Association Between Household Water Quality and Incidence of Intestinal Protozoan Infection in Children

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Abstract:.
Intestinal protozoan infections continue to pose a significant public health challenge, particularly in regions with inadequate sanitation. Contaminated water represents a major transmission route, as protozoan cysts are able to persist in various household water sources. This study aimed to examine the association between household water quality and the occurrence of intestinal protozoan infections in children. Data were collected through microscopic examinations of both fecal samples and household drinking water. This observational analytic study employed a cross-sectional design and included 50 elementary school children. The results showed that 62% of the participants were infected with intestinal protozoa. Among children who consumed refillable gallon water, 44.4% were infected, whereas 71.9% of those who consumed well water tested positive. Statistical analysis yielded a p-value of 0.055. Protozoan contamination was detected in half of the household drinking water samples; infection rates were 63.3% among children whose water was not contaminated and 50% among those whose water was contaminated (p = 0.52). In conclusion, although no statistically significant association was identified between household water quality and intestinal protozoan infections, the findings indicate a higher risk among children who consumed well water.

Keywords: children; intestinal protozoan; parasitic infection; water quality

1. INTRODUCTION

Intestinal protozoan infections (IPI) continue to represent a major global health burden, particularly in low- and middle-income countries where access to clean water and adequate sanitation remains limited. (Hailegebriel T,2018) Protozoan species such as *Giardia lamblia*, *Entamoeba histolytica*, and *Blastocystis hominis* are capable of causing gastrointestinal symptoms ranging from mild discomfort to severe, persistent diarrhea, especially in children. Transmission commonly occurs through the fecal–oral route, with contaminated drinking water recognized as one of the primary pathways.

The prevalence of intestinal protozoan infections remains relatively high (Debash H, 2023). A study in Ethiopia involving 500 children aged 1 to 5 years reported an intestinal parasitic infection prevalence of 47%, with *Giardia lamblia* being the most common infection (22%) (Osman, 2020). Similarly, in Mexico, 34% of children aged 6 months to 5 years were found to be infected with intestinal parasites such as *Ascaris lumbricoides*, *Entamoeba histolytica*, and *Giardia lamblia* (Gutiérrez-Jiménez, 2019). Research conducted in Bekasi, West Java, Indonesia, also reported a prevalence of *Blastocystis hominis* of 60.8%, *Giardia lamblia* of 33.8%, and *Entamoeba histolytica* of 1.4% (Winita R, 2016).

The clinical manifestations of intestinal protozoan infections may include nausea, vomiting, abdominal pain, and diarrhea (Pramestuti N, 2017). These parasitic infections can lead to digestive disturbances and impaired nutrient absorption, which may result from the shortening and dystrophy of intestinal microvilli or the formation of intestinal ulcers (Herbowo, 2016). A study conducted by Osman et al. reported that children with giardiasis were 3.5 times more likely to experience malnutrition compared to uninfected children.

School-aged children represent one or the most vulnerable groups due to immature hygiene behaviors, frequent contact with contaminated environments, and lower awareness of sanitation measures. In Indonesia, previous studies have shown that intestinal protozoan infections are common in rural and peri-urban areas, where household often rely on untreated water sources such as wells.

Several studies have suggested that household water sources and water quality are key determinants in the transmission of intestinal protozoa. In various regions of Indonesia, household water quality remains a major public health concern. Poor-quality water can act as an

important transmission route for numerous diseases, especially those caused by intestinal protozoa. Contributing factors such as inadequate sanitation, limited access to clean water, and close human–animal interactions further exacerbate disease spread (Ogalo, 2025). A similar situation has been reported in the quilombola community of Santa Luzia do Norte, Brazil, where most physicochemical water parameters, such as turbidity and pH, failed to meet health standards, and microbial contamination with coliforms was documented. These findings highlight the community's vulnerability due to the absence of adequate basic sanitation and emphasize the high potential for waterborne diseases (Correia MS, 2022). In Shanghai, China, wastewater-based epidemiology (WBE) has demonstrated its effectiveness in detecting *Cryptosporidium spp.*, *G. duodenalis*, and *Enterocytozoon bieneusi*. These protozoa were identified in both influent and effluent wastewater from treatment plants, suggesting a potential risk of transmission through recycled water intended for domestic or agricultural use. PCR-based detection at the genotype and subtype levels is essential for accurately tracing contamination sources and better understanding transmission dynamics (Jiang, 2024).

These findings from various regions highlight the importance of integrating cross-sectoral approaches, such as One Health, as well as the critical role of water quality monitoring in the prevention and control of waterborne diseases. Efforts to improve water treatment, provide basic sanitation infrastructure, and strengthen community education are essential components for enhancing overall public health conditions. However, community-level findings continue to show inconsistent results, likely due to variations in sanitation conditions, hygiene behaviors, and environmental exposures. Therefore, this study aimed to assess the association between household water quality, both based on water source type and laboratory-confirmed contamination, and the incidence of intestinal protozoan infections among elementary school children in Pesawaran Regency.

2. MATERIALS AND METHODS

This study employed a cross-sectional analytic design and was conducted at public elementary school at Pesawaran Regency, Indonesia, an area where household water access depends largely on refillable gallon water or groundwater wells. The study population consisted of all students enrolled at the school. Using consecutive sampling, 50 children whose parents or guardians provided informed consent were included.

Data collection involved a simple questionnaire, fecal samples and household drinking water samples. Fecal samples were examined using direct wet mount microscopy and iodine staining to detect intestinal protozoan. Drinking water samples collected from each household were concentrated using sedimentation techniques and subsequently examined microscopically for protozoan cysts. Protozoa identification was performed based on standard morphological criteria in accordance with WHO guidelines and Garcia (2016) protocols.

Data were analyzed using statistical software. Univariate analysis was used to summarize participant characteristics and infection prevalence. Bivariate analysis using chi-square test was conducted to assess associations between household water factors and intestinal protozoan infections. A p-value of < 0.05 was considered statistically significant.

3. RESULTS AND DISCUSSIONS

Total of 50 elementary school children participated in this study. Of these, 24 (48%) were male and 26 (52%) were female, indicating a relatively balanced sex distribution. This balance suggests that gender differences were unlikely to influence the outcomes of the parasitological examinations.

Based on microscopic examination of fecal samples using the formalin–ether sedimentation technique and Iodine's staining, 31 children (62%) were found to be infected with intestinal protozoa, while 19 (38%) were not infected (Table 1). These findings indicate that intestinal protozoan infections remain highly prevalent among the students.

Table 1. Distribution of Intestinal Protozoan Infection Status

Infection Status	n	%
Positive	31	62
Negative	19	38
Total	50	100

Information from questionnaires revealed that 32 children (64%) consumed well water, while 18 (36%) consumed refillable gallon water (Table 2). This indicates that well water remains the dominant source of drinking water among the study population.

Table 2. Distribution of Drinking Water Sources

Water Sources	n	%
Reffilable gallon water	18	36
Well water	32	64
Total	50	100

Microscopic examination of 15 mL drinking water samples from each household showed that 6 samples (12%) contained intestinal protozoa, while 44 samples (88%) were free of detectable protozoan contamination. Although the proportion of contaminated samples was relatively small, the presence of protozoa in drinking water reflects a potential route of exposure.

Children who consumed well water had a higher prevalence of infection (71.9%) compared to those who consumed refillable gallon water (44.4%) (Table 3). However, statistical analysis using the chi-square test yielded a p-value of 0.055, which is slightly above the conventional significance threshold. This indicates that the association between water source and intestinal protozoan infection was not statistically significant, although the trend suggests a higher risk among well-water users.

Table 3. Association Between Drinking Water Sources and Intestinal Protozoan Infection

Water Sources	Positive	Negative	Total	p-value
Reffilable gallon water	8 (44,4%)	10 (55,6%)	18	0,055
Well water	23 (71,9%)	9 (28,1%)	32	
Total	31	19	50	

Children whose household drinking water was contaminated had an infection rate of 50%, whereas those whose water was not contaminated had an infection rate of 63.6%. Statistical testing showed no significant association between water contamination status and intestinal protozoan infection (p = 0.52) (Table 4), indicating that the presence of protozoa in drinking water samples did not significantly correlate with infection status.

Table 4. Association Between Water Contamination Sources and Intestinal Protozoan Infection

Water Quality	Positive	Negative	Total	p-value
Contaminated	3 (50%)	3 (50%)	6	0,52
Not Contaminated	28 (63,6%)	16 (36,4%)	44	
Total	31	19	50	

The results of this study show that intestinal protozoan infections remain highly prevalent among elementary school children in Pesawaran Regency, with an overall infection rate of 62%. This prevalence aligns with previous findings from regions with similar characteristics, where limited sanitation and suboptimal hygiene practices contribute to the ongoing transmission of protozoa. Children who consumed well water exhibited a higher prevalence of intestinal protozoan infections (71.9%) compared with those who consumed refillable gallon water (44.4%). Although the association did not reach statistical significance (p = 0.055), the value is close to the threshold, suggesting a tendency that the use of untreated or inadequately treated well water may increase infection risk.

These findings suggest that water sources may influence infection risk, even though the association was not statistically significant. The higher proportion of infections among children relying on well water supports the possibility that untreated groundwater may act as a greater risk factor. Refillable gallon water typically undergoes filtration or sterilization, whereas well water is more susceptible to fecal contamination, particularly in areas with inadequate sanitation systems. Protozoa such as *Giardia lamblia*, *Entamoeba histolytica*, and *Blastocystis hominis* are known to survive in inadequately treated water and can cause infection when ingested.

The absence of statistical significance may reflect the influence of other factors contributing to infection risk, including children's hygiene behaviors (handwashing practices, nail hygiene, and footwear use), the cleanliness of household water storage containers, variability in refillable gallon water quality across depots, and water-handling practices prior to consumption (such as boiling). These findings are consistent with studies by Wibowo et al. (2020) in Indonesia and Tsegaye et al. (2022) in Ethiopia, which reported that while household water quality is associated with protozoan infections, the relationship often becomes non-significant when hygiene and behavioral factors are taken into account.

Only 12% of household drinking water samples were found to be contaminated in laboratory examination, and no significant association was identified between water contamination status and infection status (p = 0.52). This indicates that drinking water is not the sole exposure route. Children may acquire protozoan infections through multiple pathways, such as contaminated hands, food, soil, or fomites. Furthermore, inadequate handwashing, poor nail hygiene, and contact with domestic animals may play more substantial roles in transmission compared with water quality alone. Earlier studies, including Wibowo et al. (2020), have emphasized that hygiene practices often represent stronger predictors of infection than water quality parameters.

The discrepancy between the presence of protozoa in water samples and individual infection rates also suggests temporal variability in water contamination. Household water can become intermittently contaminated, particularly during rainy seasons or periods of increased groundwater infiltration, leading to exposure events not captured during sampling. Moreover, boiling drinking water

and household water-handling practices likely reduce the ingestion of viable cysts.

Interestingly, descriptive findings showed that children whose household water was not contaminated had a higher proportion of positive fecal results (63.6%) compared with those whose water was contaminated (50%). This further supports the notion that water contamination alone is not the primary risk factor. Children's personal hygiene practices, the cleanliness of home and school environments, handwashing habits, and food-handling behaviors likely play important roles in protozoan transmission. Although protozoa can persist for long periods in water, their presence does not always correlate with human infection, as infection risk depends on infective dose, exposure behaviors, and host immunity.

The findings of this study also align with international reports emphasizing the multifactorial nature of protozoan transmission. Research from Brazil and China has shown that inadequate infrastructure, poor sanitation, and environmental contamination contribute to the spread of waterborne protozoa. In particular, wastewater-based epidemiology studies have demonstrated widespread circulation of protozoa such as *Cryptosporidium spp.* and *Giardia duodenalis* even in treated effluent, underscoring their environmental resilience.

Overall, although this study did not identify statistically significant associations, the observed trends suggest that reliance on untreated water sources and inadequate sanitation remain important risk factors for intestinal protozoan infections. Ensuring safe drinking water, improving personal hygiene, and enhancing environmental sanitation remain essential public health strategies for preventing intestinal parasitic diseases. Public health interventions should emphasize water treatment practices, safe household water storage, improved hygiene behavior among children, and strengthened community awareness of waterborne disease risks. Future studies should consider larger sample sizes, seasonal assessments, and molecular detection methods to better elucidate transmission pathways and identify the protozoan species or genotypes responsible for infection.

4. CONCLUSIONS

The findings of this study conclude that the prevalence of intestinal protozoan infections among children in Pesawaran Regency is 62%, with 12% of household drinking water samples testing positive for protozoan contamination. No statistically significant association was found between household water quality and the incidence of intestinal protozoan infections in children. However, the trend toward higher infection rates among children consuming well water highlights the importance of promoting safe water practices. Comprehensive hygiene education and continuous monitoring of household water sources are essential to reducing the burden of protozoan infections in children.

This study has several limitations. Therefore, future research is recommended to include direct household observations to assess water sources, storage practices, and methods of drinking water preparation. In addition, further investigations using molecular diagnostic techniques are necessary due to the limitations of the conventional examination methods applied in this study.

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