The risk of *Ascaris lumbricoides* infection in children as an environmental health indicator to guide preventive activities in Caparaó and Alto Caparaó, Brazil

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Objective To develop an environmental health indicator for use as a basis for developing preventive measures against *Ascaris lumbricoides* infection in children from the rural municipalities of Caparaó and Alto Caparaó, in Minas Gerais, Brazil.

Methods A cross-sectional survey was conducted between May and September 1998 among 1171 children under 14 years of age living in 588 dwellings selected from 11 communities. Trained interviewers used a questionnaire to identify risk factors for infection (socioeconomic, sanitation and hygiene variables) and collected stool samples from each child for parasitological tests.

Results The overall prevalence of *A. lumbricoides* infection was 12.2%. The results showed the protective effects of availability of water in the washbasin and better hygiene, sanitation and socioeconomic status; the interactive effect of crowding was five times larger in households without water in the washbasin than in those having water. There was a statistically significant association between infection and children's age.

Conclusion The environmental health indicator, which incorporated the most significant biological, environmental and social factors associated with the risk of *A. lumbricoides* infection in children from these communities, should contribute to the development of surveillance tools and health protection measures in this population.

Keywords Ascariasis/epidemiology; Water supply; Toilet facilities; Prevalence; Cross sectional studies; Child; Brazil (*source: MeSH, NLM*).

Mots clés Ascaridiase larvaire/épidémiologie; Alimentation eau; Toilettes publiques; Prévalence; Etude section efficace; Enfant; Brésil (*source: MeSH, INSERM*).

Palabras clave Ascariasis/epidemiologia; Abastecimiento de agua; Baños públicos; Prevalencia; Estudios transversales; Niño; Brasil (*fuente: DeCS, BIREME*).

Voir page 44 le résumé en français. En la página 45 figura un resumen en español.

Introduction

Faecal contamination is one of the most serious environmental health problems in poor countries, where 3 million children die of enteric diseases each year and even more suffer from debilitating diseases due to intestinal parasites (*1*). The intestinal nematode *Ascaris lumbricoides* infects approximately 25% of the world's population annually (*2*). Although the infection is often asymptomatic, its effects may contribute substantially to child morbidity when associated with malnutrition, pneumonia, enteric diseases and vitamin A deficiency (*3*).

In Brazil, 70% of hospital admissions in the public health sector reflect a series of sanitation deficiencies (*4*). In the municipalities of Caparaó and Alto Caparaó, in the State of Minas Gerais, an analysis of general mortality rates by group of causes from 1980 to 1995 ranked infectious and parasitic diseases in fourth place, contributing to 5.06% of the deaths (after circulatory disorders, respiratory diseases, and neoplasms). For young children, however, infectious and parasitic diseases account for 17.46% of the deaths and represent the second most important cause of death, preceded only by perinatal conditions (*5*).

Despite the magnitude of these problems, data from epidemiological studies are seldom translated into meaningful information and health protection measures. Communication between health services and decision-makers is essential to overcome the main obstacles for community participation (*6*). The establishment of guidelines for the development of preventive measures and health programme evaluation are of high priority. Experience shows that such an approach, as opposed to documentation of technical problems alone, allows social mobilization towards the solution of specific problems, thereby contributing to the reduction of inequities in health (*7*).

The development of environmental health indicators that incorporate health data obtained using scientifically based methods is one means of translating the results from epidemiological studies into preventive tools. Such indicators provide the empirical foundation for the definition of priorities within the legal framework of primary health care and environmental protection (*8, 9*). They should be relatively

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easy to measure, and provide clear "warning signals" to decision-makers and non-specialists for the institution of specific control measures (*10*).

This study evaluated the risk of *A. lumbricoides* infection in children in rural communities in the municipalities of Caparaó and Alto Caparaó. Risk factors for the prevalence and intensity of infection were evaluated, and vulnerable groups were identified. Statistical analysis allowed the development of an environmental health indicator that incorporated the most significant biological, behavioural, environmental and social factors associated with the risk of infection in this population. The objective of such an indicator is to guide, evaluate and redefine local action to prevent ascariasis.

Methods

Study area

The study area is located on the western slope of the Caparaó mountain chain, some 340 km from Belo Horizonte, capital of the State of Minas Gerais, Brazil. The topography of the area is uneven (55% mountains, 30% hills, 15% wetlands), altitude ranging from 800 to 2890 metres. Temperature ranges from 4 °C to 27 °C and relative humidity is 75% in the rainy season. One-third of the land surface is dedicated to the cultivation of coffee (in which nearly 80% of the working population is involved), corn, beans and rice (*11*). According to the UNDP human development index, Caparaó and Alto Caparaó rank in the category of intermediate human development regions (0.572); use of the Theil L index as a proxy measure of social inequality gives these municipalities a less favourable status (0.56) in comparison with 69% of the municipalities in the rest of Brazil (*12*).

Study design

A census was conducted in 11 rural communities from Caparaó and Alto Caparaó to count children under 14 years of age.

A pilot study was performed in two communities (Galiléia and Santa Rita) in Caparaó, which represented the two extremes of social and environmental conditions, in order to train the field team, validate the questionnaire, and test field, laboratory and computing procedures. Soil samples were collected from humid and shady areas in the backyards of 118 dwellings, placed in plastic bags and subsequently tested for *A. lumbricoides* eggs according to the procedures recommended by Caldwell & Caldwell and Stoye & Horn with modifications (*13, 14*). Water samples from 67 of the dwellings were collected in sterile flasks, placed in ice-boxes, and transported by bus to the central laboratory of the Water and Sanitation Company in the State of Minas Gerais (COPASA), where they were tested for *Escherichia coli* using the Colilert kit (*15*).

A cross-sectional study was conducted during the dry season of 1998 (May–September) by means of interviews using structured questionnaires to gather information on sanitation, hygiene and socioeconomic status, and the collection of stool samples for parasitological tests to determine the prevalence of intestinal infections. With informed consent obtained previously, interviews were conducted in all households with children. The guardian, usually the mother, provided the information. House-to-house visits allowed structured observation as an additional aid in the evaluation of domestic conditions (condition of the backyard and toilet, verification of

the presence of soap on the washbasin, etc.), as used in similar field investigations (*1, 16–19*). At the end of the visit, plastic flasks with a top and a label (for identification of each child) were delivered for stool samples, which were collected the following day. *A. lumbricoides* eggs were identified and counted microscopically using the Kato-Katz technique (*20*).

For quality control purposes, different interviewers duplicated 10% of the interviews, in order to check for inter-observer variability and common patterns in the application of the questionnaires. Tests of 20% of stool samples were repeated (Kato-Katz technique), at random, and slides with dubious readings were sent to the referral research laboratory (René Rachou Centre, Oswaldo Cruz Foundation). Similarly, 10% of the bacteriological tests on water samples were repeated. The use of two different techniques (Caldwell & Caldwell and Stoye & Horn with modifications) for testing soil samples for *A. lumbricoides* eggs provided a control for this parameter.

Statistical analysis

Double-entry programs (questionnaires and laboratory results) were used to reduce error. Analysis was performed with the STATA Program (version 5.0, University Drive East, College Station, Texas, USA). Exploratory analysis was carried out to obtain descriptive statistics prior to fitting regression models. Socioeconomic, sanitation and hygiene indices were constructed using principal component analysis, which selects the optimal linear combination of variables to summarize the information, incorporating the existing correlation between variables. The percentage of explained variance can be interpreted as a measure of index quality (*21*). The variables used in the construction of the three indices were as follows:

Socioeconomic index
– ownership of cultivated land
– ownership of dwelling
– ownership of car and refrigerator
– literacy of mother

Sanitation index
– availability of piped water inside the house and its regular supply
– location of toilet (inside or outside house)
– characteristics of the backyard (dusty or paved with cement)

Hygiene index
– condition of toilet
– water treatment type
– presence of soap
– interviewer's perception of hygiene status.

Individual socioeconomic indices were determined for each child; however, since the indices were fairly homogeneous within compounds, an average community index was calculated. Communities with similar index values were regrouped in three categories, high, middle and low, using the method of multiple comparison proposed by Bonferronni (*21*). Given that the relations between the risk of *Ascaris lumbricoides* infection and the sanitation and hygiene indices were not linear, we decided to categorize these variables also. Cut-off points were based on the inflection points detected in the diagnostic plots of the regression model. For the sanitation

index, the percentile 20 was used as the cut-off point, which separated 20% of children living in dwellings with better sanitary conditions from the 80% with poorer sanitary conditions. For the hygiene index, the median was used. Multivariate regression models were used to determine the best predictors of infection and intensity of *A. lumbricoides* infection.

The following variables were included in the analyses: age, sex, years of schooling (pre-school, 0–3 years, >4 years), time since last anthelminthic treatment (<6 months, 6–12 months, >1 year, never), time of residence in the community, risk behaviours (e.g. playing with dirt, no hand-washing before eating and after using the toilet, eating meals at the agricultural plot), crowding, and the socioeconomic, sanitation and hygiene indices. The final logistic regression model for *A. lumbricoides* infection was validated by the Hosmer & Lemeshow test for goodness of fit, and the Pearson chi-square test (*22*). Using the model, the estimated mean probability of infection was evaluated for each community. This environmental health indicator allowed the identification of high-risk communities in the study area.

Intensity of infection was defined by counting the number of eggs per gram of stool sample (*20*). Analysis of intensity of infection was conducted in the sub-sample of infected individuals using the method of negative binomial regression. This technique was performed in the light of the results of the egg counts (per gram of faeces: 12–355 440), which showed a Poisson pattern with an over-dispersion component (*23–26*).

Finally, the basic characteristics of the population that provided stool samples for parasitological examination and the group that did not were compared using the *t* and chi-square tests to evaluate potential selection bias.

Results

The census revealed a total of 1171 children: Boa Vista (119), Bragunça (66), Calixto (58), Capim Roxo (220), Empossado (104), Galiléia (146), Grumarim (114), Montes Claros (45), Santa Rita (106), São Domingos (95) and Taquaruna (98) living in 588 dwellings. Full information was provided for 70% of the children, including stool samples for parasitological tests.

In 68% of the households visited the occupants did not own the dwelling and in 79% they owned no land. Most of the mothers were literate (79%) and spent, on average, the minimum monthly wage (equivalent to US$ 70) to cope with family needs. For 80% of the population, the water supply consisted of surface springs; 66% of households had piped water. Piped sewerage discharges (i.e. creeks) were identified in more than half of the dwellings. In the pilot study, 64% of the 67 water samples tested positive for *E. coli*, and 2% of the 118 soil samples tested positive for *A. lumbricoides* eggs.

The cross-sectional study showed that the overall prevalence rate of *A. lumbricoides* infection was 12.2%. Other intestinal infections detected were *Ancylostoma duodenale* (5%), *Trichuris trichiura* (5%), *Schistosoma mansoni* (2.2%) and *Enterobius vermicularis* (1.8%). As Table 1 illustrates, the highest prevalence of *A. lumbricoides* infection, the lowest hygiene index, absence of washbasin water, and crowding were more frequently detected in children from the lowest socioeconomic group. Table 2 presents the main predictors of *A. lumbricoides* infection. Children from households with high hygiene and sanitation indices had a lower risk of infection than those from

Table 1. **General characteristics of the study population, Caparaó and Alto Caparaó, Brazil, 1998**

	Socioeconomic group		
	Low	**Middle**	**High**
Prevalence of infection	37 26.80%	39 11.80%	24 6.70%
Hygiene index (high)	79 36.60%	183 43.57%	251 57.70%
Water in the washbasin	194 82.91%	391 90.93%	441 95.45%
Crowding	86 34.96%	126 28.51%	124 25.67%

households in the low categories (odds ratio (OR) = 0.54; 95% confidence interval (CI) 0.32–0.92 and OR = 0.54, 95% CI 0.30–0.95, respectively). There was an interaction between crowding and availability of water in the washbasin; according to this model, the risk of *A. lumbricoides* infection was 4.6 times greater among children from overcrowded households without water in the toilet, when compared to those having water, even after adjusting for socioeconomic, sanitation and hygiene factors and children's age (OR for crowding without water = 6.82; OR for crowding with water = 1.48). Children over 5 years of age had a higher risk of infection than younger individuals (OR 3.50, 95% CI 1.83–6.71). An inverse relation between socioeconomic status and the risk of *A. lumbricoides* infection was observed; the estimated risk was 2.5 times greater among children from communities with a low socioeconomic index, when compared to those from the middle category. In turn, the risk in the latter was twice that in those with a high socioeconomic index.

An environmental health indicator was constructed which estimated the mean probability of *A. lumbricoides* infection by community: Montes Claros (37.26%), Santa Rita (26.40%) São Domingos (21.30%), Taquaruna (17.86%), Capim Roxo (10.94%), Calixto (10.04%), Bragunça (8.79%), Galiléia (8.26%), Empossado (5.45%), Grumarim (4.74%) and Boa Vista (4.63%).

The intensity of *A. lumbricoides* infection was analysed for those positive for the infection (Table 3) and showed that children from crowded dwellings had a higher risk of intense infections than those living in non-crowded ones (relative risk (RR) = 2.15; 95% CI 1.02–4.53). This risk was lower in children with access to water in the washbasin than in those without it (RR = 0.42; 95% CI 0.20–0.89). A similar association was observed in children from dwellings with better hygiene status (RR = 0.42; 95% CI 0.18–1.00), and in those with longer residence time in their neighbourhoods (RR = 0.22; 95% CI 0.07–0.72). Children with more than 4 years of schooling also showed a lower risk of infections than those with less (RR = 0.17; 95% CI 0.07–0.38). Children from families with a higher purchasing capacity also had a lower risk of *A. lumbricoides* infection (RR = 0.42; 95% CI 0.20–0.89). Children with recent anthelminthic treatment were less likely to suffer intense infections (RR = 0.51; 95% CI 0.25–1.02).

Of the children investigated, 30% (346 out of 1171) did not provide stool samples. A large proportion of these (42%) were from the lowest socioeconomic group. The *t* and χ^2 tests showed significance for socieconomic indicators, crowding

Table 2. **Multivariate model – logistic regression analysis for *Ascaris lumbricoides* infection, Caparaó and Alto Caparaó, Brazil, 1998[a]**

Covariable		No.	%	Coefficient	Odds ratio	95% confidence interval
Crowding	Yes	190	25	1.92	6.84	2.27–20.55
	No	570	75	–	–	–
Water in the washbasin	Yes	689	90.7	– 0.64	0.53	0.23–1.21
	No	71	9.3	–	–	–
Interaction: crowding and water in the washbasin		158	20.8	– 1.53		
Sanitation index	High	139	18.3	– 0.63	0.54	0.30–0.95
	Low	621	81.7	–	–	–
Hygiene index	High	374	49.2	– 0.62	0.54	0.32–0.92
	Low	386	50.8	–	–	–
Age (child > 5 years)	Yes	518	68.2	1.25	3.50	1.83–6.71
	No	242	31.8	–	–	–
Socioeconomic index	High	328	43.1	– 0.68	0.50	0.27–0.93
	Middle	314	41.3	–	–	–
	Low	118	15.5	0.90	2.45	1.37–4.40

[a] Total number of observations = 760.

Table 3. **Intensity of *Ascaris lumbricoides* infection (eggs per gram of stool sample)[a] in children, Caparaó and Alto Caparaó, Brazil, 1998**

Covariable		No.	%	Relative risk	95% confidence interval
Crowding	Yes	32	(43.8)	2.15	1.02–4.53
	No	41	(56.2)	–	–
Water in the washbasin	Yes	50	(68.49)	0.42	0.20–0.89
	No	23	(31.51)	–	–
Hygiene index	High	19	(26.03)	0.42	0.18–1.00
	Low	54	(73.97)	–	–
Time/residence in the community	> 1 year	66	(90.41)	0.22	0.07–0.72
	< 1 year	7	(9.59)	–	–
Years of schooling	> 4 years	18	(24.66)	0.17	0.07–0.38
	< 4 years	55	(75.34)	–	–
Family income/expenditures	Spend more than 1 wage	49	(67.12)	0.42	0.20–0.89
	Spend 1 wage or less	24	(32.88)	–	–
Recent anthelminthic treatment	1–12 months	41	(56.16)	0.51	0.25–1.02
	> 12 months ago; never	32	(43.84)	–	–

[a] Negative binomial regression; total number of observations = 73.

and sanitary conditions for groups both with and without stool samples.

Discussion

It is hoped that the environmental health indicator developed as a result of this research will help to set priorities for action in an objective and systematic way (*1*). The indicator allows a meaningful translation of the risk of *A. lumbricoides* infection in children from Caparaó and Alto Caparaó in the assessment of health priorities and planning in these communities.

The indicator summarizes the most significant biological, environmental and social variables associated with the risk of *A. lumbricoides* infection in this population. The rationale was that such infection results from ingestion of viable ova, shed by infected humans on humid and shady soil, and that overcrowded living conditions increase the likelihood of faecal–oral transmission of infection (*27, 28*). Current knowledge suggests that intensity of infection is influenced by cultural and genetic factors, as well as hygiene, environmental and socioeconomic variables (*2, 17, 29, 30*). Evidence on the interaction between availability of water in the washbasin and overcrowding, as observed in this study, is scarce, however (*31*).

The overall prevalence rate of *A. lumbricoides* found in children from Caparaó and Alto Caparaó was lower than that reported from the State of Minas Gerais as a whole (*25*). This may reflect the low proportion of soils testing positive for *A. lumbricoides* eggs. Epidemiological data suggested, however, that children from poorer dwellings with lower sanitation and hygiene scores were at higher risk of infection than better-off groups (*32–40*). It is important to recall that prevalence data provide information on the presence of the infection only and do not offer any indication to decision-makers as to which preventive measures might be suitable in the prevailing conditions (*41*, *42*).

The model of intensity of *A. lumbricoides* infection illustrates the importance of crowding as a significant predictor of infection in dwellings; the proximity of infective and susceptible individuals promotes transmission (*29*, *30*, *43*). As observed in other studies (*2*, *17*, *26*, *29*, *30*, *34–36*), children with less intense infection came from better-off households, with higher socioeconomic (including purchasing power) and schooling profiles. In addition, children from households with longer time of residence in the neighbourhood had lower counts of helminth eggs in faeces than children from "unstable" families, with fewer possibilities for improving their dwellings. The importance of access to primary health care facilities was also suggested by the lower risk found in those children who had recently received anthelminthic chemotherapy.

The weaknesses of this study result mostly from the intrinsic limitations of the cross-sectional study design, which hinders examination of the chronological sequence of risk factors and health outcome (*44*). Furthermore, the information is highly local in nature, and consequently the indicator refers only to the rural communities of Caparaó and Alto Caparaó. The fact that 30% of the children, mostly from the lowest socioeconomic group, did not provide stool samples is likely to have resulted in the underestimation of the prevalence of *A. lumbricoides* infection in this population.

The environmental health indicator derived from our results provides the basis for specific protection measures. Evidently, if children are at higher risk of infection than adults (they spend more time at home and engage in risky behaviours), domestic sanitation and hygiene are priorities for action (*45*). Given the array of environmental factors influencing health risks, a summary definition of what constitutes an unhealthy dwelling is also necessary. Since water quantity is not a major issue in these communities, promoting personal use of water (e.g. through provision of washbasins) and soap for hand-washing may be a cost-effective health intervention. The synergistic impact of such interventions should reduce the combined illness burden resulting from crowding and faecal pollution and, in turn, reduce inequities in health (*7*, *37*).

The information obtained in this study provides the basis for environmental and community health surveillance. Further research is needed to validate this environmental health indicator. The sustainability of such an indicator will largely depend on community participation and dialogue with the local health team (*19*, *46*).

Ethical issues

The study protocol was approved by the Ethics Committee of the Faculty of Medicine of the Minas Gerais Federal University, and by the Ethics Committee of the Pan-American Health Organization. Free and informed consent formats were used in all the interviews and examinations. All the results were delivered individually and treatment of infections detected was carried out by local health services. Community assemblies were conducted in the communities concerned to discuss problems and alternative solutions, deliver results and create environmental health committees. ■

Résumé

Le risque d'infection par *Ascaris lumbricoides* chez l'enfant en tant qu'indicateur d'hygiène du milieu destiné à guider les activités de prévention à Caparaó et Alto Caparaó (Brésil)

Objectif Mettre au point un indicateur d'hygiène du milieu destiné à servir de base pour l'élaboration de mesures préventives contre l'infection par *Ascaris lumbricoides* chez l'enfant dans les municipalités rurales de Caparaó et Alto Caparaó dans l'Etat de Minas Gerais au Brésil.

Méthodes Une étude transversale a été réalisée entre mai et septembre 1998 sur 1171 enfants de moins de 14 ans vivant dans 588 logements sélectionnés dans 11 communautés. Des enquêteurs expérimentés ont utilisé un questionnaire pour identifier les facteurs de risque d'infection (paramètres socio-économiques et paramètres relatifs à l'assainissement et à l'hygiène) et ont effectué un prélèvement de selles chez chaque enfant pour examen parasitologique.

Résultats La prévalence globale de l'infection par *Ascaris lumbricoides* était de 12,2 %. Les résultats ont montré l'effet protecteur de l'existence d'un point d'eau dans les toilettes et de meilleures conditions en matière d'hygiène, d'assainissement et de niveau socio-économique ; l'effet interactif du surpeuplement était cinq fois plus élevé dans les ménages ne disposant pas de point d'eau dans les toilettes que dans les autres. Il y avait une association statistiquement significative entre l'infection et l'âge de l'enfant.

Conclusion L'indicateur d'hygiène du milieu, qui intègre les plus importants facteurs biologiques, environnementaux et sociaux associés au risque d'infection par *Ascaris lumbricoides* chez l'enfant dans ces communautés, devra contribuer au développement d'outils de surveillance et de mesures de protection de la santé dans la population concernée.

Resumen

El riesgo de infección por *Ascaris lumbricoides* en la población infantil como indicador de salud ambiental destinado orientar las actividades de prevención en Caparaó y Alto Caparaó (Brasil)

Objetivo Desarrollar un indicador de salud ambiental como base para idear medidas preventivas contra la infección por *Ascaris lumbricoides* en la población infantil de municipios rurales de Caparaó y Alto Caparaó, en Minas Gerais, Brasil.

Métodos Entre mayo y septiembre de 1998 se llevó a cabo un estudio transversal entre 1171 niños menores de 14 años que vivían en 588 viviendas seleccionadas en 11 comunidades. Encuestadores experimentados emplearon un cuestionario para identificar factores de riesgo de infección (variables socioeconómicas y variables relacionadas con el saneamiento y la higiene) y obtuvieron muestras de heces de cada niño para someterlas a pruebas parasitológicas.

Resultados La prevalencia global de infección por *A. lumbricoides* fue del 12,2%. Los resultados revelaron el efecto protector de la disponibilidad de agua en el baño y de las mejoras de la higiene, el saneamiento y el nivel socioeconómico; el efecto interactivo del hacinamiento fue cinco veces mayor en los hogares sin agua en el lavamanos que en los que disponían de agua. Se observó una relación estadísticamente importante entre la infección y la edad del niño.

Conclusión El indicador de salud ambiental, que incorpora los factores biológicos, ambientales y sociales más importantes asociados al riesgo de infección por *A. lumbricoides* en los niños de estas comunidades, debería facilitar el desarrollo de instrumentos de vigilancia y de medidas de protección de la salud en la población estudiada.

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