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Geographic And Demographic Influences on The Epidemiological Patterns of Giardia Lamblia Infection in Rural Sites District Swat

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ABSTRACT

This study investigates the prevalence of *Giardia lamblia* across different tehsils, genders, age groups, and healthcare facilities in District Swat, Pakistan. A total of 14,732 patients were analyzed, out of which 5,641 (38.3%) tested positive for *Giardia lamblia*. The highest tehsil-wise prevalence was observed in Babozai (59%), followed by Khwazakhela (43.1%), while Kalam recorded the lowest (10%). Gender-wise, males showed a significantly higher prevalence (59.4%) compared to females (19.3%), reflecting potential differences in exposure or susceptibility. Age group analysis indicated that children aged 0-15 years had the highest prevalence (77.3%), with infection rates decreasing in older age groups. Hospital-wise, Center Hospital in Khwazakhela reported the highest prevalence (81.3%), suggesting potential differences in diagnostic capabilities or case concentration.

These findings align with global patterns of *Giardia* prevalence and highlight the need for targeted public health interventions, especially in high-risk areas and vulnerable groups. Enhanced water sanitation, health education, and early screening are recommended to reduce *Giardia* transmission. This study underscores the significance of local epidemiological data in shaping effective control strategies and improving health outcomes in endemic regions.

INTRODUCTION

Giardia lamblia, also known as *Giardia intestinalis* or *Giardia duodenalis*, is a single-celled, flagellated parasite that causes diarrheal disease worldwide (Adam, 2001). It can infect almost all mammals, and scientific evidence indicates that giardiasis is a zoonotic disease, meaning it can be transmitted between animals and humans (Ryan and Caccio, 2013). The microscopic parasite was first discovered by Antonie van Leeuwenhoek in 1681, when he examined his own stool samples under a microscope (Dobell, 1920). Later, in 1859, a scientist named Vilem Lambl conducted an in-depth study of the parasite and initially classified it as *Cercomonas intestinalis*. Some scientists named the entire genus after Lambl in honor of his contributions, while others reserved his name for the human-specific parasite, *Giardia lamblia* (Adam, 2021).

Giardia intestinalis is considered a significant global health threat, ranked 11th on the FAO/WHO list of high-risk intestinal parasites. It causes around 180 million symptomatic infections each year (Adam, 2021). Moreover, studies have detected *G. intestinalis* in the stool samples of asymptomatic children, with prevalence rates ranging from 17% to 18% in Spain and up to 64% in subtropical regions such as Brazil, Ethiopia, Argentina, and Mozambique (Rossi et al., 2024). The parasite can colonize both humans and animals without causing symptoms, but a markedly higher prevalence is observed in people who have close or frequent contact with animals, including household pets, livestock, and exotic species (Brožová et al., 2023).

The classification of *Giardia lamblia* places it in the Domain Eukarya, Kingdom Protista, Phylum Sarcomastigophora, Class Zoomastigophorea, Order Trichomonadida, Family Hexamitidae, Genus Giardia, and Species *G. lamblia*. The *Giardia* genus includes eight species that infect various animals. For instance, *G. agilis* infects amphibians, *G. area* is found in herons, *G. cricetidarum* affects hamsters, *G. microtia* infects voles and muskrats, *G. muris* is found in rodents, *G. peramelis* in bandicoots, and *G. psittaci* in budgerigars. Only *G. intestinalis* is known to specifically infect humans (Rossi et al., 2024).

Giardia duodenalis has a relatively simple life cycle involving only one host, which is typically humans. Its life cycle is characterized by two primary stages: the trophozoite, which is the active and motile form, and the cyst, which is the dormant and infectious form that allows for transmission (Adam, 2021). The cyst, which is highly resistant and infectious, is shed in feces and can survive for long periods in the environment. It is transmitted to new hosts through contaminated water, food, or direct fecal contact (Vaillant et al., 2005; Adam, 2021). When ingested by a host, the cysts pass through the acidic environment of the stomach and reach the duodenum unharmed (Adam, 2021). In the duodenum, the cysts encounter bile and an alkaline environment, which triggers excystation, releasing the trophozoites that colonize the intestinal tract and establish an infection (Adam, 2021). In the small intestine, these trophozoites multiply and aggregate into clusters, extending into the cecum, where they differentiate back into cysts through a process known as encystation. Recent studies using animal models have shown that encystation begins shortly after infection, peaking within a week, and occurs in high-density clusters of parasites, producing large quantities of infectious cysts (Barash et al., 2017).

Giardia intestinalis typically colonizes the small intestine, leading to a disease known as giardiasis (Rossi et al., 2024). Transmission of *G. duodenalis* occurs mainly through contaminated drinking water, infected food, and tainted vegetables, all of which can harbor *G. duodenalis* cysts (Kalavani et al., 2024). Symptoms of infection can range from asymptomatic to severe and include diarrhea, malabsorption, bloating, abdominal pain, fatigue, and weight loss (Cernikova & Hehl, 2018). Some individuals may experience persistent and severe symptoms that do not respond well to treatment (Ryan et al., 2019). If untreated, the infection can persist in a chronic and sometimes symptom-free state, potentially leading to long-term health problems such as growth retardation, anemia, weight loss, iron deficiency, and cognitive impairment in children (Fakhri et al., 2021).

Treatment for giardiasis involves the use of several antiparasitic medications. Nitazoxanide, a nitro thiazolyl-salicylamide compound, is effective in treating enteric protozoan infections like *Giardia intestinalis* (Ortiz et al., 2002). Another class of effective antiparasitic drugs is nitroheterocyclic compounds, specifically 5-nitroimidazoles such as secnidazole and tinidazole, which exploit *G. duodenalis*'s unique metabolic pathways, relying on ferredoxin and flavodoxin reduction for their action (Loderstädt & Frickmann, 2021). The emergence of drug resistance in *Giardia*, driven by epigenetic and posttranslational modifications, has prompted researchers to explore a variety of alternative treatment options. These include various nitro heterocyclic. Compounds, benzimidazoles, quinacrine, aminoglycosides, ciprofloxacin, bacitracin, antiviral protease inhibitors, anti-rheumatic, and anti-tumoral substances, as well as combinations of molecules and hybrid drugs to combat resistance and improve treatment outcomes (Rossi et al., 2024; Loderstädt and Frickmann, 2021). Omeprazole, a drug typically used to inhibit gastric acid secretion, has demonstrated in vitro efficacy against *Giardia intestinalis* by inhibiting triosephosphate isomerase, a key enzyme in the parasite's glycolytic pathway, leading to the death of the parasite (Loderstädt & Frickmann, 2021). Despite the availability of effective treatments, the resistance of *Giardia* strains and the potential for treatment failure remain a concern, making ongoing research into alternative therapies crucial for managing giardiasis in the long term.

METHODOLOGY

Study Area Context

Swat District, situated in the Khyber Pakhtunkhwa province of Pakistan, is recognized for its scenic valleys and diverse ecological landscape, encompassing both urban and rural areas. However, the district also faces significant public health issues, particularly due to the transmission of intestinal protozoan parasites such as Giardia intestinalis. The presence of numerous water bodies and varying environmental conditions contribute to the spread of these parasites, which have been linked to gastrointestinal diseases, especially in rural communities with limited access to clean water (Khan et al., 2019; Ullah et al., 2018).

Geographical and Climatic Context

Swat's varied geography ranges from low-lying plains to elevated mountainous regions, resulting in a subtropical climate with distinct seasonal patterns. The climate features hot summers, mild winters, and a monsoon season that brings substantial rainfall. These climatic conditions, along with the presence of rivers, ponds, and stagnant water pools, create favorable environments for the transmission of waterborne protozoan parasites. Seasonal changes in temperature and precipitation significantly impact parasite distribution and abundance, influencing public health risks (Maqbool et al., 2019).

Study Design and Objective

A cross-sectional study was conducted between January 2019 and December 2019 in District Swat to assess the prevalence and seasonal trends of intestinal protozoan parasites in the local human population. The study focused on understanding the distribution patterns of these infections in both rural and urban communities, emphasizing rural regions due to their heightened vulnerability. Data was collected from various public and private health facilities, covering a wide demographic range to ensure a comprehensive representation of the study population.

Sampling and Data Collection

Samples were collected during routine medical examinations at key health facilities, including Saidu Teaching Hospital, Center Hospital, and Anwar Clinical Laboratory. The study included data from over 600 participants, with an emphasis on demographic variables such as age, sex, and geographic location. The sampling period from August to October 2019 coincided with the monsoon season, when waterborne diseases typically peak, allowing for a detailed understanding of seasonal variations in parasite prevalence.

Laboratory Analysis Techniques

Floatation Technique: Involved mixing fecal matter with saline on a glass slide, leaving it for 15 minutes, and examining it under a microscope to identify parasite ova, cysts, or eggs.

Sedimentation Technique: Included mixing a sample with water, filtering, and examining sediment under a microscope with saline wet mounts and Lugol staining for enhanced visualization.

Statistical Analysis

Statistical evaluation was performed using SPSS software. The data was analyzed to determine prevalence rates, seasonal variations, and demographic patterns.

RESULTS

The overall prevalence of *Giardia lamblia* across various tehsils, genders, age groups, and hospitals in Swat shows significant variability. Tehsil-wise, Babozai had the highest prevalence at 59.0%, followed by Khwazakhela at 43.1%, while Kalam had the lowest at 10.0%. Gender-wise, males had a higher prevalence (59.4%) compared to females (19.3%). Age-wise, children aged 0-15 years were the most affected group (77.3%), with prevalence decreasing with age. Hospital-wise, Center Hospital in Khwazakhela recorded the highest prevalence (81.3%), while Saidu Teaching Hospital in Matta had the lowest (19.7%). The consolidated data indicates an overall prevalence of 38.3% with 5,641 positive cases out of 14,732 samples, showing notable variations in prevalence based on location, age, and gender.

Table 1: Prevalence of Giardia lamblia in Swat Region Khayber Pakhtunkhwa.

Category	Tehsil / Group / Hospital	Total Samples	Positive Cases	Prevalence (%)	Negative Cases
Tehsil-wise	Babozai	4977	2939	59	2038
	Barikot	4599	1213	26.3	3386
	Khwazakhela	1799	776	43.1	1023
	Matta	1600	332	20.7	1268
	Kabal	1101	295	26.8	806
	Madyan	364	57	15.7	307
	Kalam	292	29	10	263
Total		14732	5641	38.3	7991
Gender-wise	Male	6965	4141	59.4	2824
	Female	7767	1500	19.3	6267
		14732	5641	38.3	7991
	Babozai (Male)	2765	2360	85.3	405
	Babozai (Female)	2212	579	26.2	1633
	Barikot (Male)	1509	815	54	694
	Barikot (Female)	3090	398	12.9	2692
	Khwazakhela (Male)	1109	521	47	588
	Khwazakhela (Female)	690	255	37	435
	Matta (Male)	998	201	20.1	797
	Matta (Female)	602	131	21.7	471
Age-wise		14732	5641	38.3	7991
	0-15 Years	1650	1275	77.3	375
	16-30 Years	5650	2379	42.1	3271
	31-45 Years	5839	1401	24	4438
	46-60 Years	1194	510	42.7	684
Hospital-wise	61 and above	399	76	19	323
	Saidu Teaching Hospital (Babozai)	2340	1690	72.2	650
	Saidu Teaching Hospital (Barikot)	2099	611	29.1	1488
	Saidu Teaching Hospital (Khwazakhela)	1130	400	35.4	730
	Saidu Teaching Hospital (Matta)	1109	219	19.7	890
	Center Hospital (Khwazakhela)	123	100	81.3	23
	Center Hospital (Matta)	180	110	61.1	70
	Anwar Laboratory (Kabal)	181	94	51.9	87

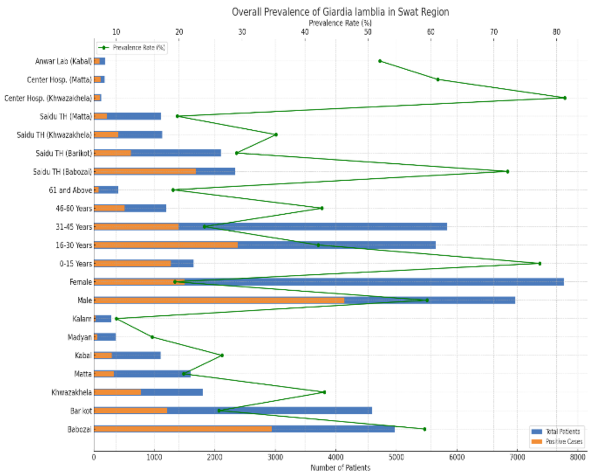


Figure 1: Prevalence of *Giardia lamblia* in Swat Region

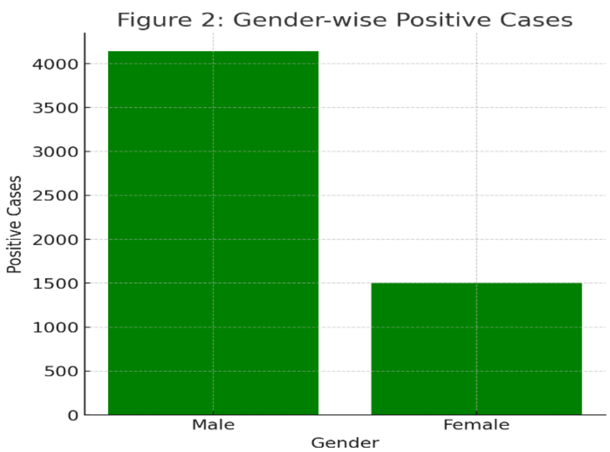
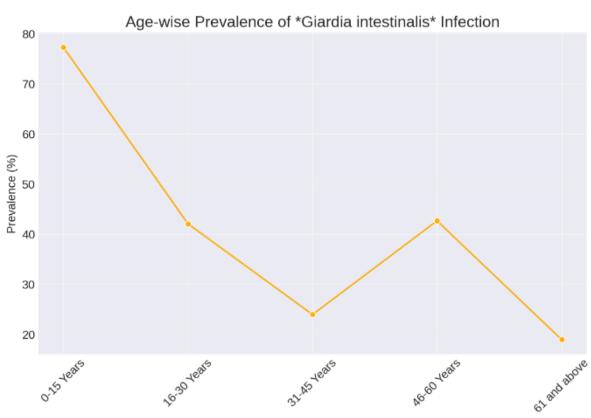


Figure 2: Gender-wise Positive Cases –.



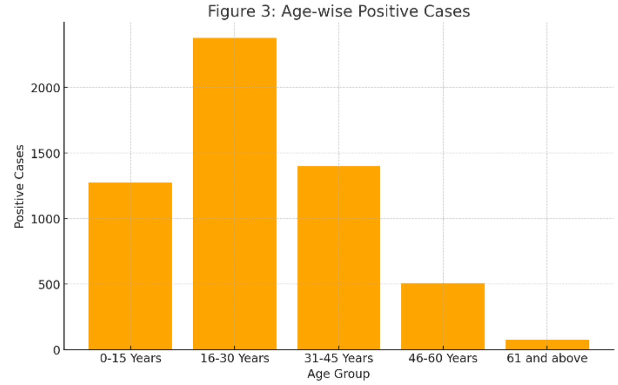


Figure 3: Age-wise Positive Cases

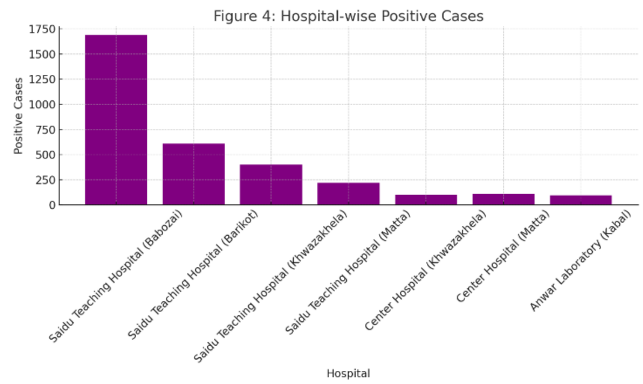


Figure 4: Hospital-wise Positive Cases

DISCUSSION

hospitals within District Swat, Pakistan. A total of 14,732 patients were examined, out of which 5,641 cases were found positive, indicating a cumulative prevalence rate of 38.3%. The results highlight considerable variations in prevalence across localities, demographic groups, and healthcare facilities, which align with findings from previous research on *Giardia lamblia* and similar parasitic infections worldwide.

In tehsil-wise analysis, Babozai exhibited the highest prevalence (59%), followed by Khwazakhela (43.1%). The significant burden of *Giardia lamblia* in Babozai could be attributed to factors such as population density, water quality, and sanitation conditions. This observation is consistent with findings reported by Barash et al. (2017), who noted

that *Giardia* tends to thrive in densely populated and socioeconomically disadvantaged areas. The lower prevalence in Kalam (10%) could reflect better hygiene practices or lower transmission opportunities, as indicated by Ryan et al. (2019), who documented similar patterns in regions with improved living standards and better access to healthcare.

The gender-wise analysis revealed that male patients had a higher prevalence (59.4%) compared to females (19.3%). This gender disparity could be due to differences in behavior, occupation, or health-seeking attitudes between men and women. Studies by Kalavani et al. (2024) and Loderstädt and Frickmann (2021) have shown that males, particularly in rural and underdeveloped settings, might be at a greater risk due to increased outdoor activities, which expose them to contaminated water sources and poor hygiene facilities. Additionally, this finding is in agreement with Bahrami et al. (2018), who found similar male predominance in *Giardia* infections in northwestern Iran. These differences may also reflect inherent variations in susceptibility or immune response, which require further exploration to understand underlying biological mechanisms.

When gender-specific prevalence was further stratified by tehsils, Babozai again stood out with the highest prevalence in males (85.3%). Interestingly, the highest female prevalence was reported in Kalam (70.0%). This contrasts with typical trends observed in other studies, such as by Cernikova et al. (2018), who documented more balanced infection rates between genders in less densely populated areas. The higher female prevalence in Kalam may be due to specific local factors, such as women's limited access to clean water or healthcare services, which merits further investigation.

Age-wise analysis showed that children aged 0-15 years had the highest prevalence (77.3%), highlighting them as a particularly vulnerable group. This is consistent with global patterns, as described by Ryan and Cacciò (2013), who emphasized that children are often more exposed due to inadequate hand hygiene and close contact in school environments. The prevalence dropped significantly in older age groups, which aligns with the findings of Adam (2021), who suggested that immunity against *Giardia* may build up over time, leading to lower infection rates in adults. However, a resurgence in the 46-60 age group (42.7%) suggests a potential decrease in immunity or increased vulnerability due to comorbidities, a pattern noted by Haque and Petri (2006) in their study of parasitic infections among aging populations.

The hospital-wise analysis revealed considerable variability in prevalence across different healthcare facilities. The highest prevalence was observed at Center Hospital, Khwazakhela (81.3%), which could indicate a higher concentration of cases due to better diagnostic capabilities or a referral bias, where more severe or suspicious cases are directed to this facility. This observation aligns with studies by Barash et al. (2017) and Brožová et al. (2023), which noted that healthcare facility types and diagnostic methodologies significantly impact reported prevalence rates. The relatively lower prevalence at Saidu Teaching Hospital in Matta (19.7%) could reflect either a lower local disease burden or differences in sample size and testing accuracy.

The observed patterns in *Giardia lamblia* prevalence align with various studies that emphasize environmental, demographic, and healthcare factors as key determinants of infection rates. For instance, research by Fakhri et al. (2021) identified contaminated water and poor sanitation as major risk factors, which are likely contributing factors in tehsils like Babozai and Khwazakhela. Similarly, studies by Arshad et al. (2019) in Karachi and Bahrami et al. (2018) in Iran support the notion that urbanization, population density, and inadequate infrastructure exacerbate the spread of *Giardia*.

Furthermore, the high prevalence in young children suggests the need for targeted interventions in schools and daycare centers, such as health education and regular screening, as recommended by Gelaw et al. (2013). The gender-specific patterns also point to the necessity of gender-sensitive approaches in public health planning, addressing specific behavioral and occupational risks associated with men's higher infection rates, as discussed by Hughes et al. (2024).

Overall, this study corroborates the findings of earlier researchers and contributes to the growing body of evidence on the epidemiology of *Giardia lamblia* in South Asia. It highlights the need for integrated control strategies, including improved water sanitation, health education, and accessible healthcare services, to reduce the burden of *Giardia* and similar parasitic diseases. Future studies should focus on exploring the specific environmental and social determinants contributing to these patterns, utilizing advanced molecular diagnostic tools as suggested by Adam (2021) and Loderstädt and Frickmann (2021) to better understand transmission dynamics and develop targeted intervention strategies.

CONCLUSION

In conclusion, this study provides a detailed epidemiological analysis of Giardia lamblia prevalence in District Swat, Pakistan, highlighting significant variations across tehsils, gender, age groups, and healthcare facilities. The overall prevalence of 38.3% underscores the substantial burden of giardiasis in the region, with notable hotspots identified in Babozai and Khwazakhela tehsils. Males and children aged 0-15 years emerged as particularly vulnerable groups, reflecting potential differences in exposure and susceptibility.

The findings from this study align with global trends in Giardia prevalence, emphasizing the importance of targeted public health interventions. Strategies focusing on enhanced water sanitation, health education, and early screening are crucial to mitigate transmission risks, especially in high-prevalence areas and among vulnerable populations. Furthermore, the observed disparities between tehsils and demographic groups highlight the need for localized intervention strategies tailored to specific community needs.

This research underscores the significance of local epidemiological data in shaping effective control measures and improving health outcomes in endemic regions. By understanding the spatial and demographic distribution of Giardia infections, healthcare authorities can better allocate resources and implement preventive measures to reduce the burden of this parasitic disease in Swat District and similar settings globally.

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