scientific reports

OPEN

Zoonotic brugian filariasis past and present trends in malaysia: A systematic review and proportionate meta-analysis

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Lymphatic filariasis is a neglected tropical disease of public health concern targeted for elimination globally. Malaysia is endemic to filariasis caused mainly by the filarial parasite *Brugia malayi*, with decades of continues elimination efforts. Despite recorded success, the disease is yet to be eliminated. Recently, reinfection in regions following mass drug administration programs and resurgence in some parts of the country raises concern as the country geared towards the 2030 filariasis elimination target. This study aims to provide pool prevalence estimates of the disease in animals and humans in Malaysia using a proportionate meta-analysis. Recent epidemiolocal data, potential filaria hotspots and the role of human induced environmental degradation on zoonotic filariasis transmission are also discussed. A Generalized Linear Mixed Model (GLMM) was used for the proportionate meta-analysis of prevalence data from 12 included studies. The result reveals overall human zoonotic filariasis estimated pool prevalence of 3% [95% CI: 0.01–0.09] and 5% [95% CI = 0.01–0.17] among animals in Malaysia, with a significant between study heterogeneity (I^2 = 97%; I^2 = 94%, p < 0.001, respectively). A subgroup meta-analysis of animal prevalence reveals high common effect estimated prevalence among monkeys 50% [95% CI = 0.43–0.58] with a random effect of 9% [0.00-0.94], with no observed between study heterogeneity (I^2 = 0%, p = 1). This study provides insight into zoonotic brugian filariasis that can be useful for the development of effective and sustainable lymphatic filariasis elimination program in Malaysia and other filarial endemic regions.

Keywords Brugian filariasis, Zoonosis, Prevalence, Malaysia, Systematic review, Environmental changes

Lymphatic filariasis is a tropical disease associated with poverty and a leading cause of permanent disability and economic burden worldwide. Filariasis is estimated to affect 51 million people worldwide, and over 657 million in 39 countries at risk, with South-east Asia bearing the greatest global burden[1]. The disease is caused by infection with *Wuchereria bancrofti*, *Brugia malayi* and *Brugia timori*, filarial nematodes transmitted by mosquitoes. The later are zoonotic and account for 10% with the former accounting for 90% of reported cases globally[2]. In Malaysia, filariasis caused by *B. malayi* accounts for majority of the reported cases[3]. *Brugia malayi* is a zoonotic filaria that can infect human, cat, dog, monkey as well as wild felids. The parasite microfilaria is ingested by vectors from vertebrate hosts, where it develops into third stage larva (L3) that is transferred to host lymphatics. Mature adults in hosts reproduce microfilaria that enter into blood circulation. Each stage of the parasite's life cycle is important in filariasis diagnosis and epidemiology.

B. pahangi is a closely related filaria to *B. malayi* and it is known to infect only animals, particularly cats and dogs[4]. The filarial parasite had previously been proven to infect humans in laboratory experiments and in the last decade, natural infections in humans had been reported[5–7].

Lymphatic filariasis (LF) caused by *B. malayi* is a significant public health challenge in Malaysia, where extensive efforts have been made to eliminate the disease through mass drug administration (MDA) programs, vector control, and community engagement initiatives since 2008[8]. Despite these efforts, zoonotic filariasis, primarily caused by *Brugia*, persists as a critical concern in endemic regions of the country. Unlike human-specific filaria,

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zoonotic filariasis infects and remain in animal reservoirs, including domestic and wild animals[5,9]. Thereby complicating elimination strategies and necessitating a deeper understanding of its transmission dynamics. Animal hosts such as cats, dogs, monkeys and wild boars act as reservoirs, perpetuating transmission even in post MDA regions. Recent epidemiological data indicating sporadic peaks in filariasis cases in 2022 and 2024, hinting at a complex interplay of reservoir hosts raises urgent questions regarding reinfections, animal reservoirs, and existing surveillance gaps in the country[3]. Addressing these challenges requires a comprehensive analysis of zoonotic filariasis, including its prevalence in both human and animal populations, host-vector interactions, and ecological factors that facilitate transmission. Therefore, a systematic approach that incorporates human, animal, and public health perspectives is crucial for achieving sustainable LF elimination in Malaysia. This review aims to synthesize data on zoonotic filariasis in Malaysia by employing systematic proportionate meta-analysis to evaluate the prevalence of brugian filarial infections in human and a variety of animal hosts across different studies from different regions of the country. By integrating findings from existing studies, this research seeks to provide insight into zoonotic filariasis prevalence, which will contribute to the development of an effective and sustainable strategy that will enhance Malaysia's LF elimination efforts, while addressing the recent challenges posed by zoonotic reservoir hosts and human reinfection in post MDA regions.

Furthermore, this study addressed the unique challenges posed by zoonotic brugian filariasis elimination, highlighting the role of human induced environmental modification to the sustained filaria transmission in the country. Understanding the extent of zoonotic brugian filariasis and complex interplay between these factors will enable public health policy makers to integrate the one health approach that will enable a more robust targeted interventions that not only will reduce filariasis transmission incidence rates but also promote community engagement and awareness regarding zoonotic filariasis in Malaysia and at large, filariasis endemic regions of the world.

Materials and methods

Systematic review and proportionate meta-analysis

This review evaluated previous studies on zoonotic brugian filariasis from human and variety of animals conducted in Malaysia using a systematic data synthesis according to PRISMA 2020 reporting guidelines and proportionate meta-analysis approach. The study also reviewed government filariasis epidemiological data and environmental role on filariasis prevalence in the country.

Review registration and reporting guidelines

The review protocol was registered on PROSPERO (ID: 1027718) and conducted in accordance with guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020.

Search strategy

A systematic review of relevant literature was conducted using health-related databases, including PubMed, Springer, Web of Science, Scopus and Wiley online library using the following search string: "(lymphatic filariasis OR filariasis OR filaria OR filarial OR zoonotic OR brugia OR brugia malayi OR brugia pahangi OR elephantiasis OR hydrocele OR oedema) AND (prevalence) AND (Malaysia OR Peninsular Malaysia OR Borneo)".

The search was restricted to studies conducted in Malaysia and published in English between 1970 and 2024. Accessible full-text articles that met inclusion criteria were downloaded and screened for eligibility.

Inclusion criteria

i. Studies with accessible full text published in English language, conducted in Malaysia reporting prevalence of natural and active infections with zoonotic brugian filariasis in humans.
ii. Prevalence of natural infections with zoonotic brugian filariasis in animal reservoirs (e.g., monkeys, dogs, cats), identified using microscopy or molecular techniques.
iii. Studies providing the latest prevalence data from drug efficacy trials involving natural infections.

Exclusion criteria

i. Laboratory-induced infection studies.
ii. Clinical case reports or studies that are not reporting prevalence data.
iii. Studies reporting only antibody prevalence (seroprevalence) without active infection data.
iv. Studies lacking identification of the specific filarial species involved (e.g., not confirmed as *Brugia* species) and studies that reported non brugian filariasis.

Risk of bias assessment

Risk of bias for all included prevalence studies was assessed using the Joanna Briggs Institute (JBI) critical appraisal checklist for prevalence studies[10]. Each study was evaluated across nine checklists addressing sampling methods, sample size, data analysis, and validity of condition measurement. Two independent reviewers conducted the risk of bias assessment for each study. Discrepancies between reviewers were resolved through discussion and consultation with a third reviewer.

The review adopted a percentage-based categorization to enhance clarity and comparability. Studies that met more than 75% of the checklist items (at least 7 out of 9 criteria) were rated as having low risk of bias; those fulfilling 50–74% (5–6 items) were considered to have moderate risk; and those with less than 50% (fewer than 5 items) were classified as high risk of bias, consistent with adaptations used in previous systematic reviews of prevalence data[10].

Sensitivity analysis

Sensitivity analysis was not conducted for this review; as only one study was rated as having a moderate risk of bias, with all remaining studies assessed as low risk. Given the minimal variation in study quality, the influence of risk of bias on the overall findings was considered negligible. However, both fixed-effect and random-effects models were applied to assess the stability of the pooled prevalence estimates under different models. Heterogeneity analysis was performed to ensure the robustness of the findings.

Data extraction

Author, year of publication, study population (humans and animals), prevalence, reported case (from government data), method of detection and study location from the screened full text included in this study were retrieved and prerecorded in Microsoft Excel for synthesis and data analysis. Data was extracted from each included study and recorded on spreadsheet by two independent reviewers. Extracted data were organized in a tabular format to enable clear presentation and analysis, consistent with PRISMA 2020 reporting standards.

Temperature and rainfall from Malaysia meteorological database

Data from 17 meteorological stations in Malaysia managed by the Meteorological Department, Ministry of Natural Resources and Environmental Sustainability, Malaysia were accessed to retrieve three decades meteorological data of temperature and precipitation for the Malaysia regions of Peninsular Malaysia, Sabah and Sarawak[11]. Data were critically analyzed for possible implication of climate change on filariasis trend in Malaysia.

Data analysis

For overall pool prevalence estimates of zoonotic brugian filaria in humans and animals, data were subjected to proportionate meta-analysis using the "metaprop" command in R-Studio (R-studio (RStudio Team, Posit PBC, Boston, MA, USA). R code was deposited on GitHub: https://github.com/Hafizdk/Proportionate-meta-analysis.git, https://github.com/Hafizdk/Proportionate-meta-analysis-Animal-studies.

Due to heterogeneity and presence of zero event in the included studies, a Generalized Linear Mixed Model (GLMM) was used for the meta-analysis. Prevalence data were transformed in the model using a logit-link function (sm = "LOGIT") to ensure appropriate modeling of proportions. Both fixed-effect and random-effect models were used to calculate the transformed prevalence estimates.

Heterogeneity was quantified using the τ^2 and I^2 statistic in order to account for between study heterogeneity. For animals' studies, similar analysis was performed with additional subgroup meta-analyses according to animal category (cat, dog, monkey and goat). Forest plots were generated for both human and animal studies to visually represent prevalence estimates from studies with their corresponding weight and confidence intervals.

There are number of limitations to the commonly used publication bias assessment tools in the proportionate meta-analysis. The tools assume that studies with negative results are less likely to be published. In addition, for prevalence studies, there is no clear definition of what constitutes a "positive" or "negative" result, making publication bias tests such as Egger's, Begg's tests and funnel plots less reliable[12]. Given these limitations, this study did not conduct a formal publication bias assessment. However, both fixed-effect and random-effects models were applied to assess the stability of the pooled prevalence estimates under different models. Heterogeneity analysis was performed to ensure the robustness of the findings.

Results

Databases search outcome and study characteristics

Search results from databases revealed a total of 794 articles. Out of which 56 potentially relevant studies were downloaded. After screening for eligibility, 12 research articles were included for the review and meta-analysis (Fig. 1).

The summary table of the characteristics of 44 excluded studies from this review is provided in supporting information table (Supplementary Table S1).

From the twelve included research articles, six studies reported only human prevalence, four studies reported animal prevalence only, of which one reported cats and dogs, and two reported on cats only while one on dogs only (Table 1). Two studies reported prevalence in both humans and animals. Most of the studies were from endemic areas which included Johor, Kelantan, Pahang, Perak, Perlis, Sabah, Taiping and Terengganu. Four studies were from the non-endemic area of Selangor: two each on humans and animals (Fig. 2).

From studies on human prevalence, a total of five studies screened *Brugia* infection using thick blood smear (TBS) only, and two studies using PCR method only, as shown in Table 1. Three studies used a combination of two methods - TBS and Elisa method. Based on the criteria for this study only the result from TBS was reported.

Risk of bias assessment

All 12 included studies were appraised using the JBI critical appraisal checklist for studies reporting prevalence data. The majority of studies ($n = 11$) were rated as having low risk of bias, fulfilling more than 75% of the checklist criteria. Only one study was classified as having a moderate risk of bias, due to uncertainty regarding sample size adequacy, however, with clear methodology. No studies were assessed as high risk of bias (Supplementary tables S2 and S3). These findings indicate that the overall methodological quality of the studies included was robust.

Sensitivity analysis

A comparison outcome of two models; fixed effect model and random effect model was used in the meta-analysis of the prevalence estimates. The findings reveal sensitivity to study variations, as reflected in the differences between the two models, which justified the use of random-effects model for results interpretation given the substantial heterogeneity among studies.

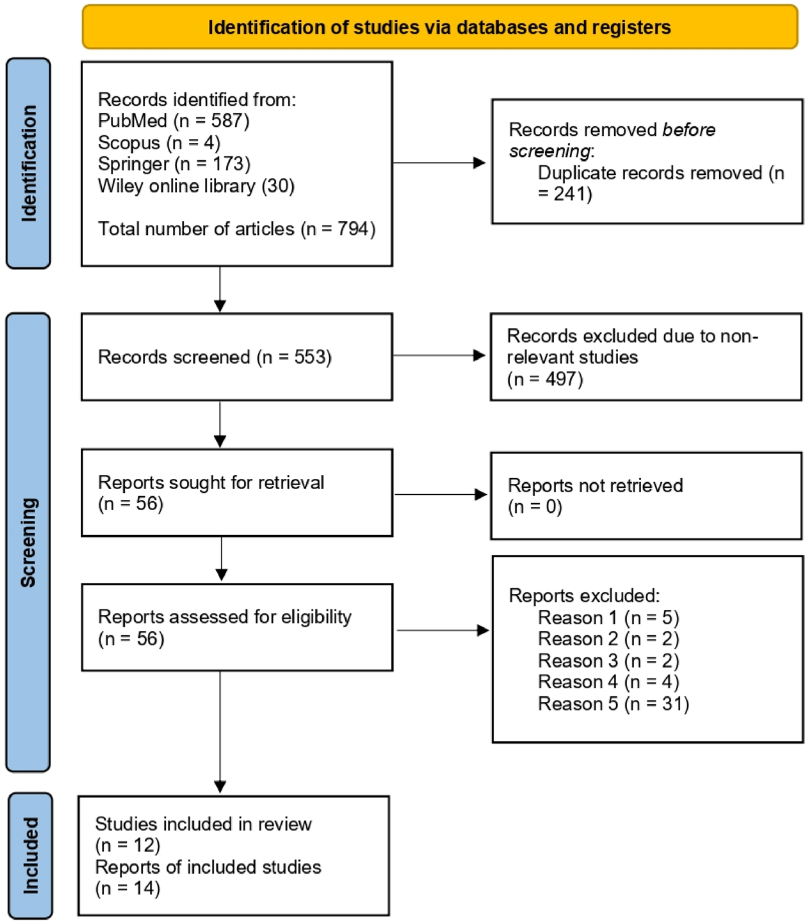

Fig. 1. Description of selection process and characteristics of selected studies. Reason 1: Laboratory infection studies; reason 2: clinical reported cases without prevalence data; reason 3: inadequate sample size for prevalence estimation; reason 4: seroprevalence studies; and reason 5: others such as thesis, conference papers, book chapters, news reports, studies conducted outside Malaysia, and studies reported earlier than 1977.

SN	Author	Brugia species	Host examined	Detection method	Study location	Status
1	Mak, et al.[13]	*B. malayi*	Human, Cat	TBS	Perlis	Endemic
2	Mak, et al.[14]	*B. malayi*, *B. pahangi*	Cat, Dog	TBS	Pahang, Perlis, Johor	Endemic
3	Mak, et al.[15]	*B. malayi*	Human, Cat, Dog, Monkey	TBS	Perak	Endemic
4	Hakim, et al.[16]	*B. malayi*	Human	TBS	Perak	Endemic
5	Cox-Singh, et al.[17]	*B. malayi*	Human	PCR	Sabah	Endemic
6	Omar, et al.[18]	*B. malayi*	Human	TBS, Elisa	Selangor	Non-endemic
7	Omar, et al.[19]	*B. malayi*	Human	TBS, Elisa	Terengganu	Endemic
8	Lim, et al.[20]	*B. malayi*	Human	TBS, Elisa	Terengganu	Endemic
9	Tan, et al.[6]	*B. malayi B. pahangi*	Cat	TBS, PCR	Selangor	Non-endemic
10	Rahmah, et al.[21]	*B. malayi*	Human	PCR	Kelantan	Endemic
11	Al-Abd, et al.[8]	*B. malayi*, *B. pahangi*	Cat	TBS	Selangor	Non-endemic
12	Vinnie-Siow, et al.[22]	*B. malayi*, *B. pahangi*	Dog	TBS, ELISA, PCR	Selangor	Non-endemic

Table 1. Description of included studies with location and epidemiological status.

Pool prevalence estimate of human zoonotic filariasis in Malaysia

The pool prevalence meta-analysis of zoonotic filariasis prevalence in humans across eight studies conducted in Malaysia between 1977 and 2010 is depicted in the forest plot below (Fig. 3). Pooled prevalence result shows 3% [95% CI: 0.01–0.09] prevalence estimate, with observed significant heterogeneity among the included studies (I^2 = 97%, $p < 0.0001$).

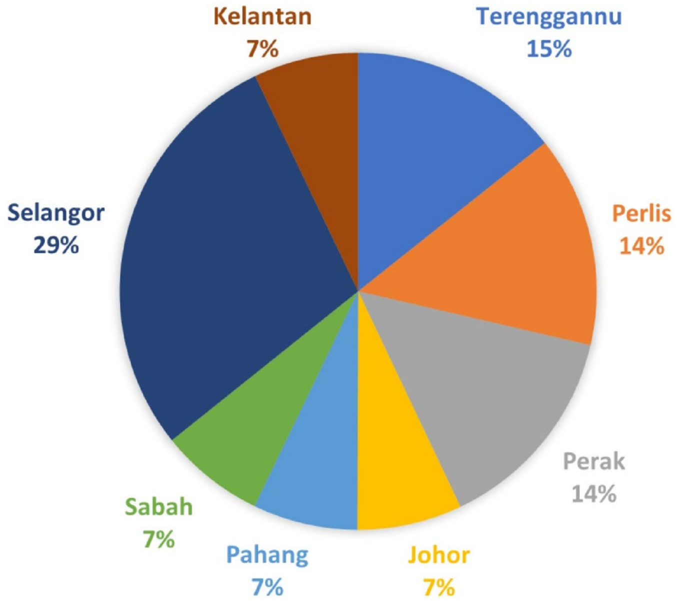

Fig. 2. Proportion of included human prevalence studies according to geographical distribution.

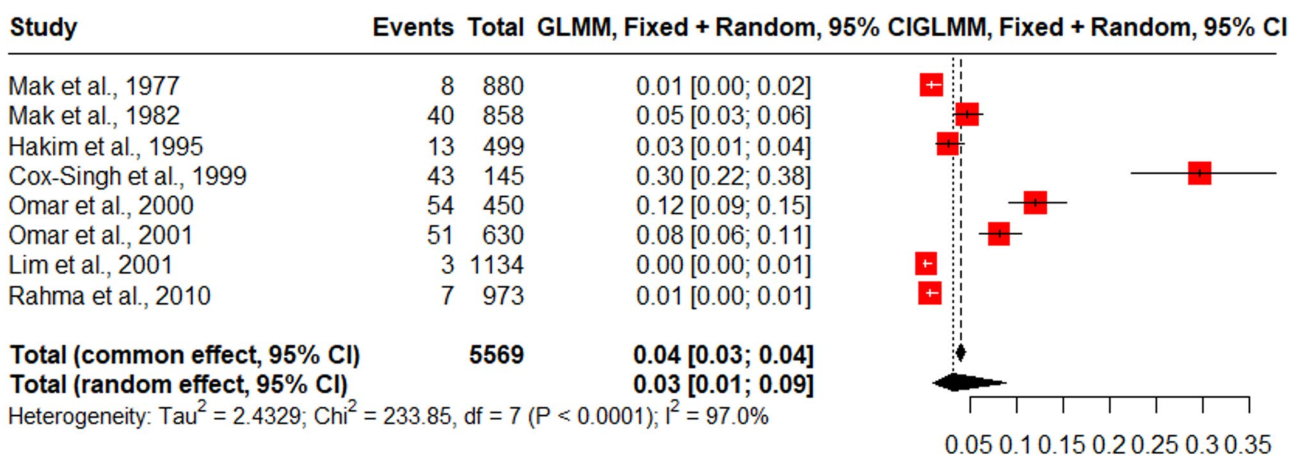

Fig. 3. Proportionate meta-analysis forest plot of human zoonotic filariasis prevalence in Malaysia.

Significant heterogeneity observed between the studies implies a substantial variability in the reported brugian filaria prevalence. The observed heterogeneity may have arisen from the differences in study methodologies, time, sampling frameworks, diagnostic methods, or the epidemiological context (endemic versus non-endemic) of the regions being examined. Furthermore, temporal variables, such as fluctuations in disease prevalence or modifications in diagnostic protocols over time, may additionally influence the differences observed across the studies.

The highest prevalence estimate was from study conducted in endemic area reported by Cox-Singh, et al[17]. with 30% [95% CI = 0.22–0.38]. The lowest prevalence estimates of 0.3% [95% CI = 0.00-0.01] was a study from Lim, et al[20].. Observed variability may be attributed to the difference in detection methods used in the reported studies.

From this analysis earlier studies tended to have lower estimated prevalence. This could be due to the availability of more accurate detection methods or parasite dynamics over time.

Malaysia lymphatic filariasis epidemiological data

Recent epidemiological data on filariasis infection due to *Brugia malayi* was obtained from the ministry of health Malaysia. The most recent and accessible data of reported cases was from 2022 to 2023 (Figs. 4 and 5).

It was observed that there was a sporadic surge in reported cases in 2022. Similarly, in 2024 the peak of reported cases was observed in the mid of that year as shown in Fig. 5.

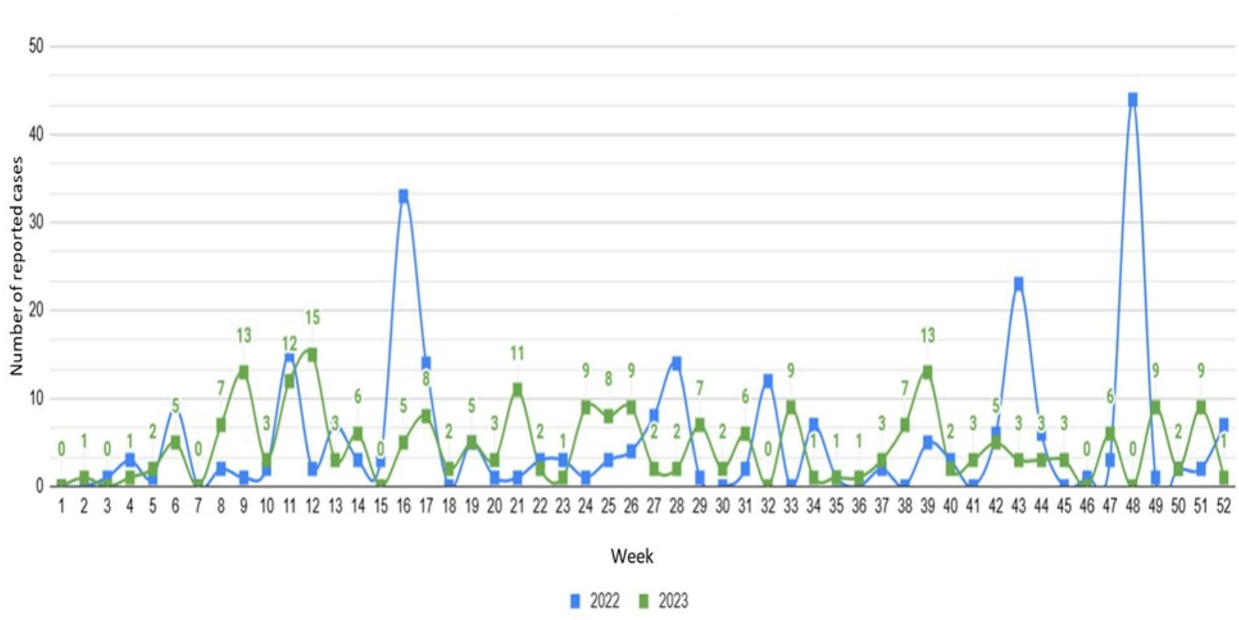

Fig. 4. Weekly trend of Malaysia filariasis reported cases between 2022–2023.Source[3]:.

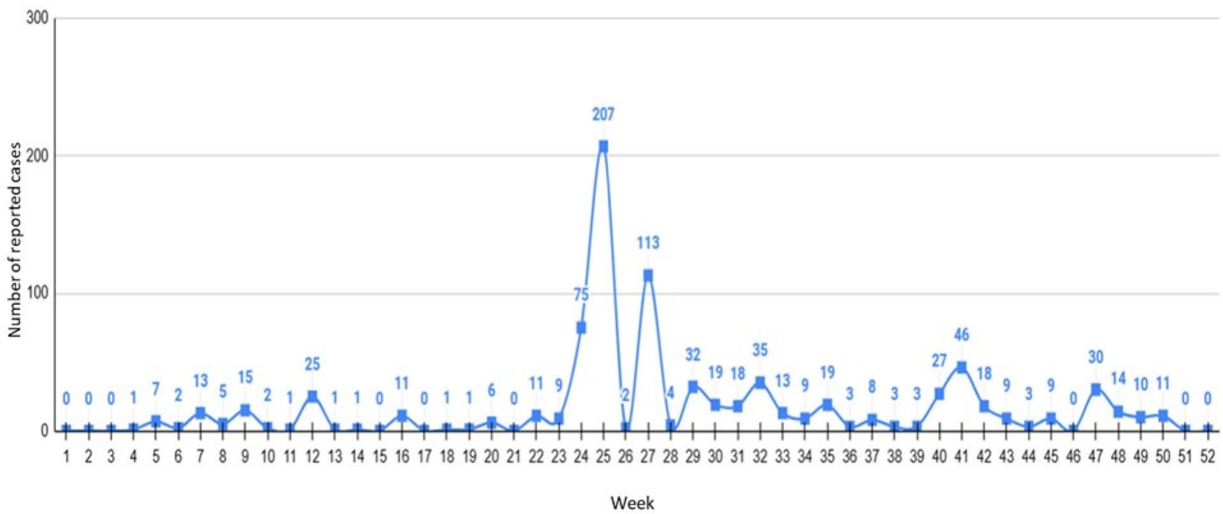

Fig. 5. Year 2024 weekly trend of Malaysia filariasis reported cases.Source[23]:.

Prevalence of animals Brugian filariasis in Malaysia

From the six reviewed prevalence studies on animals, four different animals; cat, dog, monkey and goat were reported to be infected with zoonotic *Brugia* of the species *B. pahangi* and *B.malayi*. Pool prevalence estimate of each animal was shown in Fig. 6. Monkey had the highest prevalence of 50% [95% CI = 0.43–0.58] and with the lowest between study heterogeneity (I^2 = 0%, $p = 1$) using the common effect model. Goat pool prevalence was the least with 0% prevalence [95% CI = 0.00-0.71]. Using random effect model of the GLMM, the cumulative pool prevalence of *Brugia* infection in animals from the studies in Malaysia was estimated to be 5% [95% CI = 0.01–0.17] with significant between study heterogeneity (I^2 = 94%, $p < 0.01$).

Prevalence of zoonotic Brugian filariasis in cats

Five studies reported prevalence in cats with calculated pooled prevalence of 8% [95% CI = 0.02–0.27], using the random effect model.

Substantial heterogeneity was observed across the studies [$I^2 = 60\%$, $p = 0.04$] with a relatively consistent result across study findings (Fig. 6). This indicates variability due to sample size, location, time and hosts among included studies that reflects the effect of sample size and the relatively persistent infection of cat with *Brugia* in Malaysia.

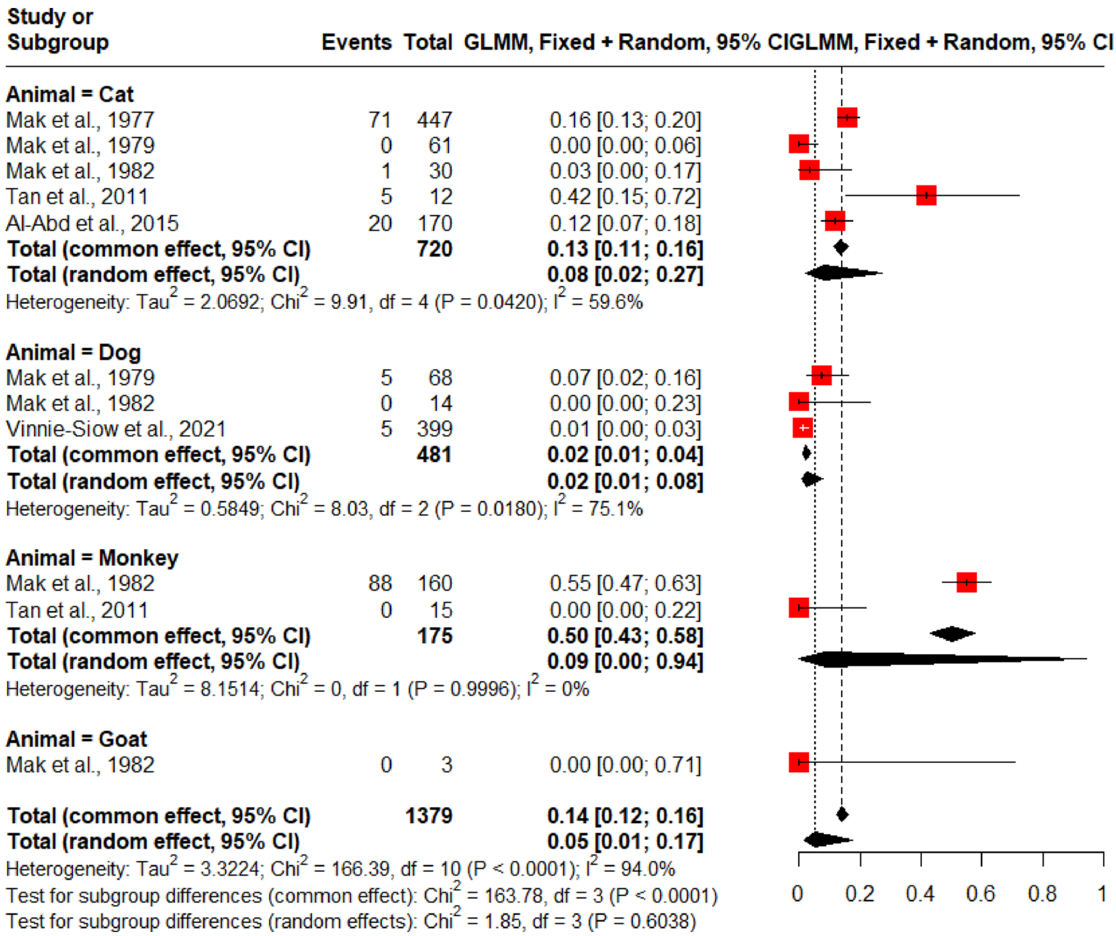

Fig. 6. Proportionate meta-analysis forest plot of animal zoonotic brugian filariasis prevalence in Malaysia.

Prevalence of zoonotic Brugian filariasis in dogs

The pool prevalence for dogs from three studies was estimated to be 2% [95% CI = 0.01–0.08] with significant heterogeneity between studies ($I^2 = 75\%$, $p = 0.02$). High variability might have risen from difference over time and low susceptibility of dogs to *Brugia* infections (Fig. 6).

Prevalence of zoonotic Brugian filariasis in monkeys

Monkey common effect model pool prevalence of zoonotic filariasis revealed trend of clearer and significantly higher prevalence compared to other animals at 50% pooled prevalence [95% CI = 0.43–0.58], with low observed heterogeneity ($I^2 = 0\%$, $p = 1.0$). The low observed heterogeneity highlights consistent infection of monkeys with *Brugia* (Fig. 6). This coupled with the high observed prevalence may highlight the sylvatic origin of *Brugia*.

Meteorological evidence of climate change in Malaysia

Meteorological Department Malaysia (MET Malaysia) collects long-term data on temperature and rainfall patterns to monitor climate change patterns in Malaysia. The mean annual temperature in Malaysia was approximately 27.0 ℃ in the 1990 s, rising to about 27.6 ℃ in recent years (Fig. 7a). This indicates a modest increase of approximately 0.6 ℃ over the 33-year span. This data also highlighted an increase in average temperatures of 0.24 ℃ in Peninsular Malaysia (Fig. 7a.i.), 0.14 ℃ in Sabah (Fig. 7aii) and 0.13 ℃ in Sarawak (Fig. 7aiii) per decade based on 54 years datasets from 1969 to 2023. Similarly, average rainfall increased by 4.23 mm per decade in Peninsular Malaysia, 4.08 mm in Sabah and 13.14 mm in Sarawak (Fig. 7b).

Discussion

This systematic review and meta-analysis revealed considerable variability in the prevalence of zoonotic filariasis among humans and animal hosts across different studies from endemic and non-endemic regions in Malaysia. While a generalized conclusion on the prevalence of human filariasis in Malaysia cannot be drawn from this analysis due to the heterogeneity of included studies, the findings support the government's report of the country's low filaria endemicity status. The overall methodological quality of the included studies was high, with most assessed as having a low risk of bias based on the JBI critical appraisal checklist. Only one study was identified as having moderate risk, due to an unclear assessment of sample size adequacy. Interestingly, no studies were rated as having a high risk of bias. This consistency in methodological quality enhances the reliability of the review

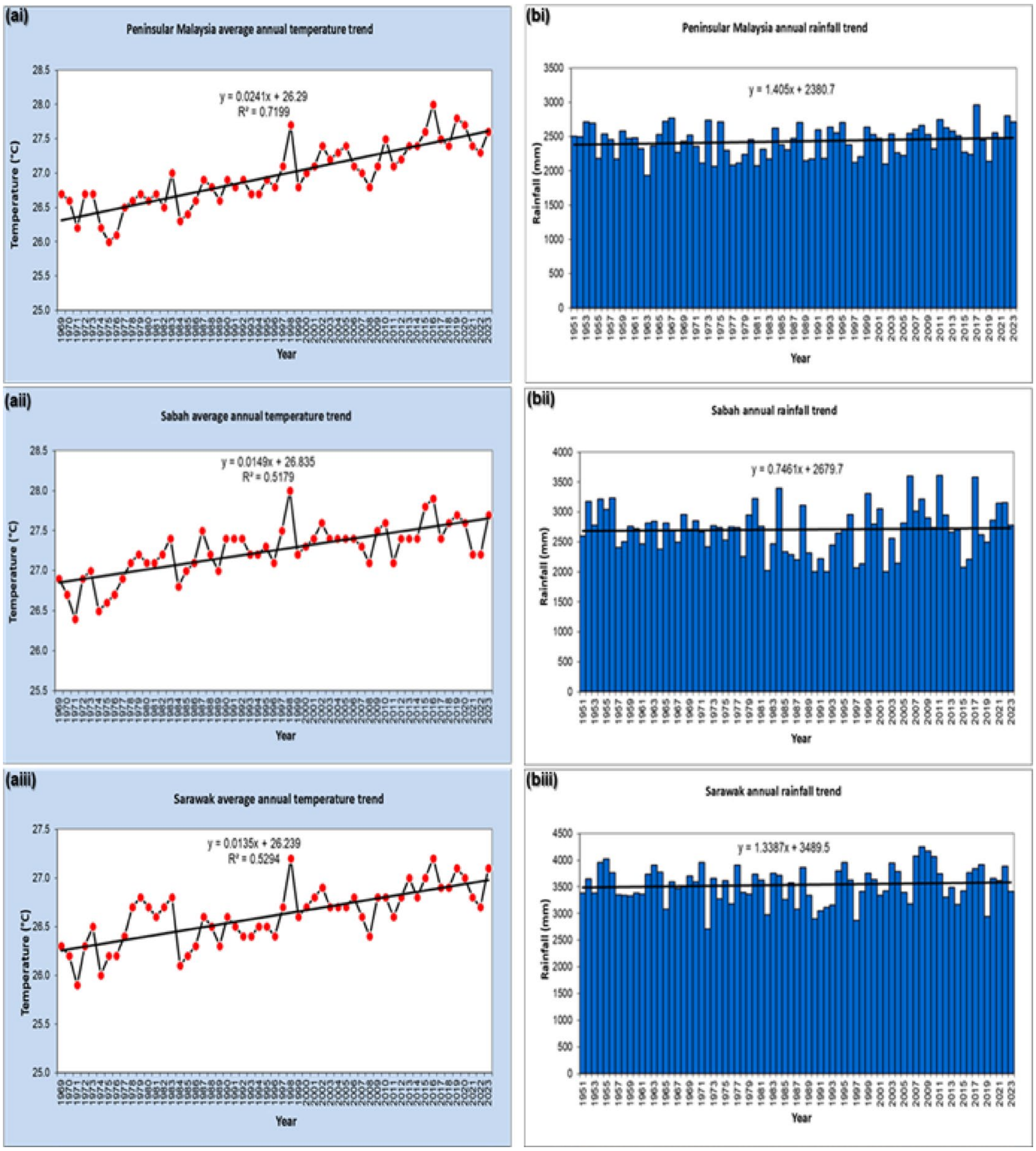

Fig. 7. **(a)** Trends of 54 years average annual temperature in: (i) Pennisular Malaysia; (ii) Sabah; and (iii) Sarawak. **(b)** Annual rainfall pattern of 73 years from Peninsular Malaysia, Sabah and Sarawak.(Source[11]:).

findings. However, the presence of a single moderate-risk study entails the need for cautious interpretation, particularly in relation to the findings derived from animal prevalence estimates of brugian filariasis for this review. In addition, sensitivity analysis demonstrated that the pooled prevalence estimates varied depending on the applied statistical model. The random-effects model, which accounts for study differences, showed a wider confidence interval compared to the fixed-effect model. This highlights the importance of considering methodological variations and regional differences when interpreting zoonotic filariasis prevalence in Malaysia.

Malaysia effort to control filariasis have been remarkable with the achievement of less than 2% prevalence in most endemic areas[24]. However, due to the asymptomatic nature of brugian filariasis infection and inherent home management of the disease symptoms among Malaysian particularly in rural areas, there are tendencies of undetected and unreported filariasis cases[8]. Our meta-analysis reveals prevalence of zoonotic brugian filariasis among humans and animals from studies in a non-endemic area. These findings in addition to reports of two clinical infections to *Brugia*[6,7], further suggest the possibility of silent ongoing transmission and likely unreported cases occurring in the area not considered for filariasis elimination efforts.

Selangor is a non-filaria endemic state in Peninsular Malaysia. It is characterized by suburban landscapes and significant forest coverage, that presents a risk for zoonotic filariasis transmission. The potential for filariasis in this region to trigger widespread epidemics that may extends beyond Malaysia, potentially impacting neighboring countries and even the global community is evident. This risk is further heightened by the state's close interaction and connectivity with Kuala Lumpur, the nation's capital.

The estimated pool prevalence of zoonotic *Brugia*infection in humans from this study supports government report of the low filaria prevalence in the country. In 2024 a total of 852 filaria cases were reported with the highest number, 580, from Sabah. The study of Cox-Singh, et al[17]. from Sabah included in our review also revealed the highest prevalence compared to other studies. This shows that for over 20 years, the state has been a hotspot for filaria transmission. There could be an existing complex transmission dynamic that needs to be studied for the implementation of adequate control measures that will not only reduce cases but also prevent possible spillover of the diseases to other regions.

The least estimated prevalence from the study by Omar, et al[19]. from Terengganu also coincides with the recent low prevalence of reported cases from the region[3]. It is important to note that the study was conducted prior to the start of MDA control programme. This suggests maintenance of the low level of endemicity in the region over the years and possible low effectiveness of the control intervention.

Although no government data is available for animal prevalence, high pool prevalence estimated in this study requires further investigation into animal prevalence due to zoonotic filaria as the government outlined reinfection in post MDA as a major challenge to elimination target in the country.

The consistent high prevalence estimates of brugian filaria in monkeys from our study indicates that monkeys may play a crucial role as a reservoir host for the transmission of zoonotic filariasis in Malaysia. The infection of monkeys with *Brugia* may pose a significant challenge to filariasis elimination efforts. The heightened risk of infection among forest-goers, hikers, and tourists is particularly alarming. Implementing policies to minimize human-primate contact may help reduce the risk of *Brugia* spillover from sylvatic reservoirs. Monkeys, particularly macaques, play a critical role in the transmission of zoonotic diseases such as malaria, Zika, and dengue. Their role in disease transmission is alarming, given the lack of feasible control measures in these animals[25].

The recent surge in reported filaria cases in Malaysia from the government database particularly among non-indigenous individuals in Pahang could be due to Malaysia's recent increase influx of migrant workers, many of whom originate from filaria endemic regions. Furthermore, occupational exposure plays a critical role, as many of these workers are employed in agriculture, construction, and plantations. These environments, characterized by outdoor activities in areas conducive to mosquito breeding, elevate the risk of transmission[26]. Combined, these factors highlight the importance of targeted interventions to address this vulnerable population's unique risks.

The increase in filaria cases in Sabah, Malaysia, can be attributed to several interrelated factors, including environmental changes, ineffective MDA, and vector ecology. These factors have contributed to the persistence and spread of lymphatic filariasis in the region, despite ongoing control efforts. The following sections detail these contributing factors.

Pahang: Pahang's population has been steadily increasing, with estimates suggesting a rise from approximately 1.59 million in 2020 to around 1.64 million in 2023[27]. The state has attracted a significant number of foreign workers, especially in sectors like agriculture, construction, and manufacturing. Many of these workers come from countries where filariasis is endemic, such as Bangladesh and Myanmar.

Nonetheless, the Malaysia's current policy for the elimination of lymphatic filariasis as a public health problem is outlined in the 'Program Eliminasi Filariasis Limfatik Kebangsaan' (PEFLK), under the Ministry of Health, Malaysia. This policy aligns with the WHO's Global Programme to Eliminate Lymphatic Filariasis (GPELF), and its strategy focuses on Mass Drug Administration (MDA), enhanced surveillance by conducting Transmission Assessment Surveys (TAS), and morbidity management.

Persistent prevalence in non-endemic and endemic regions in malaysia: insights from anthropogenic environmental modifications

Rapid economic development and urbanization in Malaysia has led to significant environmental changes, such as altered land use patterns due to agricultural practices like rice, rubber, and oil palm cultivation. These changes have affected the breeding habitats of mosquito vectors, thereby influencing the prevalence of mosquito borne diseases such as lymphatic filariasis[28]. Critical regions for filariasis in Malaysia suggest filariasis prevalence has been influenced by environmental changes.

Research indicates that forest cover in Selangor, one of the non-filaria endemic region in the country for example, has significantly declined between 2000 and 2020 with estimated decrease of over 8% in 2020[29]. This is primarily due to urban development for housing and agriculture. This trend has resulted in ecosystem fragmentation that increases risk of human exposure to vectors of sylvatic diseases.

Sabah, one of the endemic regions with the highest report of filaria cases in 2024, is also experiencing rapid urbanization that led to extensive land conversion for residential, commercial, and industrial purposes. The conversion of forests to agricultural land, particularly for oil palm plantations, has been a significant driver of deforestation in Sabah. Large-scale agricultural projects often follow urbanization trends, leading to the clearing of vast forested areas. Reports since 2014 indicated that approximately 80% of Sabah's forests have been impacted by logging or agricultural activities, with many areas being converted into oil palm estates[30].

The construction of infrastructure such as roads and highways facilitate access to previously remote forest areas, thereby increasing the risk of vector interaction between sylvatic disease agents and domestic populations. Research has documented that over 360,000 km of roads have been constructed in Malaysian Borneo (Sabah, Sarawak and Federal Territory Labuan) since 1990, further fragmenting forest habitats and accelerating deforestation rates[31,32]. In addition, uncontrolled logging practices have severely depleted Sabah's forests over the past few decades. Although there have been efforts to implement sustainable forest management practices, illegal logging remains a persistent issue.

Between the 1970s and 2010, Sabah experienced substantial forest cover loss. Research indicates that approximately 9% of the land area and 15% of forest cover were lost since 1990, primarily due to agricultural expansion and urban development[31].

Sarawak is another endemic hotspot for filariasis in Malaysia as of 2023 there is high prevalence of filaria in implementing units. In 2024, 18.4% of all filariasis reported cases in Malaysia were from Sarawak[23]. The region has experienced extensive deforestation, with over 3 million hectares of forest threatened[31]. This situation is contributed by the allocation of land for industrial timber plantations (ITPs) and oil palm cultivation[33].

The logging industry has played a critical role in deforestation since the 1980s, with selective logging practices leading to fragmentation and degradation of forests. The rapid expansion of oil palm plantations is a major contributor to forest loss in Sarawak. Reports indicate that around 596,000 hectares have been allocated for oil palm cultivation, with significant overlaps with timber concessions. This trend is driven by both domestic demand and international markets for palm oil[34].

Urbanization necessitates infrastructure development such as roads and highways that facilitate access to remote forest areas, further exacerbating deforestation. The construction of roads often leads to increased illegal logging and land clearing for agriculture.

Furthermore, long term filariasis epidemiological data that will enable thorough comparison of the disease trend with climate change could not be obtained by this study. As such, direct implication of climate change on filariasis epidemiology in Malaysia could not be made. However, climate change is recognized as a significant driver of vector-borne disease dynamics, affecting mosquito vectors through changes in temperature, rainfall, and humidity. Studies indicated that higher temperatures could shorten the development time of mosquitoes and the parasites they carry, potentially increasing transmission rates[35]. Altered rainfall patterns can influence breeding site availability, with increased rainfall potentially expanding mosquito breeding sites and habitats, both affecting vector abundance and disease transmission potential[36].

While specific studies on the impact of climate change on filariasis in Malaysia are limited, global and regional research provides a framework for understanding potential effects. Studies on dengue and malaria in tropical regions suggest that warmer climates can enhance vector distribution and transmission, which can give highlight in relation to filariasis, given that they shared mosquito vectors[35,36]. Future research should investigate climate change and filariasis epidemiology links to inform control strategies, integrating climate-informed surveillance into Malaysia's elimination program.

A holistic approach that incorporates human, animal, and environmental health perspectives is crucial for achieving sustainable LF elimination in Malaysia. Understanding the complex interplay between these factors will enable public health officials to develop targeted interventions that not only reduce transmission rates but also promote community engagement and awareness regarding zoonotic filariasis. Engaging communities in awareness programs about zoonotic filariasis and its transmission dynamics can empower individuals to take preventive measures, thereby reducing the risk of infection.

Conclusion

This review highlights the extent and complex dynamics of zoonotic filariasis in Malaysia. Zoonotic brugian filariasis remain a pressing concern for filariasis elimination in endemic areas of the country. Although a generalized conclusion from estimated prevalence cannot be made due to heterogeneity among included studies, the findings hint at the interconnectedness of hosts, vectors, and the environmental changes on persistent filaria transmission in the country. There exists a silent filariasis transmission and an endemic potential in a previously declared non-endemic region of the country. Increase human exposure to sylvatic diseases facilitated by anthropogenic environmental degradations play a key role in the transmission and increase difficulty in the control of zoonotic diseases. In addition, domestic animals such as cat and dog can serve crucial role in sustained transmission of zoonotic filariasis in Malaysia and other filaria endemic regions of the world. A multifaceted approach combining active surveillance, vector control and environmental management, and community education are essential for effective and sustainable lymphatic filariasis elimination program not only in Malaysia but in other filaria endemic countries.

Recommendation

Although Malaysia has made substantial progress in the elimination of lymphatic filariasis, the persistence of emergent zoonotic filariasis continues to pose a challenge. A comprehensive understanding of the prevalence of *Brugia* infections in both human and animal populations, along with effective host-vector management strategies, is essential for successful filariasis elimination. Therefore, in addition to vector control efforts, continuous filariasis surveillance in both endemic and non-endemic regions of the country is highly recommended. By adopting a holistic approach that integrates human, animal, and environmental management, Malaysia can enhance its efforts to eliminate filariasis and address the unique challenges posed by zoonotic reservoirs. Future research should focus on genomic sequencing, development of diagnostic methods for early detection and other advanced methodologies to substantiate the transmission dynamics of zoonotic *Brugia* between animal and human populations, ultimately leading to more effective public health interventions.

Limitation

Due to heterogeneity observed across the included studies, a generalized conclusion on the prevalence estimates was not possible. As a result of lack of prevalence data on *B. pahangi* human natural infection and fewer prevalence studies in animals, this study could not estimate subgroup proportionate prevalence of individual *Brugia* species.

Data availability

The datasets analyzed during this study are available in the supplementary information and also in the PROSPERO database (registration number 1027718) repository, https://www.crd.york.ac.uk/prospero/.

Received: 20 April 2025; Accepted: 19 September 2025
Published online: 24 October 2025

References

1. World Health Organization. *Lymphatic filariasis*, (2024). https://www.who.int/news-room/fact-sheets/detail/lymphatic-filariasis
2. Abraham, P. R. et al. Detection of Wuchereria bancrofti infection in mosquitoes in areas co-endemic with Brugia Malayi in Balasore district, Odisha, India. *Sci. Rep.* **14**, 16780. https://doi.org/10.1038/s41598-024-67188-2 (2024).
3. Ministry of Health Malaysia. *Filariasis cases 2022 and 2023*, (2023). https://sites.google.com/moh.gov.my/peflk/dashboard-filariasis-2023?authuser=0
4. Naing, C., Whittaker, M. A., Tung, W. S., Aung, H. & Mak, J. W. Prevalence of zoonotic (brugian) filariasis in asia: A proportional meta-analysis. *Acta Trop.* **249**, 107049 (2024).
5. Bhumiratana, A., Nunthawarasilp, P., Intarapuk, A., Pimnon, S. & Ritthison, W. Emergence of zoonotic *Brugia Pahangi* parasite in Thailand. *Veterinary World*. **16**, 752 (2023).
6. Tan, L. H. et al. Zoonotic *Brugia Pahangi* filariasis in a suburbia of Kuala Lumpur City, Malaysia. *Parasitol. Int.* **60**, 111–113 (2011).
7. Muslim, A., Fong, M. Y., Mahmud, R., Lau, Y. L. & Sivanandam, S. *Armigeres subalbatus* incriminated as a vector of zoonotic *Brugia Pahangi* filariasis in suburban Kuala Lumpur, Peninsular Malaysia. *Parasites Vectors*. **6**, 1–5 (2013).
8. Al-Abd, N. M. et al. Lymphatic filariasis in Peninsular malaysia: a cross-sectional survey of the knowledge, attitudes, and practices of residents. *Parasites Vectors*. **7**, 1–9 (2014).
9. Zahedi, M., Vellayan, S., Jeffery, J. & Krishnasamy, M. A case of double infection with *Brugia Pahangi* Buckley and Edeson 1956, and *Dirofilaria immitis* Leidy 1856, in a Malaysian clouded leopard, neofelis nebulosa. *Vet. Parasitol.* **21**, 135–137 (1986).
10. Munn, Z., Moola, S., Lisy, K., Riitano, D. & Tufanaru, C. Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and cumulative incidence data. *JBI Evid. Implement.* **13**, 147–153 (2015).
11. Malaysian Meteorological Department. *Malaysia climate: Climate change*, (2025). https://www.met.gov.my/pendidikan/perubahan-iklim-and-kesan-rumah-hijau/
12. Barker, T. H. et al. Conducting proportional meta-analysis in different types of systematic reviews: a guide for synthesisers of evidence. *BMC Med. Res. Methodol.* **21**, 1–9 (2021).
13. Mak, J., Cheong, W., Omar, A., Sivanandam, S. & Mahadevan, S. Filariasis in Perlis, Peninsular Malaysia. *Med. J. Malaysia*. **31**, 198–203 (1977).
14. Mak, J., Yen, P., Lim, K. & Ramiah, N. Zoonotic implications of cats and dogs in filarial transmission in Peninsular Malaysia. *Trop. Geogr. Med.* **32**, 259–264 (1980).
15. Mak, J., Cheong, W., Yen, P., Lim, P. & Chan, W. Studies on the epidemiology of subperiodic *Brugia Malayi* in malaysia: problems in its control. *Acta Trop.* **39**, 237–245 (1982).
16. Hakim, S. L., Vythilingam, I., Marzukhi, M. & Mak, J. Single-dose diethylcarbamazine in the control of periodic Brugian filariasis in Peninsular Malaysia. *Trans. R. Soc. Trop. Med. Hyg.* **89**, 686–689 (1995).
17. Cox-Singh, J. et al. Simple blood-spot sampling with nested polymerase chain reaction detection for epidemiology studies on *Brugia Malayi*. *Int. J. Parasitol.* **29**, 717–721 (1999).
18. Omar, A. W. et al. Parasitological and serological investigation into lymphatic filariasis among immigrants at Semenyih detention Centre, Selangor, West Malaysia. *J. Health Translational Med. (JUMMEC)*. **5**, 41–44 (2000).
19. Omar, A. W. et al. Epidemiological screening of lymphatic filariasis among immigrants using dipstick colloidal dye immunoassay. *Malaysian J. Med. Sciences: MJMS*. **8**, 19 (2001).
20. Lim, B., Rahmah, N., Afifi, S., Ramli, A. & Mehdi, R. Comparison of *Brugia*-Elisa and Thick blood smear examination in a prevalence study of Brugian filariasis in Setiu, Terengganu, Malaysia. *Med. J. Malay.* **56**, 491–496 (2001).
21. Rahmah, N., Nurulhasanah, O., Norhayati, S., Zulkarnain, I. & Norizan, M. Comparison of conventional versus real-time PCR detection of *Brugia Malayi* DNA from dried blood spots from school children in a low endemic area. *Trop. Biomed.* **27**(1), 54–59 (2010).
22. Vinnie-Siow, W. Y. et al. Integration of microscopic, serologic and molecular techniques for detection of filarial parasites in dogs in Malaysia. *Acta Parasitol.* **67**, 468–475 (2022).
23. Ministry of Health Malaysia. *Filariasis cases 2024*, (2024). https://sites.google.com/moh.gov.my/peflk/dashboard-filariasis-2024?authuser=0
24. The Star. *Elephantiasis prevalence target of under 2% achieved, says Health DG. Monday, Nation*, (2023). https://www.thestar.com.my/news/nation/2023/01/30/elephantiasis-prevalence-target-of-under-2-achieved-says-health-dg
25. Paixão, E. S., Teixeira, M. G. & Rodrigues, L. C. Zika, Chikungunya and dengue: the causes and threats of new and re-emerging arboviral diseases. *BMJ Global Health*. **3**, e000530 (2018).
26. Intarapuk, A. & Bhumiratana, A. Investigation of *Armigeres subalbatus*, a vector of zoonotic *Brugia Pahangi* filariasis in plantation areas in Suratthani, Southern Thailand. *One Health*. **13**, 100261 (2021).
27. Department of Statistics Malaysia. *DOS Projection: Population: Pahang*, https://www.ceicdata.com/en/malaysia/population-projection-department-of-statistics/dos-projection-population-pahang (2024).
28. Kwa, B. Environmental change, development and vectorborne disease: malaysia's experience with filariasis, scrub typhus and dengue. *Environ. Dev. Sustain.* **10**, 209–217 (2008).
29. Ma, T. Z., Teh, B. T. & Kho, M. Y. Land use change and ecological network in rapid urban growth region in Selangor region, Malaysia. *Sci. Rep.* **14**, 16470 (2024).
30. Ng, J. S. C., Chervier, C., Ancrenaz, M., Naito, D. & Karsenty, A. Recent forest and land-use policy changes in Sabah, Malaysian borneo: are they truly transformational? *Land. Use Policy*. **121**, 106308 (2022).
31. Ocampo-Peñuela, N., Garcia-Ulloa, J., Kornecki, I., Philipson, C. D. & Ghazoul, J. Impacts of four decades of forest loss on vertebrate functional habitat on Borneo. *Front. Forests Global Change*. **3**, 53 (2020).
32. Gaveau, D. L. et al. Rapid conversions and avoided deforestation: examining four decades of industrial plantation expansion in Borneo. *Sci. Rep.* **6**, 32017 (2016).
33. Sarawak Report. *Malaysia's Rainforest Threat is Focused on Sarawak*, (2024). https://www.sarawakreport.org/2024/06/malaysias-rainforest-threat-is-focused-on-sarawak/
34. World Resources Institute. *New GFW Maps Show Vast Logging, Oil Palm and Plantation Concessions in Sarawak*, https://www.wri.org/insights/new-gfw-maps-show-vast-logging-oil-palm-and-plantation-concessions-sarawak (2024).
35. Zhang, W. Long-term effects of climate change on mosquito-related ecosystem services. *J. Mosq. Res.* **14**, 276–284 (2024).
36. Azerigyik, F. A., Cagle, S. M., Wilson, W. C., Mitzel, D. N. & Kading, R. C. The Temperature-Associated effects of rift Valley fever virus infections in mosquitoes and Climate-Driven epidemics: A review. *Viruses* **17** https://doi.org/10.3390/v17020217 (2025).

Acknowledgements
This research was supported by grant provided by the Universiti Malaya, Early Career Researcher Grant (BKP035-2023-ECR).

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Study concept & design: MSH, JOQ, LYL; Data acquisition: MSH, RS, RR, FMY; Statistical analysis: RS, JOQ; Interpretation of data: JOQ, FMY, IV, LYL; Drafting of manuscript: MSH, RS, RR; Critical review of manuscript: RR, IV, FMY; Supervision: JOQ, IV, LYL. JOQ had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Declarations

Competing interests
The authors declare no competing interests.

Additional information
Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-025-21328-4.

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