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Environmental Health Indicators and
Development of Preventive Actions
against *Ascaris lumbricoides* Infections in
Rural Communities:

Caparaó and Alto Caparaó, Minas Gerais, Brazil

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Environmental Health Indicators and Development of Preventive Actions against *Ascaris lumbricoides* Infections in Rural Communities:

Caparaó and Alto Caparaó, Minas Gerais, Brazil¹

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SUMMARY

This study developed a compound environmental health indicator (*EHI*) for planning of preventive measures to be applied against *Ascaris lumbricoides* infection in rural municipalities of Caparaó and Alto Caparaó, in Minas Gerais, Brazil. A cross sectional study on the prevalence of *Ascaris lumbricoides* infection, and a secondary study on intensity of infection were carried out between May and September, 1998. The study population consisted of all children under 14 years of age, living in 588 households from eleven rural communities; 825 children provided stool samples, for parasitological examination. The development of the environmental health indicator allowed the identification those communities with the highest risk of infection, through a multivariate model for the *ascariasis* prevalence. This indicator pointed out protective associations with better sanitation conditions and hygiene patterns (OR = 0.54, 95% CI= 0.30-0.95, and OR = 0.54 and 95% CI = 0.32-0.92, respectively). Data showed a significant interaction between crowding in the dwelling and access to water in the lavatory (OR = 0.21 and 95% CI =

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0.06–0.75). In contrast, low socioeconomic status was associated with an increased risk of infection (OR = 2.45, 95% CI = 1.37–4.40). Outstanding lessons learned from the study transcend the discussion on the natural history of *A. lumbricoides* infection, and provide new methodological elements with potential applications, i.e. community health and environmental interventions.

RESUMEN

El objetivo de este estudio fue desarrollar un indicador de salud ambiental, con uso potencial en la definición de medidas preventivas contra la ascariasis, en once comunidades rurales de los municipios de Caparaó y Alto Caparaó, en Minas Gerais, Brasil. La estrategia adoptada fue un estudio de prevalencia de infección por *Ascaris lumbricoides*, realizado entre Mayo y Septiembre de 1998. La población de estudio fueron todos los niños menores de 14 años. Se realizaron entrevistas a los habitantes de 588 viviendas y exámenes parasitológicos (heces) a 825 niños. El indicador señaló las comunidades donde existe el mayor riesgo de infección, según el modelo multivariado de la prevalencia de las ascariasis; nos indicó también las asociaciones entre la infección y variables de saneamiento e higiene deficiente (OR = 0.54 e IC 95% = 0.30-0.95, y OR = 0.54, IC 95% = 0.32-0.92, respectivamente) y nivel socioeconómico bajo (OR= 2.4 e IC 95% = 1.37–4.40). El análisis mostró una interacción significativa entre el hacinamiento en la vivienda y disponibilidad de agua en el baño (OR = 0.21 e IC 95% = 0.06–0.75). La importancia de estos estudios puede trascender el campo de la historia natural de la infección por *A. lumbricoides*, aportando nuevas perspectivas metodológicas orientadas a la visualización del riesgo y evaluación de las intervenciones.

RÉSUMÉ

Cette recherche est le développement d'un indicateur compréhensible de santé d'environnement qui pourrait servir pour la planification et la définition des actions préventives contre *Ascaris lumbricoides* dans les municipalités de Caparaó et Alto Caparaó, Minas Gerais Brésil. Une étude transversale sur la prévalence d'infection avec *Ascaris lumbricoides* et autre étude sur l'intensité d'infection étaient effectuées entre Mai et Septembre, 1998. La population de l'étude consiste de tous les enfants qui ont moins de 14 ans, résidents de onze villages rurales. Une entrevue était conduit avec 588 maisons, et les *feces* de 825 enfants étaient examinés pour la parasitologie. L'indicateur EHI pouvait identifier les villages avec le risque d'infection plus grand, grâce au modèle polyvariante pour la prévalence d'*ascariasis*. L'indicateur en plus, indique une relation protecteur avec les conditions améliorées d'assainissement et avec les patrons d'hygiène (OR = 0.54, 95% CI = 0.30 – 0.95 & OR = 0.54, 95% CI = 0.32 – 0.92). Au contraire, un niveau socioéconomique bas, plus de personnes dans la maison, et l'accès a l'eau dans la cabinet de toilette étaient tous associés avec un risque plus élevé. Finalement, ce que nous avons appris avec cet étude peut dépasser l'histoire naturelle de l'infection avec *A. lumbricoides* et peut nous donner des nouveaux éléments méthodologiques qui peuvent représenter des applications universels.

INTRODUCTION

Fecal contamination is perhaps one of the most serious environmental health problems, particularly in poor countries. In such countries, 3 million children die of enteric diseases associated with this problem each year, and still a larger number suffers from debilitating diseases due to infections caused by intestinal parasites (1). The intestinal nematode, *Ascaris lumbricoides*, infects approximately 25% of the world's population, being responsible for more than one billion cases of infection annually (2). Although frequently the infection itself is 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 are the result of a lack of sanitation measures (4). In the municipalities of Caparaó and Alto Caparaó, an analysis of general mortality by group of causes, from 1980 to 1995, classifies infectious and parasitic diseases in fourth place, with 5.06% of the deaths (after circulatory disorders, respiratory diseases, and neoplasms). However, for children under one year of age, infectious and parasitic diseases account for 17.46% of the deaths; these diseases represent the second most important cause of death, after perinatal ailments (5).

In spite of the magnitude of these problems, data from epidemiological studies has seldom been translated for use by local health services. Significant information and opportune communication are essential to transcend the obstacles this task faces (6), so as to outline the necessary guidelines for the health intervention and evaluation of programs, as well as the bases for community participation in regards to governmental decision making. Documented experiences show that this approach, as opposed to technical and academic reports alone, allow social mobilization towards the solution of specific problems, thus contributing to the reduction of inequities in health (7).

The development of *environmental health indicators (EHI)* is one of the opportunities to "translate" results from epidemiological studies into preventive strategies. *EHI* may provide the empirical foundation for the definition of priorities within the legal framework of primary health care and primary environmental care (8, 9); *EHI* should be the outcome of scientifically based data, and it ought to establish a relationship between environment and health. Depending on favorable circumstances, *EHI* should be relatively easy to gather, clear for both decision-makers and non-specialists, as "warning signals" for specific preventive measures (10).

This study evaluated the risk of *A. lumbricoides* infection in children living in rural communities from the municipalities of Caparaó and Alto Caparaó, in Minas Gerais, Brazil. Risk factors for the prevalence and intensity of infection were evaluated, identifying for each case the groups of risk as per the epidemiological models developed. With the results obtained, an environmental health indicator (*EHI*) was developed, incorporating the most significant biological, behavioral, environmental and social factors associated with the risk

of infection. The objective of such indicator is to guide, define and evaluate preventive actions in these communities.

METHODS

Study Population

The zone is located on the western slope of Caparaó mountain range, roughly 340 Km from Belo Horizonte, capital of the State of Minas Gerais (Figures 1 and 2). The topography of the area is very uneven—55% mountainous country, 30% with undulations and 15% wetlands. Altitude ranges from 800 to 2,890 meters; temperature from 14 to 27° C; relative humidity is 75% in the rainy season; soils are acidic. Thirty per cent of the surface is dedicated to the cultivation of coffee (almost 80% of its population is involved in this economic activity), corn, beans and rice (11). According to the municipal index of human development (MIHD) of the United Nations Development Program (12), these municipalities are located in regions with intermediate human development (0.572) (Figure 1). The Theil-L indicator, utilized to measure social inequality, places both municipalities in an unfavorable situation in regards to 69% of the municipalities in the rest of the country (12).

Study Design

A census was carried out in eleven rural communities in the municipalities of Caparaó and Alto Caparaó, seeking to involve all children under 14: Boa Vista (119 children), Bragança (66 children), Calixto (58 children), Capim Roxo (220 children), Empossado (104 children), Galiléia (146 children), Grumarim (114 children), Montes Claros (45 children), Santa Rita (106 children), São Domingos (95 children) and Taquaruna (98 children). A pilot study was performed in two communities in the municipality of Caparaó (Galiléia and Santa Rita), in order to train the field team and validate the questionnaire. The selection of these two communities was based on the extreme and opposing socioenvironmental differences that prevail between them, in order to identify the cases of heterogeneity in the nine remaining communities. For the pilot study, soil samples were collected at every house (100%) and water samples at 90% of the houses, for the environmental validation of the questionnaire.

Water samples were collected in sterile flasks and transported in ice-boxes to be tested for *Escherichia coli*. The water samples were shipped by bus to the central laboratory of the Water and Sanitation Company in the State of Minas Gerais (COPASA), where they were analyzed in less than 24 hours using the Colilert kit (13).

Soil samples were tested for *A. lumbricoides* eggs. The samples were collected at the houses' backyard (playground), particularly in humid and shady areas. A total of 118 samples were collected, placed in plastic bags and processed according to the Caldwell & Caldwell and Stoye & Horn modified techniques (14,15).

A cross-sectional study was conducted during the dry season 1998 (from May to September). The central strategy was built around the application of questionnaires, for the identification of risk factors (e.g., sanitation, hygiene, socioeconomic), and stool samples collection, for parasitological tests (i.e. intestinal infections). Having validated and adapted the questionnaire (risk factors), and standardized fecal sample collection procedures and parasitological techniques, the study continued for the totality of the population. Interviews were carried out only in households having children, by applying a questionnaire to the person in charge of them, mostly mothers. Upon previous informed consent and adaptation to former study methods (1,16-19), the questionnaire included data on socioeconomic, sanitation and hygiene related variables from each household. Individual files for every child were prepared, describing their characteristics (e.g., age, gender, schooling, last antiparasitic treatment, time of residence in the community and risk behavior: playing with dirt, not washing hands before eating and after using the toilet). The visits allowed for a structured observation as an additional element for the evaluation of the dwelling's conditions (for instance, hygiene, conditions of the backyard, the inside of the house and the toilet), and verification of the presence of soap on the washbasin or similar. At the end of each visit, plastic flasks with a top and a label (identification of each child) were distributed. Said samples had been collected their schools, and the basic recommendation was the stool samples collection should be collected the next morning.

The children's fecal samples were transported in ice packs to the laboratory and prepared for parasitological test, the same day of delivery. The Kato and Katz technique (20) was utilized for *A. lumbricoides* egg identification and counting.

Quality control for water samples was based on the repetition of 10% of the sampling at the water sources that served the largest number of families. For *A. lumbricoides* eggs in the soil, two different techniques were used, so that the most sensitive one would become the other's control; modified techniques were used, following procedures recommended by Caldwell & Caldwell, and Stoye & Horn (14,15). 10% of the interviews were duplicated by different interviewers, in order to identify cases of incongruity and detect common data collection patterns (e.g., application of the questionnaires). The readings of 20% of fecal samples sent to the laboratory were randomly repeated, while slides with dubious readings were sent to the referral research laboratory (Centro de Pesquisas René Rachou-Fundação Oswaldo Cruz). The information obtained from the questionnaires and laboratory results underwent double capturing through the EPI INFO Program (version 6.0, CDC-WHO).

Data Analysis

Analysis was performed with the STATA Program (version 5.0, University Drive East, College Station, Texas, USA). Exploratory analysis was carried out to obtain frequencies, descriptive statistics and for variable recategorization.

Thereafter, indexes were built with the method of principal components (21), which allows incorporating the existing correlation between variables, while selecting the optimal linear combination that describes the information. The percentage of explained variance can be interpreted as a measure of the index quality. In the final multivariate model, those

indexes illustrated as continuous variables were changed to dichotomous variables, to improve representation of the differences among groups, thereby constructing three indexes with the following criteria:

Socioeconomic Index: Integrated through the relationship with the means of agricultural production (for example owner or day laborer); ownership of the dwelling and commodities (for example, a car, a refrigerator) and the literacy of the mother. This index was averaged by community, which allowed the socioeconomic classification (i.e. high, middle and low, respectively).

Sanitation Index: Availability of piped water and its regular supply, location of the toilet (for example, inside or outside the house), and characteristics of the backyard (for example, paved with cement). The sanitation index was categorized, by using the percentile 20 as the cut-off point, which separated 20% of the children who lived in dwellings with better sanitary conditions versus 80% with poorer sanitary conditions.

Hygiene Index: Conditions of the lavatory, water treatment, presence of soap in the bathroom, perception (e.g., lack of hygiene as a cause of intestinal infections). The cut-off point was chosen according to the median, where the groups became heterogeneous in the model.

Finally, the differences between the population who provided stool samples for parasitological examination and the group that did not comply were analyzed through the “t” test, searching for the occurrence of selection bias.

The prevalence and intensity of infection by *A. lumbricoides* were separately associated with the following variables: age, years of schooling (pre-school, 0-3, >4), gender, last antiparasitic treatment (<6 months, 6-12, >1 year and never) time of residence in the community (1 year, more or less) and risk behaviors such as playing with dirt, no hand-washing before eating and after using the toilet, and having meals in the countryside; crowding, hygienic conditions of the dwelling, presence of stools in the backyard, participation in community organization (church, others), water treatment (filtration), availability of piped water and lavatory inside the dwelling, source of water (spring, creek or well), lack of water, type of flooring in the backyard (cement or others), destination of served water and stools (creek, septic tank, the backyard's floor). Additionally, the prevalence and intensity of infection were analyzed in relation to the socioeconomic, sanitation and hygiene indexes.

All variables with $p < 0.15$ were considered as candidate factors to be included in the multivariate models of logistic regression and negative binomial regression (prevalence and intensity of infection, respectively). The proposed logistic regression model for the prevalence of infection by *A. lumbricoides* was validated by the Hosmer and Lemeshow test, and by Pearson's chi square test (22). The analysis of intensity of infection was conducted by using the method of negative binomial regression, exclusively for the subsample of infected individuals. This technique was performed in the light of the results of the egg count (per gram of feces: 12 – 355,440), which showed a Poisson pattern, with an overdispersion component (23-26).

Aggregations in accordance with socioeconomic criteria were carried out, so as to include the communities in the models, as indicative variables; the groups of communities were reduced from 11 to 3. To that end, analysis of variance and the Bonferroni multiple comparisons method (21) were used to detect statistical similarities among them.

The probability of each child being infected with *A. lumbricoides* was estimated through a logistic regression model for the prevalence of infection. Environmental and individual factors would alter this risk. Therefore, to obtain a scale of gradation to visualize priorities, said risk was averaged by community, in accordance with the variables that were more associated with the prevalence of ascariasis.

RESULTS

A total of 1,171 children were involved in the study. The compliance rates for the questionnaires were 98% and for stool samples delivery 70% (825 children).

The prevalence rates of intestinal helminth infections were as follows: 12.2% for *A. lumbricoides*, 5.1% *Ancylostoma duodenale*, 5.1% *Trichiuris trichiura*, 2.2% for *Schistosoma mansoni* and 1.8% for *Enterobius vermicularis*.

Data from this study showed that the water supply for 80% of the population consisted of superficial springs. As many as 66% of the dwellings have piped water. Sewerage discharges in creeks and eventual water filtration were identified in 59% and 56% of the houses, respectively. 64% of the studied population said water contamination may be one of the causes of intestinal parasitic infections. 68% of the houses visited were not the property of the dwellers, and 15% of this dwellings shelter more than 3 individuals per room. 79% of the farmers do not own the land they cultivate, and give half their production to the owner of the lot as payment. Most of the population is literate and spends, on average, an amount equivalent to a full minimum wage (US \$70) to support their household. Of the individuals surveyed, 60% do not participate actively in community organizations.

According to data on the bacteriological quality of the water (67 samples from pilot communities), as many as 64% of the water samples gave positive results for *E. coli*. The rate of soil samples (118 samples from pilot communities) that tested positive for *A. lumbricoides* eggs was 2%.

Table 1 illustrates the model and the interaction between crowding and water availability in the lavatory (i.e. bathroom); the effect of crowding was different in households with or without water in the lavatory. The OR for a child to suffer from ascariasis was 1.47 times greater in crowded dwellings, even if water was available in the lavatory, than children from non-crowded dwellings. Further, children from crowded homes and no water in the lavatory showed a 6.83 times greater risk than children from otherwise similar dwellings, except for crowding related variables. In other words, the resulting effect of crowding was approximately 5 times greater in dwellings with no water in the lavatory (OR= 6.82/OR=1.47), even after adjusting by socioeconomic level and age.

An opposite association was detected in children with higher status in the hygiene index. The risk of infection by *A. lumbricoides* was 85% smaller in this children ($1 / 0.54$), when compared to those from lower levels (95% CI= 0.32 -0.92); a similar picture was observed in children enjoying a better status in the sanitation index. Following this procedures, it was observed that the risk of infection by *A. lumbricoides* resulted 2.45 times greater among children from Montes Claros, Santa Rita, São Domingos and Taquaruna, with lower socioeconomic levels, than in children from communities of high socioeconomic level (Galiléia, Boa Vista, Grumarim and Empossado), which were twice more protected than children from communities in the medium socioeconomic levels (Capim Roxo, Calixto and Bragança) (Table1). In regards to age, the risk of infection for children aged 5 years or older was 3.5 times greater than for younger children (95% CI = 1.83–6.71).

This analysis of intensity of the infection involved only children with positive test for *A. lumbricoides* (Table 2). Of the variables included in the prevalence model (*vide supra*), only availability of water in the lavatory and better hygiene conditions played a protective role (RR= 0.26 and 0.44, with 95% CI= 0.11- 0.63, and 0.19–1.00, respectively), while the risk of heavy infections increased in crowded homes (RR= 2.20 and 95% CI= 1.07–4.52). The following variables remained in the intensity model: residence of more than a year in the dwelling (RR= 0.22 and 95% CI= 0.07–0.66), schooling (more than four years versus less than four years plus pre-school education, RR= 0.17 and 95% CI= 0.08–0.38), higher income (as compared with the minimum wage: RR= 0.39 and 95% CI= 0.19–0.82) and treatments against intestinal parasites in the last 12 months (RR= 0.53 and 95% CI= 0.27–1.03). All these variables were associated with less severe infections. Age obtained high protection values in the intensity model due to the reduced number of children who tested positive. Only children older than one year were considered as risk categories.

According to the prevalence model developed, the community with the highest estimated mean probability of infection by *A. lumbricoides* at the individual level was Montes Claros, with 37%, followed by Santa Rita 26%, São Domingos 21%, Taquaruna 18%, Capim Roxo 11%, Calixto 10%, Bragança 9%, Galiléia 8%, Empossado 5.5%, Grumarim 5%, and Boa Vista 4.6% (Figure 2).

DISCUSSION

The general low prevalence of ascariasis in children from these communities (13%) concurs with the low levels of soil contamination by *A. lumbricoides* eggs (2%), as found by the pilot study. Such relationship between environmental contamination and human infection was also found in other studies (27, 28). This prevalence was low as compared to the figures found in the international literature (22%) and those reported from the state of Minas Gerais (46%) (2, 25). The reasons for such results may be related to the intermediate level of human development found in the area, as opposed to regions with extreme poverty in Brazil (12). Nevertheless, the prevalence of infection may be considered as a mirror image of the level of environmental contamination by *A. lumbricoides* eggs and on

occasion, it is an evaluation indicator of the socioeconomic development level and quality of sanitation in the community (3).

This results suggested that the use of prevalence in a simple manner, as an indicator for the decision making, does not inform directly what preventive measures may be adopted in the local context, for it only indicates the presence of the health event. The contribution of this study is in that the environmental health indicator (*EHI*), developed for the two municipalities indicates priority actions and identifies the groups exposed to higher risk. In spite of the fact that this indicator is based on the relationship between risk factors and the health outcome, its development goes beyond the mathematical expression of the model used to predict the infection. The risk of being infected by *A. lumbricoides*, according to the community of residence, may be seen on a map. Thus, the model "translates" into an operative record for the 11 communities (Figure 2). The examples herein presented account for a compound indicator, for a specific problem of environmental health (i.e. intestinal infections with *A. lumbricoides*). Decision makers need, with ever-increasing urgency, more information of this sort, to identify priorities and specific protective measures, without impairing the scientific bases of the *EHI*'s (29-31).

The most recent studies highlight the need for defining "which", "how" and "to what end" the *EHI*'s can be used in intervention programs for communities in developing countries. The authors of these studies consider that *EHI*'s may play a relevant role in stimulating community participation and in the dialogue between planners and community, as well as in the mutual understanding of environmental health problems (19, 31). Upon establishing this relationship, we believe that we will be building a path for more coherent interventions that would lead to equity (7).

An analysis of possible interventions allowed us to verify that the prevalence model indicated an interaction between access to piped water and crowding, leading the presence or absence of any of this two to potentiate their effect on health. Several studies have proven the importance the amount of water has in promoting better domestic hygiene, including cleaner foods and kitchen utensils (32, 33). Likewise, other studies proved that a larger number of individuals per dwelling increase the likelihood of contamination of the peridomiciliary soil (34). Meanwhile, no work records that could identify an interaction between availability of water in the lavatory and crowding were found. A possible explanation for this gap may lie in the difficulty of studying this phenomenon, inasmuch as it requires large sample sizes (35). Nonetheless, this has to be taken into consideration while developing preventive measures so that isolated actions with limited impact are not applied.

The same prevalence model confirmed the role of sanitation, hygiene and the socioeconomic level in determining the infection. This finding was corroborated by the various studies already completed on this topic (1,2,17,26,32,36-38). Additionally, this lays the foundation of the idea that for measures to be more efficacious, specific measures that leave unaltered the social and environmental context of the population should not be taken. Otherwise, we would run the risk of taking actions with no social impact (39-41).

Age, according to the objectives of the study, was considered a potentially confounding factor. Several studies indicate its potential confounder role in the understanding of the relations among the variables associated with ascariasis. An example of this is geophagy, conduct prevalent among younger children (36).

An analysis of specific hygiene behavior (such as the hand washing) did not show logical associations with the prevalence or intensity of infection (42). This could be accounted for in terms of cultural and self-esteem aspects of the informant that do not contribute to a more realistic answer (43). Consequently, the hygiene index, which included variables of structured observations and other more reliable variables, was utilized (Tables 1 and 2).

Antecedents of recent medication (i.e. vermicides) and traditional remedies (e.g., infusions) had no significant effect on the prevalence, in accordance with bivariate and multivariate models. In the bivariate model, the fact of never have been treated against intestinal parasites or in the last six months generated a $p= 0.67$ and 0.50 ; and in the multivariate $p= 0.65$ and 0.97 , respectively. The same trend was shown by the time of residence variable: $p=$ of 0.98 in the bivariate model and 0.82 in the multivariate model. A possible hypothesis that accounts for these results may lie in the fact that situations such as crowding, availability of water in the lavatory and other issues relative to hygiene, sanitation and socioeconomic aspects are more important when determining the infection by *A. lumbricoides* among children from Caparaó and Alto Caparaó. A practical conclusion in regards to preventive measures, in this context, would be the prioritization of these interventions within the context of routine treatment offered by local health systems (40).

The intensity model also showed that individuals with longer time of residence in the community presented less intense infections (i.e. lower counts of helminth eggs). Probably, those families that frequently change residence (for example, those following the agricultural cycle) also have poorer socioeconomic levels, with fewer possibilities of investing in their dwellings to improve them.

Additionally, contrary to what was found in the prevalence model, the fact of having been treated more than 12 months before or never at all were risk factors for the intensity of infection (with marginal significance: $p = 0.062$), as compared to the group treated less than a year before. This association was maintained from the bivariate analysis ($p=0.020$; $p=0.094$), adjusted by age and socioeconomic level. This remark provides insight into chemotherapy, barely having an effect on the grave forms, which are aggregated and over dispersed. Such result points at integral actions, where medication should be used sensibly (40). Concurrently, they indicate that the occurrence of a recall bias, frequently present in this type of questions, does not seem to happen, as the treatment has different significance levels when comparing the models of prevalence and intensity.

The mathematical model grants the *EHI* constructed in this study statistical and epidemiological validity. In a broader perspective, validity and sustainability should be evaluated in simpler applications, recreated from explicative variables that resulted from this approach in Caparaó and Alto Caparaó. The complex techniques involved in the development of multivariate analysis models would no longer be necessary, for the

variables to be evaluated periodically would have been selected. Otherwise, the indicator could be deemed unreliable in regards to the capacity of small municipalities to collect and analyze such information.

In this regard, the indicator developed in this study achieved the integration of biological, environmental and social components, as well as risk behavior. This composition complies with the definition of possible interventions and the need for evaluating and overseeing the sustainability and efficacy of *EHI*'s (39, 41).

We must insist upon the practical implications of the outcome of this study. First, the information is local in nature, and consequently the indicator refers to rural communities in Caparaó and Alto Caparaó. The intrinsic limitations are a reflection of the study design, which is cross-sectional, and hinders the establishment of a chronological sequence between risk factors and the health outcome (44). Other implications are inherent to the composition, always incomplete, of the indicator to fill in the decision gaps; we must point out that the *EHI* is a supplement that provides epidemiological context. As an operative tool, the development of the *EHI* allowed visualizing high-risk communities and factors associated with the disease. Another limitation of the study was the selection bias (t- test): the group of children who did not deliver feces samples (346 out of 1171= 30%) was precisely the group with the poorest socioeconomic level, crowding and low dwelling sanitation status. In regards to age and the fact of earning more than one minimum wage, exclusively, no differences were found among the groups. We believe that the distribution of exposure in the study population may be underestimated in terms of the risk and intensity of infection by *A. lumbricoides*. Finally, the environmental validation of the survey by means of a pilot study was not possible. The low levels of soil contamination represented a hindrance to perform comparisons between results of the questionnaire and what was found in the environment.

However, the lessons learned from the study may transcend the field of natural history in regards to *A. lumbricoides* and provide new methodological elements, which will represent more universal applications, with a keener view of the risk and broader scope of interventions. New research should be oriented towards testing the validity and sustainability of indicators, in the ambit of community health services and epidemiological surveillance.

ETHICAL ISSUES

The protocol of the study 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. Additionally, all the results were delivered individually and treatment of the cases was carried out by local health services. Community assemblies were conducted in all the communities to discuss problems and alternative solutions, deliver results and create environmental health committees.

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Table 1
 Logistic Regression Analysis Model: Prevalence of *Ascaris lumbricoides* Infection*
 (Caparaó and Alto Caparaó, Minas Gerais/Brazil, 1998)

| Covariable | | n | (%) | OR | 95% CI |
|---|--------|-----|--------|------|------------|
| Crowding (> 2.66 persons/bedroom) | Yes | 190 | (25) | 6.84 | 2.27–20.55 |
| | No | 570 | (75) | | |
| Water in the lavatory | Yes | 689 | (90.7) | 0.53 | 0.23–1.21 |
| | No | 71 | (9.3) | | |
| Interaction: Crowding and water in the lavatory | Yes | 158 | (20.8) | 0.21 | 0.06–0.75 |
| | No | 602 | (79.2) | | |
| Hygiene index (status) | High | 374 | (49.2) | 0.54 | 0.32–0.92 |
| | Low | 386 | (50.8) | | |
| Sanitation index (satus) | High | 139 | (18.3) | 0.54 | 0.30–0.95 |
| | Low | 621 | (81.7) | | |
| Communities, according to socioeconomic strata | High | 328 | (43.1) | 0.50 | 0.27–0.93 |
| | Middle | 314 | (41.3) | | |
| | Low | 118 | (15.6) | | |
| Age (children older than 5 years) | Yes | 518 | (68.1) | 3.50 | 1.83–6.71 |
| | No | 242 | (31.9) | | |

*pseudo r2= 0.1810

Number of observations = 760

Table 2
 Negative Binomial Regression: Intensity of *Ascaris lumbricoides* Infection
 (eggs per gram of feces)*
 (Caparaó and Alto Caparaó, Minas Gerais/Brazil, 1998)

| Covariable | | n | (%) | RR | 95% CI |
|-----------------------------------|------------------------|----|---------|--------|------------|
| Water in the lavatory | Yes | 50 | (68.49) | 0.26 | 0.11–0.62 |
| | No | 23 | (31.51) | | |
| Hygiene index (status) | High | 19 | (26.03) | 0.44 | 0.19–1 |
| | Low | 54 | (73.97) | | |
| Crowding (> 2.66 persons/bedroom) | Yes | 32 | (43.8) | 2.20 | 1.06–4.52 |
| | No | 41 | (56.2) | | |
| Time/residence in the community | > 1 year | 66 | (90.41) | 0.22 | 0.07–0.66 |
| | < 1 year | 7 | (9.59) | | |
| Years of schooling | > 4 years | 18 | (24.66) | 0.17 | 0.07–0.37 |
| | < 4 years | 55 | (75.34) | | |
| Family wage / expenditures | Spend more than 1 wage | 49 | (67.12) | 0.39 | 0.18–0.81 |
| | Spend 1 or less | 24 | (32.88) | | |
| Recent anthelmintic treatment | 1–12 months | 41 | (56.16) | 0.53 | 0.27–1.03 |
| | > 12 months ago; never | 32 | (43.84) | | |
| Age (children older than 1 year) | Yes | 72 | (98.63) | 0.0002 | 0.00–0.004 |
| | No | 1 | (1.37) | | |

*Pseudo r2 = 0.0447

Number of observations = 73

ANNEXES

The following supplementary materials (tables, study design, maps, survey, questionnaire, etc.) are available in the Spanish version of this paper, as follows:

Tablas descriptivas: Características generales del grupo del estudio

- Características de los niños

- Saneamiento

- Higiene

- Situación socioeconómico

- Datos oficiales del censo de 1991

Diseño del estudio

- Selección de los niños

- Tabla para análisis del sesgo de selección

- Prueba de "t" para verificar diferencias entre el grupo con muestras y el excluido

Tabla de construcción de índices

Mapa del índice socioeconómico

Mapa del índice de saneamiento

Indicador de salud ambiental para prevalencia de *Ascaris lumbricoides*, en niños de 0 a 14 años (Comunidades rurales de Caparaó y Alto Caparaó, Minas Gerais, Brasil: 1998)

Encuesta (Cuestionario)

Consentimiento libre y esclarecido

Estudio ambiental

- Examen bacteriológico del agua

- Recuperación de huevos de *A. lumbricoides* en suelo

- Fichas para coleta de agua

- Fichas de resultado de los exámenes de suelo y agua

- Fichas para entrega de resultados de los exámenes de heces

Cartilla local sobre cómo proteger los manantiales

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