

Nota Científica

Soil of periurban dwellings like scenario of development and/or infection of potentially zoonotic parasites in northeast of Argentina

El suelo de viviendas periurbanas como escenario de desarrollo y/o infección de parásitos potencialmente zoonóticos en el Nordeste de Argentina

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Abstract

*In this research, soil contamination in household environment with soil-borne parasites species in dwellings of a periurban neighborhood and a shantytown in northeast of Argentina was described and associated with sanitary variables. Each house evaluated was considered as a unit of analysis. The samples were analyzed under three different techniques: centrifugal sedimentation; Willis Molloy flotation and flotation with Sheather's solution. Out of the 30 houses analyzed, 12 (40.0%) presented at least one parasitic forms in soil samples. We recorded three taxa, the most prevalent were nematodes larvae (related to hookworms), reported in the 30% of dwellings followed by *Toxocara canis* and *Trichuris vulpis* eggs and *Cytoisopora canis* oocyst in the 3,3% of houses. No statistical association was observed between soil contamination and the sanitary variables ($p > 0.05$). These preliminary results demonstrate that domestic environment soil could represent a high potential for infection and re-infection for humans, principally young children and their pets.*

Keywords: household environment, soil contamination, helminths, protozoa, zoonoses.

Resumen

En el presente trabajo se estudió la contaminación del suelo con especies parasitarias en el ambiente domiciliario de un barrio periurbano del Nordeste Argentino y se asoció con variables sanitarias. Las muestras de suelo fueron analizadas utilizando tres técnicas diferentes: sedimentación por centrifugación; flotación de Willis Molloy y con solución de Sheather. De las 30 casas analizadas, 12 (40,0%) presentaron al menos una forma parasitaria en las muestras de suelo. Registramos tres taxones, entre ellos, las larvas de nematodos (relacionadas a ancilostomídeos) fueron los de mayor prevalencia, reportadas en el 30% de las viviendas, seguido por huevos de *Toxocara canis* y *Trichuris vulpis* y ooquistes de *Cytoisopora canis* en el 3,3% de las casas. No se observó asociación estadística entre contaminación del suelo y las variables sanitarias ($p > 0.05$). Estos resultados preliminares demuestran que el suelo del ambiente doméstico podría representar un alto potencial de infección y re-infección para humanos, principalmente niños y sus mascotas.

Palabras clave: entorno familiar, contaminación del suelo, helmintos, protozoos, zoonosis.

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Introduction

Soil is an important route of transmission of a large number of species of nematodes, cestodes, trematodes and protozoa, to animals and humans. The source of soil contamination with species parasites is represented principally by infected animals which can spread a large number of infected elements (cysts, eggs, oocysts and larvae) in the environment through their faeces, favoring zoonotic transmission and re-infection for other animals and/or humans (Traversa, D., di Regalbano, A., Di Cesare, A., La Torre, F., Drake, J., & Pietrobelli, M. (2014). Environmental contamination by canine geohelminths. *Parasites & vectors*, 7, 1-9. Available at: <https://link.springer.com/article/10.1186/1756-3305-7-67> (Access February 2022)). Among the main zoonotic soil-borne parasites, the helminths *Ancylostoma* spp., *Toxocara* spp. and *Strongyloides stercoralis*, cause cutaneous larva migrans (CLM), visceral larva migrans (VLM) and strongyloidiasis respectively in humans, especially in children (Montes, M., Sawhney, C., & Barros, N. (2010). *Strongyloides stercoralis*: there but not seen. Current opinion in infectious diseases, 23(5), 500. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2948977/> (Access February 2022); Soares, S., de Liz, C. F., Cardoso, A. L., Machado, Â., Cunha, J., & Machado, L. (2018). Cutaneous Larva Migrans-

presentation of two typical cases. *Nascercrescer-Birth and Growth Medical Journal*, 27(1), 46–49. Available at: <https://revistas.rcaap.pt/nascercrescer/article/view/9487> (Access February 2022)). Besides environment conditions (temperature, humidity, winds, soil), factors like unsuitable personal hygiene habits, houses in poor conditions, lack of environmental sanitation as inadequate disposition of stool (animals and humans), added the access to education and health is unequal, among others, provide an ideal framework for the transmission of these parasites (Brooker, S., Clements, A. C., & Bundy, D. A. (2006). *Global epidemiology, ecology and control of soil-transmitted helminth infections*. *Advances in Parasitology*, 62, 221-261. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S0065308X05620076> (Access February 2022); Eisenberg, J. N., Desai, M. A., Levy, K., Bates, S. J., Liang, S., Naumoff, K., & Scott, J. C. (2007). *Environmental determinants of infectious disease: a framework for tracking causal links and guiding public health research*. *Environmental Health Perspectives*, 115, 1216–1223. Available at: <https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.9806> (Access February 2022)).

The study of the epidemiology of zoonotic parasite infections is important to minimize the risks to humans. For this reason, many studies have been carried out in recent years to determine the prevalence of species parasites in the environment, particularly in the soil and principally in public areas of all the world, such as parks, playgrounds, beaches, recreational spaces and sandboxes (Stojčević, Lee, D. A. B., de Oliveira, E. L. C., Lee, G. A. S., da Silva, P. L., Santos, P. O. M., & Lima, V. F. S. (2021). *Potentially zoonotic parasites in the soil of public squares in the city of Aracaju (Sergipe, Northeastern Brazil)*. *Veterinary Parasitology: Regional Studies and Reports*, 26, 100619. Available at: <https://www.sciencedirect.com/science/article/pii/S2405939021000915> (Access February 2022); Milano, A., F., & M., Oscherov, E.B. (2002). *Contaminación por parásitos caninos de importancia zoonótica en playas de la ciudad de Corrientes, Argentina*. *Parasitología latinoamericana*, 57(3-4), 119-123. Available at: https://www.scielo.cl/scielo.php?pid=S0717-77122002000300006&script=sci_arttext&tlng=pt (Access February 2022); de Figueiredo, M.I.O., Wendt, E.W., dos Santos, H.T., Moreira, C.M., (2012). *Survey of parasite eggs in sandboxes of municipal kindergarten schools in Uruguaiana, Brazil*. *Revista de Patología Tropical* 41. Available at: <https://www.cabdirect.org/cabdirect/abstract/20123185575> (Access February 2022)).

On the other hand, few studies have evaluated the soil in the household environment where has been proven that endoparasites of man and the animals live with them enter, and, in adequate conditions, they can multiply and be transmitted among the inhabitants of the house (Milano, A. M. F., Oscherov, E. B., Legal, A. S., & Espinoza, M. C. (2007). *La vivienda urbana como ambiente de transmisión de algunas helmintiasis caninas de importancia zoonótica en el Nordeste Argentino*. *Boletín de Malariología y Salud Ambiental*, 47, 199–204. Available at: http://ve.scielo.org/scielo.php?script=sci_arttext&pid=S1690-46482007000200006 (Access February 2022); Borecka, A., Gawor, J., Niedworok, M., & Sordyl, B. (2010). *Occurrence of *Toxocara* spp. eggs in household environment of children with diagnosed toxocariasis in Łódź voivodeship*. *Wiadomosci Parazytologiczne*, 56(2), 141-144. Available at: <https://europepmc.org/article/med/20707298> (Access February 2022)), moreover, most of these studies have only evaluated soil-transmitted helminths. In this sense, other soil-borne parasites, such as protozoa (e.g. *Giardia* and *Cryptosporidium*) are capable of infecting most mammals in addition to having a zoonotic potential (Tavalla, M., Oormazdi, H., Akhlaghi, L., Razmjou, E., Moradi, Lakeh, M., Shojaee, S., Hadighi, R., & Meamar, A. R. (2012). *Prevalence of parasites in soil samples in Tehran public places*. *African Journal of Biotechnology*, 11 (20): 4575-4578. Available at: <https://www.ajol.info/index.php/ajb/article/view/101348> (Access February 2022); Stojčević, et al., 2021 *Op. Cit.*). Therefore, the objective of this study was determine the prevalence of species parasites in the soil of dwellings in a periurban neighborhood and a shantytown in Corrientes Capital Department (northeast Argentina) and evaluate sanitary variables associated with soil contamination.

Materials and Methods

The research was conducted in two suburban neighborhoods in the capital department of Corrientes province (27°28'00" S, 58°50'00" W) in the North-East of Argentina (Figure 1). These neighborhoods are characterized by have poor sanitary conditions such as precarious houses built on government lands, lack of sewer service, poor supply of drinking water and high degree of contact with domestic and synanthropic animals, among others.

Collection of soil samples and laboratory analysis

Soil samples of 30 dwellings were collected during October 2021 - July 2022. Each house evaluated was considered as an analysis unit (Milano et al., 2007 *Op. Cit.*) and were randomly selected. Samples were taken from outside the houses. Per each dwelling, an average of 14 samples (about 100 g each) were taken each 4 m² from the soil surface to 5 cm in depth and subsequently preserved in plastic bags and stored in a refrigerator until processing. The subsamples from each house were combined into one composite sample and were analyzed under three different techniques: centrifugal sedimentation; Willis Molloy flotation or saturated sodium chloride solution and flotation with Sheather's solution. Every sample was staining with Lugol and examined by two experts using a stereoscopic magnifying glass (Olympus CH30; 100× and 400× magnifications). Identification of parasitic elements (eggs, larvae, cysts, oocysts) was based on their measures and morphological characteristics.

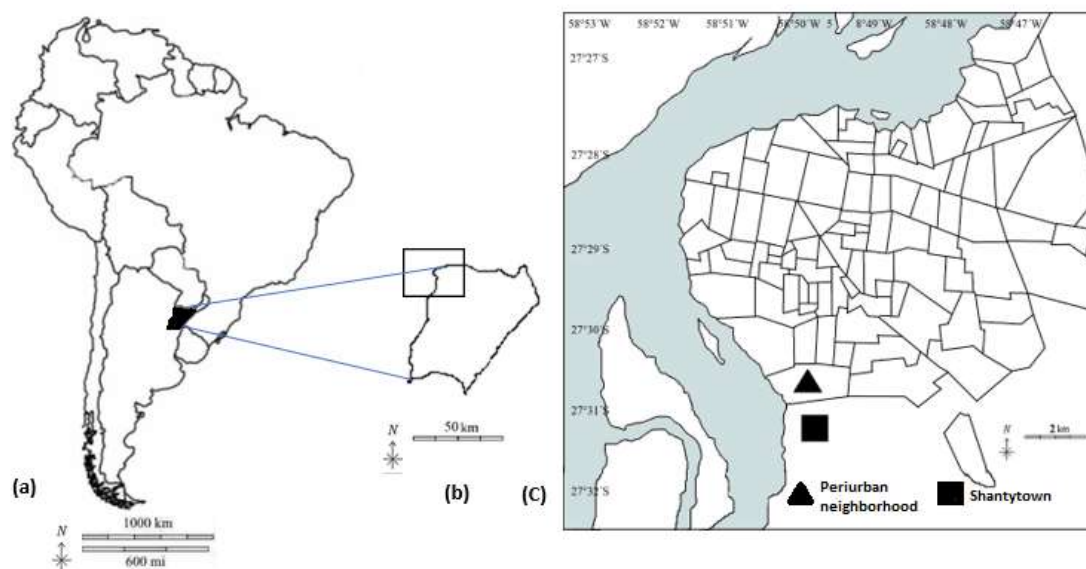


Figure 1. Geographic location of the Province of Corrientes in northeast of Argentina (a) Capital department (b), and analysed periurban neighbourhoods (c).

Sanitary data and statistical analysis

Sanitary data collection of the houses was carried out through direct observation and the application of semi-structured questionnaires. The data obtained was related to disposition of stool humans: possession of latrine or bathroom installed and disposition of stool animals: stays on the ground or throws in bags. The general prevalence (GP) (number of positive unit of analysis for at least one species divided by the total number of houses evaluated expressed in terms of percentage) was calculated. To analyze the data, databases were entered and imported to the software R (R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: <https://www.R-project.org/> (Access February 2022)). To compare the two neighborhoods like the relationship between sanitary variables and soil contamination a Chi-square test was made. If any of the frequencies were less than 5, Fisher's exact test was applied. Values of $p < 0.05$ were taken as significant.

Results and Discussion

The presence of at least one parasites species was recorded in soil samples of 12 dwellings (40,0%) corresponding to three taxa. The most prevalent were nematodes larvae, reported in the 30,0% of dwellings followed by *Toxocara canis* and *Trichuris vulpis* eggs and *Cytoisospora canis* oocyst in 3,3% of dwellings analyzed. In the periurban neighborhood (n=15) a statistically significant general prevalence was recorded compared to the shantytown (n=15) (60,0% versus 20,0%) ($\chi^2=5,16$ p-value $<0,05$). Presence of each species per each neighborhood can be observed in Table 1. Sanitary variables data of 30 houses were obtained (Table 2). Most of the family declared that had bathroom installed. Regarding to the elimination of animal excreta, 56,6% declared that collect and throw feces in bags. No association was observed between soil contamination and the sanitary variables.

Evaluation of soil contamination with affective states of parasites is an important tool in assessing to which risks are people exposed. In this sense, some previous studies have reported high rates of soil contamination in household environment with zoonotic parasitic (Gawor, J., Borecka, A., Żarnowska, H., Marczyńska, M., & Dobosz, S. (2008). Environmental and personal risk factors for toxocarasis in children with diagnosed disease in urban and rural areas of central Poland. *Veterinary parasitology*, 155(3-4), 217-222. Available at: <https://www.sciencedirect.com/science/article/pii/S0304401708002665> (Access February 2022); Borecka et al., 2010 *Op. Cit.*). In the same way, in northeast of Argentina, different authors reported the presence of zoonotic parasites in soil samples of dwellings in overall prevalence of 20,5% to 53,0% (Milano et al., 2007 *Op. Cit.*; Navone, G. T., Gamboa, M. I., Oyhenart, E. E., & Orden, A. B. (2006). Parasitosis intestinales en poblaciones Mbyá-Guaraní de la Provincia de Misiones, Argentina: aspectos epidemiológicos y nutricionales. *Cadernos de Saúde Pública*, 22, 1089–1100. Available at: https://www.scielosp.org/article/ssm/content/raw/?resource_ssm_path=/media/assets/csp/v22n5/22.pdf (Access February 2022); Gamboa, M. I., Navone, G. T., Orden, A. B., Torres, M. F., Castro, L. E., & Oyhenart, E. E. (2011). Socio-environmental conditions, intestinal parasitic infections and nutritional status in children from a suburban neighborhood of La Plata, Argentina. *Acta Tropica*, 118, 184–189. Available at: <https://www.sciencedirect.com/science/article/pii/S0001706X09001636> (Access February 2022)).

In this study, we reported 40,0% of samples soil contaminated, most with potentially zoonotic parasites in the dwellings analyzed. Therefore, these results confirmed that soil contamination in domestic environmental might be recognized as a very important factor in the epidemiology of zoonotic parasites. In nine dwellings (30.0%), we observed nematodes larvae related to hookworms. The zoonotic importance of these larvae resides in that its survive in the environment for several months being able to penetrate the human epidermis by direct contact and cause the cutaneous larva migrans syndrome (Bowman, D. D., Montgomery, S. P., Zajac, A. M., Eberhard, M. L., & Kazacos, K. R. (2010). Hookworms of dogs and cats as agents of cutaneous larva migrans. *Trends in Parasitology*, 26, 162–167. Available at: <https://www.sciencedirect.com/science/article/pii/S1471492210000176> (Access February 2022); Feldmeier, H., & Schuster, A. (2012). Mini review: Hookworm related cutaneous larva migrans. *European Journal of Clinical Microbiology & Infectious Diseases*, 31, 915–918. Available at: <https://academic.oup.com/jtm/article/14/5/326/1808671?login=false> (Access February 2022)). Coincidentally, these parasites also were reported with similar prevalences in soil samples of dwellings and public areas from Argentina such as public rides and beaches (Milano et al., 2007 *Op. Cit.*; Gamboa et al., 2011 *Op. Cit.*) (Córdoba, A., M. L. Ciarmela; B. Pezzani; M. I. Gamboa; M. Marta de Luca; M. Minvielle & J. A. Basualdo. (2002). Presencia de parásitos intestinales en paseos públicos urbanos en La Plata Argentina. *Parasitología Latinoamericana* 57(1-2): 25-29. Available at: <https://www.scielo.cl/scielo.php?pid=S0717> (Access February 2022); Milano & Oscherov, 2002 *Op. Cit.*). We consider important to mention that in 96.6% of dwellings analyzed, dogs were registered, therefore, this could explain the high prevalence of these nematodes in these houses, also it gave account of great canine faecal contamination and deficient health care of pets in dwellings.

Similarly to our results, in Chaco province, Argentina, also revealed low prevalence (1,6%) for eggs of *T. canis* in soil of dwellings (Alonso, J. M., Stein, M., Chamorro, M. C., & Bojanich, M. V. (2001). Contamination of soils with eggs of *Toxocara* in a subtropical city in Argentina. *Journal of helminthology*, 75(2), 165-168. Available at: <https://pubmed.ncbi.nlm.nih.gov/11520441/> (Access February 2022)), conversely, other authors revealed higher prevalence in dwellings (32,0% and 48,6%) and public rides (13,3) (Gamboa et al., 2011 *Op. Cit.*; Córdoba et al., 2002 *Op. Cit.*; Basualdo, J. A., Córdoba, M. A., Luca, M. M. D., Ciarmela, M. L., Pezzani, B. C., Grenovero, M. S., & Minvielle, M. C. (2007). Intestinal parasitoses and environmental factors in a rural population of Argentina, 2002-2003. *Revista do Instituto de Medicina Tropical de São Paulo*, 49, 251-255. Available at: <https://www.scielo.br/j/rimts/a/yrTN6HbHJXhBd3tchWpOnfB/abstract/?lang=en> (Access February 2022)). To local level, 40.0% of prevalence was revealed in soil samples of houses for this nematode (Milano et al. 2007 *Op. Cit.*). The differences between these results may be attributed to a wide range of factors, such as climatic conditions, dog population, soil type, number and volume of samples tested, the season in which sampling was performed, storage of samples, and the methods used (Mizgajska, H., Jarosz, W., & Rejmenciak, A. (2001). Distribution of sources of *Toxocara* spp. infection in urban and rural environments in Poland. *Wiadomosci Parazytologiczne*, 47(3), 399-404. Available at: <https://europepmc.org/article/med/16894754> (Access February 2022); Santarém, V.A., Magoti, LP, Sichert, T.D. (2009). Influence of variables on centrifuge flotation technique for recovery of *Toxocara canis* eggs from soil. *Revista do Instituto de Medicina Tropical de São Paulo*, 51 (3): 163-167. Available at: <https://www.scielo.br/j/rimts/a/PWxPckQLKL64KSSXMxfbF5H/abstract/?lang=en> (Access February 2022)).

On the other hand, *T. canis* can be transmitted mostly children by the ingestion of embryonated eggs through the soil and contaminated hands or vegetables, or by the ingestion of larvae in undercooked meat of paratenic hosts (e.g. chickens, pigs, ruminants) and cause visceral, pulmonary, ocular, neural larva migrans syndrome (Overgaauw, P. A., & van Knapen, F. (2013). Veterinary and public health aspects of *Toxocara* spp. *Veterinary parasitology*, 193(4), 398-403. Available at: <https://www.sciencedirect.com/science/article/pii/S0304401712006838> (Access February 2022); Lee, A. C., Schantz, P. M., Kazacos, K. R., Montgomery, S. P., & Bowman, D. D. (2010). Epidemiologic and zoonotic aspects of ascarid infections in dogs and cats. *Trends in parasitology*, 26(4), 155-161. Available at: <https://www.sciencedirect.com/science/article/pii/S1471492210000140> (Access February 2022)).

Regarding *T. vulpis* and *C. canis*, both were registered in only one house. In Argentina, *Trichuris* genera and Coccideos were reported in higher prevalence in soil of houses and public rides (Navone et al., 2006 *Op. Cit.*; Basualdo et al., 2007 *Op. Cit.*; Cordoba et al. 2003; *Op. Cit.*). Particularly, *T. vulpis* is a nematode found in the large intestine of dogs and gives eggs which can survive in the soil even in difficult environmental conditions (Traversa et al., 2014 *Op. Cit.*). Although its zoonotic potential has not been yet elucidated it whipworm has importance in veterinary medicine. *Cystoisospora canis*, is a common parasite protozoan of dogs, its route of transmission is through the ingestion of sporulated oocyst (infective form). Although it is not recognized as a species of zoonotic importance, has relevance in veterinary health (Traversa, D., (2011). Are we paying too much attention to cardiopulmonary nematodes and neglecting old-fashioned worms like *Trichuris vulpis*? *Parasites and Vectors*, 4:32 Available at: <https://parasitesandvectors.biomedcentral.com/articles/10.1186/1756-3305-4-32> (Accessed February 2022); Mitchell, S. M., Zajac, A. M., Charles, S., Duncan, R. B., & Lindsay, D. S. (2007). *Cystoisospora canis* Nemeséri, 1959 (syn. *Isospora canis*), infections in dogs: clinical signs, pathogenesis, and reproducible clinical disease in beagle dogs fed oocysts. *Journal of Parasitology*, 93(2), 345-352 Available at: <https://meridian.allenpress.com/journalofparasitology/article-abstract/93/2/345/4020/cystoisospora-canis-nemeseri-1959-syn-isospora> (Access February 2022)). In this study, we reported for the first time the presence of *Trichuris vulpis* and *Cystoisospora canis* in houses soil from Corrientes Province, Argentina.

On the other hand, in the periurban neighborhood, a statistically significant general prevalence was recorded compared to the shantytown (60.0% versus 20%). However, contrary to Milano et al., (2007) *Op. Cit.* we don't prove associations between soil contamination and the sanitary variables which could explain these differences. Therefore, considering the positive influence of temperature on the development and viability of parasitic forms in the soil (Melo, M.V.C., Oliveira, T.R., Rodriguez-Malaga, S. M., de Cruz, D.R.S., & Jonas, J. M., (2020). Environmental contamination: the influence of seasonality in the occurrence of geohelminths in a public area of Fortaleza. Ceara Vigilancia Sanitaria em Debate 8. <https://doi.org/10.22239/2317-269x.01333>; de Lima, J.L., de Andrade, L.D., Aguiar-Santos, A.M., Alves, L.C., Medeiros, Z., (2005). Soil contamination with *Toxocara* sp. eggs in Moreno, Pernambuco state, Brazil. Brazilian Journal of Veterinary Research and Animal Science, 42, 339–346. <https://doi.org/10.11606/issn.1678-4456>) and the highest specific prevalence in this study represented by larvae of nematodes, these could be related to periods of the year in which the sampling was carried out. In this sense, sampling in the periurban neighborhood, was carried out in summer while in the shantytown in autumn, where possibly low temperatures decrease the viability of larvae (da Mello, C.S., Mucci, J.L.N., Cutolo, S.A., (2011). Contaminação parasitárias de solo de praças públicas da Zona Leste de Sao Paulo, SP-Brasil e a associação com variáveis meteorológicas. Revista de Patologia Tropical 40. <https://doi.org/10.5216/rpt.v40i3.15976> ;de Figueiredo et al. 2012; *Op. Cit.*)

Finally, although *T. canis*, *T. vulpis* and *C. canis* were only identified in three different houses, with the identification of a single positive sample, it is already possible to suggest that there is a circulation of these taxa in the study area, considering it an aspect important to attend, in human and veterinary health. These results indicate that the main source of soil contamination with affective states of parasites in the dwellings analyzed probably come from the faeces from infected dogs. In these sense, this work represents a knowledge base for integrating parasitological results from human and domestic animal hosts. On the other hand, a better information and education of dog owners about proper disposal of feces and the necessity of periodic deworming is needed to reduce the potential risks of household and per domiciliary pollution with parasitic forms.

Table 1. Prevalence of parasitic contamination in soil samples of household environment in two neighborhoods in Corrientes city (northeast Argentina) (N=30)

Table 2. Sanitary variables linked to the disposal of excreta humans and animals in two neighborhoods in Corrientes city, northeast from Argentina (N=30)

Neighborhoods	Positives (%)	Soil contamination			
		<i>Trichuris vulpis</i>	<i>Toxocara canis</i>	Nematodes larvae	<i>Cytoisospora canis</i>
Periurban neighborhoods	9 (60,0)	1 (6,6)	1 (6,6)	7 (46,6)	-
Shantytown	3 (20,0)	-	-	2 (13,3)	1 (6,6)
Total	12 (40,0)	1 (3,3)	1 (3,3)	9 (30)	1 (3,3)

Site	Disposition of stool humans		Disposition of stool animals	
	Latrine	Bathroom installed	Stays on the ground	Throws in bags
Periurban neighborhood	4	11	8	7
Shantytown	8	7	5	10
Total	12	18	13	17

Declaration of Competing Interest

The authors declare that they have no competing interests.

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