 250 analyzed fecal samples was 38.8% (N=97). The greatest prevalence of intestinal parasites was observed among children from Pantepec (62.8%). A great concern was that about half of the children contained eggs of *Ascaris lumbricoides*, resulting in a

Table 2. Prevalence of intestinal parasites among children from three municipalities of Chiapas, Mexico

	Municipality		
	Pantepec	Chanal	Larrainzar
Intestinal parasites	N (%)	N (%)	N (%)
A. lumbricoides	50 (53.2)	25 (45.5)	9 (8.9)
T. trichiura	3 (3.2)	0 (0.0)	0 (0.0)
A. lumbricoides/*T. trichiura*	6 (6.4)	0 (0.0)	0 (0.0)
H. nana	0 (0.0)	1 (1.8)	0 (0.0)
E. histolytica/dispar	0 (0.0)	0 (0.0)	1 (1.0)
E. nana	0 (0.0)	0 (0.0)	2 (2.0)
Subtotal	59 (62.8)	26 (47.3)	12 (11.9)
Absent	35 (37.2)	29 (52.7)	89 (88.1)
Total	94 (100.0)	55 (100.0)	101 (100.0)

Table 3. Children age and infection with intestinal parasites.

	Children age (years)			
Municipality of Chiapas	0-1.9	2-5	Total	p
Pantepec*				
Enteroparasite	N (%)	N (%)	N (%)	
Present	13 (13.8)	46 (48.9)	59 (62.8)	0.000
Absent	23 (24.5)	12 (12.8)	35 (37.2)	
Total	36 (38.3)	58 (61.7)	94 (100.0)	
X^2=17.737				
Chanal*				
Enteroparasite	N (%)	N (%)	N (%)	
Present	5 (9.1)	21 (38.2)	26 (47.3)	0.001
Absent	19 (34.5)	10 (18.2)	29 (52.7)	
Total	24 (43.6)	31 (56.4)	55 (100.0)	
X^2=11.942				
Larrainzar*				
Enteroparasite	N (%)	N (%)	N (%)	
Present	0 (0.0)	12 (12.0)	12 (12.0)	0.007
Absent	35 (35.0)	53 (53.0)	88 (88.0)	
Total	35 (35.0)	65 (65.0)	100[a] (100.0)	
X^2=7.343				

*($p<0.05$), indicates statistic differences between the two age groups, based on Chi square test. [a] Not stated: 1 children (0.9%).

prevalence of 53.2% in children from Pantepec with *A. lumbricoides* as the sole intestinal parasite (Table 2). Coinfections were observed in children from Pantepec where 6.4% of the stool samples contained both *A. lumbricoides* and *T. trichiura* (Table 2).

Association between the presence of intestinal parasites and age or the nutritional state of children

The greatest intestinal parasite prevalence [statistically significant, ($p<0.05$)] was observed among preschool aged children, from 2 to 5 years of age, compared to those breast-fed children, from 0 to 1.9 years of age (Table 3).

A statistically significant association between malnutrition and the presence of intestinal parasites was found ($p<0.05$) only in children from Pantepec. Despite Chanal having the highest prevalence of child malnutrition (~80%), a statistically significant association with the presence of parasites could not be recorded. Thus, children from Pantepec had a 2.4-fold greater risk that their malnutrition was caused by the presence of intestinal parasites (OR=2.41 [0.98-5.9]), compared to those children from Chanal (OR=0.73 [0.18-2.96]) or Larrainzar (OR=0.77 [0.2-2.86]).

Discussion

This study described the prevalence of intestinal parasites and its association to the nutritional state of children living in the three most marginalized (poorest) municipalities of Chiapas, Mexico: Pantepec, Chanal and Larrainzar. The prevalence of intestinal parasites detected in Pantepec (62.8%) was found to be similar to that from another study conducted in children from the Chiapas-Guatemala border region (~67%) [16]. One great interest is that the prevalence of intestinal parasites detected in children from Larrainzar was found to be only 11.9%. This could be partly due to a deworming programme which was recently introduced by the Federal Government in Larrainzar. Since the living conditions (i.e. economy, hygienic habits, academic level, etc.) of inhabitants of these three surveyed municipalities might be similar, future work should address the reason(s) for Larrainzar showing a very low prevalence of intestinal parasites in its child population compared with the other two municipalities.

Our studies detected *A. lumbricoides* as the most prevalent parasite in the three municipalities with an average prevalence of 33.6%. It has been estimated that *A. lumbricoides* is the most prevalent intestinal parasite in children under 5 years old in Latin America [3]. Recent reports from Ecuador [17] and Brazil [18], detected a prevalence of *A. lumbricoides* in school-age children of 63% and 65.5%, respectively. In contrast to the current report, a study by Morales-Espinoza et al. (2003) showed that the most prevalent parasites in the Chiapas-Guatemala border region are *E. histolytica*/*E. dispar* (51.2%) followed by *Giardia lamblia* (18.3%). The prevalence of *A. lumbricoides* in this area was only 14.5% [16]. It is possible that environmental factors such as average annual rainfall and humidity (see below) will favour the spread of *A. lumbricoides* in children from our surveyed municipalities. In our current study, the prevalence of *A. lumbricoides* was higher in Pantepec. Some environmental factors have been associated to high prevalence of infection with *A. lumbricoides* worms. For example, O´Lorcain and Holland (2000) reported that soil and atmospheric humidity favors the development and survival of eggs and larvae of *A. lumbricoides* and *T. trichiura* [19]. At the time of sample collection, there was greater rainfall in Pantepec (2,600 mm) compared to Chanal (500 mm) or Larrainzar (100 to 1,700 mm).

Another potential factor associated with the presence of geohelminths is the type of home flooring [16]. In 2005, most houses in these municipalities had earthen floors, ~83.72% in Pantepec, ~80.32% in Chanal and ~46.38% in Larrainzar. It has been described that earthen floors allow the persistence of *A. lumbricoides* eggs for periods of months and up to 15 years after being excreted from the faeces of infected children [20].

Our study also revealed an alarmingly high prevalence of malnutrition and low stature, mainly among children from Chanal and Larrainzar. Similarly, a very high prevalence of stunting (>40%) was recorded among children from Chanal and Larrainzar according to the WHO standard. The high prevalence of stunting indicates poor nutrition and high morbidity due to infectious disease [14].

In accordance with our results, a study reported by Rivera et al. (2003) and Mexico's Nutrition and Health National Survey (2006) reported that Chiapas was first place in low weight and low height in children less than five years old [22-23]. Child malnutrition could also be explained by the fact that in 2005 it was reported that 47% of Chiapas inhabitants suffered from alimentary poverty. This is over two and a half times the national level (18.2%) [6]. As discussed elsewhere, the high prevalence of low stature and child malnutrition in Chanal and Larrainzar found in the current study can also be a result of the intergenerational cycle of growth failure [3,24-25].

Our study revealed a statistically significant association between the child's age and the presence of parasites ($p<0.05$). School-age children (2 to 5 years) had a higher prevalence of parasites compared to breast-fed infants (Table 3). Similarly, a study in Nigeria showed that children from 1 to 2.1 years had a higher risk of becoming infected with *A. lumbricoides* compared to children between 7 to 11 months old [26]. This may be due to the fact that school-age children tend to be more active, interact more with the environment by putting objects to their mouth with dirty hands (geophagy), and rarely adopt hygienic habits [2].

This current study shows that in children from Pantepec there was an association between child malnutrition and the presence of parasites, mainly by the parasitic nematode *A. lumbricoides*. This association has been reported in a previous study by Quihui et al. (2004), who found that the prevalence of helminths in school-age children from Oaxaca and Sinaloa was associated to low weight and height [27]. Another study conducted in Brazil found an association between child malnutrition and the presence of *Ascaris-Trichuris* [28]. The lack of antihelminthic drugs, the proportion of households with earthen floor, typical weather conditions in Pantepec, anorexia caused by nematode infections [3], and malnutrition and poverty are thought to contribute to the association between child malnutrition and the presence of intestinal parasites. All of these factors can also explain why the children of Pantepec have a 2.4 fold higher risk of their malnutrition associated with the presence of parasites, compared with those from Chanal or Larrainzar.

The federal government has currently focused its attention on these municipalities in order to eradicate poverty and marginalization. The recent implementation of a programme called "Piso Firme", an effort to replace earthen floors with concrete floors, is likely to help reduce the prevalence of intestinal parasites. Furthermore, interventions recommended by the OMS, such as the administration of anti-helminthic drugs on a regular basis to high risk populations and a health education programme [29] must be implemented in children from the surveyed municipalities. This can assist in reducing malnutrition and potentially lowering mortality rates. Finally, more sophisticated analyses may allow us to identify other potential etiologic agents in the future, such as bacterial or viral pathogens, that could contribute to the elevated mortality rates seen in those children

Conclusions

The observed malnutrition and high prevalence of intestinal parasites present a clear reflection of the social disparity existing between these forgotten communities and the rest of the population of Mexico. These preventable conditions need to be addressed by the local and federal government as well as global humanitarian organizations. Improved education and an ease of access to food and health services are also essential in raising the standards of health and quality of life to these poor areas of southern Mexico.

Acknowledgements

The authors would like to thank Elizabeth Aguilar Villarreal from the Rural Medical Unit of the Mexican Institute of Social Security (IMSS) in Pantepec for her kind support of this work. We would also like to express our appreciation to the health personnel at the health centre with a hospitalization unit in Chanal and to the Community Basic Hospital in Larrainzar, Chiapas. Also thanks to Dr. Leticia G. Montoya-Lievano from the SSA, San Cristobal de las Casas, Chiapas for her support of our project. We greatly appreciate Gideon Matzkin and Grant Walter for reading this manuscript and their valuable suggestions. Research for this study was supported by grants from "Programa multidisciplinario de atencion comunitaria a municipios de alto grado de marginacion 2009" of the Chiapas University of Sciences and Arts (grant number 110000 3.03.004.303.001) and the Mexican Social Development Office (SEDESOL).

References

1. Releve epidemiologique hebdomadaire / Section d'hygiene du Secretariat de la Societe des Nations (2011) Working to overcome the global impact of neglected tropical diseases - Summary = Weekly epidemiological record / Health Section of the Secretariat of the League of Nations. 86: 113-120.
2. Harhay MO, Horton J, Olliaro PL (2010) Epidemiology and control of human gastrointestinal parasites in children. Expert Rev Anti Infect Ther 8: 219-234.
3. Stephenson LS, Latham MC, Ottesen EA (2000) Malnutrition and parasitic helminth infections. Parasitol, 121 Suppl:S 23-38.
4. Hotez PJ, Brindley PJ, Bethony JM, King CH, Pearce EJ, Jacobson J, Helminth infections: the great neglected tropical diseases (2008) J Clinical Invest 118:1311-21.
5. SINAIS (2010) Situación de salud en México. Indicadores básicos. Secretaría de Salud, Sistema Nacional de Información en Salud. Available: http://www.sinais.salud.gob.mx/indicadores/basicos.html Accesed 6 September 2012.
6. CONEVAL (2008) Informe de pobreza multidimensional en México. México, D.F.: Consejo nacional de evaluación de la política de desarrollo social. Available: http://www.coneval.gob.mx/cmsconeval/rw/pages/medicion/Informe_de_pobreza_multidimensional_en_Mexico_2008.es.do. Accesed 6 September 2012.

7. CONAPO (2005) Estimación de la mortalidad infantil para México, las entidades federativas y los municipios Available: http://www.conapo.gob.mx/en/CONAPO/Estimacion_de_la_mortalidad_infantil_para_Mexico_las_entidades_federativas_y_los_municipios_2005 Accesed 6 September 2012.
8. Perfiles municipales (2010) Secretaría de Hacienda, Gobierno de Chiapas Available: http://www.ceieg.chiapas.gob.mx/perfiles/ Accesed 6 September 2012.
9. INEGI (2010) Censo de Población y Vivienda: Tabulados del Cuestionario Básico. Available: http://www3.inegi.org.mx/sistemas/TabuladosBasicos/Default.aspx?c=27302&s=est Accesed 6 September 2012.
10. Montresor A, Crompton, D.W.T., Bundy, D.A.P.,Hall, A., and Savioli, L (1998) Guidelines for the evaluation of soil-transmitted helminthiasis and schistosomiasis at community level. Available: http://whqlibdoc.who.int/hq/1998/WHO_CTD_SIP_98.1.pdf Accesed 6 September 2012.
11. Zarco A, Mora G, Pelcastre B, Flores M, Bronfman M. (2006) Acceptability of dietary supplements of the national Mexican program "Oportunidades". Salud Pub Mex 48: 325-331.
12. Norma oficial mexicana NOM-031-SSA2-1999, para la atención a la salud del niño (2001) Secretaría de Salud. Available: http://www.salud.gob.mx/unidades/cdi/nom/031ssa29.html Accesed 6 September 2012.
13. WHO Anthro for personal computers, version 3.2.2 (2011) Software for assessing growth and development of the world's children. Geneva: WHO. Available: http://www.who.int/childgrowth/software/en/ Accesed 6 September 2012.
14. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. Technical Report Series No. 8541995.
15. CLSI (2005) Procedures for the recovery and identification of parasites from the intestinal tract; approved guideline,. 2nd edition. Clinical and Laboratory Standards Institute; 109 p.
16. Morales-Espinoza EM, Sanchez-Perez HJ, Garcia-Gil Mdel M, Vargas-Morales G, Mendez-Sanchez JD, Perez-Ramirez M (2003) Intestinal parasites in children, in highly deprived areas in the border region of Chiapas, Mexico,. Salud Pub Mex. 45(5): 379-388.
17. Andrade C, Alava T, De Palacio IA, Del Poggio P, Jamoletti C, Gulletta M, Montresor A (2001) Prevalence and intensity of soil-transmitted helminthiasis in the city of Portoviejo (Ecuador). Mem Inst Oswaldo Cruz,. 96: 1075-1079.
18. Jardim-Botelho A, Brooker S, Geiger SM, Fleming F, Souza Lopes AC, Diemert DJ, Corrêa-Oliveira R, Bethony JM (2008) Age patterns in undernutrition and helminth infection in a rural area of Brazil: associations with ascariasis and hookworm. Trop Med Int Health 13: 458-467.
19. O'Lorcain P, Holland CV (2000) The public health importance of *Ascaris lumbricoides*. Parasitol 121 Suppl:S51-71.
20. Dold C, Holland CV (2011) *Ascaris* and ascariasis. Microbes Infect 13: 632-637.
21. Goncalves AL, Belizario TL, Pimentel Jde B, Penatti MP, Pedroso Rdos S (2011) Prevalence of intestinal parasites in preschool children in the region of Uberlandia, State of Minas Gerais, Brazil. Rev Soc Bras Med Trop 44: 191-193.
22. Rivera JA, Monterrubio EA, Gonzalez-Cossio T, Garcia-Feregrino R, Garcia-Guerra A, Sepulveda-Amor J (2003) Nutritional status of indigenous children younger than five years of age in Mexico: results of a national probabilistic survey. Salud Pub Mex 45 Suppl 4: S466-476.
23. INSP (2007) Encuesta nacional de salud y nutrición 2006. Resultados por entidad federativa, Chiapas. Cuernavaca, México: Instituto Nacional de Salud Pública-Secretaría de Salud. Available: http://www.insp.mx/encuesta-nacional-salud-y-nutricion-2006.html Accesed 6 September 2012.
24. Lutter CK, Chaparro CM, Munoz S (2011) Progress towards Millennium Development Goal 1 in Latin America and the Caribbean: the importance of the choice of indicator for undernutrition. Bull World Health Organ 89: 22-30.
25. Sanchez-Perez HJ, Hernan MA, Rios-Gonzalez A, Arana-Cedeno M, Navarro A, Ford D, Micek MA, Brentlinger P (2007) Malnutrition among children younger than 5 years-old in conflict zones of Chiapas, Mexico. Am J Public Health 97: 229-232.
26. Kirwan P, Asaolu SO, Abiona TC, Jackson AL, Smith HV, Holland CV (2009) Soil-transmitted helminth infections in Nigerian children aged 0-25 months. J Helminthol 83: 261-266.
27. Quihui-Cota L, Valencia ME, Crompton DW, Phillips S, Hagan P, Diaz-Camacho SP, Triana Tejas A (2004) Prevalence and intensity of intestinal parasitic infections in relation to nutritional status in Mexican schoolchildren. Trans R Soc Trop Med Hyg 98: 653-659.
28. Saldiva SR, Silveira AS, Philippi ST, Torres DM, Mangini AC, Dias RM, da Silva RM, Buratini MN, Massad E (1999) Ascaris-Trichuris association and malnutrition in Brazilian children. Paediatr Perinat Epidemiol 13: 89-98.
29. Mascarini-Serra L (2011) Prevention of soil-transmitted helminth infection. J Glob Infect Dis 3:175-182.

Corresponding author

Javier Gutierrez-Jimenez
Facultad de Ciencias Biológica
Universidad de Ciencias y Artes de Chiapas (UNICACH)
Tuxtla Gutiérrez, Chiapas
México
Email address: javier.gutierrez@unicach.mx

Conflict of interests: No conflict of interests is declared.