

The Changing Face of Helminth Infections: A 15-Year Temporal Analysis from Eastern Saudi Arabia

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Background: Helminth infections remain a significant health challenge worldwide, particularly in regions with diverse population demographics like Saudi Arabia. This retrospective study aimed to characterize the epidemiological profile, temporal trends, and seasonal patterns of helminth infections in Eastern Saudi Arabia over a 15-year period (2009–2024).

Methods: A comprehensive retrospective analysis of data from helminth-positive patients attending King Fahd Hospital of The University, Dammam, Saudi Arabia. We analyzed demographic characteristics, helminth species distribution, temporal trends, and seasonal patterns among 115 confirmed cases.

Results: The study population had a mean age of 40.20 ± 12.64 years, with most infections (59.1%) occurring in the 36–50 age group. Female patients comprised 55.7% ($n = 64$) of the study population, while males accounted for 44.3% ($n = 51$). Non-Saudi nationals represented 83.5% of cases, with Filipino (29.6%) and Indian (17.4%) nationals most frequently affected. *Ascaris lumbricoides* (31.3%) and hookworm (16.5%) were the predominant helminth species. The highest number of cases was recorded in 2013 (14.8%), with a notable declining trend thereafter. Winter exhibited the highest prevalence (36.5%) of infections, and 63.5% of cases presented as emergency visits. Gender-specific seasonal patterns were observed, with females showing higher spring prevalence (37.5%) and males higher autumn prevalence (33.3%).

Conclusion: This study reveals distinct epidemiological patterns of helminth infections in Eastern Saudi Arabia, characterized by predominance among non-Saudi nationals, winter seasonality, and declining trends over the study period. These findings highlight the need for targeted screening among expatriate populations and season-specific preventive strategies in non-endemic settings with substantial migrant populations.

Keywords: expatriate health, hospital epidemiology, infectious disease trends, parasitic infections, public health surveillance

Introduction

Soil-transmitted helminth (STH) infections remain among the most prevalent neglected tropical diseases (NTDs) worldwide, affecting approximately 1.5 billion people globally.¹ Despite significant global efforts to control these parasitic infections, they continue to pose substantial public health challenges, particularly in resource-limited settings and among vulnerable populations.² The World Health Organization (WHO) has identified STH infections as a priority for intervention, with a target to eliminate morbidity due to STH infections in children by 2030 as part of the 2021–2030 NTD road map.³ STH infections contribute significantly to the global burden of disease, accounting for approximately 1.9 million disability-adjusted life years (DALYs) annually, with the highest burden concentrated in low- and middle-income countries.¹ While STH infections rarely cause direct mortality, they contribute to an estimated 12,000–135,000 deaths annually worldwide, primarily through severe anemia, malnutrition complications, and increased susceptibility to other infectious diseases.²

Helminth infections, caused by various species including *Ascaris lumbricoides*, hookworms (*Ancylostoma duodenale* and *Necator americanus*), *Trichuris trichiura*, *Strongyloides stercoralis*, and several other species, are associated with

significant morbidity, particularly in children and women of reproductive age.⁴ These infections can lead to malnutrition, impaired physical and cognitive development, anemia, and decreased productivity, perpetuating cycles of poverty and underdevelopment.^{5,6}

The epidemiology of helminth infections is influenced by a complex interplay of environmental, socioeconomic, and behavioral factors. Climate conditions, including temperature, rainfall patterns, and humidity, play critical roles in the development and survival of helminth eggs and larvae in the environment.⁷ Consequently, seasonal variations have been observed in the prevalence and intensity of helminth infections across different geographical settings.^{8,9} Understanding these temporal patterns is essential for optimizing control strategies and predicting disease burden fluctuations.

In the Gulf Cooperation Council (GCC) countries, including Saudi Arabia, the epidemiological landscape of parasitic infections has undergone significant transformation over recent decades, largely attributed to rapid socioeconomic development, improved sanitation infrastructure, enhanced healthcare access, and changing population demographics.^{10–12} However, the influx of migrant workers from helminth-endemic regions has introduced new dynamics to parasitic infection epidemiology in these countries.^{13,14}

Saudi Arabia presents a unique epidemiological context for studying helminth infections due to several factors. First, the country has experienced rapid urbanization and economic development, leading to improved sanitation and healthcare infrastructure.¹⁵ Second, Saudi Arabia hosts millions of expatriate workers from various countries where helminth infections are endemic.^{13,14} Third, the country's climate varies significantly across regions and seasons, potentially influencing parasite transmission dynamics.^{9,13,14,16} Finally, the annual Hajj and Umrah pilgrimages bring millions of visitors to Saudi Arabia from across the globe, creating unique epidemiological scenarios for disease transmission.^{15,17,18}

Despite these distinctive characteristics, there is limited contemporary data on the epidemiology of helminth infections in Saudi Arabia, particularly regarding seasonal patterns and demographic distributions.¹³ Most existing studies are either outdated, limited in geographical scope, or focused on specific population subgroups.^{16,19} The most recent systematic review of intestinal parasites in Saudi Arabia highlighted the need for more comprehensive and current epidemiological data to inform public health strategies.²⁰

The Eastern Province of Saudi Arabia, where this study is situated, represents a particularly interesting setting for investigating helminth infections due to its substantial expatriate population, diverse socioeconomic strata, and distinctive climate patterns. King Fahd Hospital of The University in Dammam serves a diverse patient population, providing an opportunity to examine helminth infection patterns across various demographic groups.

Aim

In this context, our study aims to characterize the epidemiological profile and seasonal patterns of helminth infections in Eastern Saudi Arabia through a comprehensive retrospective analysis spanning 15 years (2009–2024). By examining temporal trends, demographic distributions, and parasite-specific patterns, this study seeks to address critical knowledge gaps in the current understanding of helminth infection epidemiology in Saudi Arabia. The findings will contribute to the evidence base for developing targeted prevention and control strategies, optimizing clinical management approaches, and informing public health policy in the region.

Methodology

Study Design and Setting

This comprehensive retrospective study analyzed data from helminth-positive patients who sought medical care at King Fahd Hospital of The University in Dammam, Saudi Arabia, between January 2009 and December 2024. The Eastern Province of Saudi Arabia covers approximately 672,522 km² and hosts the country's largest expatriate population due to its thriving oil industry and economic opportunities. King Fahd Hospital of The University is located in Dammam (26.299471°N, 50.189553°E), serving as a major tertiary care facility with a catchment population of approximately 2.5 million people, including both Saudi nationals and expatriates from various countries.

Study Population

The study population consisted of all patients who visited King Fahd Hospital of The University during the study period and had stool samples examined for parasitic infections. The hospital serves a diverse demographic including Saudi nationals and expatriates from various countries, primarily consisting of workers in the oil industry, domestic workers, construction workers, health-care professionals, and their families. This population reflects the unique demographic composition of the Eastern Province, which has attracted significant international migration due to economic opportunities.

Sample Size and Selection Criteria

This was a retrospective analysis of all available helminth-positive cases identified during the 15-year study period. No formal sample size calculation was performed as we included the entire population of helminth-positive patients identified through routine laboratory diagnosis, representing a census of all diagnosed cases rather than a sample.

Inclusion Criteria

- All patients with stool samples positive for any helminth species between January 2009 and December 2024.
- Patients of all ages and nationalities.
- Both inpatient and outpatient cases.

Exclusion Criteria

- Samples with incomplete demographic data (age, sex, or nationality missing).
- Samples positive only for protozoan parasites without helminth co-infection.
- Duplicate entries from the same patient within 30 days of initial diagnosis.
- Samples with inadequate specimen quality for accurate identification.

Withdrawal Criteria

- Not applicable for this retrospective study design.

Laboratory Procedures and Stool Examination

Stool samples were collected in clean, labeled containers provided by the laboratory and processed within 1–4 hours of collection to ensure optimal parasite recovery. Fresh samples were examined using standard parasitological techniques including direct wet mount preparations in normal saline and iodine solutions. Concentration techniques were performed for all samples using standard Polyvinyl Alcohol (PVA) concentration technique.

All microscopic examinations were conducted by qualified laboratory technicians with specialized training in parasitology, following standardized protocols established by the hospital's laboratory medicine department. Helminth identification was based on morphological characteristics of eggs, larvae, or adult worms using standard taxonomic criteria. Quality control measures included regular review of positive cases by senior laboratory staff and participation in external quality assurance programs.

Data Collection and Variables

Demographic and clinical data were systematically extracted from the hospital's electronic medical records system using a standardized data extraction form. Data were initially organized using Microsoft Excel Version 16.98 before transfer to statistical software for analysis. Variables collected included:

- Temporal variables: Year and month of sample collection
- Demographic variables: Patient age, sex, nationality
- Clinical variables: Visit type, symptoms at presentation
- Laboratory variables: Helminth species identified, developmental stage observed, single or multiple infections

Visit types were classified into three categories: Outpatient (OP) visits representing routine non-urgent care; Emergency (EP) visits representing patients seeking urgent or unscheduled care; and Inpatient (IP) visits representing hospitalized patients requiring extended medical care.

Nationalities were initially recorded as reported and subsequently grouped into Saudi versus Non-Saudi for primary analyses, with detailed subclassification of Non-Saudi nationalities for secondary analyses. Age was stratified into five clinically relevant groups based on life-stage epidemiological considerations: pediatric/adolescent (0–18 years), young adult (19–35 years), middle-aged (36–50 years), older adult (51–65 years), and elderly (≥ 66 years).

Seasons were categorized according to standard meteorological definitions: Spring (March–May), Summer (June–August), Autumn (September–November), and Winter (December–February).

Ethical Approval

The study protocol received formal approval from the Institutional Review Board (IRB) of Imam Abdulrahman Bin Faisal University (IRB# 2024-01-578). Patient consent for medical record review was waived by the IRB due to the retrospective nature of the study utilizing de-identified data from routine diagnostic procedures. This waiver was granted as the research involved minimal risk to participants, data were anonymized prior to analysis, and obtaining individual consent was impracticable given the 15-year timeframe and large number of patients involved.

The study was conducted in full compliance with the Declaration of Helsinki principles for medical research involving human subjects. All data were de-identified and anonymized before analysis to ensure patient confidentiality and privacy. No patient identifiers were recorded or analyzed, and all data handling procedures followed institutional privacy protocols and international ethical standards for retrospective studies.

Statistical Analysis

Data management and analysis were performed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). This study employed a descriptive epidemiological approach to characterize patterns and trends in helminth infections. Descriptive statistics were calculated for all variables, with categorical data presented as frequencies and percentages. Cross-tabulation analyses were conducted to examine relationships between key variables such as visit type, sex, nationality, and seasonality. Temporal trends were analyzed through descriptive analysis of annual and seasonal patterns. As this study analyzed the complete population of helminth-positive patients during the study period rather than a sample, inferential statistics were not applicable. Results were visualized using frequency tables, bar graphs, and line charts to illustrate key findings and temporal relationships.

Results

Demographic Characteristics

A total of 115 helminth-positive cases were analyzed. The mean age of patients was 40.20 ± 12.64 years (range: 8–90 years). The majority of patients (59.1%, $n = 68$) were in the 36–50 age group, followed by 19–35 years (20.9%, $n = 24$), 51–65 years (10.4%, $n = 12$), 0–18 years (6.1%, $n = 7$), and ≥ 66 years (3.5%, $n = 4$).

Female patients comprised 55.7% ($n = 64$) of the study population, while males accounted for 44.3% ($n = 51$). Regarding nationality, non-Saudi patients represented 83.5% ($n = 96$) of the cases, while Saudi nationals accounted for 16.5% ($n = 19$) of helminth infections. [Table 1](#) shows the demographic characteristics of the patients included in the study.

Distribution of Helminth Infections by Nationality

Among the non-Saudi patients, the most common nationalities were Philippine (29.6%, $n = 34$), followed by India (17.4%, $n = 20$), Ethiopia (9.6%, $n = 11$), Sri Lanka (7.0%, $n = 8$), Bangladesh (6.1%, $n = 7$), and others in smaller proportions including Sudan (3.5%, $n = 4$), Egypt (2.6%, $n = 3$), Indonesia (2.6%, $n = 3$), Pakistan (1.7%, $n = 2$), and individual cases from Jordan, Nepal, Somalia, and other countries (each 0.9%, $n = 1$).

Table I Demographic Characteristics of Patients with Helminth Infections (N = 115)

Characteristic	Category	Frequency (n)	Percentage (%)
Sex	Female	64	55.7
	Male	51	44.3
Age group (years)	0-18	7	6.1
	19-35	24	20.9
	36-50	68	59.1
	51-65	12	10.4
	≥66	4	3.5
Nationality	Saudi	19	16.5
	Non-Saudi	96	83.5
Visit Type	OP (Outpatient)	28	24.3
	EP (Emergency)	73	63.5
	IP (Inpatient)	14	12.2

Temporal Distribution of Helminth Infections

The annual distribution of helminth infections showed variation across the study period (2009–2024). The highest number of cases was recorded in 2013 (14.8%, n = 17), followed by 2012 (13.0%, n = 15), 2014 (12.2%, n = 14), 2009 (11.3%, n = 13), and 2016 (10.4%, n = 12). The remaining years showed fewer cases, with 2010 (8.7%, n = 10), 2015 and 2019 (each 6.1%, n = 7), 2011 (4.3%, n = 5), 2017 and 2020 (each 3.5%, n = 4), 2018 and 2023 (each 1.7%, n = 2). No cases were recorded for 2022 or 2024 in the dataset. Figure 1 demonstrates the annual distribution of the helminth infections in the study.

Annual Trends of Helminth Infections (2009-2024)

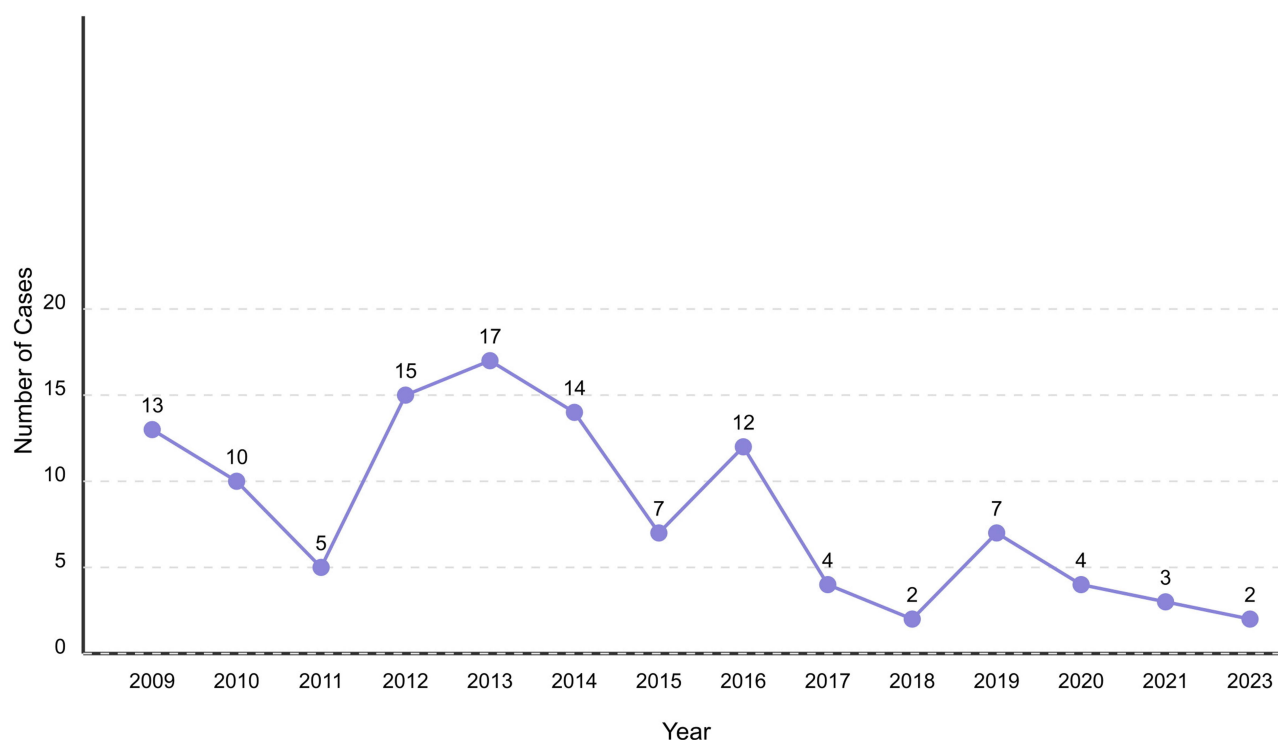


Figure 1 Annual Trends of the helminthic infections from 2009–2024.

Monthly Distribution of Helminth Infections

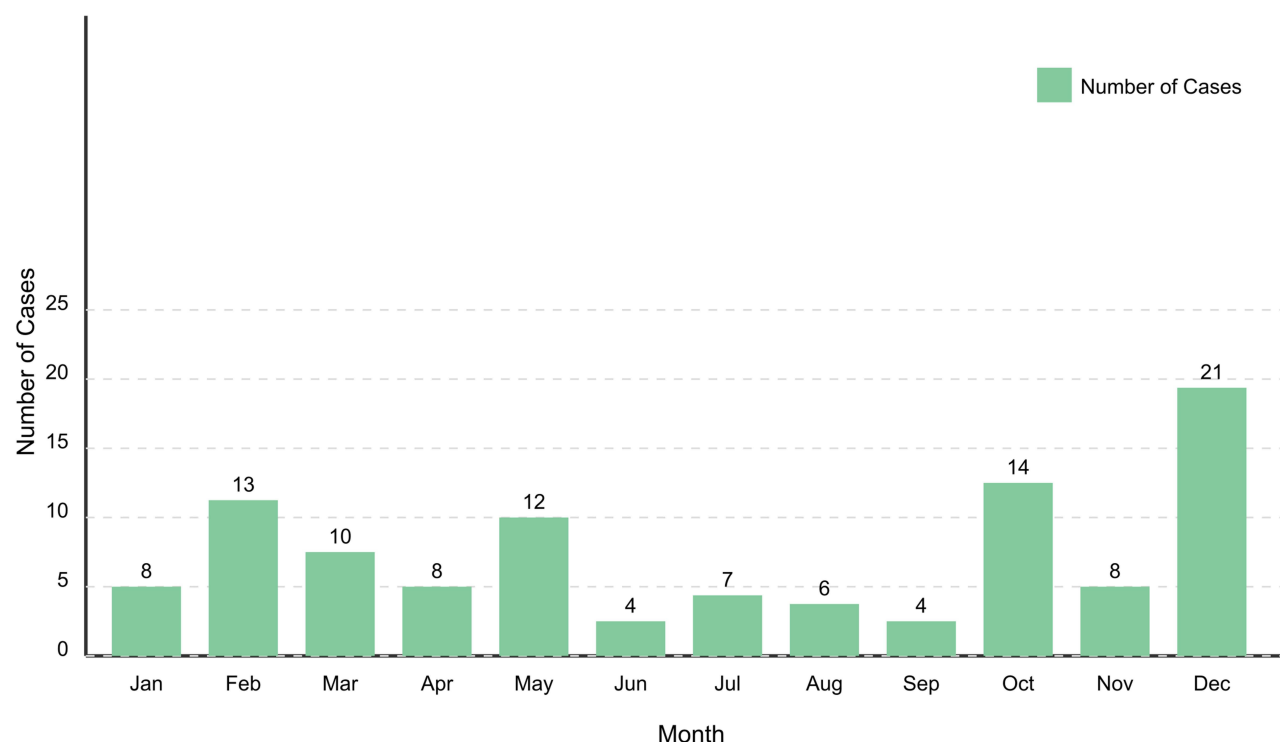


Figure 2 Total Monthly cases of helminthic infections reported.

Monthly distribution revealed December had the highest percentage of helminth infections (18.3%, $n = 21$), followed by October (12.2%, $n = 14$), February (11.3%, $n = 13$), and May (10.4%, $n = 12$). Other months showed relatively lower frequencies: March (8.7%, $n = 10$); January, April, and November (each 7.0%, $n = 8$); July (6.1%, $n = 7$); August (5.2%, $n = 6$); and June and September (each 3.5%, $n = 4$). Monthly distribution of the cases are shown in [Figure 2](#).

Regarding seasonal analysis, winter had the highest prevalence of helminth infections (36.5%, $n = 42$), followed by spring (26.1%, $n = 30$), autumn (22.6%, $n = 26$), and summer (14.8%, $n = 17$).

Types of Parasites and Infection Characteristics

Among the helminth infections, the most commonly detected parasite was *Ascaris lumbricoides* (31.3%, $n = 36$), followed by hookworm (16.5%, $n = 19$), *Hymenolepis nana* (13.9%, $n = 16$), *Trichuris trichiura* (8.7%, $n = 10$), *Enterobius vermicularis* and *Strongyloides stercoralis* (each 7.0%, $n = 8$). Mixed infections were also observed, with *Ascaris lumbricoides* and *Trichuris trichiura* being the most common combination (5.2%, $n = 6$). [Table 2](#) presents the comprehensive distribution of helminth infections by parasite type.

In terms of parasite developmental stages, most infections (89.6%, $n = 103$) were detected at the egg stage, while larvae were found in 7.0% ($n = 8$) of cases. Adult worms were identified in 1.7% ($n = 2$) of cases, and combined stages (egg and adult or larvae and egg) were observed in 1.8% ($n = 2$) of the cases. The majority of infections (89.6%, $n = 103$) were mono-parasitic, while poly-parasitic infections accounted for 10.4% ($n = 12$) of cases.

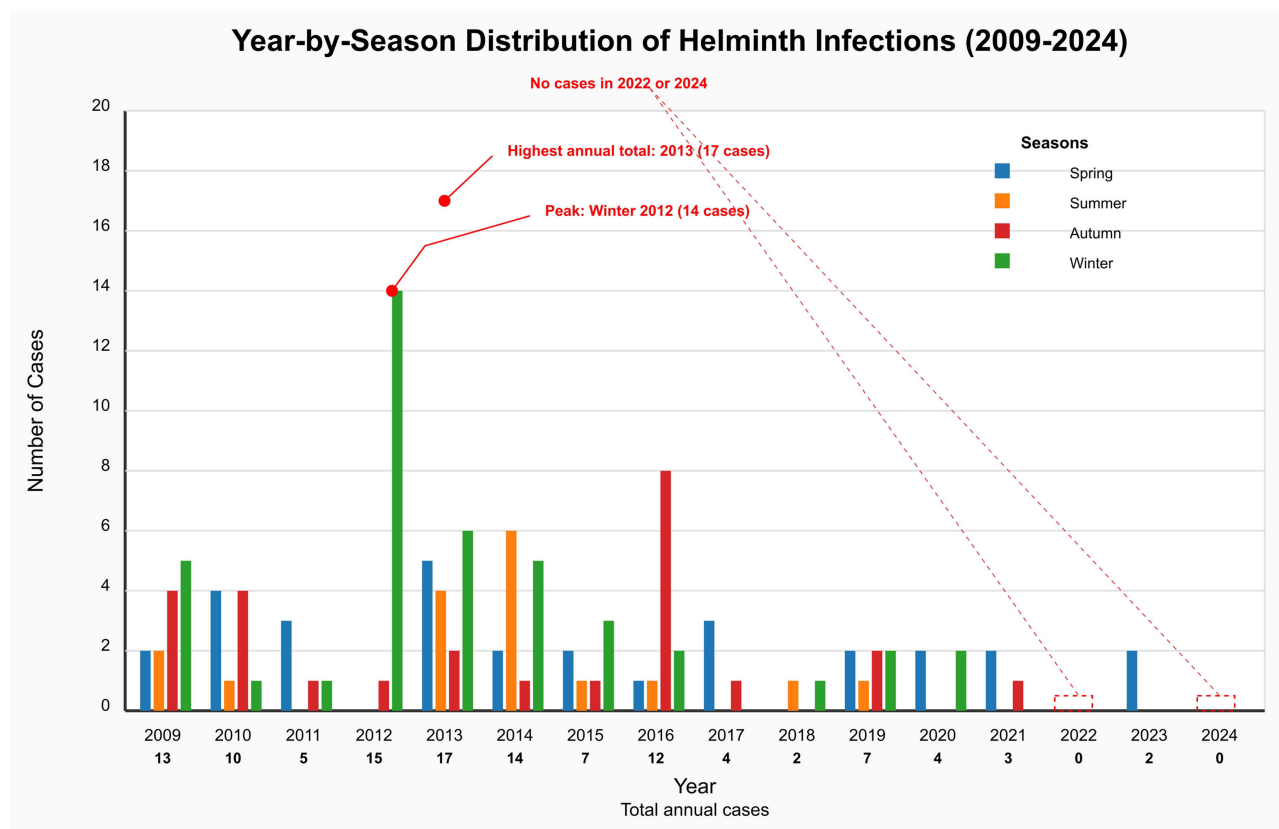
Temporal Trends and Seasonal Patterns

Analysis of helminth infection cases by year and season revealed varying patterns across the entire study period (2009–2024). In 2012, most cases (93.3%, $n = 14$) were reported in winter, representing one of the most pronounced seasonal concentrations observed. For 2013, which had the highest annual total ($n = 17$), cases were more evenly distributed across spring (29.4%, $n = 5$), winter (35.3%, $n = 6$), and summer (23.5%, $n = 4$). In 2014, cases were most common in summer (42.9%, $n = 6$) and winter (35.7%, $n = 5$), while in 2016, most cases occurred in autumn (66.7%, $n = 8$).

Table 2 Distribution of Helminth Infections by Parasite Type

Parasite Detected	Frequency (n)	Percentage (%)
<i>Ascaris lumbricoides</i>	36	31.3
Hookworm	19	16.5
<i>Hymenolepis nana</i>	16	13.9
<i>Trichuris trichiura</i>	10	8.7
<i>Enterobius vermicularis</i>	8	7.0
<i>Strongyloides stercoralis</i>	8	7.0
<i>Schistosoma mansoni</i>	3	2.6
<i>Dicrocoelium dendriticum</i>	2	1.7
<i>Taenia saginata</i>	1	0.9
<i>Ascaris lumbricoides</i> and <i>Trichuris trichiura</i>	6	5.2
<i>Trichuris trichiura</i> and Hookworm	2	1.7
<i>Ascaris lumbricoides</i> and <i>Giardia lamblia</i>	1	0.9
<i>Hymenolepis nana</i> and <i>Taenia saginata</i>	1	0.9
<i>Strongyloides stercoralis</i> and Hookworm	1	0.9
<i>Taenia saginata</i> and <i>Taenia solium</i>	1	0.9

The later years of the study period showed a general decline in case numbers. In 2019, there was a modest number of cases ($n = 7$) distributed fairly evenly across seasons. From 2020 to 2021, cases decreased further ($n = 4$ and $n = 3$, respectively), with spring becoming the predominant season for detections. In 2022, no helminth infections were recorded, followed by a small number of cases in 2023 ($n = 2$), all occurring in spring. No cases were documented in 2024 through the study conclusion. Figure 3 illustrates these temporal trends by year and season.


Figure 3 Temporal Trends (year-by-season) of helminthic infections from 2009–2024.

Seasonal Variation in Patient Demographics and Clinical Presentation Patterns

Visit Type by Season

During spring (n = 30), 56.7% (n = 17) of cases were emergency patients, 23.3% (n = 7) were consultation patients, and 20.0% (n = 6) were inpatients. In summer (n = 17), 64.7% (n = 11) were emergency patients, 29.4% (n = 5) were consultation patients, and 5.9% (n = 1) were inpatients. For autumn (n = 26), 73.1% (n = 19) were emergency patients, 15.4% (n = 4) were inpatients, and 11.5% (n = 3) were consultation patients. In winter (n = 42), 61.9% (n = 26) were emergency patients, 31.0% (n = 13) were consultation patients, and 7.1% (n = 3) were inpatients. Table 3 presents the comprehensive cross-tabulation of visit type by season.

Seasonality by Sex

Among females (n = 64), 37.5% (n = 24) presented in spring, 34.4% (n = 22) in winter, 14.1% (n = 9) in both summer and autumn. Among males (n = 51), 39.2% (n = 20) presented in winter, 33.3% (n = 17) in autumn, 15.7% (n = 8) in summer, and 11.8% (n = 6) in spring. Table 4 presents the detailed cross-tabulation of seasonality by sex.

Seasonality by Nationality

Among Saudi patients (n = 19), 52.6% (n = 10) presented in winter, 21.1% (n = 4) in both spring and autumn, and 5.3% (n = 1) in summer. For non-Saudi patients (n = 96), 33.3% (n = 32) presented in winter, 27.1% (n = 26) in spring, 22.9% (n = 22) in autumn, and 16.7% (n = 16) in summer. Table 5 presents the comprehensive cross-tabulation of seasonality by nationality.

Table 3 Cross-Tabulation of Visit Type by Seasonality

Visit Type	Spring n (%)	Summer n (%)	Autumn n (%)	Winter n (%)	Total n (%)
OP	7 (23.3%)	5 (29.4%)	3 (11.5%)	13 (31.0%)	28 (24.3%)
EP	17 (56.7%)	11 (64.7%)	19 (73.1%)	26 (61.9%)	73 (63.5%)
IP	6 (20.0%)	1 (5.9%)	4 (15.4%)	3 (7.1%)	14 (12.2%)

Table 4 Cross-Tabulation of Seasonality by Sex

Season	Female n (%)	Male n (%)	Total n (%)
Spring	24 (37.5%)	6 (11.8%)	30 (26.1%)
Summer	9 (14.1%)	8 (15.7%)	17 (14.8%)
Autumn	9 (14.1%)	17 (33.3%)	26 (22.6%)
Winter	22 (34.4%)	20 (39.2%)	42 (36.5%)

Table 5 Cross-Tabulation of Seasonality by Nationality

Season	Saudi n (%)	Non-Saudi n (%)	Total n (%)
Spring	4 (21.1%)	26 (27.1%)	30 (26.1%)
Summer	1 (5.3%)	16 (16.7%)	17 (14.8%)
Autumn	4 (21.1%)	22 (22.9%)	26 (22.6%)
Winter	10 (52.6%)	32 (33.3%)	42 (36.5%)

Discussion

This 15-year retrospective study provides valuable insights into the epidemiological landscape of helminth infections in Eastern Saudi Arabia, revealing distinct patterns in parasite distribution, demographic characteristics, and temporal trends. Our findings contribute to the understanding of helminth infection dynamics in a rapidly developing Gulf country with a substantial expatriate population.

Demographic Patterns and Risk Factors

The predominance of helminth infections among non-Saudi nationals (83.5%) in our study population aligns with findings from other GCC countries. Similar patterns have been reported throughout the Gulf region, where helminth infections are frequently diagnosed among migrant workers primarily from South Asia and Africa.^{14,21} This pattern likely reflects the importation of infections from endemic countries rather than local transmission, a phenomenon observed across the Arabian Peninsula.¹³

The substantial proportion of cases among Filipino (29.6%) and Indian (17.4%) nationals in our cohort directly reflects both their demographic representation in the Eastern Province's expatriate workforce and the endemic status of helminth infections in their countries of origin.²² These individuals might likely acquire infections in their home countries before migration, with clinical manifestation occurring after arrival in Saudi Arabia. The pattern suggests ongoing importation rather than local transmission cycles, as would be expected in a non-endemic setting with substantial population movement from helminth-endemic regions.

The age distribution in our study revealed a concentration of infections (59.1%) in the middle-aged group (36–50 years), which differs from the typical age distribution in endemic settings where children bear the highest burden.⁶ This finding likely reflects the demographic composition of the migrant workforce in Saudi Arabia, which predominantly consists of working-age adults. Similar age patterns were reported by Taha et al (2013) in their study of intestinal parasites among expatriate workers in Al-Madinah, where the majority of infections occurred in adults of working age.¹³

The slight female predominance (55.7%) in our study contrasts with some regional studies that reported higher prevalence among males.¹² This difference might be attributed to the substantial number of female domestic workers from helminth-endemic countries employed in the Eastern Province, as well as potential sex-based differences in healthcare-seeking behavior. Previous research suggests that female workers in certain occupational settings may have different patterns of healthcare access and screening, potentially leading to varying rates of detection for asymptomatic parasitic infections.^{21,23} Female workers in certain occupational categories may have different healthcare access patterns, potentially including more routine health screenings as part of employment requirements.

Parasite Distribution and Clinical Implications

The spectrum of helminth species identified in our study, with *Ascaris lumbricoides* (31.3%) and hookworm (16.5%) predominating, is consistent with global patterns in helminth epidemiology but differs somewhat from other regions of Saudi Arabia. Previous studies have reported varying helminth species distributions across different regions of Saudi Arabia, reflecting differences in environmental conditions, population demographics, and transmission dynamics across the country's diverse regions.¹⁶ The predominance of *Ascaris lumbricoides* and hookworm likely reflects the geographic origins of the expatriate population, with many individuals coming from regions where these species are highly endemic. The distribution pattern suggests successful importation of the most common soil-transmitted helminths from endemic countries.

The relatively high prevalence of *Hymenolepis nana* (13.9%) in our study population is noteworthy and exceeds rates reported in many endemic countries. This cestode, which can maintain its life cycle through direct human-to-human transmission without requiring an intermediate host, may find favorable transmission conditions in crowded living environments often experienced by expatriate workers and makes it particularly suited to persist even in non-endemic settings.²⁴ Hatam-Nahavandi et al (2024) similarly noted elevated rates of *Hymenolepis* species among certain population groups, attributing this to specific environmental and living conditions.²⁵

The predominance of mono-parasitic infections (89.6%) in our cohort differs from patterns observed in highly endemic settings, where polyparasitism is more common. For instance, studies in endemic areas have reported polyparasitism rates exceeding 30% in certain communities.²³ The lower rate of multiple infections in our study may reflect both the non-endemic status of Saudi Arabia for most helminth species and the effectiveness of preventive chemotherapy programs in countries of origin, which have reduced overall worm burdens.²⁴

Temporal Trends and Public Health Implications

The declining trend in helminth infections observed over our 15-year study period, particularly after 2016, aligns with global trends in soil-transmitted helminth control efforts.^{2,26} This decline likely reflects multiple factors, including improved sanitation infrastructure in Saudi Arabia, enhanced pre-employment health screening for expatriate workers, and successful mass drug administration programs in endemic countries of origin. Furthermore, enhanced diagnostic capabilities and treatment protocols within Saudi Arabia's healthcare system may have contributed to improved case detection and management, preventing progression to symptomatic disease requiring emergency care.

The absence of cases in 2022 and 2024 and minimal cases in 2023 may also reflect the impact of the COVID-19 pandemic on international travel and migration patterns, as well as changes in healthcare-seeking behavior during this period. Similar interruptions in neglected tropical disease programs during the pandemic have been reported globally.^{27,28}

Our finding that 63.5% of helminth infections presented as emergency cases rather than through routine outpatient visits suggests delayed diagnosis and potential complications. This pattern aligns with observations of healthcare access challenges faced by migrant populations, resulting in the diagnosis of parasitic infections only after the development of significant symptoms. This underscores the need for enhanced screening programs and improved healthcare access for expatriate populations in Saudi Arabia.

Seasonal Patterns

The pronounced seasonality observed in our study, with winter exhibiting the highest prevalence (36.5%) of helminth infections, represents a notable epidemiological pattern that requires detailed explanation. This seasonal pattern differs from those reported in endemic tropical regions, where peak transmission typically coincides with rainy seasons due to favorable conditions for environmental stages of helminths.⁴ Several interconnected factors likely contribute to this winter predominance in Eastern Saudi Arabia.

First, Climate and Environmental Factors

The cooler temperatures and increased humidity during winter months in Eastern Saudi Arabia may create more favorable conditions for helminth egg survival in the environment. *Ascaris lumbricoides* eggs, which comprised the largest proportion of infections in our study, are known to remain viable longer under cooler, more humid conditions compared to the hot, dry summer months typical of the region.^{9,29} The reduced environmental temperature stress during winter may extend the infective period of eggs in soil and on contaminated surfaces, similar to patterns observed in other geographical settings with variable climate conditions.⁹

Second, Behavioral and Dietary Factors

Winter months may coincide with increased consumption of fresh, raw, or undercooked vegetables, particularly leafy greens that are more readily available and palatable during cooler weather.²² This dietary pattern could increase exposure to soil-transmitted helminths, particularly *Ascaris lumbricoides*, through contaminated produce. Additionally, reduced hand hygiene practices due to cold weather and increased indoor crowding during winter months may facilitate transmission.

Third, Healthcare-Seeking Patterns

The winter predominance may also reflect seasonal variations in healthcare-seeking behavior, with patients more likely to seek medical attention during cooler months when travel to health-care facilities is more comfortable, and work schedules may be less demanding in certain industries.

The observed sex differences in seasonal presentation, with females showing higher spring prevalence (37.5%) compared to males (11.8%), and males showing higher autumn prevalence (33.3%) compared to females (14.1%), suggest potential sex-specific exposure patterns that warrant further investigation. Previous studies have observed sex-based differences in parasitic infection patterns that may be attributed to occupational exposures and cultural practices.²³

For Saudi nationals, the marked winter predominance (52.6%) contrasts with the more evenly distributed seasonal pattern among non-Saudis, potentially reflecting differences in healthcare-seeking behavior or seasonal travel patterns. Previous studies have identified nationality-based differences in health-care utilization patterns in Saudi Arabia.¹³

Clinical Implications and Management Considerations

The high proportion of emergency presentations across all seasons (ranging from a lowest of 56.7% in spring to a highest of 73.1% in autumn) suggests that helminth infections in our setting often progress to symptomatic disease before diagnosis. This pattern highlights potential gaps in early detection and preventive strategies, particularly among high-risk populations.

The developmental stage distribution, with 89.6% of infections detected at the egg stage, reflects standard diagnostic practices but also indicates potential opportunities for improved detection of larval forms, particularly for *Strongyloides stercoralis*, which is often underdiagnosed in routine stool examinations.³⁰ Recent advances in molecular diagnostics, including polymerase chain reaction (PCR) and improved diagnostic techniques, offer enhanced sensitivity for detecting low-intensity helminth infections and should be considered for implementation in similar settings.^{31–33}

Strengths and Limitations

Our study's strengths include its long-term retrospective design spanning 15 years, comprehensive parasitological data, and detailed demographic information. However, several limitations should be acknowledged. First, as a hospital-based study, our findings may not represent the true community prevalence of helminth infections, as asymptomatic cases likely remain undetected. Second, diagnostic techniques relied on conventional microscopy, which has lower sensitivity compared to molecular methods, potentially leading to underestimation of infection rates, particularly for species such as *Strongyloides stercoralis*. Third, information on potential risk factors such as occupation, living conditions, and travel history was not consistently available, limiting our ability to conduct more detailed risk factor analyses. Fourth, this study was designed as a descriptive epidemiological analysis and did not employ inferential statistical testing. As we analyzed the complete population of helminth-positive patients during the study period rather than a sample, statistical significance testing was not applicable to our research objectives, which focused on characterizing disease patterns rather than testing specific hypotheses.

Future Directions

Our findings highlight several areas for future research and public health action. First, targeted screening programs for high-risk expatriate populations, particularly those from countries with high helminth endemicity, could facilitate earlier diagnosis and treatment, preventing complications and potential local transmission. Second, educational interventions focused on personal hygiene and food safety, particularly during winter months when transmission appears highest, could help reduce infection risks. Third, integration of more sensitive diagnostic techniques, including serological and molecular methods, could improve detection rates, particularly for species such as *Strongyloides stercoralis* that are often missed by conventional microscopy.

Prospective studies incorporating detailed risk factor assessment, including occupation, living conditions, dietary habits, and travel history, would provide valuable insights into transmission dynamics among different population groups in Saudi Arabia. Additionally, comparative studies across different regions of Saudi Arabia would help clarify the geographical variation in helminth epidemiology within the country.

Conclusion

This comprehensive 15-year retrospective analysis successfully achieved its primary objectives of characterizing the epidemiological profile, temporal trends, and seasonal patterns of helminth infections in Eastern Saudi Arabia. Our

findings directly address each study objective: (1) *Ascaris lumbricoides* (31.3%) and hookworm (16.5%) emerged as the predominant helminth species; (2) significant demographic differences were identified, with non-Saudi nationals representing 83.5% of cases, reflecting importation patterns from endemic countries; (3) pronounced winter seasonality was observed (36.5% of cases), representing a novel epidemiological pattern in this geographical setting; (4) a clear declining temporal trend was documented, particularly after 2016; and (5) emergency presentations dominated across all seasons (63.5%), indicating delayed diagnosis and potential complications.

These findings provide crucial evidence for developing targeted public health interventions, including enhanced pre-employment screening programs for expatriate workers, season-specific prevention strategies focusing on winter months, and improved access to routine healthcare to prevent emergency presentations. The study contributes valuable insights into helminth infection dynamics in rapidly developing Gulf countries and emphasizes the importance of maintaining robust surveillance systems in non-endemic settings influenced by population movement from endemic regions.

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Disclosure

The author reports no conflicts of interest in this work.

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