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Prevention of intestinal parasites in a tri-border area of Latin America: Children perceptions and an integral health education strategy

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Summary

To investigate knowledge of school-aged children and their perception on intestinal parasites, and to assess knowledge reconstruction on prevention practices after specific training in the subject. We performed an activity package that included the analysis of children's drawings of intestinal parasites, and information and communication technologies (ITCs) to transfer knowledge about these pathogens and prevention measures. Retrieval learning activities were performed to fixation of general and specific prevention and control measures.Overall, we found that there is a knowledge gap in many aspects of parasite biology and ecology, and therefore on the risk of infection and acquisition mechanisms. After ITCs, the children improved their knowledge over non-trained children.The approaches used to transfer knowledge and for learning, fixation were valuable tools for incorporating changes in misconceptions and in the deep-rooted habits that favour entero-parasitic diseases. This has important implications for the specific design of future education materials and campaigns. Understanding of perceptions helps to provide justifications and knowledge to achieve changes in unhealthy habits, and it constitutes the basis for the transformation of many risky practices.

KEYWORDS

infectious diseases, parasitology, prevention strategies, public health

1 | INTRODUCTION

Soil-transmitted helminthiasis (STH) and intestinal protozoan diseases are the most prevalent parasitic diseases in tropical and subtropical developing countries. Despite the WHO great efforts to control or eliminate them, they constitute an issue of major public health and socio-economic concern (WHO, 2012). Substantial work has been made on deworming chemotherapy and sanitation intervention campaigns to control these diseases (WHO, 2012). However, scientific community claims about the need to implement health education approaches as an effective, low-cost tool for creating the proper environment for both chemotherapy and sanitation to thrive (Asaolu & Ofoezie, 2003; Barbosa, 1998; Crocco, Rodriguez, Catala, & Nattero, 2005; Jia, Melville, Utzinger, King, & Zhou, 2012).

Intestinal parasites prevalence in Latin America continues to reach very high values that together with social and economic situations of the populations contribute to the vicious circle of infection and disease. In Argentina, the prevalence fluctuates between 45% and 80% according to the provinces, being the subtropical provinces the most endemic regions (Juarez & Rajal, 2013). Our epidemiological surveys in children from Puerto Iguazú evidenced prevalence close to 60 per cent in concordance with others studies developed in Misiones province (Gamboa et al., 2009; Navone, Gamboa, Oyhenart, & Orden, 2006; Zonta, Garraza, Castro, Navone, & Oyhenart, 2011).

Therefore, it is of paramount importance to know population's perceptions and attitudes about parasitic infections to develop properly educational activities and to achieve success (Lesshafft et al., 2011; Nasr, Al-Mekhlafi, Ahmed, Roslan, & Bulgiba, 2013; Sy, 2009). Obtaining this information from the higher risk groups, such as school children population, is even more significant and productive to guide an intervention delivering specific and clear messages (Vivas et al., 2010; Yevstigneyeva, Camara-Mejia, & Dumonteil, 2014). Furthermore, it has been widely reported the role played by children as knowledge propagators promoting positive behavioural changes from a simplified perspective (Ayi et al., 2010; Petris et al., 2016; Vivas et al., 2010).

Among several approaches implemented to assess children's perceptions, the drawing expression method, framed as a semiotic practice (Atkinson, 2002; Puglionesi, 2016), has been considered a child-friendly, easy-to-engage tool that allows to analyse children's knowledge (concepts and notions) about the self, the others and the environment (Cox, 2005; Ring, 2006). At the same time, to promote health-enhancing behaviour, teaching strategies based on the use of information and communication technologies (ICTs) are being increasingly used at primary and high school levels (Marteau, Hollands, & Fletcher, 2012; Shigehatake et al., 2014; Yonah, 2005). Another effective strategy to enhance this teaching-learning process is the implementation of retrieval approaches (Karpicke & Roediger, 2008). These practices constitute pivotal approaches in public health interventions as they allow evaluating the enhancement of student's knowledge as well as the teaching strategy.

The main aim of our work was to evaluate a package of activities that can be applied at levels of primary education as a control strategy to prevent infectious diseases of great relevance in public health of vulnerable populations. Thus, we formulated threefold aims: (i) to assess school-aged children's knowledge and perceptions on intestinal parasites; (ii) to provide them with accurate information using ICTs, theoretical and practical lessons; and (iii) to evaluate, through a retrieval-based-learning approach, knowledge reconstruction on prevention practices and to identify the persistent major gaps after training in the subject.

Impacts

- The assessment of children's perceptions and participative information transference are appropriate tools to be incorporated in a sustainable school-based strategy to tackle intestinal parasitic diseases.
- An integral health education package from a multidisciplinary vision with emphasis on the recovery of prior beliefs can help understand the socio-environmental and contextual framing that contributes to parasite infections maintenance.
- Providing relevant knowledge and assessed knowledge reconstruction after specific training in the subject has important implications in the specific design of future education materials and campaigns to achieve changes in unhealthy habits.

2 | METHODS

2.1 | Ethical statement

Ethical approval was obtained from the research committee of the National Institute of Tropical Medicine-INMeT. School authorization to develop all the activities was obtained through the signing of a participation commitment by principals and teachers. Written informed consent was required from the parents or legal guardians of each child involved in the research. Verbal consent to participate in the study was also required from all children.

2.2 | Study participants and design

The study was carried out in Puerto Iguazú city located at Misiones province, a subtropical province of north-eastern Argentina bordering with Brazil and Paraguay. School children between 7 and 9 years old (n = 478) enrolled in six primary public schools of the city participated in the activities from March to June 2015. Four hundred and thirty-seven children were recruited to perform the activity package and 41 students constituted the control group that only participated in the final retrieval activity without previous training.

The complete package of activities included two visits. Graphic expression about a general concept and transmission of knowledge's activities was performed in the first visit. Retrieval learning assessment and final oral integration were assessed during the second visit. The work team was composed by biologists, microbiologists, veterinarians and social scientists of the National Ministry of Health and the National Scientific and Technical Research Council. Also, teachers and pedagogical teams from the schools participated advising the implementation of the activities. The total duration of the activities was 70 min with a 10-min break for the first visit and 35 min for the second one.

2.3 | Drawing performance

The research team arrived at the classroom and after a formal presentation proposed the trigger activity consisting in asking the students to create a drawing on the topic: "Intestinal parasites." Each student was provided with a white A4 sheet, and there were no restrictions on the use of colours. After 25 min, the drawings with the identification of each child (name, age, name of school and grade) were collected. A brief oral conversation was performed with each student to register general explanations and comments about the illustration content for a better contextualization of the construction of meaning (Cox, 2005; Puglionesi, 2016).

2.4 | ICTs: educational cartoon and multimedia presentation

Subsequently, a cartoon movie named "Valentin and the little invaders" (In Spanish: Valentín y los pequeños invasores) (Nores et al.,

2010) projected on a giant screen with amplified audio was employed to provide children with information about intestinal parasites. This Argentinian awarded educational material is a comic animated cartoon for 7- to 12-year-old children; it includes several techniques such as traditional 2D animation, clay animation and video recording (Nores et al., 2010). The topics addressed in the movie include clinical manifestations, disease association with nutritional status, parasites and infection, healthy habits and pets, and treatment. The video is in Spanish; it lasts 13 min, and it was complemented with an 8-min power point presentation addressing concepts about parasites of skin penetration. Afterwards, an educational session using microscopes and magnifiers to observe parasitic structures was developed in the classroom. Finally, an oral integration of all the topics covered in the class was prompted to evacuate doubts and clarify concepts. A special ID licence, adapted from the comic book version of Valentin and the little invaders (Nores, 2010), was given to each child, and it declared the student as Parasites prevention inspector, encouraging their role as knowledge propagators agents in their family and social environment (Fig. S1).

2.5 | Retrieval practice

Four weeks later, the research team came back to each school to apply a retrieval-based learning approach (Karpicke & Blunt, 2011; Karpicke & Roediger, 2008). A control group of 41 children was selected for the retrieval practice, composed by students from the six public schools that did not participate in drawing performance and ICTs activities. We analysed children's knowledge reconstruction specifically on prevention practices, which were assessed during the ICTs activities. The activity consisted in a healthy habits promotion activity sheet. Seven illustrations depicting five habits and conducts were presented: (i) washing hands and food before eating, (ii) bathing-personal cleanliness, (iii) cutting fingernails, (iv) playing barefoot, (v) washing hands after using the toilet, (vi) wearing shoes, (vii) not washing hands and food before eating (Fig. S2). Illustrations 1/7 and 4/6 are opposing pairs or contradictory statements that were introduced both, to reinforce the concept and to evaluate acquiescence response bias (Okanda & Itakura, 2010). By drawing happy or sad faces the students had to indicate whether the activities represented were correct measures or not to prevent parasitic diseases according to the information provided in our first meeting. Before starting, a general description of each illustration was provided to the classroom in order to guarantee that the represented actions were correctly understood. At the end of the activity, the correct answer to each item was provided by active participatory interchange. Conjointly, aspects of parasites ecology related to the content of the retrieval activity that arose from the drawings analysis were addressed.

2.6 | Data management and statistical analysis

2.6.1 | Drawing content

The drawings were classified under a set of issues and categories generated to cover biological and ecological aspects of the parasites. The main issues were set previously by the team, and the categories were defined after a general observation of the drawings. A template was created to compute the frequencies of the categories and subcategories included in main issues (Table 1 and Table S1).

The classification was performed by three different researchers, and in cases of discrepancies, a conjoint reclassification was accomplished. Unique features arising from some drawings will be mentioned in the Discussion section. To display the frequency distribution and possible correlations between variables, we used contingency tables and chi-squared test using R software (R Development Core Team, 2016).

2.6.2 | Retrieve-based learning performance

Answers to all the illustrations were pondered for each student, and the general performance was estimated considering the total number of children included in the activity. The degree of successes and failures was estimated for each statement. Response performance and evaluation to opposite illustrations were analysed through chi-square tests and nonparametric statistics, in view of expected and observed frequencies and comparisons with the control group of not trained children. The general performance of random answering and the control group versus trained children was evaluated with the two-sample Kolmogorov–Smirnov test. R software was used for all the statistical analysis (R Development Core Team, 2016).

3 | RESULTS

3.1 | Drawings general design

Of the 437 participants, 48% were girls and 52% boys. We obtained 436 drawings as a 7-year-old boy argued not knowing how to imagine a parasite or anything relative to it. Most children were able to achieve the activity in the set time. No remarkable differences were observed and associated with age except for the fact that illustrations from younger students tended to be simpler without extra details or decorations. No child added a message or dialogue in his/her drawing.

From the analysis of the drawings, we were able to distinguish and quantify different designs and conditions of the parasites according to the pre-established issues (Table 1 and Table S1).

3.1.1 | Parasite design

This item contains information linked to the Shape, Size and Parasite′s mood (Table 1 and Table S1). Regarding the shape (Figure 1), worm-like shapes prevailed, being depicted in the 64% of the cases; the most common were the roundworms (78%), predominating bristles as accessory structure (75%) and the smooth surface texture (70%). Monster-like forms (16%) were significantly most frequent in boys' illustrations than in girls' ($\chi^2 = 13.67$, $df = 1$, $p < .001$). Arthropod-like parasites were observed in 29% of the drawings, where figures resembling spiders and fleas were majority, and we only detected few cases

TABLE 1 Drawing's content categorization

Issue	Variable	Category	Frequency (%)
Parasite design	Shape[a]	Worm	64
		Arthropod	29
		Monster	16
		Inside the egg	1
	Size	Micro	24
		Macro	53
		Micro and macro	24
	Mood	Kind	48
		Aggressive	22
		No defined	31
Parasite host[b]	Host type	Human	75
		Animal	20
		Human and animal	5
	Host mood	Happy	98
		Sad	2
Parasite location	Location with respect to the host[b]	Inside the body	20
		Outside the body	69
		Inside and outside	11
	Location with respect to the house[c]	Indoor	36
		Outdoor	58
		Indoor and outdoor	6
Parasite acquisition	Entrance	Oral	17
		Skin	2
		No defined	81
Others	Number	One	58
		More than one	42
	Type[d]	Equal	67
		Different	33

Parasite design main features. When it is not specified, the frequencies observed in each created category were calculated from the total of the drawings (n = 436).
[a]The total percentage exceeds 100 per cent because many children drew parasites with different shapes in their artwork.
[b]Percentages calculated considering the drawings that included the host (n = 81).
[c]Percentages calculated considering the drawings that included the house (n = 169).
[d]Percentages calculated considering the drawings that included more than one parasite (n = 184).

of flies. The least represented category was parasite inside the egg with 1%.

Size variable contained two categories: microscopic and macroscopic. From the illustrations and the oral explanations, we observed that most of the children (78%) recognized the macroscopic- small size represented by a white worm about 1–2 cm. Another parasite described was a roundworm about 15 cm (macroscopic-medium size, 16%) and a small group of children claimed to know bigger parasites, as large as the size corresponding to the length of their fully open arms (6%). Regarding parasites mood, almost a half of the children depicted happy and kind faces and only 22% aggressive facial expression (Table 1). Girls mainly drew "happy parasites" figures, while boys' productions tend to illustrate frowning and aggressive parasites (χ^2 = 32.20, df = 1, p < .001).

3.1.2 | Host and location of parasites

These issues were created considering three variables namely host type, parasite location with respect to the host and parasite location regarding the housing (Table 1). A low percentage of the students-associated parasites with a host (19%), distributed among humans, animal figures (dogs) or both (Figure 2a, Table 1). From the host body perspective, exogenous location was the most common (Table 1). Drawings of human figures and animals were significantly higher in the case of girls (χ^2 = 22.33, df = 1, p < .001).

Houses appeared in 37% of the drawings (Figure 2b, Table 1). Outdoor parasite localization prevailed over indoor localization (Table 1). Girls tended to draw parasites inside the house more often than boys (χ^2 = 32.08, df = 1, p < .001). Urban school children

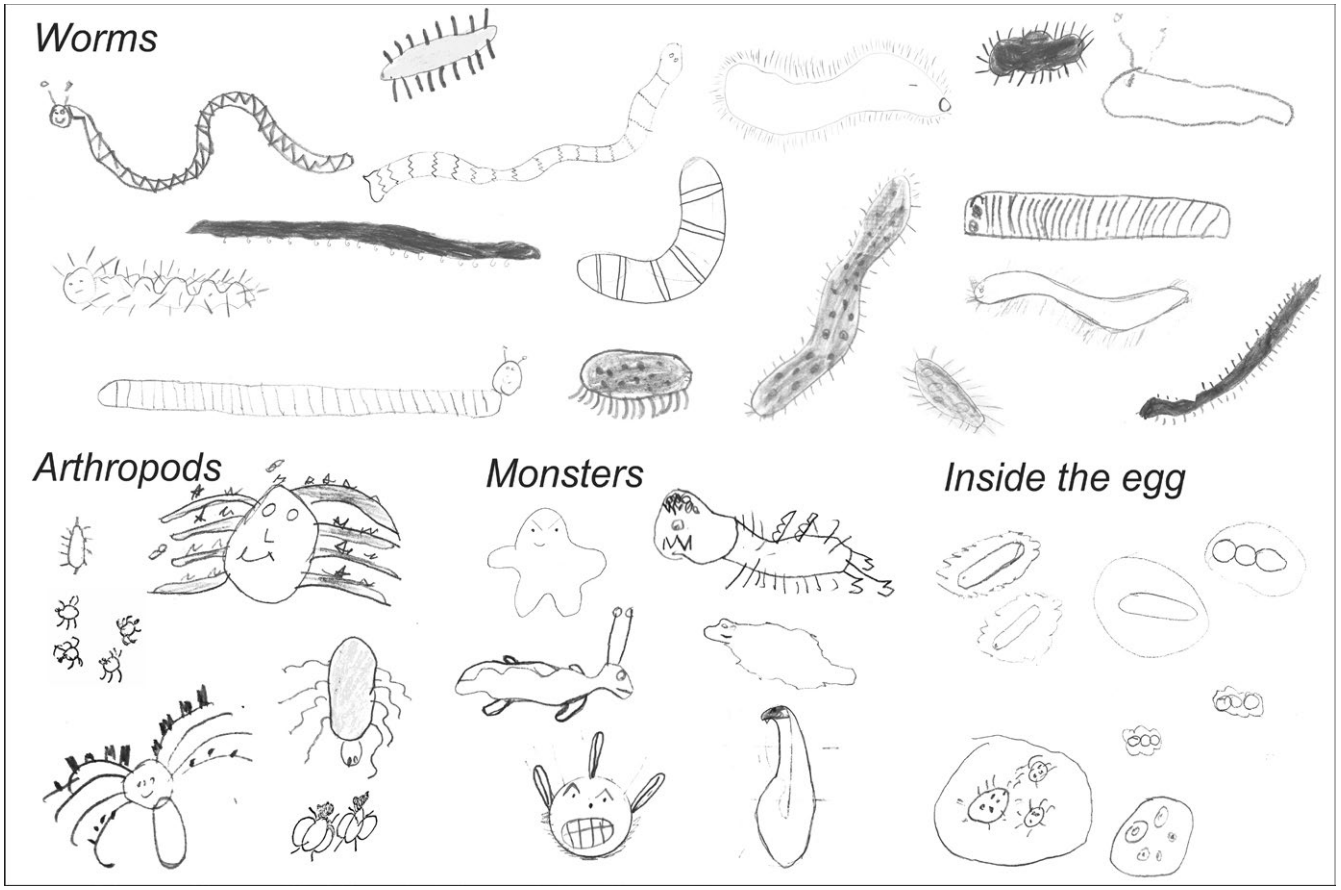

FIGURE 1 Perceptions of parasites shapes. Children's drawing examples of the most prevalent parasite shapes

presented higher trend to schematize parasites on exterior locations, while rural school children showed even distribution between inside and outside location with respect to the house ($\chi^2 = 2.97$, $df = 1$, $p < .085$). Although not significant, this was the only distinguishing feature between rural and urban school children.

3.1.3 | Parasite infective route

Parasites entering through skin were clearly assigned (Figure 3a), but the oral acquisition route was less clear. Even though many students drew parasites in the belly (17%), they may not associate this location with oral acquisition (Figure 3b). Indeed, during the verbal interchange, several children claimed that they were born with parasites; for example, a 7-year-old-boy said: Children have always parasites from the belly of their mothers… and then they pass to my belly… If I'm small they are small and when I grow they grow. Exit ways of intestinal parasites were neither evident nor mentioned in any case.

3.1.4 | Parasites and environment

Soil was the only environmental aspect represented by children. It appeared in the 37% of the illustrations not only as a baseline, but also as key participant in parasites transmission. Soil depth also appeared in some cases with buried egg-like structures or worms lying in the ground.

3.1.5 | Other parasite biological features

Other aspects that we considered in the drawings are related to the Number and Type of depicted parasites, that is the quantity and different forms observed in the sheet. Regarding the number, one single parasite was most common in the drawings (Table 1). In multiple parasites compositions, one-third of the children represented different types of parasites (Table 1).

3.1.6 | Intestinal parasite disease description and risk perception

To evaluate whether children perceived potential relationship between parasites and disease, humans' and animals' moods were assessed based on facial expression, as described in other researches (Yevstigneyeva et al., 2014). Most of the human and animal figures presented happy expressions (Table 1), and only two students illustrated sad crying people (Figure 4).

3.2 | Retrieval practice

The practice was performed by 412 of the 437 children that participated during the activities of the first visit (trained children) plus the 41 students selected as the control group (untrained children).

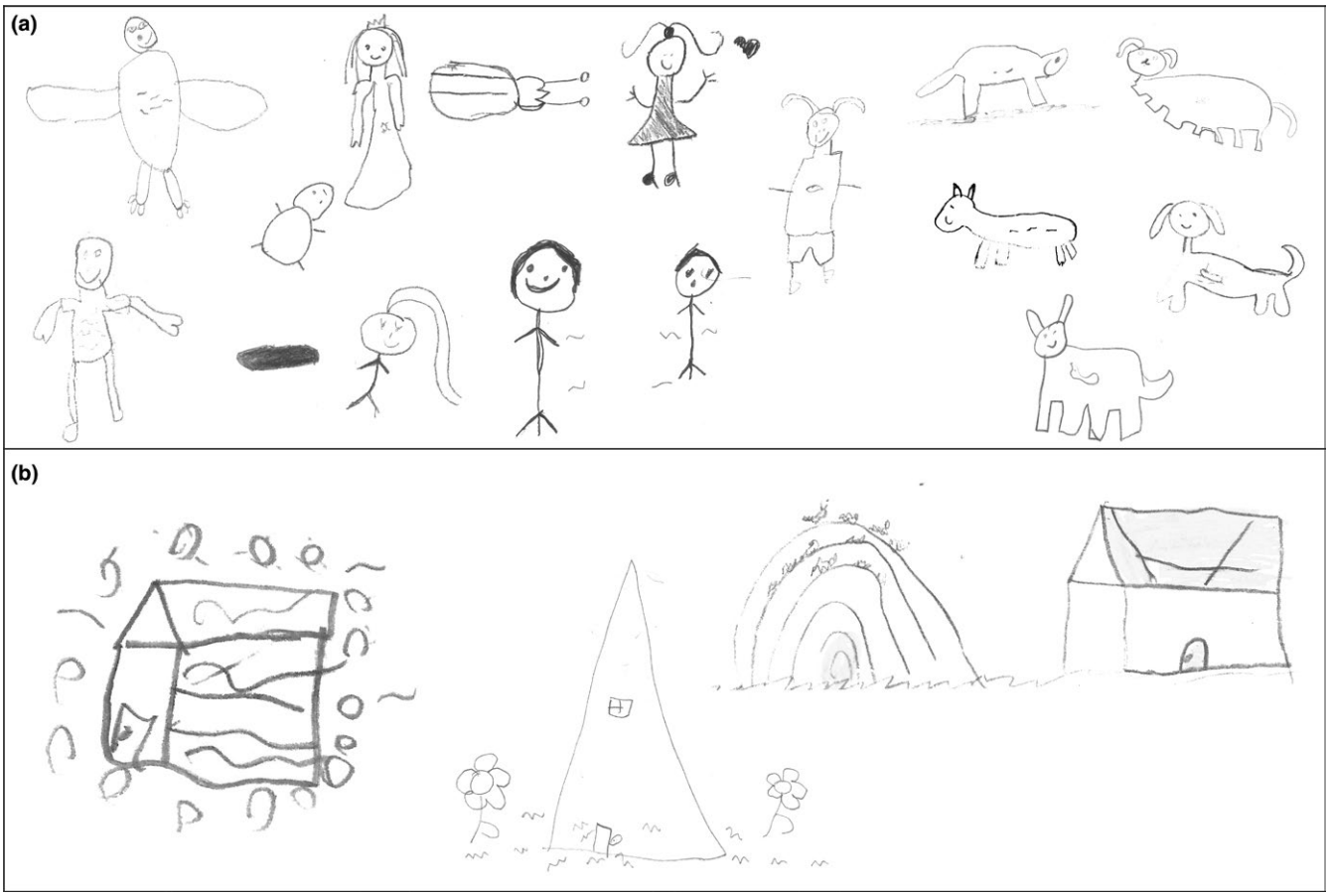

FIGURE 2 Parasite Host and Locations. (a) Examples of drawings of human and animal figures and its relation with parasites locations. (b) Examples of drawings representing parasites location regarding the house

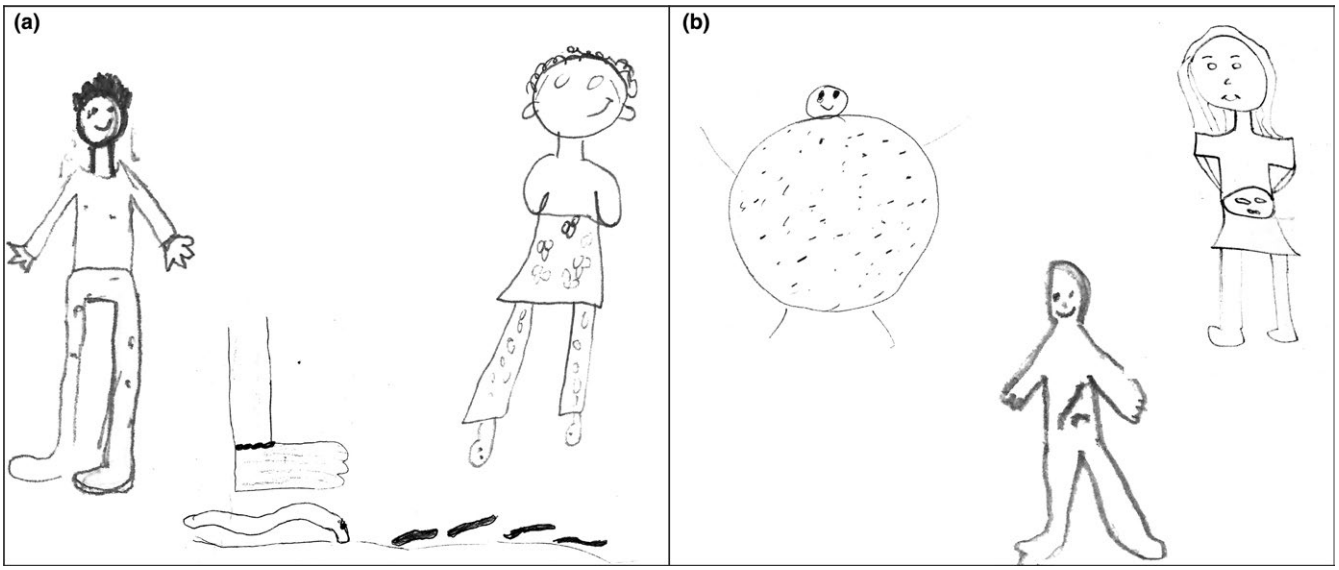

FIGURE 3 Parasite infective route. Examples of children's drawings depicting skin penetration (a) and oral penetration- (or belly parasites; b)

Twenty-five trained children were absent during the retrieval practice. In the retrieval activity, there was not any case of illustrations unanswered. The 65% of the trained children completed successfully all the activity (seven of seven) and only a low proportion (3%) answered wrongly ≥3 of the illustrated situations. The general performance of the trained children in the test was clearly better than a random

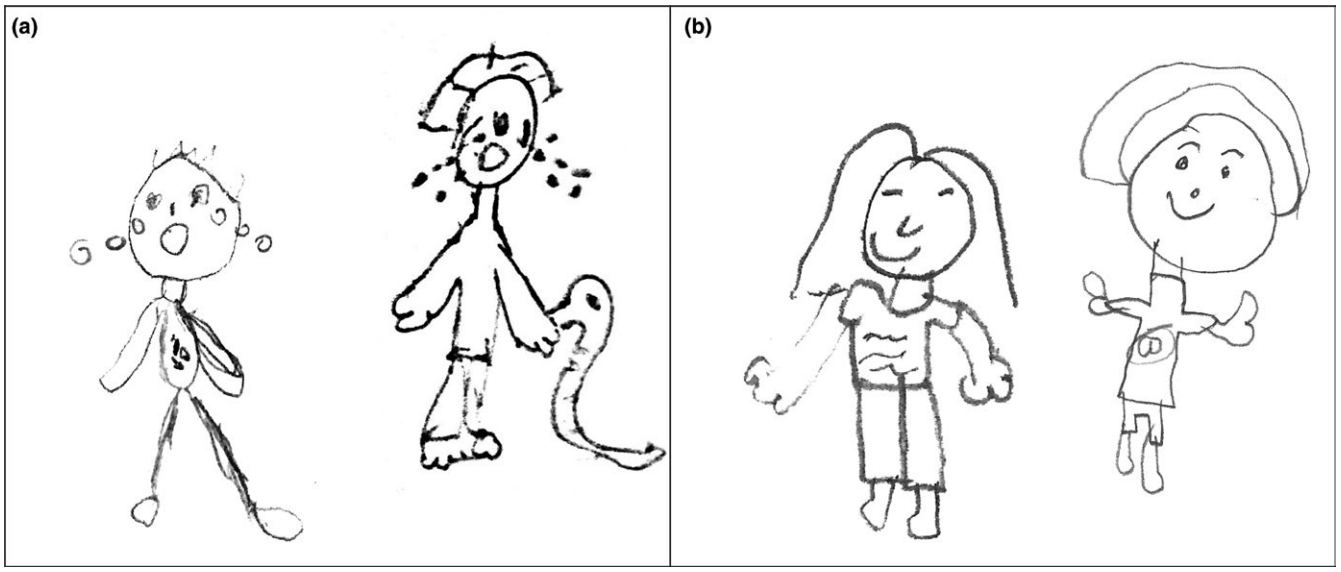

FIGURE 4 Parasite disease and risk perception. Hosts' facial expression as an indicator. Sad people drawings are depicted in panel a. Examples of happy hosts are in panel b

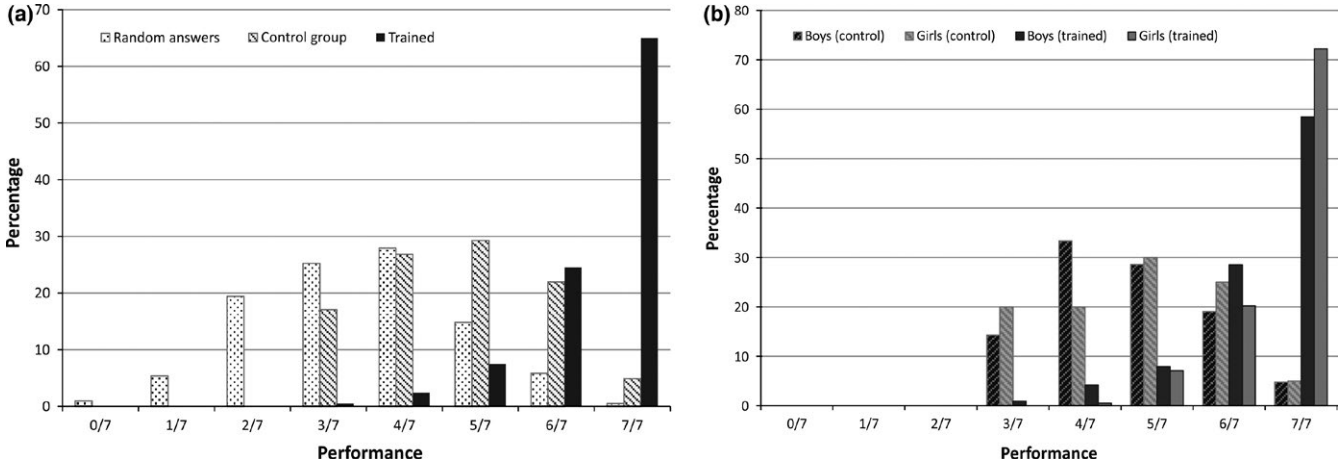

FIGURE 5 Children performance in retrieval activity. (a) The bar graphics shown retrieval activity performance after training, control untrained children and random answers simulation. (b) Performance disaggregated by gender. Boys versus untrained boys; girls versus untrained girls answers

answering (Figure 5 left panel, $D = .83$, $p < .001$) and the control group (Figure 5 left panel, $D = .63$, $p < .001$), which performed only a 5% of seven of seven questions and 44% of them had ≥3 wrong answers. The 7/7 optimum qualification was obtained by 72% of the girls and by 58% of the boys. The general performance of trained girls was slightly better than trained boys (Figure 5 right panel; $D = .14$, $p = .039$), but both of them performing better than the control groups of boys and girls (Figure 5 right panel; Boys: $D = .63$, $p < .001$; Girls: $D = .67$, $p < .001$). General performance between children from rural and urban schools was similar ($D = .03$, $p = 1$). Both groups had similar values in both; the percentage of cases with the optimal rate (rural = 64%, urban = 66%) and in the cases of minimal rate of correct answers (3/7; rural = 0.48%, urban = 0.50%).

The trained children showed a significantly better performance than the control group in five of the seven illustrations (Figure 6: I1: $\chi^2 = 5.70$, $df = 1$, $p = .02$; I3: $\chi^2 = 27.92$, $df = 1$, $p < .001$; I4: $\chi^2 = 62.49$, $df = 1$, $p < .001$; I6: $\chi^2 = 39.92$, $df = 1$, $p < .001$; I7: $\chi^2 = 50.49$, $df = 1$, $p < .001$). Although they were low, the higher frequency of errors in trained children was detected in those illustrations concerning the cutting fingernails practice (14%) and the habit of playing barefoot (22%; Figure 6), but also these were the illustrations that showed the greatest difference in better performance of trained children over the untrained ones, together with I7 ("not washing hands and food before eating"). Both trained and untrained children raised the same high rate of correct answers in the illustration about bathing-personal cleanliness (I2: 100%) and the illustration related to washing hands after using the toilet (I5: 97.6%; Figure 6).

The performance concerning responses about the opposing pairs was also assessed. Thus, in the case of 1–7 pair relative to personal hygiene, 95% correctly answered both illustrations, while the control

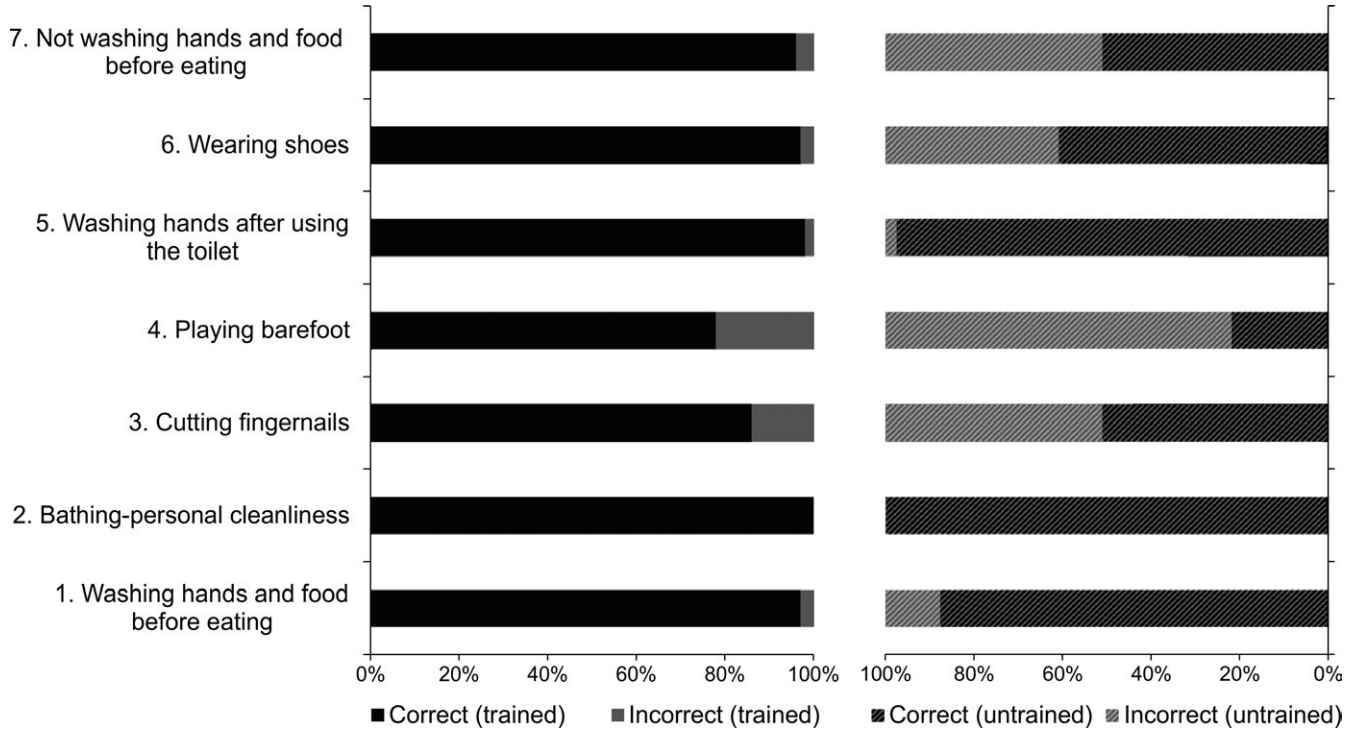

FIGURE 6 Healthy habits assessment. Frequencies of correct (green bars) and incorrect answers (red bars) in each illustrated situation of the retrieval activity. Trained children performance (left, control group (right)

group only raised 41.5% of combined correct answers (χ^2 = 65.81, *df* = 1, *p* < .001). On the other hand, for the 4–6 pair about wearing shoes the level of correct answers raised to 78%, lower than the other pair but still significantly higher than the 22% raised by the untrained children (χ^2 = 59.46, *df* = 1, *p* < .001).

4 | DISCUSSION

The tools used to accomplish the three aims— perception assessment, participative information transference and retrieval— and showed being appropriate to be incorporated in a sustainable school-based strategy to tackle intestinal parasitic diseases.

Analysing children's perceptions through drawings proved to be a very productive tool in terms of the enriching information that allows extracting. According to shape categories, the predominance of roundworm-like drawings suggests that the word parasite is an accurate trigger, due to children's formal or informal previous knowledge, or even their own visual experience. Actually, the most common oral descriptions would correspond to *Enterobius vermicularis* and *Ascaris lumbricoides*, both nematode parasites of high prevalence in the region (Gamboa et al., 2009). However, the fact that many depicted worms presented bristles may be explained by several accidents caused by the caterpillar *Lonomia obliqua* reported in the region during the development of the project (Sanchez, Mignone Chagas, Casertano, Cavagnaro, & Peichoto, 2015). An aboriginal child's death caused by this caterpillar had high impact on the community and within the classroom, while the media coverage showed images of the bristled "killer." Other pathogens represented would correspond to subcutaneous parasitic insects, as the sand flea *Tunga penetrans* and the human botfly *Dermatobia hominis*, agents of "Pique" and "Ura," respectively, both very common in the region (Salomón, 2005). Spiders also appeared and children referred to the black widow (*Latrodectus* spp), the banana spider (*Phoneutria* spp) and the corner spider (*Loxosceles* spp); in Misiones, these three genera cause serious poisoning accidents (Orduna et al., 2012) and they are a matter of study in the schools. Thus, although parasites could be identified by the shape, parasitism does not seem an internalized concept, and the health-disease perception is focused on acute exceptional accidents probably due to adult discourses about prevention, but not in naturalized regular ones.

Considering parasites' mood, we observed a trend to represent pathogens with expressive faces, either happy or frowning according to the sex, a component of the emotional and imaginative world extended to the drawing domain (Picard & Boulhais, 2011), as it is also the "monster" predominance for boys. Happy faces drawings were also reported in a Chagas disease study where facial expression was used as an indication of a potential relationship between triatomines and a disease (Yevstigneyeva et al., 2014). Infectious diseases are regarded by the population as events that repeatedly occur in a child's life and not as an alteration of the general health condition. Consequently, people act following socially accepted parameters, rather than knowledge of the risks (Castaño & Stella, 2009; Cockerham, 2005).

Regarding size, many children assigned "microscopic size" to the small parasites—but still visible to the naked eye—because they did not distinguish those which demand the use of magnifying equipment. Given the importance of preventing intestinal protozoan and

helminthic infections through the acquisition of their microscopic forms such as (oo) cyst and eggs, respectively, the microscopic concept was assessed during practical demonstrations.

The indoor/outdoor location of the parasites also showed girl/boy differences in urban schools. Children's illustration usually represented familiar environments, where boys develop competitive sports and girls more sedentary activities (Martínez-Bello & Moragón-Alcañíz, 2015). Interestingly, rural school children depicted both the exterior and the interior of the houses in a similar way suggesting that they do not distinguish structural differences in favour of healthy places.

In terms of oral acquisition, there were no illustrations presenting or schematizing the entry path of parasites from the mouth to the stomach. Most children said that they are born with parasites and the problem is present from an early age. This conception was also reported in communities from Misiones Province in other studies (Sy, 2009) strongly suggesting a cultural belief in the area. Oral acquisition needs to be addressed by emphasizing the importance of hand washing, proper meat preparation, vegetable washing and drinking water quality.

Skin penetration parasites did appear in some cases, being the feet the only part of the body identified as a place of entrance, and even ending in the belly. Nevertheless, as it was mentioned above the flea *T. penetrans* produces "Pique," well known by the children because of its foot skin penetration and intense itching. Additionally, although an important number of children recognized soil as a parasite habitat, walking barefoot is an ingrained habit, especially in boys, even more in those from rural areas. In fact, this issue presented the highest percentage of wrong answers in the retrieval activity. Furthermore, this effect was strongly evidenced in the control group which not received the ICTs activities where there was strong emphasis on this issue. Children that play football shoeless in many cases claim that they only have one pair of shoes, and mothers do not allow them to play with footwear because the lateritic soapy soil of Misiones is very difficult to clean. Therefore, any recommendation on this issue should take into account the actual agency to accomplish it, encouraging personal hygiene measures, selecting healthy places to play and involving mothers in the educational strategy. Although a core habit and so difficult to change, walking barefoot is a risk factor in many infections (Lesshafft et al., 2011; Schär et al., 2013; Winter, Oliveira, Wilcke, Heukelbach, & Feldmeier, 2009), as that by *Strongyloides stercoralis* that is endemic in the region and is responsible for systemic infections with severe complications, particularly in immune-compromised hosts (Beknazarova, Whiley, & Ross, 2016).

In this study, we used audio-visual material in cartoon format and power point presentation to transfer knowledge about intestinal parasites, parasitic disease, treatment and prevention. Moreover, besides the contents, it was the first chance for many children from humble neighbourhoods to come across giant screens and amplified audio, a fact that reinforced the attention and impact of the tool. This material was presented after understanding the main perception and misconceptions of the children regarding parasites. The difference observed in the performance of trained and untrained groups enhances the educational value of these activities.

From the "Valentin and the little invaders" activity emerged the Parasite Inspector licence, an extra useful instrument to transfer the treated issues into children's environments. This was provided to each child as a motivational tool, to enhance their commitment in transmitting the learned contents to their family and friends. The effect of this instrument was assessed during the second visit, where children were encouraged to share their experience as Parasite Inspectors. In general, all the children kept their licence in good conditions, and some added colours and plasticize it. They described different situations where they talk about parasites with family members and neighbourhood friends.

Regarding ICTs, most teachers explained they do not use them due to technical difficulties for integrating technology in the classroom. Investment in the field of public education to promote ICTs appropriation and creative use is necessary. Teachers should be encouraged to use technology; supported when using it; and, more importantly, teachers should understand the benefits of using technology themselves (Uluyol & Şahin, 2014).

Educational researchers highlight the importance of fixation activities, and the importance of tracking closely the results of educative activities to achieve organizational learning (Karpicke, 2012; Karpicke & Roediger, 2008). The performance of children in this activity was very good; they were able to respond adequately to the situations in the panels and with a very prominent performance in relation to the control group. However, we recognized a couple of specific issues as cutting nails and walking barefoot, important for parasitism prevention (Bello et al., 2011; Sah et al., 2013), that require specific approaches. Main biases are culturally driven (Karpicke & Roediger, 2008; Okanda & Itakura, 2010, 2011), for instance, going barefoot is associated with pleasant behaviours—to play football—and social positive inputs—mother indication to not wear shoes in some situations. Regarding this, there is evidence to suggest that subjecting children to several rounds of fixation activities provide better learning improvement (Karpicke & Roediger, 2008). It will be a great challenge to assess whether these practices would bring progress in dealing with deeply rooted sociocultural issues considering the particularities of the region.

In border areas, sociocultural issues and epidemiological features depict a confluence of behaviours, practices and knowledge that determine a unique complexity. In this regard, in Asia, for example, there exist international strategies that include the implementation of effective health education campaigns at primary school level to decrease the prevalence of Malaria disease in the international Greater Mekong Subregion (Okabayashi et al., 2006; Wang et al., 2016). Among the countries bordering with our region, Brazil has developed several approaches based on health and environmental education to prevent Schistosomiasis and other intestinal infections (Gazzinelli, Gazzinelli, Santos, & Goncalves, 2002; Gazzinelli, Kloos, de Cassia Marques, dos Reis, & Gazzinelli, 2008; Gazzinelli et al., 2006). Although there is a substantial growing work directed to face the infection diseases based on educational strategies, more efforts have to be made to attend these issues from a joint perspective among neighbourhood countries. Implementation of cross-border health education strategies would support the ideal scenery in benefit of healthy people and environments.

This package of perception assessment, participative information transference and retrieval activities can be an appropriate tool in a sustained school-based strategy to tackle intestinal parasitic diseases on specific scenarios. Changes in risky and unhealthy behaviours together with improvement of household conditions were stated as parts of a definitive solution for eliminating parasitic diseases. Therefore, efforts to bring together scientists, decision-makers and community members into the educational sphere, alongside with political commitment have to be persistent to achieve an integral improvement of people's life quality.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

Asaolu, S. O., & Ofoezie, I. E. (2003). The role of health education and sanitation in the control of helminth infections. *Acta Tropica*, *86*(2–3), 283–294.

Atkinson, D. (2002). *Art in education: Identity and practice*. Dordrecht: Kluwer Academic Publishers.

Ayi, I., Nonaka, D., Adjovu, J. K., Hanafusa, S., Jimba, M., Bosompem, K. M., … Kobayashi, J. (2010). School-based participatory health education for malaria control in Ghana: Engaging children as health messengers. *Malaria Journal*, *9*,98. https://doi.org/10.1186/1475-2875-9-98

Barbosa, C. S. (1998). Epidemiology and anthropology: An integrated approach dealing with bio-socio-cultural aspects as strategy for the control of endemic diseases. *Memorias do Instituto Oswaldo Cruz*, *93*, 59–62.

Beknazarova, M., Whiley, H., & Ross, K. (2016). Strongyloidiasis: A disease of socioeconomic disadvantage. *International Journal of Environmental Research and Public Health*, *13*(5), 517. https://doi.org/10.3390/ijerph13050517

Bello, J., Nunez, F. A., Gonzalez, O. M., Fernandez, R., Almirall, P., & Escobedo, A. A. (2011). Risk factors for Giardia infection among hospitalized children in Cuba. *Annals of Tropical Medicine and Parasitology*, *105*(1), 57–64.

Castaño, L. S. A., & Stella, L. (2009). Los determinantes sociales de la Salud, más allá de los factores de riesgo. *Revista Gerencia*, *69*–79.

Cockerham, W. C. (2005). Health lifestyle theory and the convergence of agency and structure. *Journal of Health and Social Behavior*, *46*(1), 51–67.

Cox, S. (2005). Intention and Meaning in Young Children's Drawing. *International Journal of Art & Design Education*, *24*(2), 115–125. https://doi.org/10.1111/j.1476-8070.2005.00432.x

Crocco, L., Rodriguez, C., Catala, S., & Nattero, J. (2005). Chagas disease in Argentina: Tools for schoolchildren to exercise vector surveillance and identify household risk factors. *Cadernos de Saúde Pública*, *21*(2), 646–651.

Gamboa, M. I., Kozubsky, L. E., Costas, M. E., Garraza, M., Cardozo, M. I., Susevich, M. L., … Navone, G. T. (2009). Asociación entre geohelmintos y condiciones socioambientales en diferentes poblaciones humanas de Argentina. *Revista Panamericana de Salud Pública*, *26*, 1–8.

Gazzinelli, M. F., Gazzinelli, A., Santos, R. V., & Goncalves, L. A. (2002). The interdiction of disease: A cultural construction of schistosomiasis in an endemic area in Minas Gerais, Brazil]. [Research Support, Non-U S Gov't. *Cad Saude Publica*, *18*(6), 1629–1638.

Gazzinelli, M. F., Kloos, H., de Cassia Marques, R., dos Reis, D. C., & Gazzinelli, A. (2008). Popular beliefs about the infectivity of water among school children in two hyperendemic schistosomiasis areas of Brazil. [Research Support, N I H, Extramural Research Support, Non-U S Gov't]. *Acta Tropica*, *108*(2–3), 202–208.

Gazzinelli, M. F., Reis, D. C., Kloos, H., Velasquez-Melendez, G., Dutra, I. R., & Gazzinelli, A. (2006). The impact of two education methods on knowledge of schistosomiasis transmission and prevention among schoolchildren in a rural community in northern Minas Gerais, Brazil. [Research Support, Non-U S Gov't]. *Memorias do Instituto Oswaldo Cruz*, *1*, 45–53.

Jia, T.-W., Melville, S., Utzinger, J., King, C. H., & Zhou, X.-N. (2012). Soil-transmitted helminth reinfection after drug treatment: A systematic review and meta-analysis. *PLoS Neglected Tropical Diseases*, *6*(5), e1621.

Juarez, M. M., & Rajal, V. B. (2013). Intestinal parasitoses in Argentina: Major causal agents found in the population and in the environment. *Revista Argentina de Microbiologia*, *45*(3), 191–204.

Karpicke, J. D. (2012). Retrieval-based learning active retrieval promotes meaningful learning. *Current Directions in Psychological Science*, *21*(3), 157–163.

Karpicke, J. D., & Blunt, J. R. (2011). Retrieval practice produces more learning than elaborative studying with concept mapping. *Science*, *331*(6018), 772–775.

Karpicke, J. D., & Roediger, H. L. (2008). The critical importance of retrieval for learning. *Science*, *319*(5865), 966–968. https://doi.org/10.1126/science.1152408

Lesshafft, H., Schuster, A., Reichert, F., Talhari, S., Ignatius, R., & Feldmeier, H. (2011). Knowledge, attitudes, perceptions, and practices regarding cutaneous larva migrans in deprived communities in Manaus, Brazil. *The Journal of Infection in Developing Countries*, *6*(05), 422–429.

Marteau, T. M., Hollands, G. J., & Fletcher, P. C. (2012). Changing human behavior to prevent disease: The importance of targeting automatic processes. *Science*, *337*(6101), 1492–1495.

Martínez-Bello, V., & Moragón-Alcañíz, F. (2015). Juegos de niñas y juegos de niños: Estudio sobre la representación del juego infantil a través del dibujo. *Revista Educación*, *40*(1), 1–17.

Nasr, N. A., Al-Mekhlafi, H. M., Ahmed, A., Roslan, M. A., & Bulgiba, A. (2013). Towards an effective control programme of soil-transmitted helminth infections among Orang Asli in rural Malaysia. Part 2: Knowledge, attitude, and practices. *Parasites & Vectors*, *6*(1), 1–12. https://doi.org/10.1186/1756-3305-6-28

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.

Nores, M. (2010). *Valentin y los pequeños invasores*. Córdoba: Secretaría de Extensión Universitaria. Universidad Nacional de Córdoba.

Nores, M. J., Caminos, R., Rivero, M. R., Vidal, M. E., Ropolo, A. S., & Touz, M. C. (Producer). (2010). *Valentín y los pequeños invasores*. Tema: Parasitosis intestinal infantil. Retrieved from http://vimeo.com/16281264

Okabayashi, H., Thongthien, P., Singhasvanon, P., Waikagul, J., Looareesuwan, S., Jimba, M., … Tateno, S. (2006). Keys to success for a school-based malaria control program in primary schools in Thailand. [Research Support, Non-U S Gov't]. *Parasitology International*, *55*(2), 121–126.

Okanda, M., & Itakura, S. (2010). When do children exhibit a "yes" bias? *Child Development*, *81*(2), 568–580.

Okanda, M., & Itakura, S. (2011). Do young and old preschoolers exhibit response bias due to different mechanisms? Investigating children's response time. *Journal of Experimental Child Psychology*, *110*(3), 453–460.

Orduna, T. A., Lloveras, S. C., De Roodt, A. R., Costa de Oliveira, V., García, S. I., & Haas, A. (2012). *Guía de prevención, diagnóstico, tratamiento y vigilancia epidemiológica de los envenenamientos por arañas*. (1st ed.). Buenos Aires: Ministerio de Salud de la Nación.

Petris, A. O., Tatu-Chitoiu, G., Cimpoesu, D., Ionescu, D. F., Pop, C., Oprea, N., & Tint, D. (2016). "You can also save a life!": Children's drawings as a non-verbal assessment of the impact of cardiopulmonary resuscitation training. *Internal and Emergency Medicine*, *27*, 27.

Picard, D., & Boulhais, M. (2011). Sex differences in expressive drawing. *Personality and Individual Differences*, *51*(7), 850–855.

Puglionesi, A. (2016). Drawing as instrument, drawings as evidence: Capturing mental processes with pencil and paper. *Medical History*, *60*(3), 359–387.

R Development Core Team (2016). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing.

Ring, K. (2006). Supporting young children drawing: Developing a role. *International Journal of Education through Art*, *2*(3), 195–209.

Sah, R. B., Bhattarai, S., Yadav, S., Baral, R., Jha, N., & Pokharel, P. K. (2013). A study of prevalence of intestinal parasites and associated risk factors among the school children of Itahari, Eastern Region of Nepal. *Tropical Parasitology*, *3*(2), 140–144.

Salomón, O. D. (2005). *Artrópodos de interés médico en Argentina*. Buenos Aires: Fundación Mundo Sano.

Sanchez, M. N., Mignone Chagas, M. A., Casertano, S. A., Cavagnaro, L. E., & Peichoto, M. E. (2015). Accidents with caterpillar Lonomia obliqua (Walker, 1855). An emerging problem. *Medicina*, *75*(5), 328–333.

Schär, F., Trostdorf, U., Giardina, F., Khieu, V., Muth, S., Marti, H., … Odermatt, P. (2013). Strongyloides stercoralis: Global distribution and risk factors. *PLoS Neglected Tropical Diseases*, *7*(7), e2288.

Shigehatake, Y., Yokota, C., Amano, T., Tomii, Y., Inoue, Y., Hagihara, T., … Minematsu, K. (2014). Stroke education using an animated cartoon and a manga for junior high school students. *Journal of Stroke and Cerebrovascular Diseases*, *23*(6), 1623–1627.

Sy, A. (2009). Everybody is a bit of ill and crazy. The parasitosis and the parasite disease in the valley of Cuña Piru, province of Misiones, in Argentina. *Gazeta de Antropología*, *25*(1), 11.

Uluyol, Ç., & Şahin, S. (2014). Elementary school teachers' ICT use in the classroom and their motivators for using ICT. *British Journal of Educational Technology*, *47*(1), 65–75.

Vivas, A., Gelaye, B., Aboset, N., Kumie, A., Berhane, Y., & Williams, M. A. (2010). Knowledge, attitudes, and practices (KAP) of hygiene among school children in Angolela, Ethiopia. *Journal of Preventive Medicine and Hygiene*, *51*(2), 73–79.

Wang, R. B., Dong, J. Q., Xia, Z. G., Cai, T., Zhang, Q. F., Zhang, Y., … Zhang, J. (2016). Lessons on malaria control in the ethnic minority regions in Northern Myanmar along the China border, 2007-2014. *Infectious Diseases of Poverty*, *5*(1), 95.

WHO (2012). *Accelerating work to overcome the global impact of neglected tropical diseases* Geneva: World Health Organization.

Winter, B., Oliveira, F. A., Wilcke, T., Heukelbach, J., & Feldmeier, H. (2009). Tungiasis-related knowledge and treatment practices in two endemic communities in northeast Brazil. *Journal of Infection in Developing Countries*, *3*(06), 458–466.

Yevstigneyeva, V., Camara-Mejia, J., & Dumonteil, E. (2014). Analysis of children's perception of triatomine vectors of chagas disease through drawings: Opportunities for targeted health education. [Research Support, Non-U S Gov't]. *PLoS Neglected Tropical Diseases*, *8*(10), e3217.

Yonah, Z. (2005). *ICTs as tools for poverty reduction*. Paper presented at the Proceeding of the Discourse on Engineering Contribution in Poverty Reduction, Dar es Salaam, Tanzania.

Zonta, M. L., Garraza, M., Castro, L. E., Navone, G. T., & Oyhenart, E. E. (2011). *Pobreza, estado nutricional y enteropasitosis infantil: Un estudio transversal en Aristóbulo del Valle, Misiones*, Vol. 31. Nutrición Clínica y Dietética Hospitalaria: Argentina.

SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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