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RESEARCH ARTICLE

Neglected Tropical Diseases (NTDs) in Saudi Arabia: Systematic Review and Meta-analysis

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Abstract

Neglected tropical diseases (NTDs) pose a significant public health challenge in tropical and subtropical regions, particularly in the Kingdom of Saudi Arabia (KSA), where epidemiological data remain scarce. These diseases disproportionately affect vulnerable populations, leading to chronic morbidity and economic burdens. Understanding their distribution and burden is crucial for effective public health interventions. This study aimed to systematically evaluate the prevalence, distribution, and etiological patterns of NTDs in KSA, identifying key research gaps and informing future policy directions. A systematic review and meta-analysis were conducted on peer-reviewed studies published between 1950 and 2024 that investigated NTDs in humans in KSA. Ninety-four articles met the inclusion criteria. The majority (69.15%, $n=65$) were published after 2010, with most studies concentrated in the western ($n=35$, 37.23%) and southwestern ($n=15$, 15.96%) regions, areas known for environmental and socioeconomic factors that may contribute to disease transmission. Protozoal NTDs were the most frequently reported ($n=28$, 29.78%), followed by viral ($n=26$, 27.66%), helminthic ($n=18$, 19.15%), and ectoparasitic ($n=9$, 9.57%) infections. Bacterial ($n=5$, 5.32%), fungal ($n=4$, 4.26%), and venom-related ($n=4$, 4.26%) NTDs were less commonly reported. Meta-analysis yielded pooled prevalence estimates of leishmaniasis at 0.59 (95% CI: 0.38–0.77, I^2 = 94.2%) and dengue at 0.20 (95% CI: 0.05–0.53, I^2 = 98.8%), highlighting a substantial disease burden and high heterogeneity among studies. The findings emphasize the urgent need for strengthened national surveillance, improved diagnostic capacity, and region-specific interventions to control NTDs in KSA. Future research should focus on underrepresented regions, expand community-based epidemiological studies, and integrate cross-border surveillance strategies to mitigate disease importation risks. By addressing these gaps, KSA can enhance its preparedness and contribute to global NTD elimination efforts.

Keywords Viral etiology · Tropical diseases · Soil-transmitted · Helminths · Leishmaniasis · Dengue · Climate changes · NTD · Saudi Arabia

1 Introduction

Neglected tropical diseases (NTDs) are a class of disorders caused by a variety of pathogens (including viruses, bacteria, parasites, fungi and toxins), are associated with connected to disastrous social, economic, and health effects [1]. They are associated with severe social, economic, and health consequences, disproportionately affecting populations in low-income settings with tropical and subtropical climates, inadequate healthcare services, and poor sanitation [2, 3]. Globally, NTDs affect more than one billion people, leading to chronic disability, reduced workforce productivity, and increased healthcare costs. These diseases impose a significant economic burden on endemic countries by straining healthcare resources and limiting socioeconomic development. The World Health Organization (WHO) currently lists 20 disease categories as NTDs. The list consists of both infectious and non-infectious illnesses, including leishmaniasis, foodborne trematodiases, ectoparasites,

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soil-transmitted helminthiasis (STH), and envenomation from a snakebite [4].

The majority of NTDs are primarily spread by mosquitoes and flies that are harboring a parasite, bacteria, or virus [5]. These diseases are associated with high morbidity, adverse maternal health outcomes, and developmental delays in children, which collectively diminish the quality of life in affected communities and perpetuate cycles of poverty [6]. Due to their widespread impact, NTDs have been integrated into global public health priorities. The Sustainable Development Goals (SDGs) emphasize the need to "end the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases, and combat hepatitis, water-borne diseases, and other communicable diseases by 2030" [7]. Additionally, the WHO's NTD Roadmap 2021–2030 has reinforced international commitment to eliminating these diseases through enhanced research, surveillance, and intervention strategies [4, 8].

Despite these global efforts, many endemic countries—including Saudi Arabia—face challenges in controlling NTDs due to a lack of comprehensive epidemiological data. The absence of precise disease mapping and prevalence estimates hampers the implementation of effective control and elimination programs. Although public and private initiatives have contributed to closing knowledge gaps, further epidemiological research is required to assess the true burden of NTDs and optimize intervention strategies [6].

The Kingdom of Saudi Arabia (KSA), a country spanning 2,150,000 km² in West Asia and the Middle East, has a population of 34.1 million as of 2021 [9, 10]. Although KSA has achieved substantial healthcare advancements, epidemiological data on the prevalence and distribution of NTDs remain scarce. The country has been identified as having the second-highest prevalence of leishmaniasis in the Middle East and North Africa region [11]. However, some NTDs, such as dracunculiasis and echinococcosis, have been reported less frequently (11 Additionally, dengue fever is endemic in KSA, and emerging arboviruses such as Rift Valley fever and Alkhurma hemorrhagic fever have also been documented [11].

In light of these gaps, this systematic review aims to determine the prevalence, distribution, and etiological patterns of NTDs in KSA, while identifying key epidemiological knowledge gaps. Although the WHO recognizes 20 NTDs globally, this study includes all NTDs reported in the literature from KSA. The focus is determined by available published data rather than the full WHO NTD list. By compiling data from multiple studies, this review provides insights into the burden of NTDs in Saudi Arabia and highlights areas requiring further investigation and public health intervention.

2 Materials and Methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines 2020 [12]. The study investigated all 20 WHO-recognized NTDs [13], including protozoan infections (Chagas disease, human African trypanosomiasis, leishmaniasis), helminth infections (taeniasis/cysticercosis, dracunculiasis, echinococcosis, food-borne trematodiases, lymphatic filariasis, onchocerciasis, schistosomiasis, soil-transmitted helminthiases (ascariasis, hookworm diseases, trichuriasis, strongyloidiasis)), bacterial infections (Buruli ulcer, leprosy, trachoma, yaws), viral infections (dengue and chikungunya fevers, rabies), fungal infections (mycetoma/chromoblastomycosis), ectoparasitic infections (scabies/myiasis), and venom-related conditions (snakebite envenoming).

2.1 Literature Search Strategy

A comprehensive literature search was performed from January 1950 to August 2024 across the following electronic databases: PubMed/MEDLINE, Embase, Scopus, Web of Science Core Collection, Cochrane Library, Google Scholar, CINAHL, and Ovid Global Health. In addition, grey literature sources, including institutional reports, theses, and conference proceedings, were examined to ensure a more complete literature review. The reference lists of selected articles were also screened for additional relevant studies.

The following search terms were used: (nematode* OR helmint* OR soil transmitted helmint* OR STH* OR ascari* OR chagas OR chikungunya OR roundworm* OR trichur* OR whipworm* OR hookworm* OR necator OR ancylostom* OR strongy* OR enterobi* OR geohelmint* OR schisto* OR haematobium OR mansoni OR bilharzia* OR esquisto* OR lymphatic filaria* OR LF OR elephantiasis OR bancrofti OR onchocerc* OR oncocerc* OR river blindness OR simulium OR blackfl* OR guinea worm* OR dracuncul* OR fluke* OR cysticerc* OR taenia* OR tenia* OR solium OR saginata OR tapeworm* OR fasciola* OR echinococ* OR equinococ* OR hydatid* OR hidatidosis OR leishmania* OR infantum OR donovani OR trofica OR sand fl* OR sandfl* OR african trypano* OR trypano* OR HAT OR brucei OR mycetoma OR scabies OR snakebite OR chromoblastomycosis OR gambiense* OR rhodesiense* OR sleeping sickness OR tsetse OR glossina OR trachoma* OR tracoma* OR trichiasis OR buruli ulcer* OR lepro* OR lepra* OR Hansen OR rabies OR lyssavir* OR RABV OR dengue OR aedes OR albopictus OR aegypti) AND (epidemiology OR incidence OR prevalence) AND (Saudi Arabia OR KSA).

All search and retrieval processes were performed independently by two authors (N.Z.A. and A.M.A.), and any discrepancies were resolved by a third author (A.M.A.S.).

2.2 Study Selection

Studies Eligible studies for inclusion in this systematic review were those that investigated the epidemiology of NTDs in Saudi Arabia using cross-sectional, ecological, cohort, or survey study designs. Case reports and case series were also included if they exclusively documented cases within the country. Exclusion criteria were applied to studies that did not have full-text availability, were published in languages other than English (as most peer-reviewed literature on this topic is in English), or focused on imported cases of NTDs rather than those acquired within Saudi Arabia. Non-human studies, abstracts, reviews, and letters to the editor were also excluded. Studies that reported multiple NTDs were carefully examined, and data extraction was conducted separately for each disease to ensure clarity in the analysis while avoiding duplication. The study selection process was performed independently by two authors (N.Z.A. and A.M.A.), with any disagreements resolved through consultation with a third author (A.M.A.S.).

2.3 Data Extraction

Data from the selected studies were systematically extracted using a standardized data sheet. The extracted information included the first author's name, year of publication, study location, study period, study design, study setting, sample size, age of participants, type of samples collected, methods of diagnosis, number and name of reported pathogens, and the number of positive cases for each pathogen. Two independent reviewers (N.Z.A. and A.M.A.) performed the data extraction to minimize bias and ensure accuracy. Discrepancies in extracted data were reviewed and resolved through discussion or consultation with a third reviewer.

2.4 Risk of Bias Assessment

Given the heterogeneity in study design, population characteristics, and diagnostic methodologies, we were unable to apply standardized risk of bias tools such as RoB-2, NOS, or QUADAS-2. Instead, we adopted a modified risk assessment approach based on the QUADAS-2 framework [14], specifically evaluating the accuracy and reliability of diagnostic techniques used in each study. Studies were classified as having a high or low risk of bias based on the diagnostic methods reported. High-risk studies were those that did not specify their diagnostic approach or relied on unvalidated serological tests without confirmatory techniques. In contrast, studies that used WHO-recommended, CDC-recommended, or molecular diagnostic techniques, such as PCR, culture, or histopathology, were classified as low risk. For example, a study that simply stated "serological testing" without further details was categorized as high risk, whereas a study that used PCR-based detection for Leishmania species was classified as low risk. The risk of bias assessment was conducted independently by two reviewers, with a third reviewer involved in resolving any discrepancies.

2.5 Analysis of Data

All included studies were classified according to their study design into five categories: observational studies, outbreak investigations, cross-sectional studies, case reports and case series, and survey studies. The study population was stratified into two age groups: children and adolescents (under 18 years) and adults (18 years and above). To assess the geographic distribution of NTDs in Saudi Arabia, studies were categorized based on the province and region where they were conducted. Reported pathogens were further classified into seven groups: viral, bacterial, protozoal, helminthic, fungal, ectoparasitic, and venom-related NTDs (snakebite envenoming).

A meta-analysis was performed for studies reporting the prevalence of leishmaniasis and dengue. A random-effects model was employed to account for variability across studies. The DerSimonian-Laird random-effects model was used to estimate pooled prevalence rates, given the anticipated heterogeneity in study populations, diagnostic methods, and geographic regions. Heterogeneity was quantified using I^2 statistics, with an I^2 value greater than 75% indicating substantial heterogeneity. The statistical analysis was conducted using RStudio (Version X.X) with the meta and metafor packages. To explore potential sources of heterogeneity, subgroup analyses were conducted where sufficient data were available. These analyses examined variations by geographic region, study design, and diagnostic methodologies. Additionally, sensitivity analyses were performed to assess the robustness of the pooled prevalence estimates by excluding studies with a high risk of bias. Due to limitations in data availability, meta-regression could not be performed but is recommended for future studies to further investigate the underlying sources of heterogeneity. This analytical approach ensured the generation of robust prevalence estimates while accommodating variations in study methodologies, thereby providing a comprehensive understanding of the epidemiology of NTDs in Saudi Arabia.

3 Results

3.1 Identification of Studies

The database search identified 2984 studies to be screened, of which 1720 abstracts were identified as potentially eligible and retrieved for full text review. Eligibility criteria were met by 94 articles, which were included in this systematic review. The PRISMA flowchart is shown in Fig. 1.

3.2 Risk of Bias Assessment

Risk of bias assessment revealed that 20 studies (21.28%) were categorized as high risk, 55 studies (58.51%) were categorized as low risk, and 19 studies (20.21%) had an unclear risk of bias due to incomplete reporting of diagnostic methodologies (Table S1). Most high-risk studies lacked specificity in describing diagnostic procedures, often using general terms such as "serological test" without further methodological details or failing to specify whether tests were conducted on paired sera. The majority of low-risk studies employed molecular techniques, PCR, culture, or histopathology, aligning with established diagnostic recommendations from the WHO and CDC.

3.3 Year of Publication and Geographic Location

The included studies spanned a publication range from 1980 to 2024, with 69.15% (*n*=65) published after 2010, reflecting increased research interest in NTDs over the past decade (Table S2). The majority of studies were conducted in the western region (*n*=35, 37.23%), followed by the southwestern region (*n*=15, 15.96%), with fewer studies in the eastern (*n*=9, 9.57%) and central (*n*=8, 8.51%) regions. Additionally, five studies (5.32%) were conducted in the southern region and three studies (3.19%) in the northwest

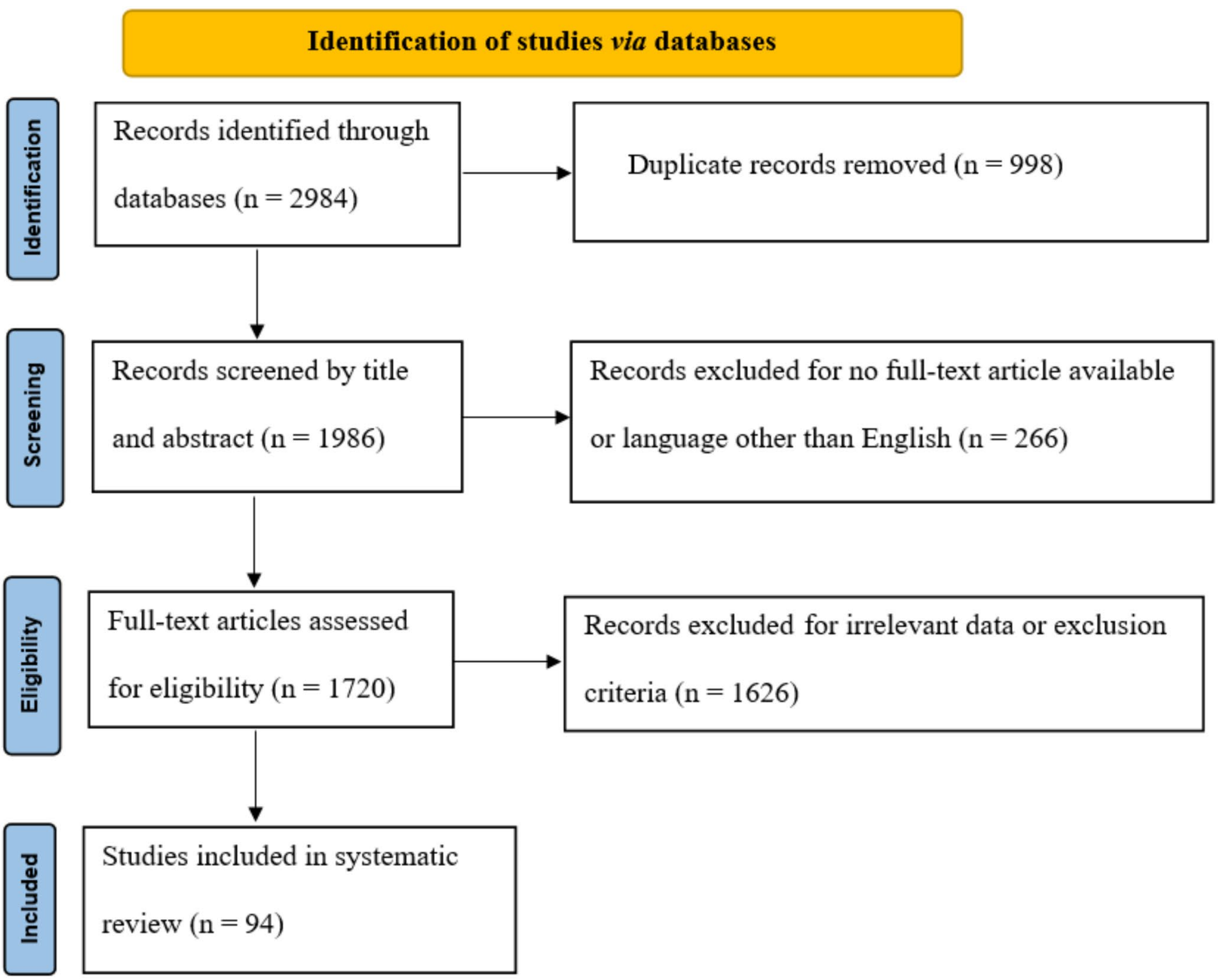

Fig. 1 PRISMA flow diagram

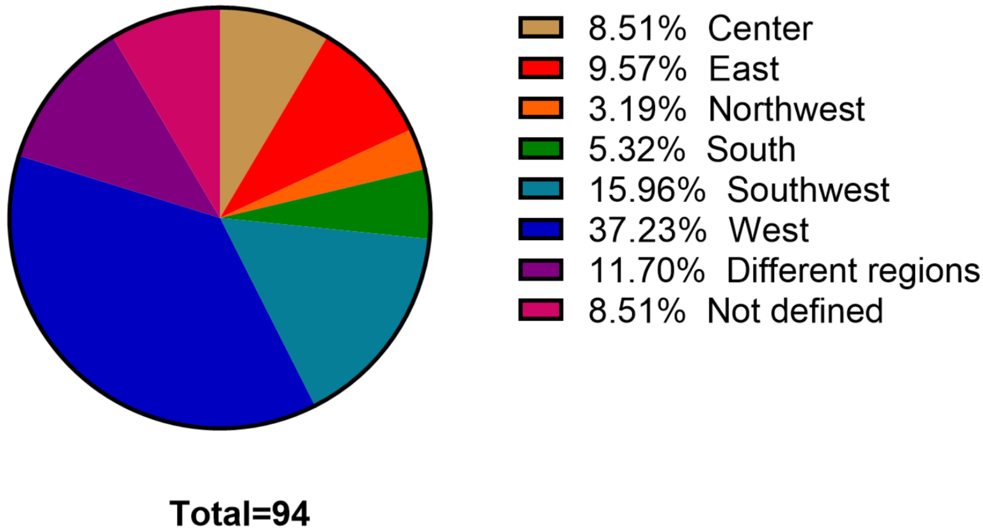

Fig. 2 Geographic location of the included studies

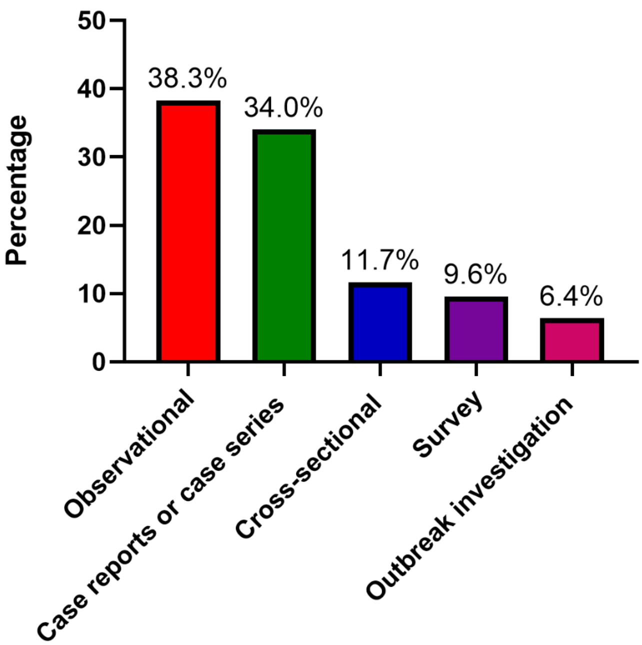

Fig. 3 Study design of the included articles

region, while eight studies (8.51%) did not specify a location (Fig. 2).

- The high concentration of studies in the western and southwestern regions aligns with their dense populations, increased human mobility, and environmental conditions favorable for vector-borne diseases such as dengue and leishmaniasis. The western region, particularly Jeddah and Makkah, is characterized by warm and humid conditions that support Aedes mosquito breeding, contributing to recurrent dengue outbreaks. Conversely, the southwestern region, with its rural and mountainous terrain, may provide ecological niches for sandflies and parasitic NTDs such as leishmaniasis. The relatively low number of studies in the central and southern regions may not reflect a lower disease burden but rather a gap in research efforts, underscoring the need for region-specific epidemiological studies.

3.4 Study Design

With respect to study design, observational studies and case reports or case series constituted the majority ($n=36$, 38.3% and $n=32$, 34%, respectively), followed by cross-sectional studies ($n=11$, 11.7%), survey studies ($n=9$, 9.6%) and outbreak investigation studies ($n=6$, 6.4%) (Fig. 3).

3.5 Study Population and Study Settings

Regarding participant demographics, 48.94% ($n=46$) of studies included both adults and children, while 32 studies (34.04%) focused exclusively on adults and 11 studies (11.70%) examined only children and adolescents. However, five studies (5.32%) did not specify participant age groups (Fig. 4).

The majority of studies were hospital-based ($n=73$, 77.66%), followed by community-based studies ($n=16$, 17.02%). Additionally, four studies (4.26%) were conducted in health care centers, while one study (1.06%) was laboratory-based (Fig. 5).

3.6 Types of Samples

The included articles featured a range of samples that were gathered and examined. The most frequently analyzed samples were blood and serum which featured in 25 studies (26.9%), followed by skin biopsy specimens in 23 articles (24.7%). However, 19 (20.4%) articles did not specify the type of sample. The remaining 26 (28%) articles analyzed

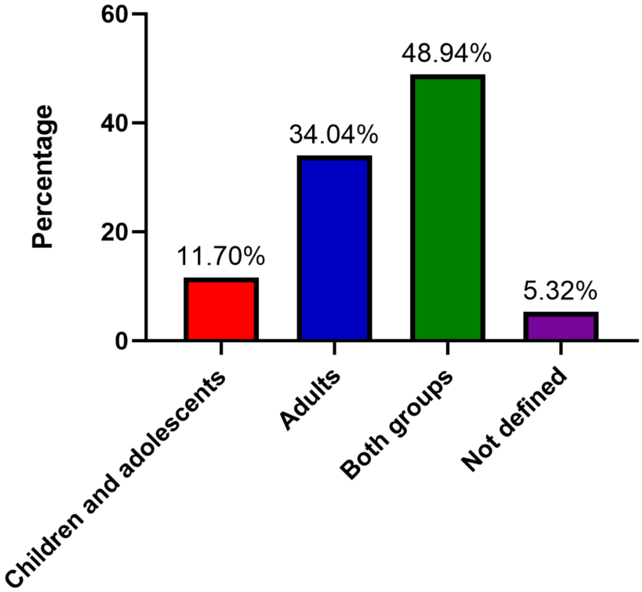

Fig. 4 Study population

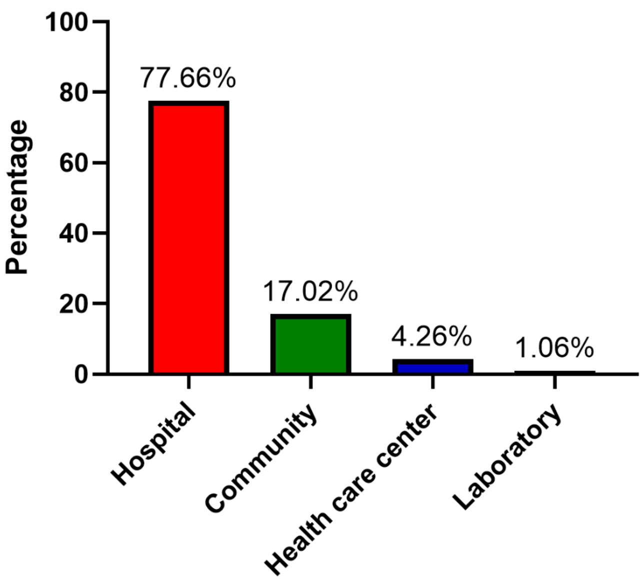

Fig. 5 Study setting

urine, bronchoalveolar lavage fluid, bone marrow, duodenal tissue specimen and other tissue samples.

3.7 Diagnostic Methods

The included articles used various diagnostic techniques. In 27 articles (29%) more than one type of diagnostic method was used, while 11 articles (11.8%) did not mention the diagnostic method. In 17 publications (18.3%), microscopy was utilized, followed by molecular approaches in 16 articles (17.2%), serology in 8 studies (8.6%), clinical examination in 6 articles (6.5%), and imaging technique in 5 articles (5.4%) and. The remaining 3 (3.2%) articles used sedimentation method, culture and histopathology.

3.8 Etiology of NTDs

Among the 94 included studies, protozoal infections were the most frequently reported (n=28, 29.78%), followed by viral NTDs (n=26, 27.66%), helminthic infections (n=18, 19.15%), and ectoparasitic infections (n=9, 9.57%). Bacterial (n=5, 5.32%), fungal (n=4, 4.26%), and venom-related NTDs (n=4, 4.26%) were less frequently documented (Fig. 6).

3.9 Prevalence of Leishmaniasis and Dengue in Saudi Arabia

The pooled prevalence of leishmaniasis was estimated at 0.59 (95% CI: 0.38–0.77, $I^2 = 94.2\%$), indicating substantial heterogeneity across studies. The forest plot (Fig. 7) reveals notable differences in prevalence between geographic regions, likely due to variations in diagnostic criteria, study populations, and environmental conditions. The highest prevalence rates were reported in the western and south-western regions, where Phlebotomus sandflies are endemic.

For dengue, the pooled prevalence was 0.20 (95% CI: 0.05–0.53, $I^2 = 98.8\%$), reflecting considerable heterogeneity (Fig. 8). Subgroup analysis by region demonstrated that dengue prevalence was highest in the western region, particularly in Jeddah and Makkah, where outbreaks are recurrent.

The high heterogeneity ($I^2 > 90\%$) observed in both meta-analyses underscores significant variations in study methodologies and population characteristics. To explore potential sources of heterogeneity, sensitivity analyses were conducted by excluding high-risk studies, confirming the robustness of the pooled prevalence estimates. However, due to limited data, meta-regression could not be performed, and further studies using standardized diagnostic techniques are recommended to refine prevalence estimates.

4 Discussion

This systematic review compiled all peer-reviewed publications on neglected tropical diseases (NTDs) reported in Saudi Arabia (KSA) up until August 2024, providing a comprehensive assessment of their epidemiology. Through a rigorous search across eight different databases, 94 articles were selected from an initial pool of 2,984 records. The results highlight the prevalence, distribution, and etiological patterns of NTDs in KSA, identifying critical research gaps and public health implications. Compared to other countries

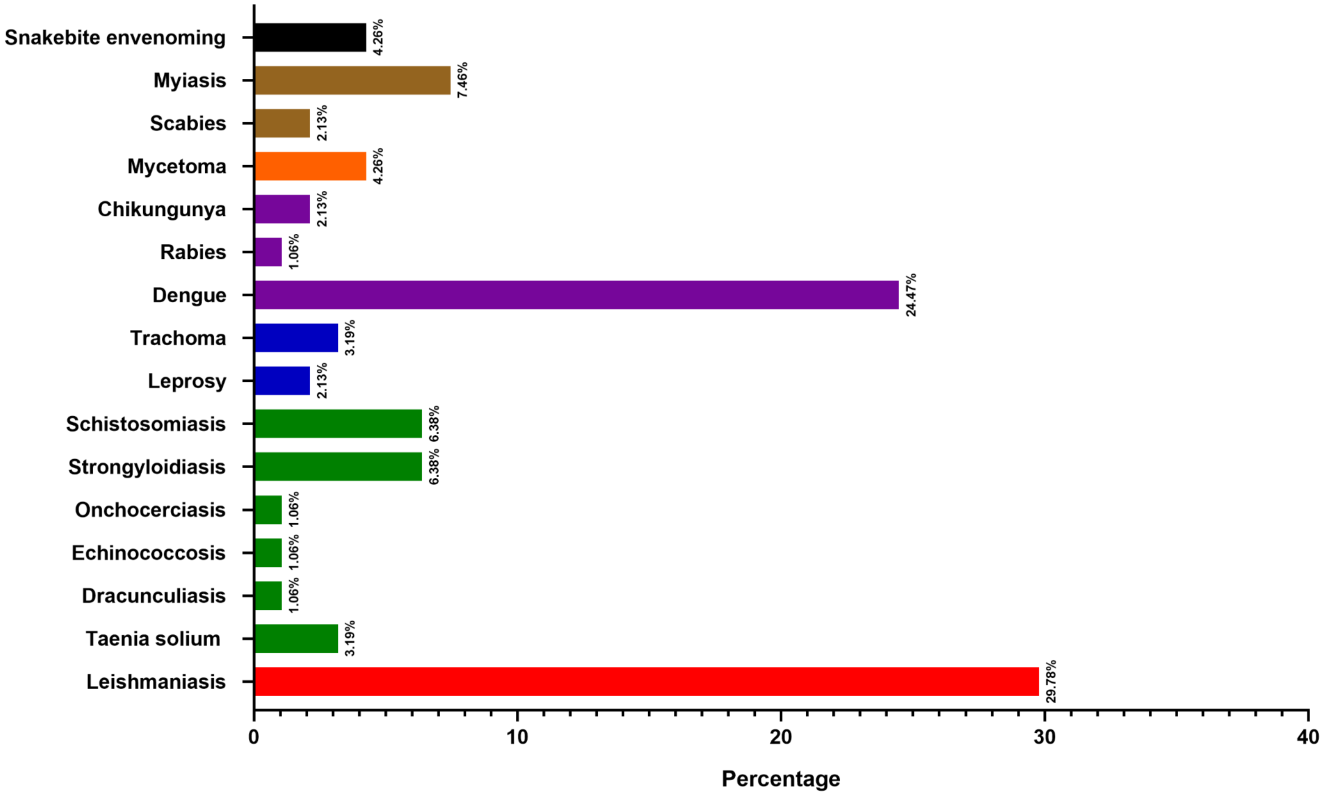

Fig. 6 Etiology of NTDs in Saudi Arabia

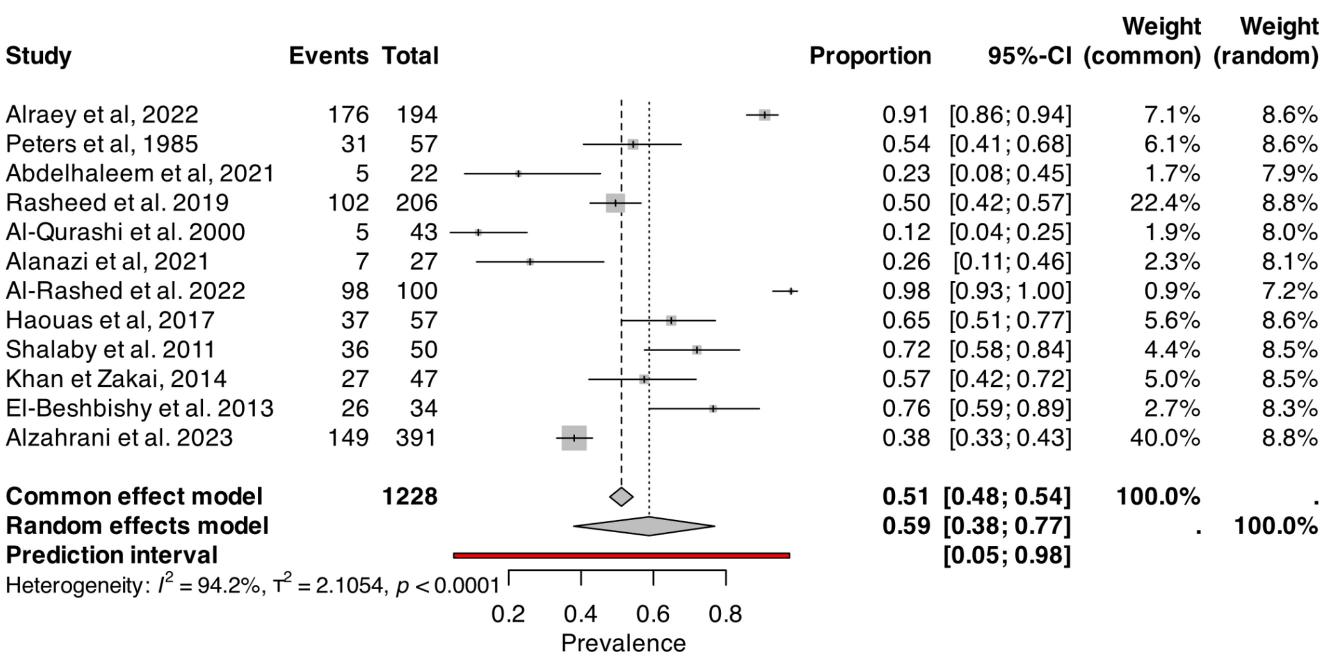

Fig. 7 Forest plot of leishmaniasis prevalence estimates in KSA

in the Middle East and North Africa (MENA) region, Saudi Arabia exhibits a relatively lower reported prevalence of some NTDs, possibly due to better healthcare infrastructure and disease control efforts [15, 16]. However, the high burden of leishmaniasis and dengue aligns with trends observed in neighboring endemic countries such as Sudan, Egypt, and Yemen, where similar environmental and vector-related factors facilitate disease transmission [17].

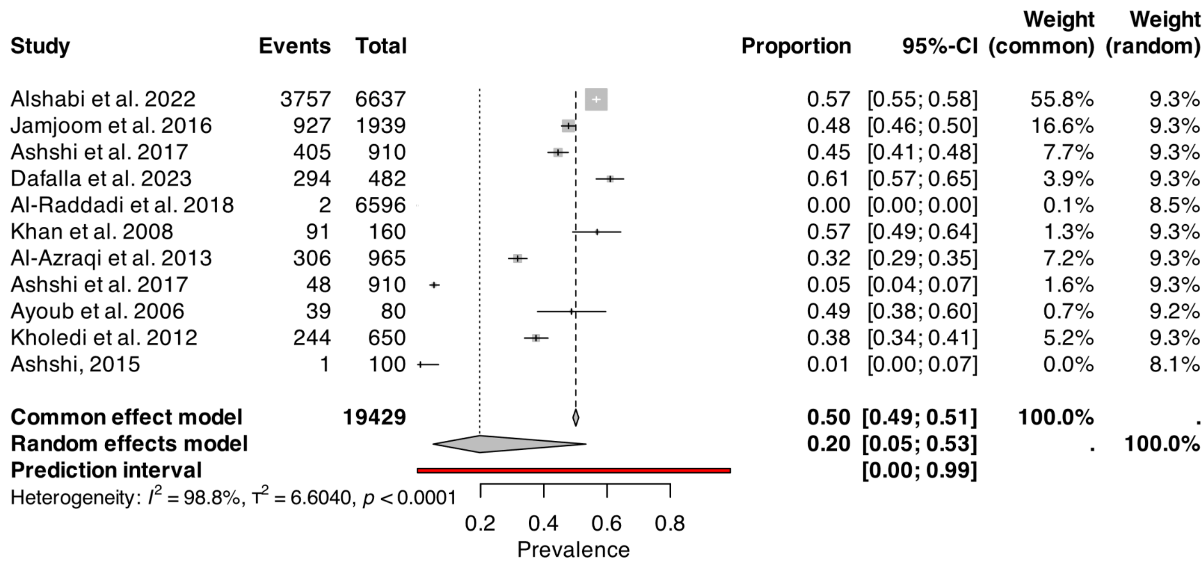

Fig. 8 Forest plot of dengue prevalence estimates in KSA

The protozoan parasite Leishmania spp. is the cause of leishmaniasis, a complicated disease with a wide range of clinical symptoms [15]. It is spread by the bites of sand flies carrying the infection (Phlebotomus or Lutzomyia spp). 350 million individuals are at risk of contracting the disease, and there are an estimated 1.5 to 2 million new cases, 70,000 fatalities, and 1.5 million new cases worldwide each year [16]. In the eastern province of Saudi Arabia, primarily in the Al-Hassa Oasis, cutaneous leishmaniasis is endemic. The disease's primary natural host in Saudi Arabia is the sand fly, with desert rodents serving as a backup host. The primary cause of cutaneous leishmaniasis in the Al-Hassa Oasis, Leishmania major, typically results in skin lesions that do not spread. Phlebotomus sergenti is L. tropica's primary vector [17]. The findings of this systematic review revealed that the majority of cases of leishmaniasis were detected in the western [18–23] and eastern [24–28] provinces of KSA, followed by southwest region [29–32]. However, only three studies described the prevalence of leishmaniasis in the south [33–35] and northwest [36–38] regions of KSA. Previously, enzyme electrophoresis and microscopic examination of Giemsa-stained smear were used to diagnose leishmaniasis [39, 40]. Nowadays, leishmania species are identified by highly specific/sensitive quantitative and qualitative PCR [41, 42].

One of the four serotypes of the dengue virus (DENV1-4) is the source of dengue fever, a virus spread by mosquitoes. Even in cases with high viral loads, most infected people merely show flu-like symptoms or show no symptoms at all [43]. In this systematic review, 26 studies (28%) reported viral etiology of NTDs in KSA. Dengue was the most frequent viral etiology reported in KSA. Interestingly, the majority of studies were conducted in the western province of KSA [44–61]. That could be explained by the fact that Jeddah city, in the western province, had the first dengue outbreak in the KSA, in 1994. After multiple outbreaks over the previous ten years, the virus eventually spread to other adjacent cities, including Makkah, and the Western region was officially classified as dengue endemic [43]. Furthermore, multiple recent epidemiological investigations have demonstrated that the virus and/or its vector have been discovered in hitherto unexplored geographical regions of the kingdom such as the southwest and central regions of KSA [62–64].

However, only two studies reported Chikungunya virus in KSA. The first study described the first case of autochthonous acute chikungunya infection in KSA [65], while the second one reported a confirmed case of chikungunya virus in the southern region [66]. Chikungunya virus detection techniques are not regularly used, and the virus may be present in areas with a high mosquito population. Arboviruses that have an impact on health, such the chikungunya virus, should be given special attention.

The rabies virus, which is endemic in animals on the Arabian Peninsula, is the cause of this zoonotic disease. Rabies virus was also detected in KSA in a 60-year-old Saudi man [67]. Even though human rabies is uncommon in Saudi Arabia, there is always a chance because of a number of factors, such as the country's high animal rabies prevalence, its proximity to other rabies-prone nations, and the millions of pilgrims who travel there each year.

In KSA, helminth NTDs were reported in 18 studies. Six case reports detected strongyloidiasis among Saudi kidney transplant recipient [68–73]. Strongyloides stercoralis, an intestinal helminth, is found in polluted soil in hot and humid tropical and subtropical regions of Africa, South and East Asia, and South America. Post transplant helminth infections are uncommon and affect about 2% of transplant recipients [68]. Schistosomiasis was also reported in six studies [74–79]. The trematode helminth of the genus Schistosoma is the cause of schistosomiasis. It is a fatal parasite illness that affects over 200 million people globally [74]. Intermittent contact with parasite-contaminated water during daily activities is one of the major factors contributing to intestinal schistosomiasis. In order to address schistosomiasis in Saudi Arabia, it is necessary to implement more comprehensive and intensive One Health programs due to the disease's persistence and the differences in demographic characteristics.

One of the main causes of helminth diseases of the human nervous system worldwide is neurocysticercosis, a consequence of infection by the larvae of the pork tapeworm, Taenia solium. Mexico, Central and South America, sub-Saharan Africa, Portugal, Spain, India, China, Bali, Korea, and other nations have widespread endemic cases of cysticercosis in their rural areas [80]. Three cases reports have described the incidence of Taenia solium in KSA [81–83]. The first case of neurocysticercosis in Saudi Arabia was reported in 2003 [81]. Feco-oral contact to housekeepers who had recently immigrated from endemic areas is the most likely cause of infection in Saudi patients [81]. Interestingly, only one case report of dracunculiasis [84], echinococcosis [85], and onchocerciasis [86] were found in KSA. The low incidence of these helminths in KSA could be explained by the fact that these diseases have been eradicated from many endemic regions of the world.

Ectoparasites NTDs that were reported in KSA included myiasis and scabies. Scabies is a very contagious skin condition. It is rare to find reports of scabies in Saudi Arabia's literature. However, more than 1700 new instances of scabies were reported in schools in Mecca, in the Western area of Saudi Arabia, during the first half of 2018, according to the Saudi Ministry of Health [87]. The Mecca region is not the only place where the Saudi Ministry of Health reports new cases of scabies. Unfortunately, the primary factors that contribute to scabies infestation and its epidemiological characteristics are not formally recorded [88]. On the other side, seven case reports described the incidence of myiasis in KSA. The majority of studies were reported in the western province [89–92]. Myiasis is caused by fly larvae or maggots infesting living mammalian tissue; most human occurrences of myiasis are cutaneous infestations. Less frequently infected areas include the genitourinary, abdominal-intestinal, nose, eye, and ear [93]. After an extensive search of scientific literature, very few cases were found to be reported by KSA. Thus, the rarity of this condition makes it liable to be missed [94, 95].

Leprosy and trachoma were the two bacterial NTDs reported in KSA. Caused by Mycobacterium leprae, leprosy is a chronic illness. In Saudi Arabia, 57% of individuals with a diagnosis of leprosy are immigrants, and the prevalence of leprosy is 3:1 higher in men than in women [96]. Assiri et al. reported 242 new cases of leprosy in Saudi Arabia throughout a 10-year period from 2003 to 2012, providing information on the epidemiology of the disease in that country [97].

One of the first known conditions affecting the eyes, trachoma is an infectious ocular process that usually affects the cornea and conjunctiva and is brought on by Chlamydia trachomatis. The historical patterns of inadequate hygiene in Saudi Arabia are changing quickly, and so is the distribution of the diseases that these patterns are linked to [98]. Trachoma was a blinding disease that was quite prevalent in Saudi Arabia a few years ago, especially in the Eastern Province. Nevertheless, there are signs that the condition is fast declining, most likely as a result of increased living standards and easier access to eye treatment [99, 100].

Mycetoma was the only fungal NTD reported in KSA. Four case reports described the incidence of this disease in KSA. Three case reports were detected in eastern province [101–103] while one case was revealed in western province [104]. Mycetoma is a frequent condition found in tropical and subtropical regions. It is more common in arid and dry regions like Sudan, Nigeria, Ethiopia, and Saudi Arabia. The 20th century's ease of movement allowed for the presentation of this pathology to physicians world-wide.

It was reported that seven out of every 1000 patients who visited the emergency room over a three-year period in the southwest region of Saudi Arabia had experienced a snake bite. This represents 2.4% of all admissions in the summer, when snake bites are most common [105]. With the exception of sea snakes, at least five snakes that can bite people fatally can be found in Saudi Arabia [106]. According to the study of Al-Sadoon, 2015, the majority of the bites implicate Cerastes Cerastes Gasperettii, making it the snake of medical significance in the province of Riyadh [107]. In the years between 2015 and 2018, 14,697 cases of snake bites caused by venomous snakes were reported nationwide [108]. Hence, the general public should be made aware of the potential life-saving benefits of early diagnosis and appropriate use of snake antivenoms. Delays in receiving the right care can increase morbidity and mortality rates significantly.

4.1 Limitations of the Study

This study has several limitations that should be considered when interpreting the findings. Publication bias may have influenced the reported prevalence of NTDs, as studies with significant or positive findings are more likely to be published than those with negative or inconclusive results. Additionally, heterogeneity among the included studies in terms of study design, sample size, and diagnostic methodologies introduces inconsistencies in disease detection and reporting, impacting prevalence estimates. The uneven geographic representation, with most studies concentrated in the western and southwestern regions, suggests that NTD epidemiology in central, eastern, and southern Saudi Arabia remains underexplored. Furthermore, the inability to conduct a meta-regression analysis due to limited data restricted the ability to identify key factors contributing to disease distribution. Future studies should focus on standardizing diagnostic techniques, ensuring comprehensive geographical coverage, and using robust epidemiological methods to provide a clearer picture of NTD prevalence in Saudi Arabia.

4.2 Recommendations for Future Research and Public Health Strategies

To enhance NTD control efforts in Saudi Arabia, regionally representative epidemiological studies should be conducted, particularly in underreported areas, using standardized diagnostic protocols to improve comparability across studies. Nationwide seroprevalence surveys for leishmaniasis, dengue, and schistosomiasis should be prioritized, alongside expanded laboratory capacity to enhance molecular and rapid diagnostic testing. Integrating One Health approaches by strengthening vector control programs, improving surveillance of zoonotic reservoirs, and expanding real-time disease monitoring systems will be critical. Cross-border collaborations with endemic neighboring countries should be reinforced to mitigate imported cases and share disease intelligence. Additionally, investment in public health infrastructure, community awareness campaigns, and accessible treatment programs will enhance disease prevention and control efforts. Lastly, leveraging digital health tools, geospatial mapping, and machine learning for predictive modeling can improve early outbreak detection and optimize intervention strategies, ensuring a proactive approach to NTD management in alignment with the WHO's 2030 NTD Roadmap.

5 Conclusion

This systematic review provides a comprehensive analysis of neglected tropical diseases (NTDs) in Saudi Arabia, highlighting their prevalence, geographic distribution, and etiological diversity. The findings underscore the significant burden of leishmaniasis and dengue, particularly in the western and southwestern regions, with limited epidemiological data from other parts of the country. Helminthic, bacterial, fungal, and venom-related NTDs remain underreported, suggesting potential gaps in surveillance and diagnosis. The high heterogeneity among studies reflects the need for standardized diagnostic methods and nationally representative research efforts. To effectively control and eliminate NTDs, enhanced epidemiological surveillance, vector control strategies, and strengthened cross-border disease monitoring are essential. A multi-sectoral approach, integrating One Health principles, digital health tools, and predictive analytics, will be critical for improving disease control efforts. By implementing these strategies, Saudi Arabia can significantly reduce the burden of NTDs and contribute to global health goals outlined in the WHO's 2030 NTD Roadmap.

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Declarations

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