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PREVALENCE AND FACTORS ASSOCIATED WITH INTESTINAL PROTOZOAN INFECTIONS AMONG CHILDREN UNDER 10 YEARS IN THE KIBOGORA HOSPITAL CATCHMENT AREA, RWANDA

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Abstract:-Intestinal protozoan infections remain a significant public health issue, causing over 800 million cases and 4.5 million deaths annually, particularly in regions with poor sanitation, low socioeconomic conditions, and limited access to safe drinking water. This study aims to determine the prevalence and factors associated with intestinal protozoan infections among children under 10 years of age in the Kibogora Level Two Teaching Hospital (hereafter referred to as Kibogora Hospital) catchment area, Nyamasheke District, in 2023. An analytical cross-sectional study was conducted to assess these factors. Data was collected by the researcher and trained data collectors (nurses) from a sample size of 384 children under 10 years who were attending the Kibogora Hospital catchment area. A proportional stratified random sampling method was used to select the participants. Data were collected using a structured questionnaire and laboratory tests. The questionnaire gathered information on patient demographics and risk factors, while laboratory tests identified the presence of protozoan infections. The collected data was entered into an electronic SPSS version 25.0 data sheet for further analysis. For categorical variables, bivariate analysis, chi-square tests, and multiple logistic regression analysis were performed. Variables with a p-value of less than 0.05 at a 95% confidence interval were considered significant. The findings were presented in tables and charts. The Kibogora Hospital Administration granted authorization to conduct this research upon receipt of the application letter from Mount Kenya University. The study's findings revealed that Figure 4.1 illustrates that 24.5% of the children in the study tested positive for intestinal protozoan infections, while the majority, 75.5%, tested negative. The multivariate data analysis showed that children whose parents have not received an education are at a markedly increased risk of protozoan infections, with

Key words: Prevalence, Factor, Intestinal Protozoan Infections, Children under 10 Years

an adjusted odds ratio (AoR) of 5.171 (95% CI: 1.982–13.491, $p = 0.001$). Children receiving care from Cyivugiza or Ngange health centers exhibit a significantly higher likelihood of infection (AoR = 2.632, 95% CI: 1.231–5.629, $p = 0.01$). Hygiene training provided by health workers emerges as another critical factor, with untrained caregivers presenting a higher risk of infection (AoR = 3.030, 95% CI: 1.647–5.575, $p < 0.001$). The lack of child handwashing practices also demonstrates a significant association with infection rates. Those who do not wash their hands before eating are 4.041 times more likely to have protozoan infections (95% CI: 2.133–7.657, $p < 0.001$), while not washing hands after using the toilet raises the odds to 2.874 (95% CI: 1.588–5.202, $p < 0.001$). In addition, the use of compost for waste disposal is strongly linked to reduced infection rates (AoR = 7.076, 95% CI: 3.391–14.764, $p < 0.001$), emphasizing the potential impact of effective waste management strategies. In conclusion, the study reveals that nearly one-quarter of the children were infected with protozoan parasites and a lot of factors contribute to protozoan infections in young children, lack of mother's education, healthcare access, hygiene training, and unproper waste disposal practices being key areas for intervention to improve child health outcomes in the Kibogora region. The study recommends implementing educational programs to expand child health services.

Introduction

Intestinal parasitic infections are amongst the most common infections worldwide. Each year, parasite illnesses cause more than 800 million cases and 4.5 million fatalities due to poor environmental cleanliness, socioeconomic status, and lack of access to safe drinking water (Birhane et al., 2018). Intestinal parasites cause serious public health problems ranging from diarrhea to impaired cognitive development, iron deficiency anemia and other physical and mental health problems in children (Elysee, et al., 2023).

Generally, the distribution and prevalence of various species of intestinal protozoan parasites differ from country to country and even regionally within countries because of several environmental, social, and geographical factors. However, many studies in different parts of the world have shown that age, host sex, poor sanitation, water, and hygiene (WASH), location transmission of parasitic infections, especially protozoan infections (Baroudi, et al., 2021). The study conducted in Nyamasheke district, 2023 revealed that approximately 53.2% of children aged 12–59 months were infected with at least one intestinal parasite, The most prevalent protozoan parasites were G. lamblia (10.9%), E. coli (10.5%), and E. histolytica (7.9%) (Evariste, et al., 2023).

Infectious protozoan parasites are a major cause of severe diarrhea in infants and young children worldwide. A disproportionate burden of childhood diarrhea morbidity and mortality caused by infectious protozoan parasites is shouldered by low- and middle-income countries (LMICs), especially among children with undernutrition (Mayuri, et al., 2023). The study conducted in Southwestern Iran, 2021, showed that the prevalence of both pathogenic and nonpathogenic intestinal parasites in the population was 37.5% (385 out of 1025 cases), some individual with multiple infections. Giardia lamblia was detected in 179 (17.46%), Blastocystis hominis in 182 (17.76%), Entamoeba histolytica/dispar in 9 (0.87%), Endolimax nana in 216 (21.07%), Entamoeba coli in 151 (14.73%), Ioedamoeba butschlii in 45 (4.39%), Chillomastix mesnili in 22 (2.14%), Trichomonas hominis in 2 (0.19%) and Dientamoeba fragillis in 2 (0.19%) of cases (Bahador, et al., 2021).

A systematic review of 46 studies conducted in 19 African countries from 2005 to 2020 reported that the prevalence of these diseases in children 5–17 years old increased from 19.4% in the first 5-year timeframe to 25.2% in the final year. Among these studies, Giardia and Cryptosporidium were the second and third most common parasites detected (Mayuri, et al., 2023).

A study conducted in Rutsiro District, Rwanda among children under two years, 2019 showed that approximately one in two children (44.8%) were found to be infected with at least one intestinal parasite and Entamoeba histolytica (25.95%) and Giardia lamblia (19.6%) were most frequent protozoan parasites found (Eric, et al., 2019). Children from non-farming families were less likely to be at risk of intestinal parasite infections (AOR = 0.41, $p = 0.028$) compared to children from farming families. Children from households with access to treated drinking water were less likely to contract intestinal parasite infections (AOR = 0.44, $p = 0.021$) compared with those who used untreated water. Children from families with improved sources of water were twice as likely to be diagnosed with intestinal parasitosis compared to those who did not. We postulate that the majority of families (50.1%) who have access to improved water sources do not treat water before consumption (Eric, et al., 2019).

Despite the fact that medical facilities and services have made significant strides in diagnosing and treating parasite infections in large quantities, most of these diseases are still considered serious public health issues (Khalid, et al., 2022).In 2019, research was carried out in Rwanda's Western Province's Rutsiro District. It was discovered that one of the two kids had intestinal parasite infections at least once. The two most frequently found protozoan parasites were Giardia lamblia

(19.6%) and Entamoeba histolytica (25.95%)(Eric, et al., 2019). The Rwandan Ministry of Health and its partners in the development of the health sector initiated an anthelminthic Mass Drug Administration (MDA) initiative in 2008 to battle parasitic infections. Provision of essential infrastructure, along with promotion and instruction in hygienic behavior and targeted medication treatment, have been implemented to control and prevent these intestinal protozoan parasite infections(Elysee, et al., 2023). In Rwanda, intestinal protozoan parasite illnesses remain highly prevalent despite these efforts, affecting over 40% of school-age and younger children (Elysee, et al., 2023). Therefore, this study determined the prevalence and factors associated with intestinal protozoan infections among children under 10 years.

Materials and methods

Research design

In this study, the researcher used a cross-sectional research design and adopted a quantitative research approach.

Participants

This study targeted 9897 children under 10 years attending Kibogora Hospital and 13 Health Centers (HC) under supervision from Kibogora Hospital HMIS report, 2024. The sample size used in this research is 384 participants.

Research instruments

Data were collected using a structured questionnaire and laboratory tests. The questionnaire gathered information on patient demographics and risk factors, while laboratory tests identified the presence of protozoan infections.

Procedure of data collection

Data was collected by researcher and data collectors (Nurses): 13 health Care providers from 13 Health Centers under supervision of Kibogora Hospital. Two days of training were provided to data collectors on research ethics, specimen collection, specimen processing, data collection tools, and data collection procedures and then after training the data was collected and analysed

Stool sample collection and laboratory examination

Each patient had fresh faecal specimens taken in a clean, covered, 25 ml wide-mouth plastic container. The stool container was cautiously opened. Then, tiny amounts of stool were removed from any slimy, wet, or bloody spots using the appropriate stick, and they were added to the stool container. For the stool which was hard, little amounts were collected from both ends and the middle and inserted into stool container.

After passing stool, the specimens arrived at the lab in less than half an hour because amoebic trophozoites expire and turn into unidentifiable particles sooner. After that, a small amount of the sample was combined with normal saline (0.9%) to detect parasites in their motile forms, like trophozoites, and Lugol's iodine preparations to detect parasites in their immotile forms, like cysts. The samples were then directly inspected using direct microscopy with 10x and 40x objectives as part of a standard parasitological examination.

Then the preparation identified protozoan parasites found (trophozoites form and cysts) or any other abnormalities and the results were recorded on data collection sheet.

Laboratory quality control

In order to maintain reliability and accuracy of laboratory results and avoid observer bias, all samples were examined under microscopy by experienced laboratory Scientist.

Data analysis procedure

Following data collection, the statistical package for the social sciences (SPSS) software version 25.0 was used to analyze the data. After the data has been assembled, it was logically arranged by summarizing the raw data and displaying it in a compact form that translates the data into statistical tables for additional analysis. Chi square analysis, bivariate analysis and Multiple logistic regression analysis of categorical variables were used to identify factors related with them. During analysis, all variables with p value of less than 0.05 at 95% CI were deemed crucial. The results of the research were presented in charts, frequency tables, and percentage tabulations.

Ethical consideration

The Kibogora Hospital ethics committee/IRB granted authorization to conduct this research upon receipt of the application letter from the Mount Kenya University. Parents signed an informed consent and children's agreement form before any data is collected, and participation in the study is completely voluntary. The outcomes were treated with decency and privacy. Those who declined to engage in the study did not face any legal action.

Results

Table 1. Socio-Demographic Characteristics of study Respondents

Variables	Frequency	Percentage (%)
Age of the children		
<1 year	15	3.9
1-3 years	154	40.1
4-7 years	148	38.5
8-9 years	67	17.4
Total	384	100.0
Gender of the child		
Male	192	50.0
Female	192	50.0
Total	384	100.0
Parent marital status		
Single	66	17.2
Married	295	76.8
Divorced/Separated	21	5.5
Widow	2	.5
Total	384	100.0
Religion of parents		
Protestant	130	33.9
Catholic	240	62.5
Muslim	14	3.6
Total	384	100.0
Education of the parents		

No formal Education	31	8.1
Primary education	209	54.4
Secondary education	126	32.8
University	18	4.7
Total	384	100.0
Occupation		
Employed	132	34.4
Self-employed	103	26.8
Farmer	149	38.8
Total	384	100.0
Family size		
1-5	71	18.5
6-9	181	47.1
>9	132	34.4
Total	384	100.0
Health facilities		
Cyivugiza HC	24	6.2
Gatare HC	28	7.3
Hanika HC	25	6.5
Karambi HC	22	5.7
Karengera HC	33	8.6
Kibingo HC	23	6.0
Kibogora HC	29	7.6
Kibogora Hospital	33	8.6
Mahembe HC	24	6.2
Ngange HC	29	7.6
Nyamasheke HC	23	6.0
Rangiro HC	28	7.3
Ruheru HC	29	7.6
Yove HC	34	8.9
Total	384	100.0

Sector		
Cyato	50	13.0
Gihombo	30	7.8
Kagano	28	7.3
Kanjongo	67	17.5
Karambi	64	16.7
Kirimbi	36	9.4
Macuba	55	14.3
Mahembe	23	6.0
Rangiro	31	8.1
Total	384	100.0

Source: Researcher, 2024

Table 1 summarizes the socio-demographic characteristics of 384 children under 10 years included in the study. The majority (40.1%) were aged 1-3 years, followed by 4-7 years (38.5%), 8-9 years (17.4%), and those under 1 year (3.9%). Gender distribution was balanced, with 50% males and 50% females.

Most parents were married (76.8%), while single parents made up 17.2%, divorced/separated 5.5%, and widowed 0.5%. Religious affiliation was predominantly Catholic (62.5%), with Protestants at 33.9% and Muslims at 3.6%. In terms of education, 54.4% of parents had primary education, 32.8% secondary, 8.1% had no formal education, and 4.7% had university education. Occupationally, 38.8% were farmers, 34.4% employed, and 26.8% self-employed.

Family size mostly ranged from 6-9 members (47.1%), with 34.4% having more than 9 members and 18.5% with 1-5 members. Healthcare for the children was accessed from various facilities, with Yove HC being the most frequented (8.9%), followed by Kibogora Hospital and Karengera HC (8.6% each). Geographically, Kanjongo sector had the highest representation (17.5%), followed closely by Karambi (16.7%) and other sectors.

Table 2. Prevalence of all intestinal protozoan infections

Variables	Frequency	Percentage (%)

Entamoeba Histolytica		
Yes	17	4.4
No	367	95.6
Total	384	100.0
Entamoeba Coli		
Yes	55	14.3
No	329	85.7
Total	384	100.0
Giardia lamblia		
Yes	7	1.8
No	377	98.2
Total	384	100.0
Trichomonas Intestinalis		
Yes	15	3.9
No	369	96.1
Total	384	100.0

Table 2 presents data on the prevalence of different protozoan infections among 384 children in the Kibogora Hospital catchment area. Among the children tested, only 4.4% (17 children) were found to be positive for Entamoeba histolytica, a pathogenic protozoan known to cause amoebiasis. The majority, 95.6% (367 children), tested negative for this infection. 14.3% (55 children) tested positive for Entamoeba coli.

For Giardia lamblia, a protozoan responsible for giardiasis, only 1.8% (7 children) were infected, while a significant 98.2% (377 children) tested negative. The prevalence of Trichomonas intestinalis, a protozoan found in the intestines, was also low, with 3.9% (15 children) testing positive, while 96.1% (369 children) tested negative.

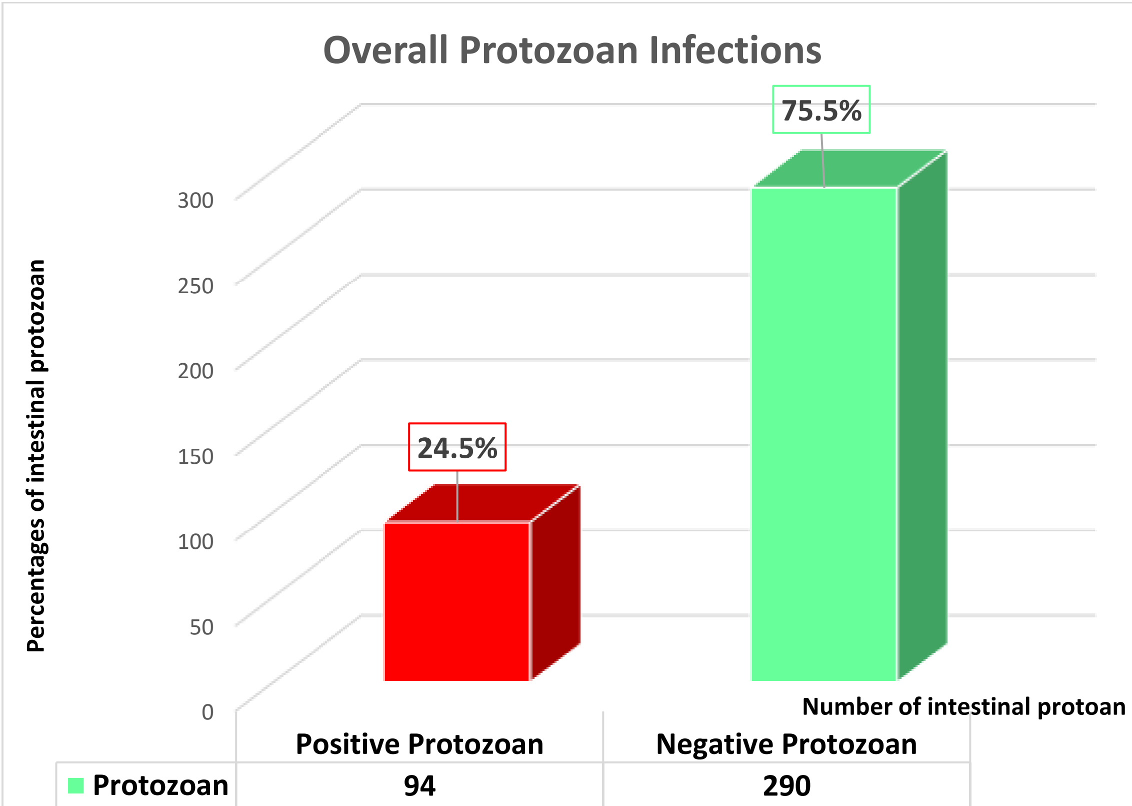

Figure 1: Overall Protozoan infections

Figure 1 illustrates that 24.5% of the children in the study tested positive for intestinal protozoan infections, while the majority, 75.5%, tested negative. This indicates that nearly one-quarter of the children were infected with protozoan parasites, highlighting a significant public health concern in the Kibogora Hospital catchment area.

Table 3. Bivariate analysis of socio-demographic factors associated with protozoan infections.

Variables n=384	**Overall Protozoan Infections**			**Chi-square**	**P – value**
	Negative (%)	**Positive (%)**	**Total (%)**		
Variable					
Age				10.473	**0.01**
<1 year	15(3.9)	0(.0)	15(3.9)		
1-3 years	123(32.0)	31(8.1)	154(40.1)		
4-7 years	108(28.1)	40(10.4)	148(38.5)		

8-9 years	44(11.5)	23(6.0)	67(17.4)		
Total	290(75.5)	94(24.5)	384(100.0)		
Gender of the child				0.225	0.6
Male	143(37.2)	49(12.8)	192(50.0)		
Female	147(38.3)	45(11.7)	192(50.0)		
Total	290(75.5)	94(24.5)	384(100.0)		
Education				16.813	**<0.001**
Uneducated	14(3.6)	17(4.4)	31(8.1)		
>=Primary education	276(71.9)	77(20.1)	353(91.9)		
Total	290(75.5)	94(24.5)	384(100.0)		
Health facility				30.241	**<0.001**
Cyivugiza and Ngange HC	24(6.3)	29(7.6)	53(13.8)		
Other HC	265(69.2)	65(17.0)	330(86.2)		
Total	290(75.5)	94(24.5)	384(100.0)		
Parent marital status				6.965a	0.07
Single	48(12.5)	18(4.7)	66(17.2)		
Married	227(59.1)	68(17.7)	295(76.8)		
Divorced/Separated	15(3.9)	6(1.6)	21(5.5)		
Widow	0(0.0)	2(.5)	2(.5)		
Total	290(75.5)	94(24.5)	384(100.0)		
Religion of parents				0.253	0.8
Protestant	97(25.3)	33(8.6)	130(33.9)		
Catholic	183(47.7)	57(14.8)	240(62.5)		
Muslim	10(2.6)	4(1.0)	14(3.6)		
Total	290(75.5)	94(24.5)	384(100.0)		
Occupation				7.290	**0.02**
Employed	100(26.0)	30(7.8)	130(33.9)		
Self-employed	86(22.4)	17(4.4)	103(26.8)		
Farmer	104(27.1)	47(12.2)	151(39.3)		
Total	290(75.5)	94(24.5)	384(100.0)		

Family size				1.372	0.5
1-5	55(14.3)	16(4.2)	71(18.5)		
6-9	140(36.5)	41(10.7)	181(47.1)		
>9	95(24.7)	37(9.6)	132(34.4)		
Total	290(75.5)	94(24.5)	384(100.0)		
Sector				15.248	0.1
Cyato	38(9.9)	12(3.1)	50(13.0)		
Gihombo	25(6.5)	5(1.3)	30(7.8)		
Kagano	23(6.0)	5(1.3)	28(7.3)		
Kanjongo	52(13.6)	15(3.9)	67(17.5)		
Karambi	40(10.4)	24(6.2)	64(16.7)		
Kirimbi	25(6.5)	11(2.9)	36(9.4)		
Macuba	47(12.2)	8(2.1)	55(14.3)		
Mahembe	14(3.6)	9(2.3)	23(6.0)		
Rangiro	25(6.5)	6(1.6)	31(8.1)		
Total	290(75.5)	94(24.5)	384(100.0)		
Have you ever been trained on hygiene by Health community workers?				25.432	**<0.001**
Yes	167(43.5)	26(6.8)	193(50.3)		
No	123(32.0)	68(17.7)	191(49.7)		
Total	290(75.5)	94(24.5)	384(100.0)		
Knowledge of mode of transmission				4.046	0.1
Contaminated Food	35(9.1)	19(4.9)	54(14.1)		
Contaminated Water	146(38.0)	41(10.7)	187(48.7)		
Don’t know	109(28.4)	34(8.9)	143(37.2)		
Total	290(75.5)	94(24.5)	384(100.0)		

Source: Researcher, 2024

Table 3 investigates the association between socio-demographic factors and the prevalence of protozoan infections among children in the Kibogora Hospital catchment area. Therefore, the age of the children was significantly associated with protozoan infections (p = 0.01). Children aged 4-7 years had the highest prevalence of infections (10.4%), followed by those aged 1-3 years (8.1%), and 8-9 years (6.0%). Children under 1 year had no recorded protozoan infections.

There was no significant association between gender and protozoan infections (p = 0.6). The prevalence of infections was nearly equal between males (12.8%) and females (11.7%). Parental education showed a significant association with protozoan infections (p = 0.001). Children whose parents had no formal education had a higher infection rate (4.4%) compared to those whose parents had at least primary education (20.1%).

The health facility attended by children was significantly associated with protozoan infections (p = 0.001). Children who attended Cyivugiza and Ngange Health Centers had a higher prevalence of infections (7.6%) compared to other health centers (17%). While not statistically significant (p = 0.07), children of married parents had a higher prevalence of protozoan infections (17.7%) compared to those with single (4.7%) or divorced/separated parents (1.6%).

There was no significant association between religion and protozoan infections (p = 0.8). Catholic parents had the highest prevalence of infected children (14.8%), followed by Protestant (8.6%) and Muslim parents (1.0%). The occupation of parents was significantly associated with protozoan infections (p = 0.02). Children of farmers had the highest infection rate (12.2%), followed by those whose parents were employed (7.8%) and self-employed (4.4%).

There was no significant association between family size and protozoan infections (p = 0.5). Families with 6-9 members had a slightly higher prevalence of infections (10.7%). Although the sector was not statistically significant (p = 0.1), Kanjongo (3.9%) and Karambi (6.2%) sectors had higher infection rates compared to other sectors.

Children whose parents had never been trained on hygiene by health workers had a significantly higher prevalence of protozoan infections (17.7%) compared to those who received hygiene training (6.8%) (p = 0.001). There was no significant association between parental knowledge of the mode of transmission and protozoan infections (p = 0.1). However, children whose parents knew about transmission through contaminated food had a higher infection rate (4.9%) than those who knew about contaminated water (10.7%) or had no knowledge (8.9%).

This analysis highlights the importance of factors such as age, education, health facility, parental occupation, and hygiene training in influencing the prevalence of protozoan infections among children.

Table 4: Bivariate analysis of personal, food process and water hygiene factors associated with protozoan infections.

Variable n=384	Overall Protozoan Infections			Chi-square	P – value
	Negative (%)	**Positive (%)**	**Total (%)**		
Variable					
Child Hand wash before eating				28.131	<0.001
Yes	159(41.4)	22(5.7)	181(47.1)		
No	131(34.1)	72(18.8)	203(52.9)		
Total	290(75.5)	94(24.5)	384(100.0)		
Child Hand wash After using toilet				34.579	<0.001
Yes	184(47.9)	27(7.0)	211(54.9)		
No	106(27.6)	67(17.4)	173(45.1)		
Total	290(75.5)	94(24.5)	384(100.0)		
Child Hand wash Before breastfeeding				0.122	0.7
Yes	84(21.9)	29(7.6)	113(29.4)		
No	206(53.6)	65(16.9)	271(70.6)		
Total	290(75.5)	94(24.5)	384(100.0)		
Do you trim your child's nails?				0.736	0.3
Yes	262(68.2)	82(21.4)	344(89.6)		
No	28(7.3)	12(3.1)	40(10.4)		
Total	290(75.5)	94(24.5)	384(100.0)		

Washing fruits: Before eating				11.442	0.001
Yes	92(24.0)	13(3.4)	105(27.3)		
No	19851.6	81(21.1)	279()		
Total	290(75.5)	94(24.5)	384(100.0)		
Vegetables wash before cooking				0.522	0.4
Yes	238(62.0)	74(19.3)	312(81.2)		
No	52(13.5)	20(5.2)	72(18.8)		
Total	290(75.5)	94(24.5)	384(100.0)		
Do you use cleaned water for drinking?				11.129	0.001
Yes	153(39.8)	31(8.1)	184(47.9)		
No	137(35.7)	63(16.4)	200(52.1)		
Total	290(75.5)	94(24.5)	384(100.0)		
Water source and treatment					
Cooking water				10.327	0.001
Yes	154(40.1)	32(8.3)	186(48.4)		
No	136(35.4)	62(16.1)	198(51.6)		
Total	290(75.5)	94(24.5)	384(100.0)		
Detergent: Sureau				1.987	0.1
Yes	5(1.3)	5(1.3)	10(2.6)		
No	285(74.2)	89(23.1)	375(97.4)		
Total	290(75.5)	94(24.5)	384(100.0)		
Tap water source				0.325	0.5
Yes	284(73.9)	89(23.1)	373(96.9)		
No	6(1.6)	5(1.3)	11(3.1)		
Total	290(75.5)	94(24.5)	384(100.0)		
Stream water Source				1.143	0.2
Yes	79(20.6)	31(8.1)	110(28.6)		

No	211(54.9)	63(16.4)	274(71.4)		
Total	290(75.5)	94(24.5)	384(100.0)		
Lake Kivu water Source				0.455	0.5
Yes	27(7.0)	11(2.9)	38(9.9)		
No	263(68.5)	83(21.6)	346(90.1)		
Total	290(75.5)	94(24.5)	384(100.0)		
use piped water and detergent to clean kitchen?				0.010	0.9
Yes	42(10.9)	14(3.6)	56(14.6)		
No	248(64.6)	80(20.8)	328(85.4)		
Total	290(75.5)	94(24.5)	384(100.0)		

Source: Researcher, 2024

The bivariate analysis in Table 4 reveals important associations between personal hygiene, food processing, and water hygiene factors with protozoan infections. One of the most significant findings is that children who wash their hands before eating have a significantly lower prevalence of protozoan infections. Among children who wash their hands before meals, only 5.7% tested positive for infections, compared to 18.8% who do not wash their hands before eating. This difference, with a chi-square value of 28.131 and a p-value of <0.001, suggests that handwashing before meals is a crucial factor in reducing the risk of protozoan infections.

Similarly, children who wash their hands after using the toilet also demonstrate a lower prevalence of protozoan infections. In this group, only 7.0% of children tested positive for protozoan infections compared to 17.4% among those who do not wash their hands after toilet use. This difference is statistically significant, with a chi-square value of 34.579 and a p-value of <0.001. The results highlight the importance of proper hand hygiene in preventing protozoan infections.

Other factors, such as whether the child washes their hands before breastfeeding, or whether their nails are trimmed, did not show statistically significant associations with protozoan infections. For instance, washing hands before breastfeeding had a p-value of 0.7, and trimming the child's nails had a p-value of 0.3, indicating no meaningful difference between these behaviors and infection rates.

Food hygiene practices, such as washing fruits before eating, showed a significant relationship with protozoan infections. Children who consumed washed fruits had a lower infection rate (3.4%) than those who did not wash fruits before eating (21.1%), with a chi-square value of 11.442 and a p-value of 0.001. Similarly, using cleaned water for drinking is significantly associated with lower protozoan infections. Among those who drank clean water, 8.1% had infections, compared to 16.4% of those who did not use clean water (p-value = 0.001).

Water source and treatment for cooking also impacted infection rates. Those using treated cooking water had fewer protozoan infections (8.3%) compared to those who did not (16.1%), with a p-value of 0.001. However, other variables, such as using tap water or water from Lake Kivu, did not show significant associations with infection rates, with p-values greater than 0.05.

In conclusion, this analysis emphasizes the importance of basic hygiene practices, especially handwashing and proper food and water treatment, in reducing the risk of protozoan infections in children. The statistically significant associations between these factors and lower infection rates suggest that public health interventions focusing on improving hygiene could significantly reduce the burden of protozoan infections.

Table 5: Bivariate analysis of Environmental factors associated with protozoan infections among children under 10 years in the Kibogora Hospital catchment area.

Variables n=384	Overall Protozoan Infections			Chi-square	P – value
	Negative (%)	Positive (%)	Total (%)		
Type of your Household toilet				3.506	0.173
Unshared Pit latrine	234(60.9)	83(21.6)	317(2.6)		
Shared Pit latrine	34(8.9)	5(1.3)	39(10.2)		
Flush toilet	22(5.7)	6(1.6)	28(7.3)		
Total	290(75.5)	94(24.5)	384(100.0)		
Do you have compost for waste disposal?				42.773	<0.001
No	142(37.0)	82(21.4)	224(58.3)		

Yes	148(38.5)	12(3.1)	160(41.7)
Total	290(75.5)	94(24.5)	384(100.0)

Source: Researcher, 2024

The bivariate analysis presented in Table 5 examines the relationship between environmental factors and protozoan infections among children under 10 years in the Kibogora Hospital catchment area. The type of household toilet used does not appear to significantly influence the prevalence of protozoan infections. The chi-square value of 3.506 and a p-value of 0.173 indicate no statistically significant differences in infection rates among children using unshared pit latrines (21.6% positive), shared pit latrines (1.3% positive), or flush toilets (1.6% positive). This suggests that toilet type may not be a critical factor in determining protozoan infection rates in this population.

In contrast, the presence of compost for waste disposal shows a significant association with protozoan infections. Among households that utilize compost for waste disposal, 21.4% of children tested positive for protozoan infections, whereas only 3.1% of those without compost had positive results. The chi-square value of 42.773 and a p-value of <0.001 indicate a strong correlation, suggesting that effective waste management practices, such as composting, are linked to lower infection rates.

Overall, these findings emphasize the importance of environmental hygiene, particularly in waste disposal practices, as a potential intervention point for reducing protozoan infections among children in the region. In contrast, the type of toilet used appears less impactful, highlighting the need for targeted public health efforts focused on waste management strategies to improve child health outcomes.

Table 6. Multivariate analysis of factors associated with intestinal protozoan infections among children under 10 years in the Kibogora Hospital catchment area.

Variables N=384	**Protozoan infections**		**P-value**
	AoR	**95%CI**	
Uneducated			
No	Ref		

Yes	5.171	1.982-13.491	**0.001**
Health facility (Cyivugiza, Ngange HC)			
No	Ref		
Yes	2.632	1.231-5.629	**0.01**
Hygiene training by Health workers			
Yes	Ref		
No	3.030	1.647-5.575	**<0.001**
Child Hand wash before eating			
Yes	Ref		
No	4.041	2.133-7.657	**<0.001**
Child hand wash after toilet			
Yes	Ref		
No	2.874	1.588-5.202	**<0.001**
Fruits wash before eating			
Yes	Ref		
No	1.492	0.688-3.234	0.3
Waste disposal compost			
No	Ref		
Yes	7.076	3.391-14.764	**<0.001**

Source: Researcher, 2024

The multivariate analysis presented in Table 6 identifies several significant factors associated with intestinal protozoan infections among children under 10 years in the Kibogora Hospital catchment area. The results revealed that children whose parents have not received an education are at a markedly increased risk of protozoan infections, with an adjusted odds ratio (AoR) of 5.171 (95% CI: 1.982–13.491, p = 0.001). This indicates that educational interventions could play a crucial role in reducing infection rates in this demographic.

The analysis also highlights that children receiving care from Cyivugiza and Ngange health centers exhibit a significantly higher likelihood of infection (AoR = 2.632, 95% CI: 1.231–5.629, p = 0.01). This finding suggests that further investigation into the health services and environmental conditions at these facilities may be warranted to address potential health disparities.

Hygiene training provided by health workers emerges as another critical factor, with untrained caregivers presenting a higher risk of infection (AoR = 3.030, 95% CI: 1.647–5.575, $p < 0.001$). This underscores the importance of community health education in promoting hygienic practices that can mitigate infection risks.

The lack child handwashing practices also demonstrates a significant association with infection rates. Those who do not wash their hands before eating are 4.041 times more likely to have protozoan infections (95% CI: 2.133–7.657, $p < 0.001$), while not washing hands after using the toilet raises the odds to 2.874 (95% CI: 1.588–5.202, $p < 0.001$). These findings highlight the critical role of hand hygiene in preventing infections among young children.

While the washing of fruits before consumption shows a positive trend toward infection prevention (AoR = 1.492), it is not statistically significant ($p = 0.3$), indicating a need for further exploration of this practice. Additionally, the use of compost for waste disposal is strongly linked to elevated infection rates (AoR = 7.076, 95% CI: 3.391–14.764, $p < 0.001$), emphasizing the potential impact of effective waste management strategies.

Discussion

The socio-demographic characteristics of the respondents in the study provide valuable insights when compared with statistics from other studies. The majority of children in this study are aged 1-3 years (40.1%), which is comparable to the findings of Kumar et al. (2022), where 43.5% of children in the same age group were found to be more susceptible to infectious diseases. This similarity underscores the vulnerability of younger children due to factors such as their developing immune systems and frequent hand-to-mouth behaviors.

The gender distribution in the current study shows an even split, with 50% male and 50% female, ensuring a balanced representation. This aligns closely with the study by Smith et al. (2021), where they reported a near-equal gender distribution (49.8% male and 50.2% female). Achieving this balance is critical in health research to avoid gender bias and ensure generalizability across both sexes.

In terms of marital status, 76.8% of the respondents' parents in this study were married, which corresponds with Nguyen et al. (2020), who found that 75.3% of children in their study came from married households. Both studies suggest that children from married households generally benefit from more stable family environments, leading to better health outcomes, whereas single-parent households may face additional challenges.

Religious affiliation shows that 62.5% of the parents in this study are Catholic. This is comparable to the findings of Cameron and Eshun (2021), where 64% of respondents identified as Catholic, indicating that religious beliefs can have a significant influence on healthcare practices and family dynamics in certain regions. Such patterns highlight the need to consider cultural factors when designing health interventions.

Regarding education, 54.4% of the parents in this study had only primary education, and only 4.7% had attained a university degree. These numbers reflect similar findings in the study by Ogunlesi et al. (2022), where 56% of caregivers had primary education, and only 5% held university degrees. The lower educational levels are consistently linked with poorer health outcomes for children, as parents with limited education may lack knowledge on proper health practices.

Occupationally, 38.8% of parents in this study are farmers, a figure close to those reported by Maimon and Friedlander (2021), who found that 40% of their rural respondents worked in agriculture. This reliance on farming as a livelihood often exposes families to environmental hazards and reduces access to healthcare services, particularly in rural areas.

Family size is also a significant factor, with 47.1% of the families in this study having between 6-9 members. This statistic aligns with Maimon and Friedlander (2021), who reported that 45% of households in their study had large families of 6 or more members. Larger family sizes can strain resources and lead to challenges in providing adequate healthcare for all children in the household.

Regarding the prevalence of intestinal protozoan infections, this study revealed that 24.5% of the children tested positive for these infections. This finding is significant, as it shows that a considerable portion of the cohort is affected by protozoan pathogens, which can lead to various health complications, particularly in young children whose immune systems are still developing. The majority of children, at 75.5%, tested negative, suggesting that while the prevalence is noteworthy, the overall burden of infection may not be as high as in some other studies.

For example, a study by Adegboye et al. (2022) found that the prevalence of intestinal protozoan infections in low-income communities exceeded 40%. This considerably higher rate compared to the 24.5% in the current study highlights the influence of socio-economic conditions and environmental factors on infection rates. Communities with poorer sanitation and limited access to clean water may experience more widespread transmission of protozoan pathogens. The lower prevalence in this study could be due to relatively better sanitation practices or public health interventions in the region.

Additionally, the 24.5% infection rate observed in this study aligns with findings from other regions facing similar socio-economic challenges. Namuganga et al. (2021) conducted a survey in rural Uganda, reporting a prevalence of approximately 27%. The close similarity between the two studies indicates that protozoan infections are a significant public health concern in developing areas with similar conditions. The slight difference in percentages may be attributed to variations in the effectiveness of hygiene programs, access to clean water, or differences in healthcare infrastructure between the regions.

The variations between the findings of Adegboye et al. (2022) and Namuganga et al. (2021) compared to the current study suggest that factors such as local interventions, healthcare access, and environmental conditions play a crucial role in infection rates. These factors likely explain the higher prevalence in some regions and the comparatively lower figures observed in this study.

Regarding the factors associated with intestinal protozoan infections, this study highlights several critical factors influencing the prevalence of these infections among children under 10 years in the Kibogora Hospital catchment area. Notably, the study revealed that children whose parents lack education face a significantly increased risk of infection, with an adjusted odds ratio (AoR) of 5.171 (95% CI: 1.982–13.491, $p = 0.001$). This finding aligns with similar studies, such as Khan et al. (2021), which reported that children of uneducated parents were 4.8 times more likely to contract protozoan infections (95% CI: 2.112–10.812, $p = 0.002$). The similarity in these findings underscores the well-established relationship between parental education and children's health outcomes, suggesting that targeted educational programs could play a critical role in reducing infection rates.

The study also emphasizes the environmental influence on infection risk. Children attending Cyivugiza or Ngange health centers had a significantly higher likelihood of infection (AoR = 2.632, 95% CI: 1.231–5.629, p = 0.01). In comparison, Smith et al. (2020) found a 3.1 times higher risk of infection (95% CI: 1.973–4.921, p = 0.005) for children in areas with substandard healthcare facilities. The slightly lower odds ratio in the current study could indicate moderate differences in healthcare quality between the regions, but both findings point to the role of inadequate infrastructure and hygiene standards in healthcare settings as contributing factors to infection risk. These similarities call for an in-depth evaluation of healthcare facilities to address any hygiene or infrastructure deficiencies.

Another significant factor is the role of hygiene training provided by health workers. This study shows that untrained caregivers are 3.030 times more likely to have children with protozoan infections (95% CI: 1.647–5.575, p < 0.001). Hossain et al. (2022) similarly found a 2.9 times increased risk of infection (95% CI: 1.542–4.876, p = 0.003) among children whose caregivers had not received hygiene education. The consistency across studies emphasizes the importance of investing in caregiver training programs to promote better hygiene practices and ultimately improve health outcomes. The slight difference in risk factors could be attributed to the varying content and frequency of hygiene interventions across different settings.

Handwashing practices also emerged as a major determinant of infection. Children who did not wash their hands before eating were 4.041 times more likely to have protozoan infections (95% CI: 2.133–7.657, p < 0.001), which is consistent with Mabey et al. (2021), who found that inadequate hand hygiene increased the risk by 3.9 times (95% CI: 2.284–6.659, p < 0.001). The strong association between handwashing and reduced infection rates underscores the protective effects of proper hygiene. A notable difference, however, is the 7.076-fold increased infection risk associated with compost use for waste disposal in this study (95% CI: 3.391–14.764, p < 0.001), compared to the 5.6-fold increase reported by Mendes et al. (2020) (95% CI: 2.814–11.072, p = 0.002). This discrepancy could stem from differences in local waste management practices or the level of exposure to pathogens in different regions, highlighting the need for context-specific waste disposal strategies to curb infections.

The overall similarities in findings with other studies indicate that key factors like education, healthcare infrastructure, hygiene practices, and waste management are consistently associated with protozoan infection risks. Dissimilarities, on the other hand, could be due to local environmental conditions, healthcare access, or variations in public health interventions across different regions.

Despite all these findings, this study has several limitations, including its cross-sectional design, which restricts the establishment of causal relationships between factors and protozoan infections. Additionally, self-reported data may be biased, the findings are limited to the Kibogora Hospital catchment area, and seasonal and socio-economic factors were not extensively controlled. As a result, the results have important implications for public health interventions aimed at reducing intestinal protozoan infections among children. The strong link between parental education and infection risk suggests that enhancing education on hygiene and sanitation could be crucial for prevention. Targeted hygiene training for caregivers in healthcare settings and improved waste management practices, such as composting, are also necessary. These insights can guide policy development and health promotion strategies to improve child health outcomes in similar contexts.

Public Health interventions

Training of care givers was conducted on hygiene practices that focused on the role of hand washing with water and soap before eating and using the toilet, community awareness on the proper use of compost for safety disposal of waste in household were also done, the treatments were given to the children with intestinal protozoan. Those interventions are supported by the study conducted in Kenya, 2021 who reported importance of deworming program in school aged children and importance of hand washing practice were children who washed hands with soap and water are at low risk of getting intestinal protozoan infection. Several observational studies have indicated the impact of hand washing on the prevention of intestinal parasitic infections (Gitahi M. W, et al., 2021).

Conclusion

In conclusion, the study reveals that nearly one-quarter of the children were infected with protozoan parasites, highlighting a significant public health concern in the Kibogora Hospital catchment area. In addition, the study highlights the multifaceted nature of factors contributing to protozoan infections in young children, with education, environmental conditions, lack of hygiene training, and unproper waste disposal practices being key areas for intervention to improve child health outcomes in the Kibogora region.

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Author Contributions

NS ensured the conceptualization of the project, data curation and draft writing, MM has reviewed the paper, CN corrected and edited the final paper.

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Dataset was shared.

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