Intestinal Parasites In Children of Cochabamba – Bolivia

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Abstract

Background: A high percentage of the population in Latin America lives with intestinal parasitic infections, neglected tropical diseases frequently not treated. Intestinal parasitism is associated with nutritional diseases but the information about the epidemiological situation in countries like Bolivia is scarce. Environmental conditions play an important role in the prevalence of certain parasites. The main objective was to know the current situation of parasitic infections among children under twelve years old from different geographical areas of the department of Cochabamba – Bolivia.

Methods: We analysed the laboratory reports of four second-line hospitals of different areas and the Tertiary Care Hospital. Results of stool examinations performed between 2011 and 2015 in children under twelve years of age were collected.

Results: We gathered the results of 23221 examinations. The 89 % of children were less than five years old. Pathogenic parasites were found in 31 %. Entamoeba histolytica and Giardia lamblia were the two most prevalent parasites in all areas. Helminths were found in only 19% of positive samples and Ascaris lumbricoides was the most prevalent. Parasitic infections are more frequent in tropical area and helminths are highly concentrated in this area.

Discussion and Conclusions: Parasitic infections in children are still very prevalent in Bolivia. Protozoan infections are the major problem while the prevalence of helminths seems to be decreasing. The most vulnerable population is still concentrated in tropical areas where the risk of parasitic infection is probably increased due to the environmental conditions. Our results will enable the planning of more efficient policies to control parasitic diseases.

Background

Parasitic infections are distributed all around the world, and the establishment of some species is defined by favourable conditions such as temperature, humidity, host, etc. For example, tropical areas present many conditions for infections produced by soil-transmitted helminths (STH) 1. Data available in Latin-America show that 20% of the population lives with an intestinal parasitic infection of one, two or more species2. For this reason, these infections are defined as “the most common infections among poor people in the Americas.”

Intestinal parasites are primarily associated more with morbidity and disability than with mortality itself. For the World Health Organization, the Intestinal parasitism is still important because they are related to nutritional disorders and development injuries in very young and school-age children3. Some illnesses related to parasitic infections are malnutrition, iron deficiency, anaemia, malabsorption syndrome, intestinal obstruction, chronic dysentery, rectal prolapse, respiratory complications, and poor weight gain. Species commonly associated with these disorders are directly or indirectly STH, although certain protozoa also have been implicated2,4.
Epidemiological information about of STH or protozoan infections is poor in Latin America. A brief review of studies on parasitic infections conducted by the Pan American Health Organization (PAHO), reports a prevalence of STH of 50% and even higher in schoolchildren and indigenous groups\(^5\). In Bolivia, a country with many ecological areas such as Andean mountains, valleys and the Amazon basin, the national policy of control for helminth infections is limited to children under five years and the epidemiological surveillance system follows infections caused by protozoa\(^6\). Mothers take their children under five years old more frequently to health controls and consultation in general. In both cases, either for protozoa or helminths, there are no studies that assess the impact of these programs in child population.

The department of Cochabamba with an area of 55,631 km\(^2\) and 1,758,143 inhabitants, located in the middle of Bolivia, presents different ecological areas: low and high valleys, semi-tropical and tropical areas. The climate (temperature, atmospheric pressure and humidity) varies greatly depending on altitude\(^7\),\(^8\). The variation of these conditions is important to understand interactions between the environment and the frequency of parasitic infections, as well as other variables such as social determinants in the population\(^9\).

The objective of our study was to describe, by geographical areas, the distribution of intestinal parasites that affect children under 12 years old in the department of Cochabamba. This knowledge will allow us to identify vulnerable populations that could be defined by geographical areas. In addition, it will allow us to set out a combined intervention for children susceptible to parasitic infections. This could help to start a process of evaluation of the present programs or policies in public health for intestinal parasites and also for taking better decisions for the future.

**Methods**

We performed a retrospective study of laboratory reports of 2011 to 2015 from hospitals of 3rd and 2nd line situated in different geographical areas of Cochabamba. The High valley area over 2761 m.a.s.l (metres above sea level), average of humidity of 40% and variation from 6 to 23 °C of temperature. The lower valley area is between 2200 to 2700 m.a.s.l with an average of humidity of 55% and variation from 10 to 26 °C of temperature. The semi-tropical area, from 1800 to 900 m.a.s.l, has an average of humidity around 60% and variation from 25 to 30 °C of temperature and finally, the tropical area under 900 m.a.s.l with an average humidity of 70% and temperature variations from 21 to 35 °C (1).

We choose reference centres in the referred areas taking into account the availability of the reports of the period of the study:

- The third line hospital of the main city (Cochabamba) is the only third line public centre in Cochabamba city and in the department. Therefore it is the reference hospital for all the population with no social insurance (80% of the population): more or less 1 500 000 habitants depend on it. People living in the city represent 60% of the patients and the other 40% come from different areas of the department. Only two years of reports were available (2014 and 2015).
Four second line hospitals from each geographical region of the department; we have:

- High valley area: Hospital of Punata that corresponds to 8 first line centres and 40288 habitants.
- Lower valley area: Hospital of Vinto that corresponds to seven first line centres and seven points of health care and 46924 habitants.
- Semi-tropical area: Hospital of Mizque with 7 first line centres and 40173 habitants.
- Tropical area: Hospital of Ivirgarzama that assembles other 7 first line centres and 25094 habitants.

From the laboratory reports, we obtained data from stool samples that were requested in medical consultation for detection of parasites. No link to the medical records of each patient was possible because of the absence of digital systematization. We included samples of children from 0 to 12 years old. We included one stool sample per child, per year and the first sample of the year, regardless of the result. This means that a child could have repeated samples within the period of 5 years but not a repeated sample in one year. We also excluded samples from patient whose age data was missing.

The technique for stool samples analysis were direct simple examination and direct serial examination (one stool sample per day during three days). Incomplete serial procedures (only 2-stool examination) were classified as a direct simple examination and we considered a positive result even if just one of the two samples was positive or negative in case the two samples were negative. Other kinds of process, like concentrated technique (Ritchie), ELISA (Enzyme-Linked ImmunoSorbent Assay) just for *Entamoeba histolytica/dispar* or a method similar to a culture for *Strongyloides stercoralis* (Dancescu method) in stool were also included in the collecting data.

For this study, enteroparasites considered as pathogenic are Complex *Entamoeba histolytica/dispar*, *Giardia lamblia*, *Ascaris lumbricoides*, Ancylostomidae (*Ancylostoma duodenale/Necator americanus*), *Trichuris trichiura*, *Strongyloides stercoralis*, *Taenia solium*, *Enterobious vermicularis* and *Hymonolepis nana*. All the other intestinal parasites reported were considered as commensals and were not detailed in our description: *Blastocystis hominis*, *Entamoeba coli*, *Chilomastix mesnilli*, *Iodamoeba bütschlii* and *Endolimax nana*.

It is worth mentioning that most of the secondary care centers use simple examination as the main diagnosis technique, techniques with higher sensitivity such as Ritchie concentrated technique, molecular tests are barely used and for this reason is not possible to distinguish between *E. histolytica* and *E. dispar*.

Most hospitals of the public health services in Bolivia do not have a digital system but handwriting notebooks of monthly reports. The third line hospital (city hospital) was able to keep the reports only for two years (2014 and 2015). Transcribing and cleaning process was developed by the main researcher. This study has the approval of the ethical committee of the University of San Simon and the local health direction of the department of Cochabamba (SEDES) to have access to laboratory reports and use just the data concerning to the study.
Statistical analysis included main descriptive like mean, standard deviation and two-variable analysis with chi-square test to look into differences between regions and age groups. The age groups used for analysis took account of the paediatric groups classification used in Bolivia to follow child development. For so we have:

- Minor infant: From day zero to 12 months (0–1 year old).
- Older infant: From 12 months 1 day to 24 months (1.1–2 years old).
- Pre-school age child: From 24 months 1 day to 48 months (2.1–4 years old).
- School age child: From 48 months 1 day to 12 years old (4.1–12 years old).

## Results

### 1. General data

We gathered 23535 reports, among which we excluded 314 samples for age data missing. The data available from each hospital selected is presented in Table 1. From the 23221 reports, 75% were from second line (5 years of reports) and 25% from the third line hospital of Cochabamba (two years of reports).

| AREA         | Year 2011 | Year 2012 | Year 2013 | Year 2014 | Year 2015 | Total (%) |
|--------------|-----------|-----------|-----------|-----------|-----------|-----------|
| High Valley  | 938       | 1009      | 982       | 1140      | 979       | 5048 (22) |
| Lower Valley | 521       | 520       | 569       | 628       | 573       | 2811 (12) |
| Semi Tropical| 369       | 367       | 383       | 407       | 390       | 1916 (8)  |
| Tropical     | 1332      | 1455      | 1347      | 1718      | 1866      | 7718 (33) |
| City*        | 0         | 0         | 0         | 2188      | 3540      | 5728 (25) |
| TOTAL        | **3160**  | **3351**  | **3281**  | **6081**  | **7348**  | **23221 (100)** |

*City - Refers the only 3rd line Hospital from Cochabamba

The median age was 1 year old. Nearly 90% of the samples were from children under 4 years old. The age distribution was similar in all regions, major group was older infant group. Minor infant group were second in percentage of samples and less than 20% in each of the other two groups (Pre-school age and school age).

The sex ratio (male/female) was 1.16. A simple examination was done in 22514 patients (96.9%), and serial examination in 675 (3.1%). Direct examination was performed in all but 32 samples (0.1%) on
which concentration method (Ritchie), ELISA, or culture were used.

2. Distribution of positive samples

30.8% (N: 7161 of 23221) of the samples were positive for at least one pathogenic parasite. We found also a non-pathogenic parasite in 1277 samples (5.5%).

The distribution of parasites is displayed in Fig. 1. The protozoa *E. histolytica/dispar* and *G. lamblia* were identified in more than 90% of the positive samples as unique or combined diagnosis. Helminths were observed in one quarter of positive samples (N: 1817) with *A. lumbricoides* as the most important.

Regarding multiparasitism, 5956 (83%) positive samples had only one parasite, 1028 (14%) samples two parasites and 177 (2.5%) samples three to four parasites. We found 41 combinations of multiparasitism, *G. lamblia* with *E. histolytica/dispar* was the most common combined diagnosis, two helminths combination were the second one (*A. lumbricoides* and *A. duodenale/ N. americanus*).

2.1. Positive samples according to geographic areas

The proportion of positive stools was different by area (P-value < 0.05); the higher percentage being observed in the semi-tropical area, where half of the stool samples showed a pathogen (Fig. 2).

In all areas, protozoa are found in more than 90% of the positive stools except in the tropical area where helminths represents nearly half of the pathogens (43%). *E. histolytica/dispar* and *G. lamblia* are present in all areas as the main diagnosis. Only in the tropical area we found a higher prevalence of *G. lamblia* (33%) over *E. histolytica/dispar* (24%) (P < 0.05).

Figure 3 shows the distribution of helminths in the tropical area, in which, *A. lumbricoides* is the most prevalent followed by *A. duodenale/ N. americanus* and *S. stercoralis*.

2.2. Positive samples according to age and sex

No differences were found as to sex group, 3683 of 12003 samples (30,7%) were positive in males, while 3341 of 10349 samples (32,3%) were positive in females. The repartition of parasites is different according to age groups (P < 0.05). Protozoan infections are more common in younger groups while helminths have an increasing proportion with respect to age groups: from 12% in minor infants to 18%, 24% and 21% in older infants, preschool age and school age respectively. In the tropical area, an increase of helminths according to age is also found but with higher prevalence than in other areas (Fig. 4).

Discussion

This study focused on the current situation of parasitic infections in children under 12 years of age in one region of Bolivia (Cochabamba) which includes four ecological areas. Our study confirms that parasitic infections remains still a public health problem in Bolivia as pathogenic parasites were found in nearly one third of stool samples, and with the highest percentage in the tropical area. Protozoan infection
remains the major problem except in tropical area where both helminthic and protozoal infections are frequent.

Only two publications on parasitic infections that included all Bolivian regions had been published. The first one was a cross-sectional study performed in 1987 that includes 22828 laboratory reports of patients from all age groups from children to adults of social security hospitals in urban and peri-urban areas from different regions of the country. It showed different prevalence of parasitic infections by areas, 47% in andean areas, 75% in valleys and 65% in tropical areas. Protozoan prevalence was 29% in general. The most important protozoan was G. lamblia with a similar distribution in all areas (15 to 18%) while E. histolytica was important just in valley areas (24%). Helmithic infections were identified more in tropical areas with a 69% of prevalence, where the most important were A. lumbricoides (42%), A. duodenale/N. americanus (10%) and S. stercoralis (4%).

The second one was a compilation of different research reports about intestinal parasites in different populations and areas of Bolivia from 1975 to 2004. It showed a great prevalence variability depending on geographical area: Andean areas (66%), valleys (73%) and tropical areas (81%). The conclusion of these different studies shows that prevalence of parasitic infections increases from Andean to tropical areas. For both groups, protozoan and helminths, the rising is clear but it is more evident for helminths. In the three regions the protozoan prevalence rise from 20 to 40% and for helmiatoms from 10 to 90%. This confirms a higher rate of parasitic infections in the tropical area and great percentage of them produced by helminths. Our results goes in the same way even if it is difficult to compare because of the methodology design or age groups of population included are quite different.

Making a comparison between other countries in Latin America is quite difficult. Many studies of regional literature are concentrated just on an ecological area. A study in Argentina could be the most comparable because it gathers information on different ecological areas. This study shows that the prevalence of pathogenic parasites is different. G. lamblia is an important pathogen in many ecological areas from Argentina while our study has E. histolytica as the main one. Among helminths, we also have different distributions, in Argentina, the E. vermicularis has an important prevalence (from 14–51%) while we found in our study more aggressive helminths in Bolivia.

It has been many years of diligence in South-America to decrease the prevalence rate, nevertheless according to some authors, there was not a big change in many areas compared to 50 years ago. According to a national health care plan of 2002, all children under five years old should receive systematic helminthic treatment with mebendazole 500 mg every six months, specially in endemic areas. This was part of the recommendations by childhood insurance coverage called SUMI (from spanish abbreviation of Universal Maternal and Infant Insurance). The decreasing prevalence of helminths found in our study could be related to this governmental policy. Unfortunately, we did not find a report of evaluation of this policy, about its effectiveness or verification of the compliance. Even so, it is remarkable that the prevalence of intestinal parasites remains high in younger groups and in tropical areas.
Therefore, the tropical area concentrates our attention for its high prevalence in helminths. Comparing with other tropical areas in the region, the distribution is similar. *A. lumbricoides* is the most important helminth in tropical areas of Ecuador, Peru, Brazil\textsuperscript{15,16} with an average prevalence of 25%; just in Venezuela hookworm with 72% is most important\textsuperscript{17}. However in Argentina it is different, *E. vermicularis* is the helminth with higher prevalence (20 to 51%) while the most aggressive helminths where less than 10\%\textsuperscript{12}. The prevalence of helminths in Bolivia, besides environmental conditions, could be related also to social factors like unsatisfied basic needs, poor sewage system and lack of safe water in almost 70\% of the population living in this area according to statistical reports of past-previous years\textsuperscript{7,18}.

An additional factor also important for spreading parasitic infections is the low level of education, specially in rural areas. Risky behaviors are more frequent in children without health education in very simple matters like the correct form of washing hands\textsuperscript{1}.

Our study has several limitations. Even if we included a large number of samples from different areas of Cochabamba, the main source of the data was the hospital laboratory reports. It means that samples came from children that reached the hospitals for specific reason. Second, the reason for stool examination was unknown. It could have been a routine analysis or a clinical problem. Unfortunately this data was not available in laboratory reports. Third, there is a high representation of children younger than 5 years old explained by the coverage in the Bolivian public health system for this group.

Moreover, detection of the pathogen was based mainly on direct examination, which is dependent on the personal training from who performed the test. Techniques with higher sensitivity such as Ritchie, ELISA or PCR were not used and it was not possible to distinguish between *E. histolytica* and *E. dispar*, the main protozoan in our study.

**Conclusions**

In conclusion, parasitic infections are still a major public health problem. It is clearly a neglected tropical disease due to lack of specific health policies for early detection or treatment, specially in vulnerable populations. Trends of these infections have somewhat changed through the last ten years but not enough to stop the struggle against parasitic infections in children under twelve years old in countries like Bolivia.

The knowledge of intestinal parasites distribution by area would help to reconsider current measures. New control policies related to parasitic infections should be more local and specific for each area, particularly in the tropical area where maybe some other factors are interacting, such as lack of education and/or sanitation policies. A combination of treatment and education could be an interesting intervention in vulnerable areas. It would help to improve access to diagnosis and treatment.

**Abbreviations**
• ELISA: Enzyme-Linked Immuno Sorbent Assay
• a.s.l: metres above sea level
• PAHO: Pan American Health Organization
• PCR: Polymerase Chain Reaction
• SEDES: From Spanish abbreviation “Servicio Departamental de Salud” corresponds to local health direction of the department of Cochabamba.
• STH: Soil-transmitted helminths
• SUMI: from spanish abreviation of “Seguro Universal Materno – Infantil” corresponds to Universal Maternal and Infant Insurance.

Parasites names

• duodenale: Ancylostoma duodenale
• lumbricoides: Ascaris lumbricoides
• histolytica/dispar: Complex Entamoeba histolytica/dispar
• vermicularis: Enterobius vermicularis
• lamblia: Giardia lamblia
• nana: Hymonolepis nana.
• americanus: Necator americanus
• stercoralis: Strongyloides stercoralis
• solium: Taenia solium
• trichiura: Trichuris trichiura

Declarations

Ethics approval and consent to participate: This study was approved by the local health authorities from Cochabamba to have access to laboratory reports of the different hospitals.

Consent to participate was not applicable in this study.

Consent for publication: Not applicable

Availability of data and material: All data engendered or analysed during this study is presented within the manuscript as an additional supporting file [DATASET CBBA_PAR].

Competing interests: The authors declare that they have no competing interests

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Authors' contributions: IC analyzed and interpreted the hospitals data regarding the stool examination results. FJ and PG were contributors in writing the manuscript. JML contribute in the review process as well. All authors read and approved the final manuscript.

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