The impact of ecological sanitation on parasitic infections in rural El Salvador*

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Abstract

This study was designed to evaluate the impact of latrines on intestinal parasitic infection in rural areas of El Salvador where a variety of latrine designs are used, including double-vaulted, urine-diverting desiccating latrines (LASFs), solar desiccating latrines, pit latrines and no latrines. Demographic, environmental, and behavioral factors surrounding the disposal of human excreta were also examined. The objectives of this study were (1) to provide an estimate of the baseline prevalence of helminth infection in rural areas of El Salvador, (2) to identify the determinants of intestinal parasitic infection in each study region, and (3) to provide recommendations to guide future latrine interventions within the social and environmental context of rural El Salvador. Interviews were conducted with 113 heads of households, and faecal samples from 566 individuals were evaluated for the presence of intestinal parasites. Pathogens identified were: *Ascaris lumbricoides* (8%), *Trichuris trichiura* (20%), hookworm (21%), *Giardia* (12%), and *Entamoeba histolytica* (17%). LASF latrines were found to be significantly associated with an increased prevalence of *Ascaris* and *Trichuris* (OR=16 and 5, respectively). Both LASFs and solar latrines were protective against other pathogens. In this population, biosolids are rarely used as fertilizer, and are usually dispersed in the yard or buried. Increased contact with inadequately treated human excreta during emptying of latrines may explain the increased risk for *Ascaris* infection we observed.

Introduction

The containment of human excreta through the provision of safe sanitation services is one of the most basic and important interventions for preventing the transmission of intestinal parasites and reducing the grave impact that they have on human health. Through various government and NGO-sponsored projects, a variety of latrine models, including LASF and solar desiccating latrines have been installed in rural areas of El Salvador. These are designed to inactivate microbial pathogens while producing a soil conditioner that can be used in agriculture. The theoretical impact of these latrines on health is well accepted, but latrines are often not used in a way that allows for the complete destruction of pathogens in human excreta, and little scientific research has been conducted to evaluate the impact of these interventions on the prevalence of parasitic infection.

In order to maximize the efficacy and safety of latrines and provide the best protection against parasitic infection, public health interventions must consider the biological and environmental

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contexts, as well as behavioral, demographic and acceptability factors that will determine the most appropriate and effective latrine type for a given area and population.

Methods

Information was gathered through interviews with heads of households from 113 households in 8 communities where one of the four sanitation disposal methods is used. Fresh stool samples were collected from 566 individuals from these households and analyzed for the presence of intestinal parasites. Only persons for whom we had both stool sample results and interview information were in included in the study, resulting in a total of 499 individuals. Thirty-one households used LASF latrines, 22 used solar latrines, 31 used pit latrines and 25 had no latrines. We included 22 households with desiccating latrines that reported use of the excreta in agriculture.

Interviews were conducted with female heads of households at their homes. Names, ages and gender of up to 8 household members were requested. Information was gathered on parental education and literacy, recent antihelminthic treatment, water supply, diarrhea, and the use of natural remedies for the prevention or treatment of parasitic infection. Observations were made of the construction materials of the house, and whether any member exhibited overt signs of malnutrition. Relative socio-economic status (SES) was scored based on house construction and ownership of household appliances. For families with latrines, we asked how latrine contents were used or discarded, how many people used the latrine, whether the users experienced any problems such as flies or bad odor, and about their general level of satisfaction with the latrine. For households that did not have latrines, we gathered information about their defecation practices and preferences. Faecal samples were processed using Evergreen Scientific brand Fecal Parasite Concentrator Kits®, a modification of the Ritchie formalin-ether method that increases the sensitivity of helminth ova detection in stool. Processed samples were checked for the presence of intestinal parasites by light microscopy, and classified as either positive or negative, regardless of load. The field team returned to the study households to provide the results of the laboratory tests and provide medication for persons who tested positive for helminths or protozoa.

Results

Fifty-two percent (258/499) of the population was infected with one or more of the parasitic infections identified. The overall prevalence of *Ascaris* was 8%, *Trichuris* 20%, hookworm 21%, *Giardia* 12%, and *E. histolytica* 17%. Prevalence of infection with helminths and protozoa by latrine type is shown in Figures 1a and 1b, respectively. Table 1 shows the odds ratios for infection by latrine type, controlling for other risk factors (logistic regression analysis).

The study communities differed by several factors that can affect parasitic prevalence, including latrine type, SES, age structure, distribution of antihelminthic medication, literacy, having a dirt floor, and owning pigs. The majority of *Ascaris* (77%) and *Trichuris* (58%) infections were concentrated in one LASF community where 28% and 56% of the population was infected, respectively.

In bivariate analysis, having a dirt floor was associated with a higher prevalence of infection for all parasites, but was significant for *Trichuris* (OR=1.9), hookworm (OR=2.6), and *Giardia* (OR=3.4). Being in the lowest SES group was a risk factor for all pathogens, but significant for *Trichuris* (OR=2.4) and *Giardia* (OR=6.2). Having taken antihelminthic medication in the last 3 months was significantly protective only for hookworm (OR=0.17). Owning pigs was significantly associated with helminth infection (*Ascaris* OR=3.2;*Trichuris* OR=2.8; hookworm OR=2.4). Males had a higher prevalence of *Trichuris* (OR=1.6) and hookworm (OR=2.0) than females. *Ascaris* and *Trichuris* infections were highest among the 6-12 year age group, while hookworm infection peaked in young adults (19-30). Overt signs of malnutrition were observed in associa-

tion with *Trichuris* and hookworm. Discarding stored latrine contents in fields or around the house protected against pathogens with shorter survival in the environment (hookworm, *Giardia*, and *E. histolytica*), but was associated with an increased prevalence of infection with *Ascaris* and *Trichuris* (Table 2).

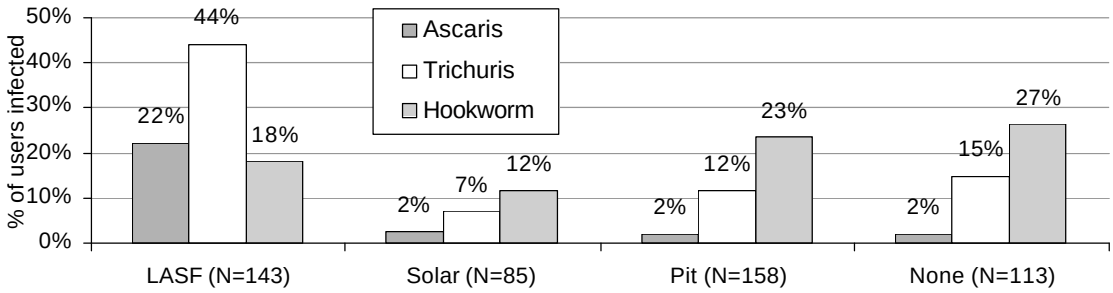

Figure 1 a: Prevalence of helminth infection among users of different latrine types or no latrine

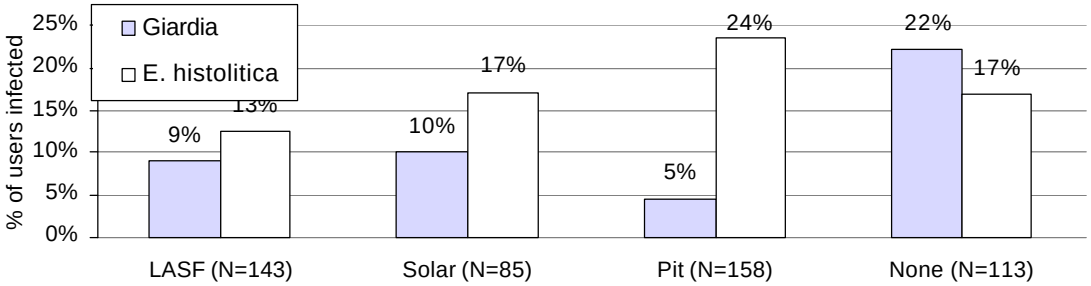

Figure 1 b: Prevalence of protozoa infection among users of different latrine types or no latrine

	Ascari	*Trichur*	Hookwo n	*Giardi*	*E. histoly ca*
LASF	**27.1 (p=0.0002)**	**7.7 (p<0.0001)**	**0.4 (p=0.02)**	0.5 (p=0.12)	0.7 (p=0.53)
Solar latrine	2.5 (p=0.41)	1.7 (p=0.34)	**0.4 (p=0.05)**	**0.3 (p=0.04)**	1.9 (p=0.15)
Pit latrine	1.4 (p=0.75)	0.6 (p=0.39)	1.0 (p=0.93)	**0.2 (p=0.04)**	1.5 (p=0.40)

*ORs for latrine and parasite, controlling for SES, age, gender, maternal literacy, dirt floor, having taken antihelmi n-thic medication, malnutrition, owning pigs, and agriculture. Analyzed using SAS 8.0 (SAS Institute, Inc. Cary, NC). Reference group is having no latrine

Table 1: Odds ratios for latrine type and infection from logistic regression analysis*

How contents are discarded	*Ascari*	*Trichur*	Hookw rm	Giardi	*E. histolyti a*
Fertilize fields	**6.9 (p=0.002)**	**8.3 (p<0.0001)**	1.6 (p=0.16)	1.0 (p=0.97)	1.3 (p=0.53)
Fertilize yard or garden	**11.3 (p<0.0001)**	**9.6 (p<0.0001)**	**0.26 (p=0.005)**	1.0 (p=0.94)	1.1 (p=0.88)
Buried in yard	**9.2 (p<0.0001)**	**3.9 (p=0.0008)**	**0.33 (p=0.01)**	**0.14 (p=0.03)**	**0.31 (p=0.03)**

*Reference group is pit latrine users (latrine contents not discarded)

Table 2: Odds ratios for infection and how latrine contents are discarded (bivariate analysis)*

Discussion

More than half of the population was infected with one or more pathogen, indicating a significant health problem. Differences in prevalence by community were observed, suggesting that community-specific factors affect the prevalence of these pathogens. Communities with no latrines and pit latrines were typically poorer, more remote and less contaminated. One limitation of this study is that, because latrine interventions were carried out as community-wide initiatives, we could not compare households with different latrine types in the same community.

The lower prevalence of hookworm, *Giardia* and *E. histolytica* among users of LASF and solar latrines probably reflects more effective containment and destruction of these less-persistent pathogens as compared to having a pit latrine. In contrast, our previous studies have found that *Ascaris* and *Trichuris* may survive in stored latrine samples for more than 2 years and are highly resistant to destruction by temperature, pH and humidity. We also found that the solar latrines generally achieve higher internal temperatures and lower humidity than LASFs, which should promote more rapid inactivation of helminth ova (Moe CL, R Izurieta, LF Cohen, and SA Esrey. Microbiological studies of ecological sanitation in El Salvador. First International Conference on Ecological Sanitation, November 2001, Nanning, China). It is not clear why the prevalence of *Trichuris* was higher than that of *Ascaris* since they have the same route of transmission and similar survival.

It was striking that the prevalence of *Ascaris* and *Trichuris* infections is higher among LASF latrine users than among users of other latrine types and those with no latrine, suggesting that LASF latrines may pose an increased risk for certain helminth infections. Opportunities for exposure to environmentally persistent pathogens occur during maintenance and emptying of the latrine, or if the biosolids are used as fertilizer in agriculture or dispersed around the home. If contents are buried in the yard, the same risks for contamination exist as for pit latrines, with an additional risk introduced through handling the biosolids when emptying the vault.

When we examined the distribution of enteric infection in the 2 LASF communities, we found that the majority of cases were in 1 community, while the prevalence in the other LASF community was not significantly higher than for other latrine types. Factors other than latrine type may also contribute to the differences observed in prevalence of infection. A higher level of contamination and crowding, and differences in age structure, SES, water source, having a dirt floor, and the distribution of antihelminthic medication impact pathogen transmission independently and are also believed to modify the effectiveness of the latrines. The results of this study must be interpreted with caution because of the relatively small number of study households and possible effects of confounding factors.

Conclusions

- The use of LASF latrines was associated with an increased prevalence of *Ascaris* and *Trichuris*, which survive the conditions achieved by these latrines. Handling of biosolids during maintenance and discarding of latrine contents increases exposure to enteric pathogens, suggesting the need to improve maintenance techniques and/or design to ensure the complete inactivation of biosolids.
- Environmental and demographic factors modify the effectiveness of latrines to control the spread of enteric pathogens and should be considered in latrine interventions.
- LASF and solar latrines were associated with lower prevalence of less persistent pathogens, including hookworm, *Giardia*, and *E. histolytica.*
- Solar latrines appear to be a more effective intervention than LASFs in this environment, and therefore should be promoted in rural areas of El Salvador.