

Geographic Differences in the Distribution of Parasitic Infections in Children of Bolivia

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Research

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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 other disorders but the information about the epidemiological situation in countries like Bolivia is scarce. Environmental conditions play its 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 Cochabamba – Bolivia.

Methodology: 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 19% of positive samples and *Ascaris lumbricoides* was the most prevalent. Parasitic infections are more frequent in tropical area where helminths are highly concentrated. Pre-school age children (OR: 5.296; 95% CI: 4.81 - 5.83) and semi-tropical area (OR: 3.26; 95% CI: 2.90 - 3.66) were strongly associated to the presence of pathogenic parasites.

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 semi tropical and tropical areas where the risk of parasitic infection is probably increased due to the poor environmental conditions. Our results could allow reconsidering more effective parasitic disease control policies taking into account regional characteristics.

Introduction

Parasitic infections are distributed all around the world, and the establishment of some species is defined by favourable conditions such as temperature, humidity, season, 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 species ⁽²⁾. 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 children ⁽³⁾. 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 implicated ⁽²⁾ ⁽⁴⁾.

Epidemiological information about of STH or protozoan infections is poor in Latin America. A brief review of studies on parasitic infections conducted by PAHO, reports a prevalence of STH of 50% and 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⁾. 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 km² 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⁾. Unfortunately non-official data or publications were found of mortality association with intestinal parasites in Bolivia. Some estimates in a document of 2006 tell that 36% of deaths under five years old were related with enteric diseases in general ⁽¹⁰⁾.

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 and set out a combined intervention for children susceptible to parasitic infections. More than a contribution with new knowledge, it is an update of the situation of intestinal parasites in Bolivia, specifically in Cochabamba, since little recent documentation has been found in order to propose an evaluation of programs or policies and the possibility of improving the current measures for these.

Methodology

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. Bolivian health system, based on Primary Health Care (PHC), has a basic level of care close to the most remote populations as a first line, a second line offers more complex services (e.g. laboratory) and third line are hospitals of more complexity and capacity usually located in big cities ⁽¹¹⁾. Areas considered were: high valley with an altitude of 2761 m. (meters) with average of humidity of 40% and variation from 6 to 23°C of temperature according to the season; Low valley, between 2200 to 2700 m. with an average of humidity of 55% and variation from 10 to 26°C of temperature; semi-tropical area, from 1800 to 900 m., has an average of humidity around 60% and variation from 25 to 30°C of temperature and finally, the tropical area under 900 m. with an average humidity of 70% and temperature variations from 21 to 35°C ⁽⁸⁾.

One of the greatest difficulties of the Bolivian health system is the dispersion of its population. The difficulty of access and road communication makes people look for the nearest primary health centre. In most of the cases, a laboratory is offered from the second level forward ⁽¹¹⁾. Thus, the cases collected from second line hospitals can be considered as the closest and most representative to their area. We choose reference centres in each areas taking into account the availability of reports of the period for 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 eight 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 seven first line centres and 40173 habitants.
 - Tropical area: Hospital of Ivirgarzama that assembles other seven 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, results are registered in handwritten books at the time of receiving samples. No link to the medical records of each patient was possible because of the absence of digital systematization of laboratory or medical records in public health system. 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. This was ensured by Government insurance identification system for children with the birthdate and initials of their first and last names, which allows in a certain way to measure the number of visits that a child makes to a centre, however, it is not systematized and a child can be taken as new if he visits another establishment. A child can visit the first level as a new case and if he does not find a solution, he is referred to the second line and he will also be counted as a new case, hence the importance of only taking the data corresponding to second level hospitals and / or third level.

It was excluded illegible, incomplete or confusing data. We also excluded samples from patient whose age data was missing. Only available data at the hospitals were digitized for this study.

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 duodenal/Necator americanus*), *Trichuris trichiura*, *Strongyloides stercoralis*, *Taenia solium*, *Enterobius 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*. These parasites were not considered pathogenic for this study because they are not considered for treatment either in the epidemiological surveillance of the Bolivian PHC⁽¹²⁾.

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.

Descriptive data such as mean, standard deviation for age variable and frequencies for the others: area (high valley, low valley, semi-tropical, tropical and city), group of parasites (helminths, protozoan), diagnosis (pathogenic, non-pathogenic, non-parasites observed), season (spring, summer, autumn, winter) and age groups used for analysis took account the paediatric 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).

The association of available variables (gender, age group, area, and season) with presence of pathogenic parasites were analysed using binary logistic regression model and the degree of associations were expressed in odds ratio (OR). The defined value of $p < 0.05$ were considered as statistically significant.

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).

Table 1
Number of laboratory reports by area/year in target population of Cochabamba, Bolivia 2011–2015.

AREA	Year					Total	(%)
	2011	2012	2013	2014	2015		
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 gender ratio (male/female) was 1.16.

Simple examination was done in 22514 patients (96.9%), and serial examination in 675 (3.1%). Concentration method (Ritchie), ELISA, or culture were used just in 32 samples (0.1%).

2. Distribution of positive samples

At least one pathogen parasite was found in a 30.8% (n: 7161). 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 *Giardia 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, 83% of the positive samples (n: 5956) had only one parasite, 14% samples two parasites (n: 1028) and 2,5% samples (n:177) three to four parasites. We found 41 combinations of multiparasitism, *Giardia 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 and seasons

The proportion of positive stools was different by area (p-value < 0,05 Chi²); the higher percentage observed was in the semi-tropical area, where half of the stool samples showed a pathogen (see Fig. 2). In all areas, protozoa are found dominant in the positive stools except in the tropical area where helminths represents nearly half of the pathogens. *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%). 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*.

The distribution of the positive samples according to the seasons and their annual trends does not show a clear pattern that the presence of protozoa or helminths is predominant in any one season (Fig. 4). There were large variations each year that do not establish a significant association to the presence of pathogenic parasites (p-value = 0,28 Chi²).

2.2. Positive samples according to age and gender

No differences were found as to gender 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-value < 0,05 Chi²). 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, see Fig. 5.

3. Analysis with available variables

Binary logistic regression model showed that group of pre-school children have a significantly high risk (OR: 5.296; 95% CI: 4.81–5.83) to the presence of pathogenic parasites, over the other groups. In the same model, semi-tropical area is strongly associated with parasitic infection (OR: 3.26; 95% CI: 2.90–3.66). While the gender and the seasons of the year have not been shown to have a significant association to explain the presence of pathogenic parasites in children, see Table 2.

Table 2

Binary logistic regression analyses of available variables associated with parasitic infections.

Variables	N	Positive Stool		Univariate analysis	Multivariate analysis
		n	%	OR (95% CI)	OR (95% CI)
Gender					
Male	12003	3683	31	1	1
Female	10349	3341	32	1.07 (1.01–1.14)*	1.02 (0.96–1.08)
Age group					
Minor infant	7137	1049	15	1	1
Older infant	9634	3137	33	2.80 (2.59–3.03)*	2.72 (2.50–2.95)*
Pre-school age	3612	1730	48	5.34 (4.86–5.85)*	5.30 (4.81–5.83)*
School age	2838	1245	44	4.54 (4.11–5.01)*	4.66 (4.20–5.16)
Area					
High Valley	5048	1159	23	1	1.
Low Valley	2811	868	31	1.50 (1.35–1.66)*	1.49 (1.34–1.67)*
Semi-Tropical	1916	930	49	3.17 (2.83–3.54)*	3.26 (2.90–3.66)*
Tropical	7718	2573	33	1.68 (1.55–1.82)*	1.80 (1.66–1.96)*
City	5728	1631	28	1.34 (1.22–1.46)*	1.37 (1.25–1.50)*
Season					
Spring	6508	1938	30	1.04 (0.96–1.12)	1.08 (0.99–1.17)
Summer	5149	1770	34	1.28 (1.18–1.39)*	1.23 (1.13–1.34)*
Autumn	5457	1681	31	1.09 (1.01–1.18)*	1.07 (0.98–1.17)
Winter	6107	1772	29	1	1
Not: *= $p < 0.05$					

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 semi-tropical and 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 ⁽¹³⁾. 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%). Helminthic 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 helminths from 10 to 90%. This confirms a higher rate of parasitic infections in the tropical area and great percentage of them produced by helminths ⁽¹⁴⁾. 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 ⁽¹⁰⁾.

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 ^{(15) (16)}. 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) ^{(6) (12)}. 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 ⁽¹⁷⁾⁽¹⁸⁾ with an average prevalence of 25%; just in Venezuela hookworm with 72% is most important ⁽¹⁹⁾. However in Argentina it is different, *E. vermicularis* is the helminth with higher prevalence (20 to 51%) while the most aggressive helminths were less than 10% ⁽¹³⁾. 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 ^{(7) (20)}.

Similarly on updated data on intestinal parasites situation in Bolivia, no documents have been found that could demonstrate the negative impact on the Bolivian health system or social security, since as a neglected tropical disease, policies have improved little or not at all in recent years ⁽²¹⁾. An additional factor also important for spreading parasitic infections could be 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 ⁽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 a reason. Second, the reason for stool examination was not available in laboratory reports, it could have been a routine analysis or a clinical problem. 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. Fourth, not having the complete third level data, not available in the hospital anymore, does not allow the comparison of results according to urbanization and the effect of this factor on the prevalence of intestinal parasites, since it is assumed that the children who go to the third level hospital have been mainly those living in the urban or peri-urban area of the city. Finally, detection of the pathogen was based mainly on direct examination, techniques with higher sensitivity such as Ritchie or ELISA were not used and it was not possible to distinguish between *E. histolytica* and *E. dispar*, the main protozoan in our study. Due to the limitation of the Bolivian health system, more complex examinations are not performed in second-line hospitals, for that reason also other type of parasites were not detected.

Conclusion

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 most important contribution of the findings is to make visible the differences in prevalent species by geographical areas, since in Bolivia public health policies still have weakness in considering this factor

when implementing control measures such as mass deworming with anthelmintic and not with more specific treatments according to what is present in each region.

The knowledge of intestinal parasites distribution by area could help to reconsider current measures. New control policies related to parasitic infections could 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. Further studies are needed on the individual factors associated with the presence of parasitic infections that could help to improve acces to diagnosis and treatment.

Abbreviations

- ELISA: Enzyme-Linked Immuno Sorbent Assay
- CI: Confidence interval
- m.: meters
- OR: Odds ratio
- PAHO: Pan American Health Organization
- PCR: Polymerase Chain Reaction
- PHC: Primary Health Care
- 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 abbreviation of “Seguro Universal Materno – Infantil” corresponds to Universal Maternal and Infant Insurance.

Parasites names

- *A. duodenale*: *Ancylostoma duodenale*
- *A. lumbricoides*: *Ascaris lumbricoides*
- *E. histolytica/dispar*: *Complex Entamoeba histolytica/dispar*
- *E. vermicularis*: *Enterobius vermicularis*
- *G. lamblia*: *Giardia lamblia*
- *H. nana*: *Hymenolepis nana*.
- *N. americanus*: *Necator americanus*
- *S. stercoralis*: *Strongyloides stercoralis*
- *T. solium*: *Taenia solium*
- *T. 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: The dataset supporting the conclusions of this article is included within the article and its additional file [DATASET CBBA_PAR].

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

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Authors' contributions: Camacho-Alvarez Ivana digitized, analyzed and interpreted the hospitals data regarding the stool examination results. Jacobs Frédérique and Goyens Philippe were contributors in writing the manuscript. Luizaga-López Marcela contribute in supervision and the review process as well. All authors read and approved the final manuscript.

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Figures

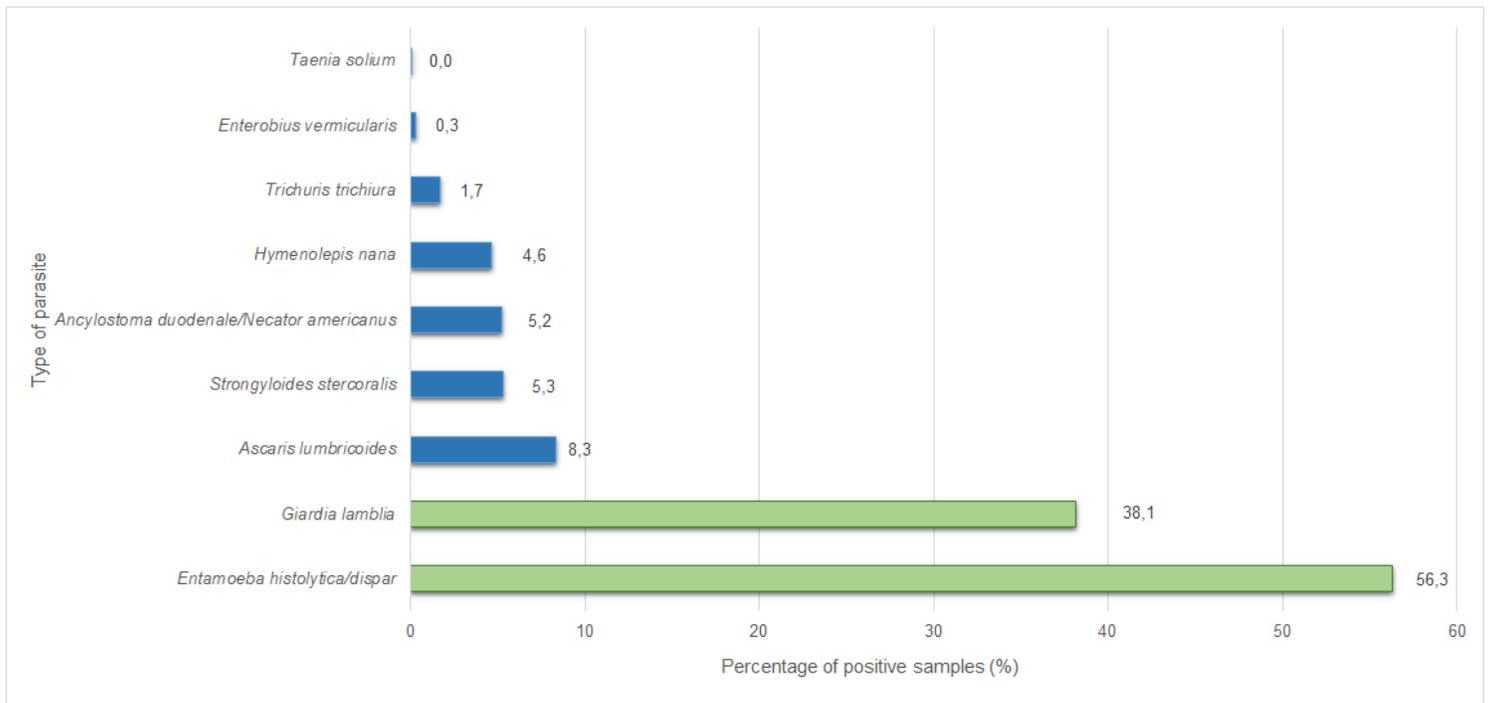


Figure 1

Distribution of parasite species in positive stool samples (%). Legend: Some species are the main diagnosis or could be combined with others.

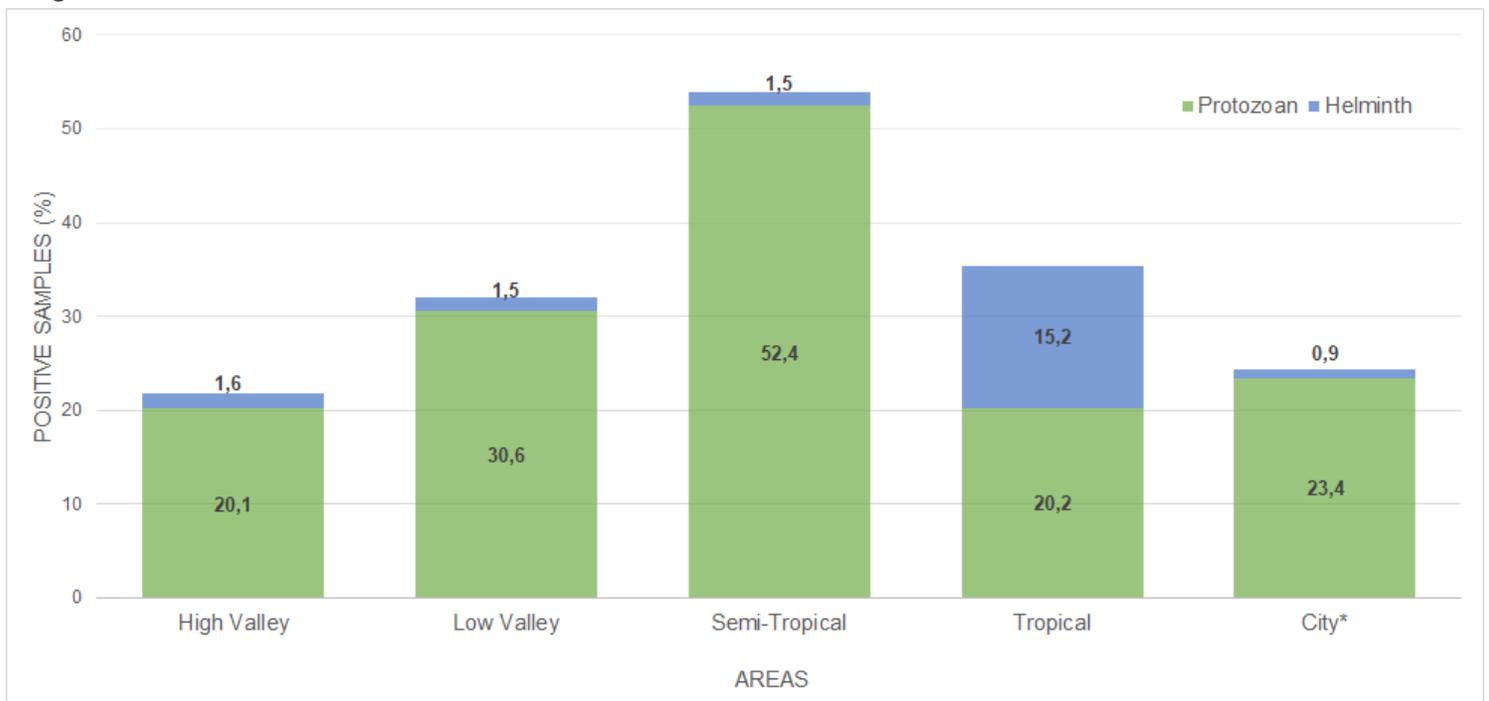


Figure 2

Distribution of positive stool samples by area with a differentiation of group of parasites (%). Legend: Difference between areas is significant (p -value < 0,05 Chi²) *City - Refers the only 3rd line Hospital from Cochabamba

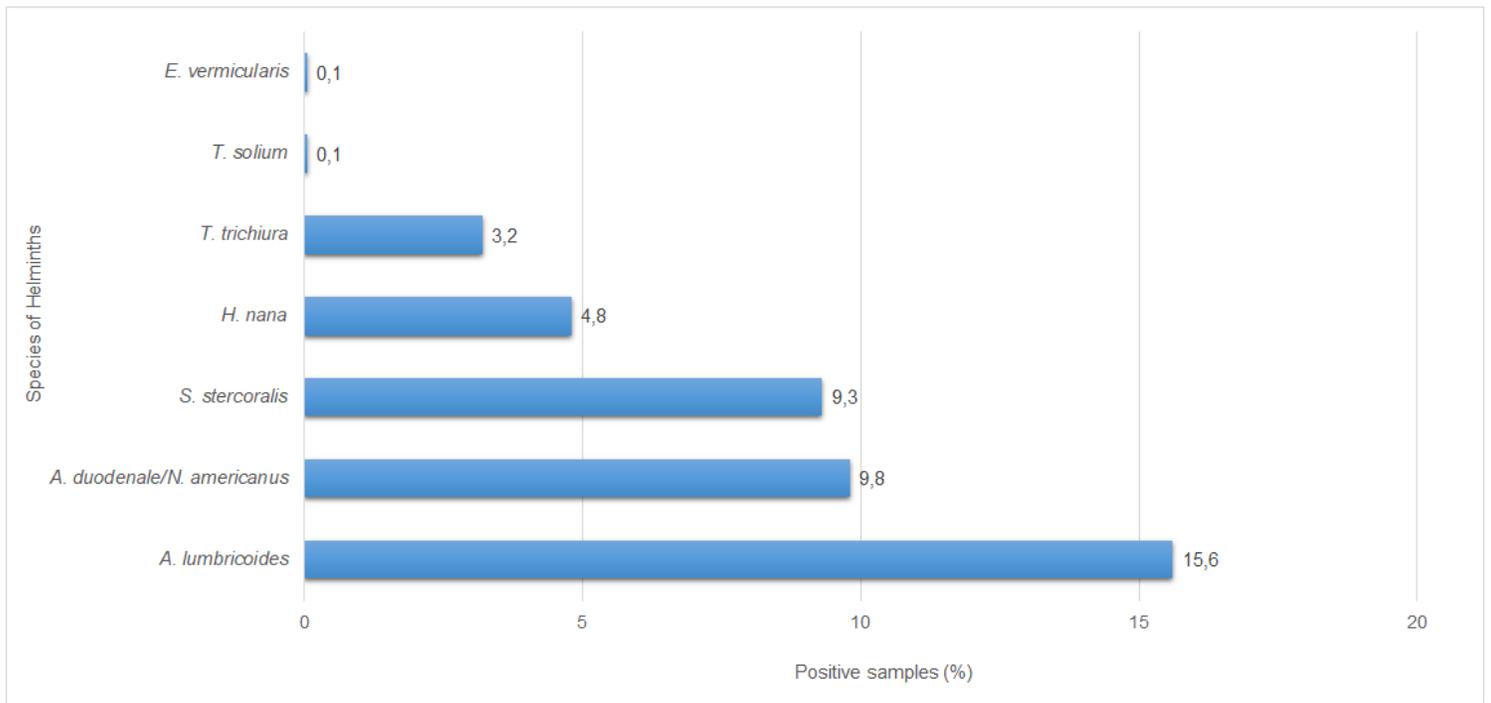


Figure 3

Distribution of the most prevalent helminths species in positive samples of tropical area (%).

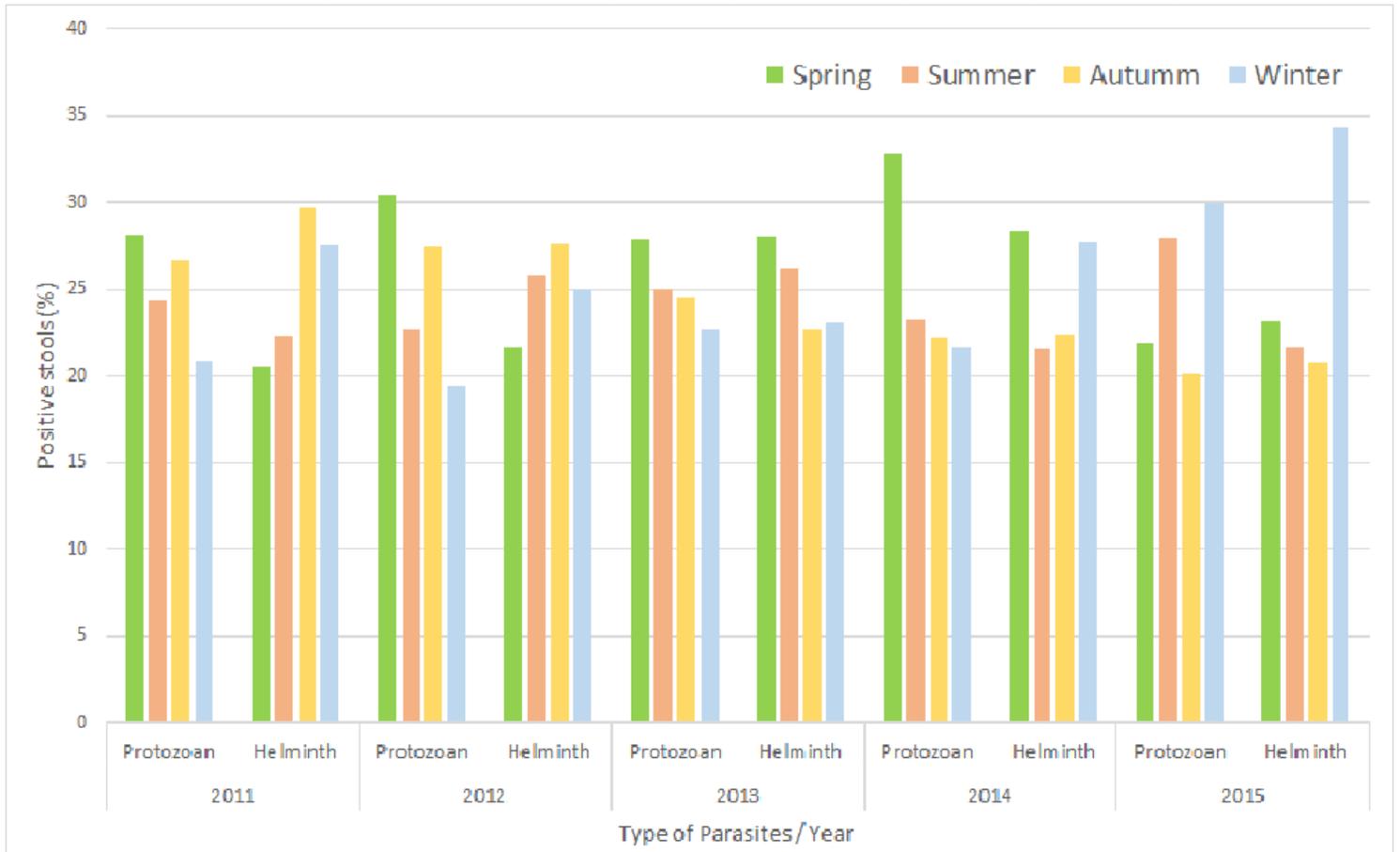


Figure 4

Distribution of positive samples by season with a differentiation of group of parasites (%).

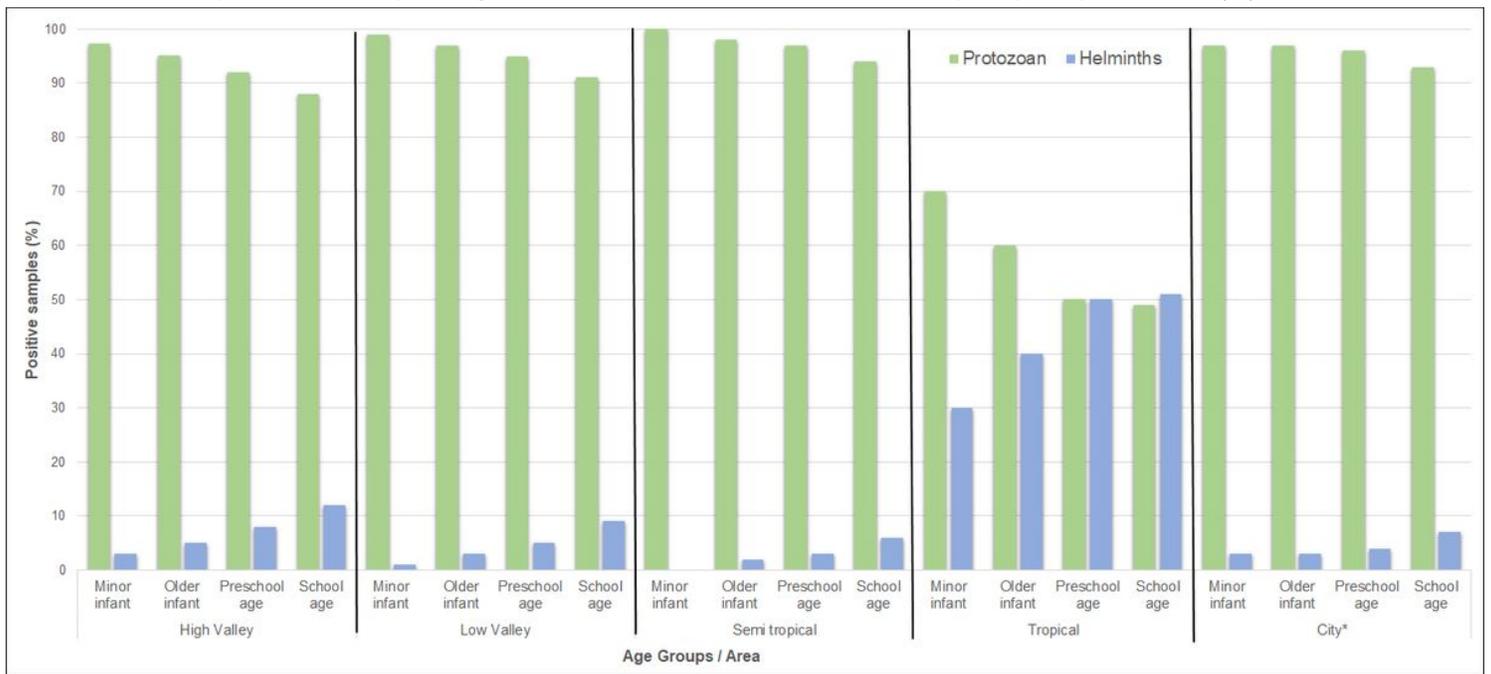


Figure 5

Repartition of parasites (%) according age groups per geographical area where data was collected.
 Legend: *City - Refers the only 3rd line Hospital from Cochabamba.

Supplementary Files

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- [DATASETCBBAPAR.xlsx](#)