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Impact of water supply, domiciliary water reservoirs and sewage on faeco-orally transmitted parasitic diseases in children residing in poor areas in Juiz de Fora, Brazil

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SUMMARY

The objectives of this study were to characterize faeco-orally transmitted parasitic diseases and to identify the factors associated with these diseases, with emphasis on environmental factors, in children ranging from 1 up to 5 years old residing in substandard settlement areas. A population-based cross-sectional epidemiological design was used in a non-random selection of 29 out of the 78 substandard settlement areas in the municipality of Juiz de Fora, Brazil. A sample of 753 children were assessed from the target population consisting of all children of the appropriate age range residing in the selected areas. Data were collected by means of domiciliary interviews with their mothers or with the person responsible for them. The Hoffmann–Pons–Janer method was used in the parasitological examination of faeces. Binary logistic regression models were used to identify the factors associated with the diseases. A total of 319 sample children presented faeco-orally transmitted parasitic diseases. The factors associated with these parasitic diseases included the children's age, family income, number of dwellers in the domicile, consumption of water from shallow wells, consumption of water from natural sources, absence of covered domiciliary water reservoirs, and the presence of sewage flowing in the street.

INTRODUCTION

Intestinal parasites are among the pathogens most frequently found in human beings. Several factors can lead to an increased risk of infection, but absent or deficient environmental sanitation, inappropriate hygiene practices, and poor living conditions are the most important.

In 1997, the World Health Organization estimated that there were, worldwide, approximately one billion people infected by *Ascaris lumbricoides*, between 800 and 900 million people hosting *Trichuris trichiura* and hookworms, 400 million infected by *Entamoeba histolytica*, and 200 million by *Giardia lamblia* [1]. The injuries that intestinal parasites may cause to their bearers include, amongst others, intestinal obstruction (*A. lumbricoides*), under-nourishment (*A. lumbricoides* and *T. trichiura*), iron deficiency anaemia (hookworm), diarrhoea and poor absorption of nutrients (*Entamoeba histolytica* and *G. lamblia*). The clinical manifestations are usually proportional to the parasitic load carried by the individual [2].

Studies on the connection between excreta and the transmission of parasitic diseases led to the proposal of a unitary environmental classification for water- and sewage-related diseases, consisting of seven disease

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categories [3]. In this classification, the 'faeco-orally transmitted parasitic diseases' category included the presence in the faeces of eggs and/or cysts of *A. lumbricoides*, *T. trichiura*, *Entamoeba histolytica*, *G. lamblia*, *Enterobius vermicularis or Hymenolepis nana*.

In Juiz de Fora, Brazil, around 78 substandard settlement areas in the municipality, i.e. areas illegally occupied or invaded areas (some of which are under a legalization process and some not) sheltered approximately 32 000 people in 8400 houses in 2001 [4]. This implies that at least 7% of the urban population live under poor conditions. Data from the Brazilian Geographic and Statistics Institute (IBGE) census of 1991 [5] showed that the number of substandard housing settlements in the municipality was 50. This source also indicated that, in the 1991–2000 period, the number of people living in invaded areas had increased 3·1 times more than the population of the city as a whole, the respective yearly percentage increases being 5·88% and 1·89%. As is the case for the rest of Brazil, most of the dwellers of substandard housing areas are either unemployed, underemployed or migrants from smaller towns who view the chance of a better life in large- or medium-sized cities. Thus, owing to unemployment and lack of income, the problem of occupation of substandard settlement areas has become worse in the past years, exposing millions of Brazilians to poor living conditions, mainly with respect to food, housing, sanitation and hygiene conditions. The importance of this fact was emphasized by the results of the 2000 census in Brazil, which showed the huge growth in the population of large- and medium-sized cities with growing numbers of slums, unemployment, poverty and the likelihood of intestinal parasitic diseases.

The purpose of the present work was to characterize faeco-orally transmitted parasitic diseases and to identify the factors associated with the transmission of these diseases, with an emphasis on environmental factors, in children ranging from 1 up to 5 years old residing in invaded areas. The results from this study should help towards the improvement of health and sanitation in order to protect the children's health.

METHODS

Ethical aspects

The Committee of Ethics in Research (COEP) of the Federal University of Minas Gerais approved this study in April 2002. All of the procedures employed were in accordance with the ethical standards for experiments involving human beings as stipulated in the 1964 Helsinki Pact, reformulated in 1975, 1983, 1989, 1996 and 2000, and also with Resolution 196/96 of the Brazilian National Health Council.

Cross-sectional epidemiological design

A cross-sectional design was employed in order to provide an epidemiological study in which both factor(s) and effect(s) could be observed simultaneously. The sample size was determined by means of Epi-Info version 6.0 software [6] from the expected prevalence of different faeco-orally transmitted intestinal parasites as derived from the literature. For the purposes of this comparison, exposed children were defined as those (i) living in dwellings lacking sanitary infrastructure, (ii) not performing hygienic practices, and (iii) living in close proximity to transmission vectors. Non-exposed children were defined as those (i) living in dwellings containing adequate sanitary services, (ii) having satisfactory hygiene practices, and (iii) having no contact with transmission vectors. The expected frequencies among exposed children were taken as: *A. lumbricoides* 66·4% [7], *T. trichiura* 87·8% [7], hookworm 25·2% [7], *G. lamblia* 17·6% [8], and *Entamoeba histolytica* 7·4% [8]. The corresponding frequencies expected among unexposed children were: *A. lumbricoides* 38·0% [7], *T. trichiura* 68·1% [7], hookworm 9·4% [7], *G. lamblia* 5·9% [8], and *Entamoeba histolytica* 1·7% [8].

Geographical area studied

The studied areas were selected after discussions with agencies of the city administration of Juiz de Fora, including those responsible for municipal sanitation and regional housing. Non-governmental agencies associated with the Catholic church and with human rights groups were also consulted. Twenty-nine settlements with approximately 2700 houses and an estimated population of 12 000 inhabitants were selected for the study.

Domiciliary interviews and faecal examinations

In total, 659 interviews were carried out in the 29 selected settlements. Interviews were conducted by a team who were specially trained for the purpose and selected from amongst interviewers who worked in the city of Juiz de Fora on the 2000 census in Brazil.

Prior to the interviews, forms containing the Terms of Consent were signed individually by those parents or guardians who wished to allow their children to take part in the study, in accordance with Resolution 196/96 of the Brazilian National Health Council. At each house visited, however, all children within the age range of 1–5 years were offered a faecal examination whether they were to take part in the study or not.

The selection procedures consisted of (i) the characterization of children of appropriate age resident in the target area, followed by random selection of children for the purpose of the study; (ii) the determination of the socio-economic status of the families involved; (iii) the collection of information about the sanitary installations of the dwellings, including the water supply, food and personal hygiene, sewage fittings, rain water drainage, and presence of transmission vectors; and (iv) validation of the information gathered concerning the level of exposure of the individual child.

The parents of 753 children ranging from 1 to up to 5 years old allowed their children to take part in the study and collected their children's stool specimens for the analysis of parasites. Faecal samples were collected from each house visited by the interviewer 2 or 3 days after the interview, and delivered immediately to an ISO 9002-certified medical laboratory that used the Hoffmann–Pons–Janer method [9] for the parasitological faecal examination. Based on the results of the parasitological examination, children were considered infected if their faeces contained eggs and/or cysts of *A. lumbricoides*, *T. trichiura*, *G. lamblia*, *H. nana*, *Entamoeba histolytica* or *Enterobius vermicularis*.

Statistical analysis

The data were analysed by means of SPSS software version 10.0 [10]. The significance level of the study was set at 5%, and the statistical power of the test was 80%. An initial exploratory analysis of the data was carried out using simple frequency tables in addition to univariate analyses with measures of association and significance tests. A binary logistic regression technique was then applied to a group of 45 independent variables, using the stepwise backward method in the manual mode in order to discard variables. In this way non-significant variables could be eliminated, thus permitting the identification of any associations between independent variables and the parasitic infections being studied. For this purpose the Hosmer and Lemeshow model [11] was adopted together with odds ratio (OR) for data analyses.

Multivariate analysis of the data was developed by means of an evolutive process, in sequential phases, in order to allow the progressive elimination of the exposures not associated with the diseases. Such process involved the following activities: (i) preliminary selection of variables with $P<0{\cdot}25$ in order to produce the initial model; (ii) analysis of the pre-selected variables according to eight explicit subgroups; (iii) elimination of variables of the subgroups that presented $P>0{\cdot}15$; (iv) construction of the final model from the remaining variables in each of the eight subgroups, for the group of diseases studied, maintaining the variables that presented $P<0{\cdot}05$.

RESULTS

Characterization of the faeco-orally transmitted parasitic diseases

Within the sample of 753 children studied there was a 1:1 ratio between those exposed to risk factors associated with infection by faeco-orally transmitted parasitic diseases and those considered to have been unexposed. Parasitological faecal examination revealed that 319 (42·4%) children presented faeco-orally transmitted parasitic diseases. The prevalences were 14·7, 8·6, 17·1, 0·1, 11·0 and 1·1% for infection with *A. lumbricoides*, *T. trichiura*, *G. lamblia*, *H. nana*, *Entamoeba histolytica* and *Enterobius vermicularis*.

Risk factors for faeco-orally transmitted parasitic diseases

In the multivariate analysis, 29 variables formed the initial model consisting of: (i) family structure, 6 variables; (ii) socio-economic level, 7 variables; (iii) hygiene habits, 4 variables; (iv) water supply, 2 variables; (v) sanitation and sewage, 3 variables; (vi) handling of solid waste, 3 variables; (vii) storm water drainage, 2 variables; and (viii) presence of vectors, 2 variables. In the final adjustment of the multivariate model, the variables shown in the Table presented statistically significant associations with the faeco-orally transmitted parasitic diseases, according to the respective OR.

DISCUSSION

The final model (Table) obtained from the multivariate analysis of the faeco-orally transmitted parasitic

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Table. *Multivariate analysis of the exposure risks associated with faeco-orally transmitted parasitic diseases amongst children*

Exposure	Categories	OR point estimate (95% CI)	*P*
Child's age	Continuous variable	1·4 (1·2–1·6)	<0·001
Family income	⩾1 and <2 MS <1 MS	0·5 (0·4–0·8)	0·001
Family income	⩾2 and <3 MS <1 MS	0·4 (0·2–0·7)	0·001
Family income	⩾3 MS <1 MS	0·4 (0·2–0·8)	0·007
Number of dwellers	Continuous variable	1·2 (1·1–1·3)	<0·001
Origin of drinking water	From shallow wells From public supply system	1·7 (1·0–2·8)	0·046
Origin of drinking water	From natural sources From public supply system	2·6 (1·5–4·3)	<0·001
Existence of covered domiciliary water reservoir	No Yes	1·6 (1·1–2·3)	0·021
Presence of sewage in the street	Yes No	1·5 (1·1–2·1)	0·018

CI, Confidence interval; MS, minimum monthly salary (which was R$ 240.00 ≈ US$ 80.00 at the time of the study).

diseases showed that the variables related to family structure (child's age), to socio-economic conditions (family income and number of dwellers in the domicile), and to the child's living environment (consumption of water from shallow wells, consumption of water from natural sources, non-existence of a covered domiciliary water reservoir, and the presence of sewage flowing in the street) were factors associated with the diseases studied.

As indicated by the results of the present work, the most important protective measure to safeguard the health of children rests in the provision of a suitable water supply system, as explained in the specialized literature [12]. Shallow wells are very vulnerable to contamination by ground water, particularly when standard constructional and operational precautions are not followed. From the sample wells investigated, 45·2% were either poorly covered or not covered at all, 21·0% had water extracted by bucket and rope, and chlorination was verified in just 24·2% of the wells. This group of factors may have favoured the contamination of the shallow well water by faeco-orally transmitted parasitic diseases with an OR of 1·7.

With respect to the consumption of water from natural sources (OR 2·6), it is important to note that, according to the municipal sanitation authority, most of the natural water sources in the municipality are contaminated. This, taken together with the inadequate means of transportation and storage of this water (usually by means of inappropriate bowls, etc.), may explain the high risk of contracting faeco-orally transmitted parasitic diseases associated with this method of obtaining water.

The role of the domiciliary water reservoir in the preservation of health was evaluated under a single aspect, namely, the existence or not of a covered reservoir. By comparing the houses that had adopted alternative solutions to water storage, such as storage in bowls or the consumption of water directly from the street, with those houses that had installed a covered water reservoir, a risk factor was found for the faeco-orally transmitted parasitic diseases with an OR of 1·6. It is believed that the lack of a covered reservoir represents a source of exposure to these parasitic diseases primarily because of the introduction of microorganisms by means of dust, insects or the use, by the dwellers, of contaminated bowls in contact with the water. In addition, the consumption of water obtained directly from the street supply, with no storage reservoir, also produces a risk to health probably because of the poorly constructed clandestine connections to the water supply and poor quality intra-domiciliary hydraulic installations.

The presence of sewage flowing in the street can be linked to both direct and indirect contact resulting in faeco-orally transmitted parasitic diseases. In addition, a World Health Organisation report [13] states that sewage flow increases the risk of transmission of

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pathogens by the faecal–oral cycle, mainly because hygiene practices associated with food handling are compromised under such conditions. These aspects are totally consistent with the risk association (OR 1·5) found in this study between the presence of sewage flowing in the street and the prevalence of faeco-orally transmitted parasitic diseases.

CONCLUSIONS

Considering the high prevalence found for the faeco-orally transmitted parasitic diseases (42·4%), it is recommended that the programmes intended for their control are intensified in the substandard settlement areas in Juiz de Fora, Brazil. Special attention should be given to the health of children in the age range of 2 up to 5 years and/or with family income lower than two minimum wages and/or living with many people in the same domicile. The present study also indicates that the control of faeco-orally transmitted parasitic diseases requires a public water supply system of good quality, covered domiciliary water reservoirs, and the elimination of sewage flowing freely in the streets, preferably through the construction of sewage collecting systems or effective static solutions. Finally, further research allowing a better understanding of the risk factors associated with the faeco-orally transmitted parasitic diseases should be aimed at increasing the effectiveness of the control measures of these diseases.

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DECLARATION OF INTEREST

None.

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