The burden, clinical outcomes and risk factors related to neglected tropical diseases and malaria in migrant populations in the Middle East and North Africa: a systematic review and meta-analyses

Eman Elafef,[1,2,3] Taha Maatoug,[2,3,4] Stella Evangelidou,[2] Helena Marti-Soler,[2] Asad Adam,[1] Ahmed Hamed Arisha,[5] Mahmoud Hilali,[1] Sally Hargreaves [ID],[6] Ibrahim Bani,[7] Farah Seedat [ID],[6] Ana Requena-Méndez [ID] [2,8,9]

For numbered affiliations see end of article.

Correspondence to
Dr Ana Requena-Méndez;
requena.mendez@ki.se

ABSTRACT

Introduction This systematic review investigates the burden, clinical outcomes and risk factors of neglected tropical diseases (NTDs) and malaria in the Middle East and North African region, highlighting the urgency and scope of these health challenges.

Methods We searched six databases for peer-reviewed literature and additional sources to capture grey literature in any language from 2000 to 28 August 2024. Studies were included if they provided primary data on outcomes in migrants. Primary outcomes were prevalence, incidence and mortality. Peer-reviewed articles were critically appraised using Joanna Briggs Institute tools, while the AACODS (Authority, Accuracy, Coverage, Objectivity, Date and Significance) checklist was used for grey literature. Estimates were pooled using random-effects meta-analysis where possible or synthesised narratively.

Results We included 39 studies with 81 678 migrants across 11 countries for NTDs and 16 studies encompassing 12 823 migrants across five countries for malaria. The pooled prevalence of specific NTDs among migrants was 4.7% for hookworm (95% CI 0.9% to 11.3%, I^2=99%), 1.8% for *Trichuris trichiura* (95% CI 0.3% to 4.3%, I^2=98%), 1.75% for *Ascaris lumbricoides* (95% CI 0.6% to 3.5%, I^2=96%) and 1.8% for taeniasis (95% CI 0.3% to 4.4%, I^2=98%). Compared with non-migrants, migrants exhibited higher prevalence rates for hookworm (1.8% vs 0.03%), *Ascaris lumbricoides* (0.3% vs 0%), *Trichuris trichiura* (0.5% vs 0%), dengue (26% vs 3.5%) and chikungunya (4.2% vs 0.5%). Migrants had a higher proportion of confirmed cases of schistosomiasis (0.21–20.3% vs 0–0.013%), cystic echinococcosis (7.4% vs 3.5%) and dengue (57.2% vs 56.4%) among suspected cases compared with non-migrants. Case fatality rates were 3.1% for dengue and 0.2–1.5% for malaria. Malaria incidence was only reported in Sudan (internally displaced persons: 6.8/1000; refugees: 2.72/1000; refugees <5 years old: 7.3/1000). While hospitalisation and intensive care unit rates for malaria were 25.8% and

1.3%, respectively, severe malaria was higher in non-migrants compared with migrants in Qatar (50% vs 5.2%, respectively).

Conclusions Despite a wide range of diseases reported in 55 studies, there were gaps in the evidence, primarily related to risk factors, clinical outcomes and the subregion of North Africa. We generally found that migrants were disproportionately affected by both NTDs and malaria, especially in the Middle East.

PROSPERO registration number CRD42023407748

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The Middle East and North African (MENA) region has experienced a rise in migration from neglected tropical diseases (NTDs)-endemic and malaria-endemic countries.

⇒ Without adequate access to prevention and treatment, there is a risk of reintroducing or increasing the burden of NTDs and malaria in MENA countries that have achieved or made progress towards their elimination.

⇒ Despite the critical importance of understanding the burden, clinical outcomes and risk factors of NTDs and malaria among migrants in the MENA region, little is known about these diseases in this population.

⇒ Such knowledge is essential for designing effective interventions, delivering targeted care and monitoring morbidity and mortality.

INTRODUCTION

The Middle East and North African (MENA) region serves as a point of origin, transit and

WHAT THIS STUDY ADDS

⇒ Overall, migrants in the MENA region were disproportionately affected by NTDs and malaria.

⇒ They had a higher prevalence of soil-transmitted helminths and a higher seroprevalence of dengue and chikungunya than non-migrants.

⇒ There was also a higher proportion of confirmed cases of schistosomiasis, cysticercosis, echinococcosis, dengue, scabies and malaria among suspected cases.

⇒ Migrants also represented a higher percentage of reported cases of malaria, dengue, scabies, leprosy, schistosomiasis and cutaneous leishmaniasis.

⇒ Outcome and risk factor data and North African data on NTDs and malaria were limited.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Migrants in most MENA countries are disproportionately affected by NTDs and malaria, highlighting their vulnerability as at-risk groups.

⇒ However, their needs have not been prioritised in research. There is an urgent need to strengthen research on NTDs and malaria for migrants in the region to fill existing knowledge gaps and guide evidence-based approaches for effective prevention, early diagnosis and treatment of NTDs and malaria to serve migrant populations better.

destination for different migrant groups and is marked by significant health disparities, ongoing regional and subregional conflicts and complicated mixed-migration flows.[1] In 2020, the MENA region hosted 42.7 million international migrants, making it the third largest region receiving international migrants, including forced migrants, labour migrants, refugees, asylum seekers and internally displaced persons (IDPs).[2] This trend has only intensified with the mass displacement of over 1.7 million people in Gaza and the armed conflict in Sudan, which has forced 2.1 million people to cross borders and displaced 7.9 million within the country.[3]

Globally, migrants face heightened risks of neglected tropical diseases (NTDs) and malaria due to a complex interaction of several factors, including higher disease prevalence in their countries of origin and socioeconomic factors, living conditions and barriers to healthcare access in their countries of transit and destination.[4] NTDs are a group of 23 diseases, such as trachoma and scabies,[5] and are related to environmental and socioeconomic conditions in low-income communities (ie, lack of appropriate medical infrastructure or sanitation).[6] Migrants can experience precarious living and working conditions throughout their migration journey, which can make them susceptible to NTDs.[6] McCarthy *et al* found that schistosomiasis was diagnosed in 13% of 2804 migrants from 153 countries at 41 GeoSentinel clinics across 19 countries,[7] which is seven times higher than global estimates.[8] Similarly, understanding the movement patterns of migrants and the factors that increase their risk of malaria is essential to improve migrant health outcomes, ultimately protecting the health of migrants and host

communities.[9] Indeed, the WHO's 2030 roadmap for NTDs and the global strategy for malaria recognises migration as a risk factor and migrants as a marginalised high-risk group, calling for intervention strategies to ensure timely and free access to prevention, diagnosis and treatment for migrant populations.[10–12]

Despite this, little is known about the burden, clinical outcomes or risk factors of NTDs and malaria in migrants living in the MENA region. This knowledge gap is of critical importance as many countries in the region, most recently Egypt, have achieved malaria elimination,[13] and increased migration from endemic countries could increase the risk of reintroduction if effective prevention interventions are not in place.[13] Likewise, many migrants in the region live in poor conditions, which increases their vulnerability to NTDs,[14] and clinicians may be unfamiliar with these diseases, leading to delays in diagnosis and treatment.[10 11 15] This systematic review aimed to identify, appraise and synthesise the empirical evidence on the burden, clinical outcomes and risk factors related to NTDs and malaria in migrant populations in the MENA region.

METHODS

This systematic review and meta-analysis is reported according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 guidelines.[16] The protocol is registered on PROSPERO (CRD42023407748) and published.[17]

Search strategy

We searched Medline, Embase, Web of Science, Cumulative Index to Nursing and Allied-Health Literature, Index Medicus for Eastern Mediterranean Region and Q Science for articles published between 2000 and August 2024 in any language, combining three sets of search terms using free text and subject heading for migrants, NTDS and malaria, and countries in the MENA region (online supplemental annex 1). We also conducted an extensive search of grey literature sources from the following websites: WHO, International Organisation for Migration, United Nations High Commissioner for Refugees, United Nations Department of Economic and Social Affairs, Médecins Sans Frontières, Commission of Refugee and Ministry of Health websites for each country in the MENA region, reference-checked all included studies and relevant systematic reviews, and contacted experts for additional references.

Eligibility criteria

We included studies that met the following criteria:

► Population: Migrants, defined as people who move away from their usual residence, whether within a country or across an international border, temporarily or permanently, and for various reasons.[18] This included refugees, asylum seekers, undocumented migrants, labour migrants and IDPs.[19]

► Geographical scope: 18 MENA countries (Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates (UAE) and Yemen).[20]

► Health outcomes: Primary data on the burden (eg, prevalence, incidence), clinical outcomes (eg, treatment results, long-term morbidity, mortality) or risk factors of NTDs and malaria in migrants.

► Diseases of interest: Malaria and the following NTDs: buruli ulcer, dengue and chikungunya, dracunculiasis, echinococcosis, human African trypanosomiasis, leishmaniasis, leprosy, lymphatic filariasis, mycetoma, onchocerciasis, rabies, scabies and other ectoparasites, schistosomiasis, soil-transmitted helminthiases, snakebite envenoming, taeniasis/cysticercosis, trachoma and yaws.[5]

► Study design: Cohort studies, cross-sectional studies, case-control studies, systematic reviews, narrative reviews and clinical trial studies (data only extracted from baseline characteristics or the control group as appropriate).

► Time frame and language: Published in any language from 2000 to August 2024.

We excluded the following NTDs because they are not endemic in the countries from which migrants living in the MENA region originate: foodborne trematodes, chromoblastomycosis, other deep mycoses and Chagas disease. We excluded studies if they did not meet the key definitions for migrants, MENA countries, or NTDs or malaria; studies published before 2000; and studies in which migrant data could not be disaggregated from host populations. We excluded case series, case reports, qualitative studies and studies not providing primary data. Systematic and narrative reviews were not included but were comprehensively reviewed for additional studies providing primary data.

Records were imported into Rayyan[21] and deduplicated. Two reviewers (EE and TM) independently screened the titles, abstracts and full texts of all identified records, and disagreements were discussed with a third reviewer (FS) when necessary.

Data extraction
EE and TM independently extracted relevant data using an a priori-defined extraction sheet, which was piloted and refined before implementation. Extracted data were cross-checked for consistency, and any disagreements were resolved through discussion with a third reviewer (FS) to ensure accuracy and reliability. Data extracted included study information (country, publication year, design and study setting), study population (sample size, migrant and host population definitions and characteristics), disease(s), outcome definitions and results (burden, clinical outcomes, risk factors) (online supplemental annex 2). From studies with adjusted and unadjusted analyses, we prioritised the adjusted analysis, and we calculated any missing statistical parameters of

importance and variability measures (eg, 95% CIs), when data permitted. We contacted the authors of included studies to obtain missing or additional data.

Quality appraisal
EE and TM independently appraised the risk of bias in studies using Joanna Briggs Institute checklists for peer-reviewed articles.[22] The checklists contain eight domains for cross-sectional studies, nine for prevalence and 10 for case-control studies, including participant and setting description, outcomes/exposure measurements and appropriate statistical analyses. Every criterion was rated 'yes', 'no', 'unclear' or 'not-applicable'. The AACODS checklist was used to appraise grey literature. This checklist contains six domains: Authority, Accuracy, Coverage, Objectivity, Date and Significance. Each domain is assigned a rating of 'yes', 'no' or 'unclear'. Studies were not excluded based on quality; however, the results of quality assessments contributed to the analysis and the discussion.[23] Any disagreements were resolved by discussion, involving a third reviewer if necessary (FS).

Data analysis
Meta-analyses were conducted only when there was sufficient data and homogeneity. A minimum of three data points was required to meet the volume threshold, and homogeneity was assessed based on population type, diseases, outcome measurements and consistent outcome definitions. When these criteria were met, we conducted a random-effects meta-analysis on single proportions using the Metaprop function in R software (V.4.2.2).[24] We assessed heterogeneity among studies by inspecting the forest plots, using the χ^2 test for heterogeneity with a 10% level of statistical significance and using the I^2 statistic. Where data volume or homogeneity was insufficient, we synthesised findings narratively and presented them in tables, text and figures. We calculated statistical parameters (ie, risk ratios (RRs)) when authors had not provided them but adequate data were available.

RESULTS
Characteristics of the included studies
Our search identified 1598 database records and 80 from additional sources. After assessing the titles, abstracts and full texts, we included 55 peer-reviewed studies (figure 1, online supplemental annex 3). 16 studies, including 12 823 migrants, reported on malaria,[25–40] and 39 studies, including 82 728 migrants, reported on NTDs; specifically 12 on cutaneous leishmaniasis (CL)[41–52]; 8 on intestinal helminthic infection[53–60]; 5 on dengue and chikungunya[61–65]; 3 on schistosomiasis, cystic echinococcosis,[66–68] trachoma[69–71] and scabies[72–74]; 2 on leprosy[75 76] and cysticercosis[77 78] and 1 on lymphatic filariasis.[79] Studies spanned 11 countries, 80% (n=44) in the Middle East,[25–28 32–35 37 39–48 50–63 65 66 66 67 67 72–79] and 20% (n=11) in North Africa (Algeria, Morocco, Sudan (n=9). 34 studies investigated non-nationals,[25–28 32–35 37 39–43 51 53–59 61 63 65–68 75–79] 10 refugees[29 36 44–48 50 69 71] and 11 IDPs.[30 31 38 49 52 60 64 70 72–74]
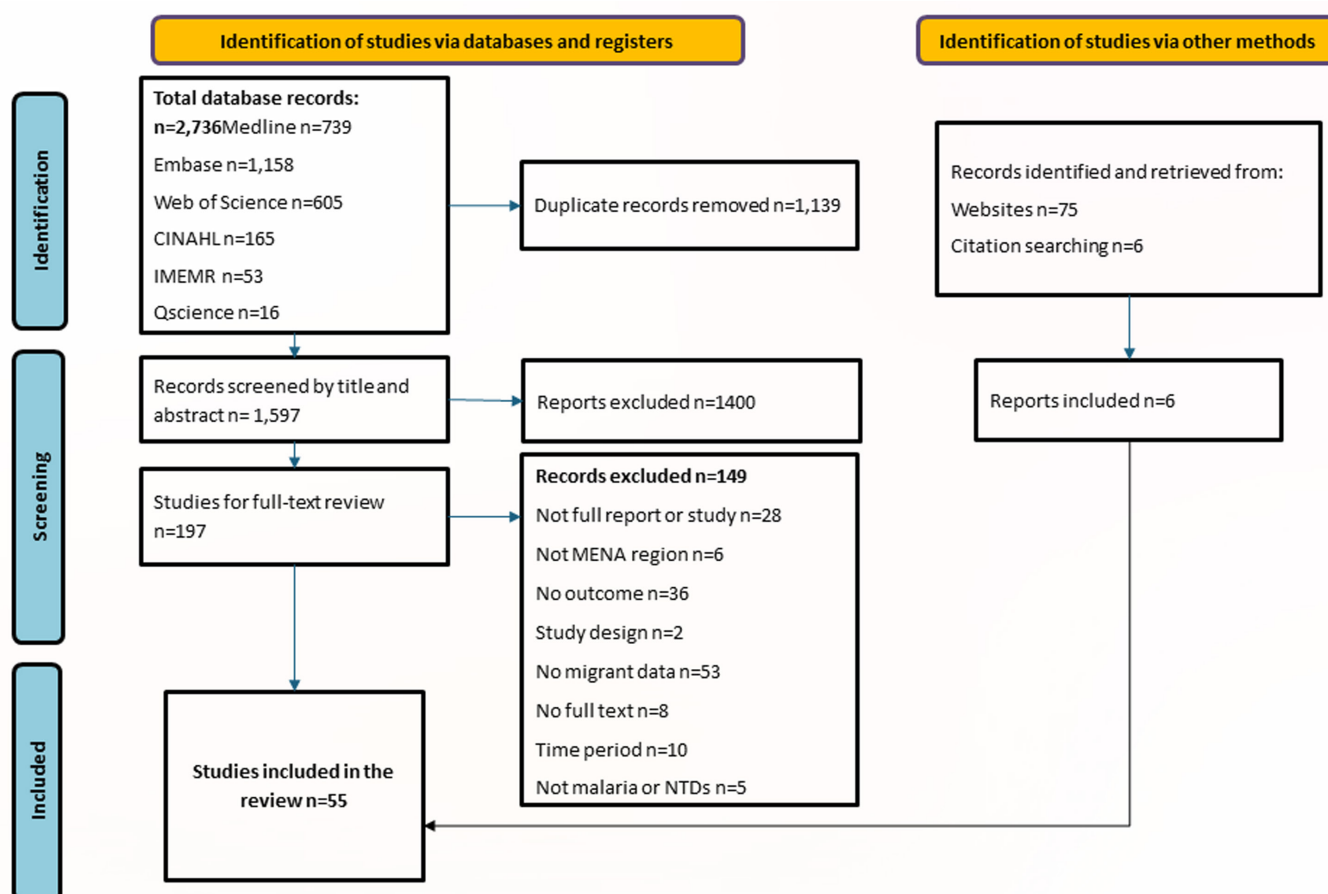
Figure 1 Flowchart of included studies. MENA, Middle East and North African; NTDs, neglected tropical diseases.

14 studies reported prevalence or seroprevalence of diseases,[49 53–59 61 69–71 77 79] 4 examined incidence,[31 36 50 65] 13 documented number of confirmed cases among suspected cases[25 29 30 35 38 48 60 62 64 66 67 73 74] and a majority (n=24) investigated the distribution of confirmed cases between migrants and non-migrants.[26–28 32–34 37 39–47 51 63 68 72 75 76 78] Only six studies were conducted on clinical outcomes, including severe malaria, severe dengue haemorrhagic fever and the case fatality rate of dengue and malaria.[30 33 34 36 48 64] Finally, 14 studies reported risk factors for dengue and chikungunya,[61] cystic echinococcosis,[66] schistosomiasis,[66] malaria,[29 31 33–35 38] soil-transmitted helminths (STH),[53 54 56] CL[52] and cysticercosis.[77] 34 studies compared the burden of diseases in migrant versus non-migrant populations,[26–29 32 34 35 37 39–44 46 47 51–55 61–63 65–68 72 73 75 76 78] and 21 were only conducted in a migrant group.[25 30 31 33 36 38 45 48–50 56–60 64 69–71 74 77 79]

Quality assessment

None of the 40 cross-sectional studies were judged as having a low risk of bias across all domains. The highest risk of bias was observed in domains related to confounding factors, with 37 studies failing to apply any strategies to address potential confounding factors, and 2 studies not discussing variables that could influence the outcomes. Additionally, a high risk of bias was identified in outcome measurement in 10 studies, either because of sole reliance on clinical diagnosis or a lack of detailed information about the diagnostic method used.

Five of the 14 prevalence studies had a low risk of bias in all domains, particularly for domains related to the study subjects and setting, using an appropriate sample frame, sufficient study acceptance and completion rate and using valid methods and standard criteria to measure the condition. The domains at unclear risk of bias included sample size adequacy and appropriateness of sampling method, as the study did not provide details in these areas (figure 2).

Burden of disease

Soil-transmitted helminths

Seven studies evaluated the prevalence of STH.[53–59] After pooling the data from four screening studies, including 25 491 adult migrants in Gulf Cooperation Council (GCC) countries,[56–59] we found that, based on microscopic stool examination, the prevalence of hookworm was 4.7% (0.9–11.1%, n=259, I^2=99%), *Trichuris trichiura* was 1.8% (0.4–4.3%, n=125, I^2=98%) and *Ascaris lumbricoides* was 1.7% (0.6–3.5%, n=166, I^2= 96%), (figure 3). The other three studies, also based on microscopic stool examination, compared the prevalence of STH among long-term migrants (n=19 929) versus non-migrants (n=9357) attending hospitals from 2005 to 2014 in Qatar.
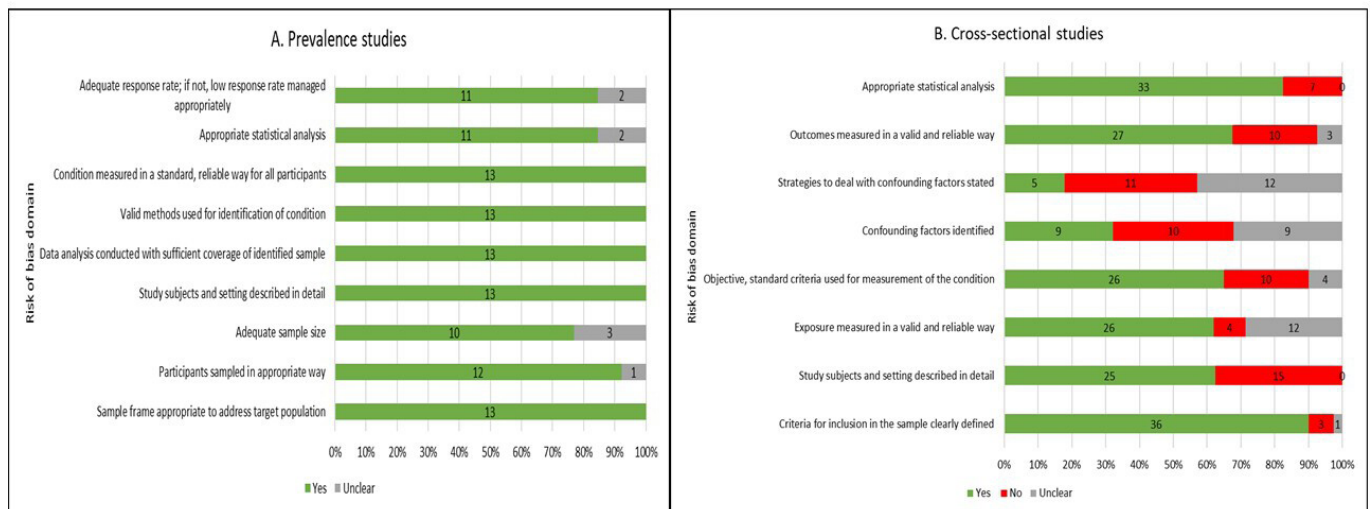
Figure 2 Risk of bias across 55 peer-reviewed studies using JBI critical appraisal tools for (A) Prevalence and (B) Cross-sectional studies. Note: 5 of the 14 prevalence studies had a low risk of bias in all domains. The two JBI domains on confounding factors were not applicable for 12 of 40 cross-sectional studies. JBI, Joanna Briggs Institute.

They found no cases of *Ascaris lumbricoides* and *Trichuris trichiura* among non-migrants, while in migrants, prevalence was 0.3% for *Ascaris lumbricoides* (n=62) and 0.5% for *Trichuris trichiura* (n=97). Additionally, migrants exhibited a higher prevalence of hookworm at 1.8% compared with 0.03% in non-migrants (unadjusted RR 55.56 (17.8–173.04)).[53–55]

There were only two studies on risk factors for STH from Qatar. Abu-Madi *et al* reported that, compared with other nationalities, Asian migrants had a higher prevalence of

hookworm (3.38% vs 0%, p<0.001), *Ascaris lumbricoides* (0.58% vs 0%, p<0.001) and *Trichuris trichiura* (0.91% vs 0%, p<0.001)[53] (see online supplemental annex 4). In 2016, Abu-Madi *et al* found that hookworm infections were more common among newly arrived migrants in Qatar who were aged 38–58 years (p=0.011) and male (4.4% (3.3–5.8%) vs 2.8% (2.0–3.9%), p=0.033). Additionally, parasitic load (mean eggs per gram of faeces) was higher among those aged 38–58 years (p=0.004), and females had a higher mean egg count (2.5, SD=0.8 vs 2.2, SD=0.4, p=0.032).[56]
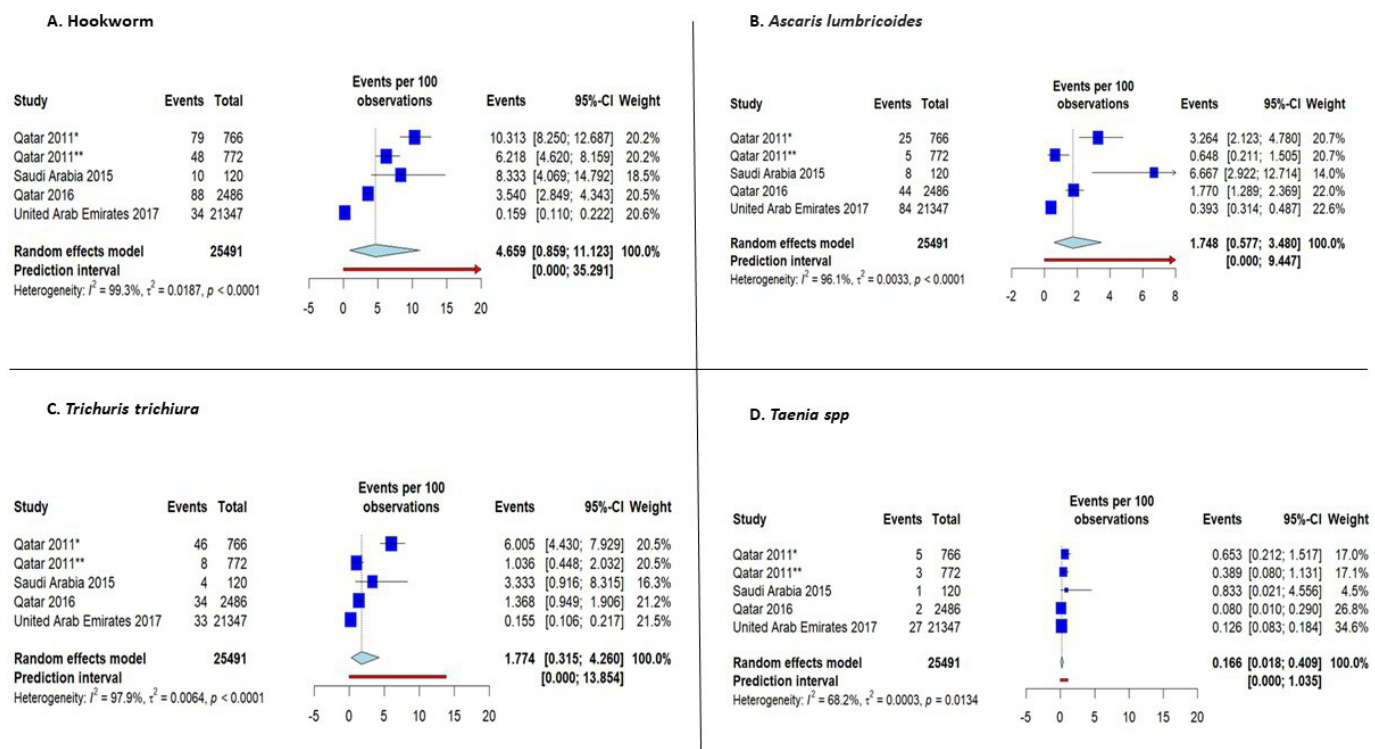

Figure 3 Forest plots of the pooled prevalence of intestinal helminths among migrants in the Middle East and North African region: (A) Hookworm, (B) *Ascaris lumbricoides*, (C) Trichuris and (D) Taenia. Note: Qatar 2011*: newly arrived migrants, Qatar 2011**: long-term resident migrants.

Taeniasis, cysticercosis and other helminthic infections

The pooled prevalence of taeniasis in four studies containing 25 491 adult migrants in GCC countries, based on microscopic stool examination, was 0.2% (0.0–0.4, n=38, I^2=68%).[56–59] A study in Kuwait found a seroprevalence of cysticercosis of 4.2% in a sample of 1000 newly arrived migrants.[77] A study in Iraq found 2 (0.05%) stool positive cases among 3925 suspected taeniasis in IDPs.[60] Another study in Qatar compared the distribution of neurocysticercosis cases by migration status, using radiographic imaging, histology and ECG, and found that migrants represented a higher percentage (98.8%, n=415/420) than non-migrants.[78] Another study in Kuwait reported a higher proportion of cystic echinococcosis (positive serology) in migrants among suspected cases (7.4% (n=42/568) vs 3.5% (n=15/423), unadjusted RR 2.08 (1.2–3.7)).[66] In this study, Bedouin (3.7%, n=21/568), Syrians (1.7%, n=10/568) and North Africans (0.9%, n=5/568) had a higher proportion of cystic echinococcosis compared with other nationalities (p<0.001).[66] Another study in migrant workers in Kuwait found a prevalence of filarial infection of 18.3% (192/1050) using immunochromatographic test methods and 20.3% (n=213) with the TropBio assay. Additionally, microscopy detected 32 cases (3%) of *Wuchereria bancrofti*, with a mean microfilaria count of 816 per millilitre.[79]

Schistosomiasis

Two studies investigated the prevalence of schistosomiasis among migrants, finding a prevalence of 0.3% among 772 long-term resident migrants in Qatar[57] and 0.83% among 120 migrant workers in Saudi Arabia, determined by microscopic stool examination.[59] Two studies compared the proportion of positive cases among suspected schistosomiasis cases between migrants and nationals. In Saudi Arabia, migrants exhibited a higher positive rate (0.2%, n=4/1891) than nationals (0.01%, n=29/232 364),(unadjusted RR 16.9 (6.0–48.2)) based on stool microscopy.[67] In Kuwait, migrants with suspected schistosomiasis had a rate of 20.3% (n=186/916), whereas in non-migrants there were zero positive cases, based on serological screening.[66] In this study, being Egyptian (14.1%, n=129/916) and Bedouin (6.1%, n=56/916) was associated with schistosomiasis (p<0.001).[66] A third study in Morocco reported that all cases (n=27) of schistosomiasis were in migrants.[68]

Cutaneous leishmaniasis

A study of CL among IDPs in Sudan found the prevalence of CL to be 55.7% (n=688/1236), using tissue smear microscopy.[49] Another study on the incidence of CL in Syrian refugees residing in Lebanon found a rate of 0.21% in 2013 and 0.04% in 2014 (1683 cases from 2013 to 2019).[50] Another three studies also investigated CL among Syrian refugees; one found that the proportion of positive among suspected CL cases in Syrian refugees in Lebanon was 11.6% (n=110/948), based on microscopy and PCR.[48] The other two studies reported that 92.1% of clinically diagnosed CL cases among 558 Syrian refugees in Jordan were imported. In contrast, 2.5% were locally acquired.[44 45]

Seven studies compared the distribution of CL among migrants and non-migrants, with conflicting results (see online supplemental annex 5). Three studies based on laboratory analysis showed that migrants represented a higher percentage of CL cases compared with non-migrants; 96.5% (n=1206/1256) of CL cases in Lebanon were Syrian refugees,[47] and 54% (n=5393/9962) and 80.5% (n=132/164) in the other two studies in Saudi Arabia were migrants.[41 42]

By contrast, four studies found that non-migrants represented a higher percentage of CL; based on clinical diagnosis, migrants represented 28.6% of CL cases in Iraq[46] and 44.97% (n=559/1243) in Jordan[44] and based on microscopic examination, 9.3% (n=559/1234) in Asir and 46.9% (n=739/1575) in Tabuk in Saudi Arabia were migrants.[43 51]

Only one study on treatment outcomes described an initial cure rate of CL in migrants in Lebanon of 81.8%.[48] Another study on risk factors for CL found that a history of displacement was associated with CL (unadjusted OR 5.18 (3.84–6.98)).[52]

Dengue and chikungunya

Five studies compared the burden of dengue between migrants and non-migrants, finding that migrants have a higher burden.[61–65] In Jizan, Saudi Arabia, although migrants represented a lower percentage of confirmed dengue cases (26.6%, n=910/3427), diagnosed by PCR or serology from 2015 to 2020, the incidence rate from 2015 to 2019 surpassed that of non-migrants, except in 2016. This disparity was particularly pronounced in 2015 when the incidence for migrants was 26.8/100 000 compared with 14.5/100 000 among non-migrants.[65] Likewise, in Qatar, the seroprevalence of dengue among blood donors was six times higher among migrants (26% (n=466/1792)) than among nationals (3.5% (n=7/200)) (unadjusted RR 5.9 (2.8–12.3)).[61] Another study in Qatar found that migrants (98%, n=163) represented more of the serologically confirmed dengue cases than nationals.[63] By contrast, only one study in Saudi Arabia found that migrants had a similar rate of serologically confirmed cases among suspected dengue cases as nationals (57.2%, n=1752 vs 56.4%, n=4885).[62] The study investigating blood donors in Qatar also compared the seroprevalence of chikungunya but found a non-significant higher rate in migrants compared with nationals (4.2% (n=75/1792) vs 3.5%, (n=7/200), unadjusted RR 1.14 (0.5–2.5)).[61]

There was also only one study on clinical outcomes, which found that 15.7% of 204 Sudanese IDPs had dengue, 75% of whom had severe disease with haemorrhagic fever and 3.1% died.[64] Only one study examined risk factors for dengue and chikungunya, finding that Asian migrants had higher odds of being seropositive for anti-DENV and anti-CHIKV antibodies than those from Qatar (aOR 0.23 (0.10–0.53)), the Middle East (aOR 0.09
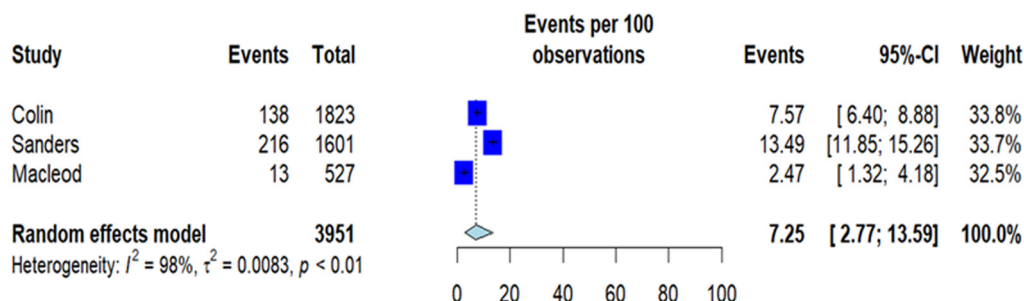
Study	Events	Total	Events per 100 observations	Events	95%-CI	Weight
Colin	138	1823		7.57	[6.40; 8.88]	33.8%
Sanders	216	1601		13.49	[11.85; 15.26]	33.7%
Macleod	13	527		2.47	[1.32; 4.18]	32.5%
Random effects model		3951		7.25	[2.77; 13.59]	100.0%

Heterogeneity: $I^2 = 98\%$, $\tau^2 = 0.0083$, $p < 0.01$

Figure 4 Forest plot of the pooled prevalence of trachoma among migrant children in the Middle East and North African region.

(0.05–0.16)) and North Africa (aOR 0.37 (0.20–0.67)), even after adjusting for age and other arboviruses.[61]

Other parasitic neglected tropical diseases

Three studies investigated ectoparasites among IDPs in Iraq, two of which compared the burden between migrants and non-migrants.[72–74] In one study, migrants accounted for 95% of scabies cases (n=145/195), a significantly higher percentage than non-migrants based on clinical criteria for scabies diagnosis.[72] Another study compared the proportion of positive cases among suspected scabies in migrants and nationals and found no difference (5.45% (n=342/6264) vs 5.5% (n=1612/29 183), respectively, unadjusted RR 0.99 (0.88–1.1)), based on clinical features, microscopy or dermatoscopy.[73] A third study found that 45% of suspected scabies cases among Iraqi IDPs were microscopically confirmed (n=585/1300).[74]

Bacterial neglected tropical diseases

Three studies investigated the prevalence of trachoma, and two investigated the distribution of leprosy cases by migrant status.[69–71 75 76] The pooled prevalence of acute trachoma infection follicular among refugee children (n=3951) across three studies was 7.25% (2.8–13.6, I^2=98%), based on clinical examination[69–71] (figure 4). The prevalence of trachoma trichiasis among adult refugees ranged from 0.75% (16/2139) to 3.07% (53/1734) based on clinical examination.[69 70] Studies on leprosy found that migrants were more highly represented than nationals among all cases in Saudi Arabia (57.4%, n=139/242)[76] and Kuwait (89.1%, n=41/46), based on WHO criteria and classification.[75]

Malaria

There were 16 studies on malaria; 2 reported malaria incidence,[31 36] 5 reported the proportion of positive among suspected malaria cases,[25 29 30 35 38] and 9 reported the distribution of malaria cases by migration status.[26–28 32–34 37 39 40] The incidence of malaria was 6.8/1000 among IDPs,[31] 2.72/1000 among refugees and 7.3/1000 among refugee children (<5 years) in Sudan.[36] Two studies compared the proportion of positive cases among suspected malaria cases between migrants and non-migrants. In Saudi Arabia, there was a higher rate in migrants (14.2%; n=19/134) versus non-migrants (7.8% n=11/141), based on PCR.[35] In Sudan, there was

a lower rate in migrants (6.6% (n=23/348)) versus non-migrants (17.9% (n=157/878)) based on microscopy.[29] Three studies investigated malaria cases in migrants alone (n=1248). They found the following rates of positive cases: 8% (n=24/300) in IDPs in Khartoum, based on microscopy,[30] 61.4% (n=226/365) in IDPs in Darfur, Sudan, based on nested-PCR[38] and 76.4% (n=448/583) in non-nationals in Qatar based on microscopy (figure 5).[25] Three studies reported *P. vivax* cases, which ranged from 3.7% (5/134) in Saudi Arabia,[35] 5.9% (23/384) in Sudan[29] to 20% (118/583) in Qatar.[25]

Of 11 studies 10 reported that migrants represented a higher percentage of malaria cases based on microscopy compared with non-migrants (online supplemental annex 6). The highest difference was in the UAE, where all cases were non-national (100%, n=629),[33] followed by Qatar (96.7%, n=4078/4092),[32] while the lowest difference was in Saudi Arabia (63%, n=19/30), diagnosed by PCR.[35] In contrast, the study in Sudan reported that non-migrants represented a higher proportion of malaria cases than Ethiopian refugees (migrants 12.8%, n=23/180, p<0.000).[29] Interestingly, the study in the UAE found that the median time from arrival to diagnosis in migrants was 2 days (IQR 1–4 days) and from symptoms onset to diagnosis was 5 days (3–8 days).

Six studies on risk factors found that water source, tribe, language and percentage of income spent on food expenditure (as a proxy for socioeconomic status) were associated with malaria in migrants; however, water storage at home, educational level, occupation, marital status, species, housing condition, being a camp visitor or resident, knowledge, attitude and practice were not associated (online supplemental annex 4).[29 31 33–35 38] In the adjusted analyses of a study in Sudan, the malaria attack rate within the last year was five times higher in IDPs who sourced water from a venting cart compared with a hand pump (OR 4.67 (2.81–7.76)).[31] Additionally, spending 50% (OR 2.11 (1.08–4.11)) of all income (OR 1.97 (1.09–3.61)) on food, speaking Dinka (a local language) compared with Arabic (OR 2.71 (1.43–5.13)) and being from a Southern tribe compared with others (OR 1.94 (1.14–3.29)) resulted in higher odds of malaria in the last 12 months.

Four studies examined the clinical outcomes of malaria[30 33 34 36]; severe malaria was developed in 1.6% (5/300) of IDPs in Sudan,[30] and 0.3% (12/4092) of
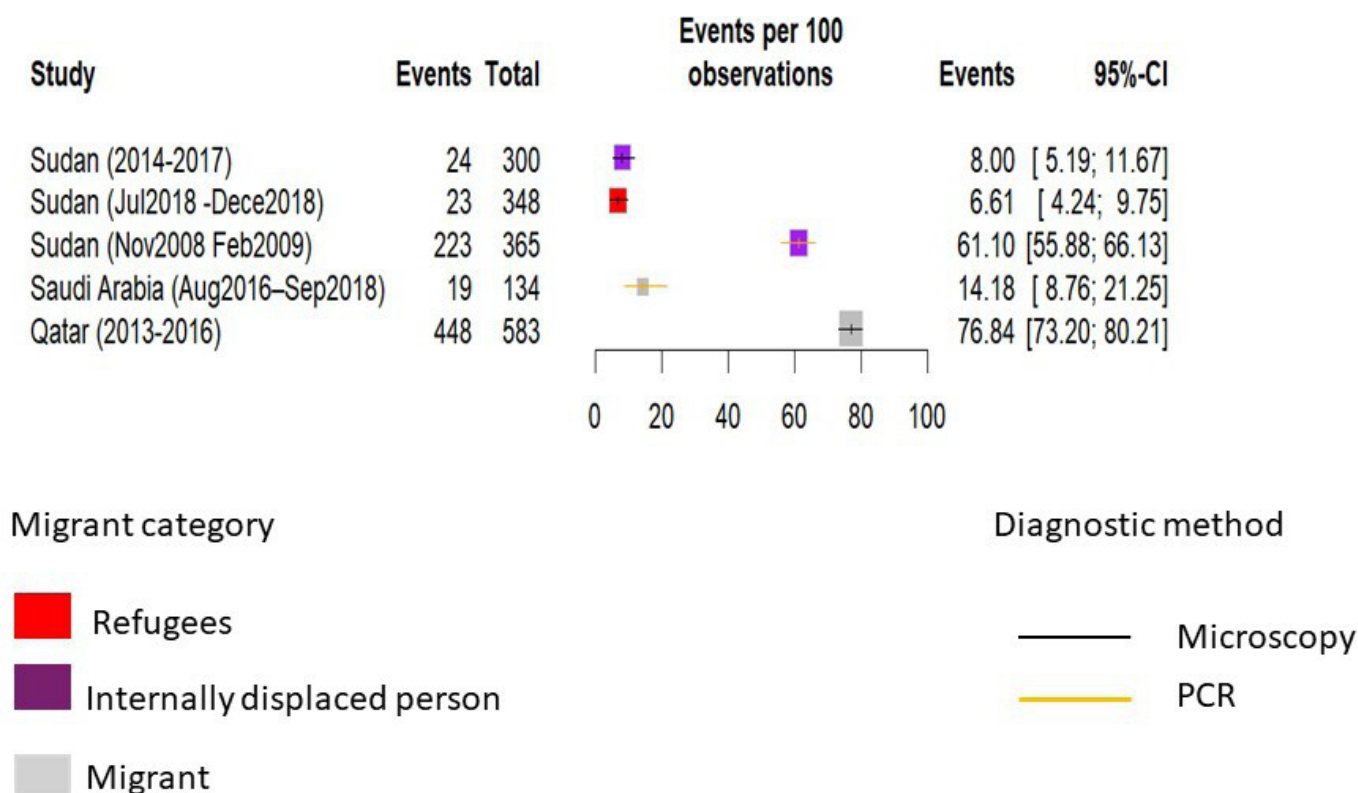
Figure 5 Distribution of individual studies on the proportion of positive malaria cases among suspected cases in the MENA region. MENA, Middle East and North African.

non-nationals in the UAE.[33] Conversely, in Qatar, 50% (n=2/4) of non-migrant cases developed severe malaria compared with 5.2% (4/77) of migrants (p=0·02).[34] A study in the UAE found that, out of 692 malaria cases, all of which were in migrants, 25.8% were hospitalised and 1.3% were admitted to intensive care unit (ICU). Two studies examined malaria mortality; in the study in the UAE, case fatality was 0.14% (n=1)[33] while in Sudan, it was 12.1% (9.7–14.9%) in all refugees and 15% (10.6–20.6%) in children.[36] The annual malaria mortality rate in Sudan was 0.9 (0.7–1.1) per 1000 in all refugees, while in children, it was 4.1/1000 (2.9–5.6).[36] Concerning risk factors for clinical outcomes, the study in the UAE found that *P. falciparum* was associated with hospitalisation and ICU compared with other species, but was not associated with death (online supplemental annex 4).

DISCUSSION

In this systematic review and meta-analysis, we presented the evidence on the burden, risk factors and clinical outcomes of NTDs and malaria among migrants in the MENA region. Despite a wide range of diseases reported in 55 studies, evidence gaps remain, primarily related to risk factors, clinical outcomes and the subregion of North Africa. Nevertheless, we found that in some countries, especially in the Middle East, migrants were disproportionately affected by both malaria and NTDs. Migrants showed a higher prevalence of STH and a higher seroprevalence of dengue than non-migrants, with up to

22.5% difference for dengue between the two groups. Among suspected cases, there was also a higher proportion of positive cases of schistosomiasis, cysticercosis, echinococcosis, dengue, scabies and malaria in migrants, the difference ranging from 0.8% for dengue to 20.3% for schistosomiasis. Finally, migrants accounted for a higher proportion of reported cases of malaria, dengue, scabies, leprosy, schistosomiasis, CL and STH compared with non-migrants; indeed, migrants constituted 100% of STH cases in GCC countries. Among studies that only included migrants, malaria, scabies and trachoma were highly prevalent among IDPs and refugees. Regarding the region of origin, Asian migrants had a higher STH prevalence and higher odds of being seropositive for anti-DENV and anti-CHIKV antibodies compared with migrants from African and Mediterranean regions. Those of Bedouin, Syrian or North African origin had a higher proportion of cystic echinococcosis, and being Egyptian or Bedouin was associated with schistosomiasis.

Our findings highlight both consistencies and differences within the included studies and with data from other regions. Generally, most studies within the MENA region and globally find that the burden of NTDs and malaria disproportionately affects migrant populations.[80] A systematic review of parasitic and vector-borne NTDs among migrants in Europe[81] reported a STH prevalence (4%) comparable to the MENA region; however, it found lower prevalence of filariasis and dengue in migrants (15.69% and 21.09%) compared with our findings in

the MENA region, and diseases like CL, rare in migrants in Europe (prevalence of 0.42%), were highly endemic among Sudanese IDPs (55.7%). Similarly, the proportion of positive cases among suspected scabies in Iraq IDPs (5.5–45%) exceeded pooled European estimates, attributable to overcrowded camp conditions that facilitate transmission. In contrast, schistosomiasis and taeniasis were more common in migrants in Europe (10.8% and 1.98%) compared with the MENA region, likely reflecting Europe's broader geographical origin and population diversity. These observed variations in disease burden among migrant populations appear closely tied to both origin and destination contexts. First, within GCC countries, studies predominantly identified STH and taeniasis among labour migrants, a pattern reflecting the region's reliance on foreign workers from South and South-East Asia, and its mandatory pre-employment screening programme. This contrasts with European data where STH primarily affected sub-Saharan Africa (SSA) migrants, likely due to migration flows.[82] Schistosomiasis risk showed particularly stark disparities: African migrants in our analysis were twice as likely to be infected compared with Bedouin populations and 129 times more likely than Iraqi migrants, mirroring European findings of elevated risk among SSA migrants.[83]

Second, conflict-affected areas focused on CL and hygiene-related NTDs. The Syrian crisis drove significant CL outbreaks among refugees in Jordan and Lebanon,[84 85] while IDP camps in Sudan and Iraq reported high burdens of hygiene-related NTDs (trachoma: 5.5–45% scabies prevalence) likely due to overcrowding and deficiencies in water, sanitation and hygiene services. CL transmission dynamics are particularly complex, with risk influenced by both migrant status and local factors like vector exposure and prevention awareness—explaining why some studies in Iraq[46] and Saudi Arabia[43] found higher CL rates among non-migrants. Similarly, dengue affected over 15% of IDPs in Sudan,[64] a pattern attributable to the breakdown of environmental controls and health systems in protracted conflict settings—known risk factors for dengue transmission.[84] Importantly, IDPs were also found to have a higher proportion of malaria-positive cases than refugees,[29 30 38] as well as a high risk of scabies and trachoma.[70] This implies several challenges—IDPs are not eligible for international aid until their home country requests it explicitly and are not as well organised as refugee camps, making access to healthcare complex and limited research exists on the health issues of IDPs compared with refugees, possibly due to their lack of international status.[85]

Third, malaria distribution also followed geographical and demographic context: GCC nations reported primarily imported cases (higher among migrants than travellers), while endemic Sudan showed greater burden in local populations. Regional parasite distribution varied predictably, with *P. vivax* dominating among Asian migrants and *P. falciparum* among Africans. Together, these regional and global differences in disease burden among migrant populations demonstrate how geopolitical context, migrants' status, country of origin and vulnerability, diagnostic variability and health system priorities interact to shape disease burdens,[86] underscoring the need for surveillance systems that capture this complexity and for interventions tailored to specific migrant subgroups.

Our findings have potential public health implications. Priority should be given to high-risk groups, such as Syrian refugees vulnerable to CL in Lebanon and Jordan, or Asian migrant workers in the GCC at risk of STH, with interventions like predeparture and postarrival screening and deworming. Effective prevention and early diagnosis for migrants, including inclusive care, is essential to prevent the reintroduction of diseases like malaria.[87] Indeed, malaria outbreaks have occurred in MENA countries that achieved elimination; falciparum malaria was reintroduced in Oman after decades due to imported cases among refugees, leading to 21 local cases.[88] Climatic conditions in the MENA region could increase mosquito proliferation and, together with the influx of migrants from endemic areas, could facilitate malaria transmission.[12]

Additionally, clinicians and administrative staff involved in screening and healthcare provision should receive specific training to deliver proficient health services for NTDs and malaria,[89] particularly in malaria-free countries. Surveillance systems should include migrants, IDPs and refugees indicators in health information systems to evaluate the burden of malaria and NTDs in these populations.[1] All this can be achieved through increased resource allocation for NTDs and malaria healthcare provision; partnerships with local and international NGOs, and through community engagement to map and reach mobile populations.

Significant gaps persist in the current evidence base, highlighting critical needs for future research. None of the studies examined the role of socioeconomic factors in the occurrence of these diseases among migrants. Enhanced education, better healthcare access and economic development have been linked to substantial reductions in the burden of NTDs and malaria.[86] Further studies should specifically evaluate the impact of socioeconomic factors on the burden of these conditions in migrants in the MENA region. Moreover, we only found 11 out of 23 NTD studies in three North African countries, and data regarding risk factors for NTDs in migrants were limited. Future research in the North African subregion is critical as countries like Egypt are hosting millions of migrants from Sudan, Palestine, Syria and Yemen as a result of regional conflicts, while countries like Morocco and Tunisia are transit destinations for migrants moving to Europe. However, such research is often challenging due to methodological and ethical challenges. A lack of trust in authorities or researchers and concerns related to privacy and informed consent, together with high mobility of many migrants, further contributes to low recruitment, limited participation and poor long-term follow-up in studies involving migrants.[90] Undocumented

migrants are also frequently excluded from studies due to legal and logistical constraints.

Strengths and limitations

Our study has several limitations. First, although we searched for grey literature, we included only peer-reviewed articles because we did not find grey literature on the burden, risk factors or clinical outcomes in migrants in the MENA region. Second, the available evidence was limited and highly fragmented across diseases and outcomes—most studies did not differentiate between migrant groups, limiting the ability to estimate pooled prevalence. We were unable to calculate pooled estimates for most diseases due to heterogeneity across studies, variations in disease definitions, diagnostic methods, migrant categories (ie, refugees and undocumented migrants) and other outcomes, low data quality in some cases and the limited number of studies. Although five studies reported similar outcomes for malaria, we did not pool their estimates because of differences in diagnostic methods and migrant categories. We were also unable to disaggregate analyses by year of arrival or assess publication bias. Third, data included in the meta-analysis exhibited high heterogeneity; consequently, we interpreted the results with caution.

CONCLUSIONS

Migrants in multiple MENA countries are disproportionately affected by malaria and NTDs, highlighting their vulnerability. Future research should systematically assess the risk factors and clinical outcomes of malaria and NTDs among migrant populations, particularly in North Africa, to guide evidence-based approaches for effective prevention, early diagnosis and treatment.[11]

Author affiliations

[1]Blue Nile National Institute for Communicable Diseases, University of Gezira, Wad Madani, Sudan
[2]Migrant Health Research group, Barcelona Institute for Global Health (ISGlobal, Hospital Clinic—University of Barcelona), Barcelona, Spain
[3]Faculty of Medicine, University of Barcelona, Barcelona, Spain
[4]University of Sousse, Faculty of Medicine of Sousse, Research Laboratory Quality of Care and Management of Maternal Health Services, LR12ES03, Sousse, Tunisia
[5]Faculty of Veterinary Medicine, Badr University in Cairo, Cairo, Egypt
[6]The Migrant Health Research Group, Institute for Infection and Immunity, School of Health & Medical Sciences, City St George's University of London, London, Spain
[7]Chronic Disease Epidemiology Department, Yale School of Public Health, New Haven, Connecticut, USA
[8]Department of Infectious Diseases, Karolinska University Hospital Department of Infectious Diseases, Stockholm, Sweden
[9]CIBERINFEC, ISCIII - CIBER de Enfermedades Infecciosas, Instituto de Salud Carlos III, Centro de Investigación Biomédica en Red de Enfermedades Infecciosas, Madrid, Spain

ORCID iDs

Sally Hargreaves https://orcid.org/0000-0003-2974-4348
Farah Seedat https://orcid.org/0000-0002-3563-7875
Ana Requena-Méndez https://orcid.org/0000-0002-4422-241X

REFERENCES

1 Requena-Méndez A, Wickramage K, Ito C, *et al*. Understanding health inequities among transiting migrants within the Middle East and North African (MENA) region through strengthening data systems. *Travel Med Infect Dis* 2021;42:102094.
2 International Organisation for Migration. International data | Migration data portal. Available: https://www.migrationdataportal.

org/international-data?i=stock_abs_&t=2020 [Accessed 14 Dec 2024].

3 OACHA, OACHA. Humanitarian situation Update_Gaza. 2023. Available: https://www.unocha.org/publications/report/occupied-palestinian-territory/humanitarian-situation-update-245-gaza-strip [Accessed 14 Dec 2024].

4 Abubakar I, Aldridge RW, Devakumar D, et al. The UCL-Lancet Commission on Migration and Health: the health of a world on the move. Lancet 2018;392:2606–54.

5 World Health Organization. Neglected tropical diseases. 2024. Available: https://www.who.int/health-topics/neglected-tropical-diseases#tab=tab_1 [Accessed 09 Mar 2024].

6 Holmes KK, Bertozzi S, Bloom BR, et al, eds. Major infectious diseases. Disease control priorities. 3rd edn. Washington, DC: World Bank, 2017.

7 McCarthy AE, Weld LH, Barnett ED, et al. Spectrum of Illness in International Migrants Seen at GeoSentinel Clinics in 1997–2009, Part 2: Migrants Resettled Internationally and Evaluated for Specific Health Concerns. Clin Infect Dis 2013;56:925–33.

8 Zhang Y, Ming Y. Burden of schistosomiasis in global, regional, and national 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019. Travel Med Infect Dis 2024;61:102751.

9 World Health Organization. World malaria report 2023. Geneva World Health Organization; 2023.

10 World Health Organization. Global technical strategy for malaria, 2016-2030. Geneva Global Malaria Programme, World Health Organization; 2015.

11 World Health Organization. Ending the neglect to attain the sustainable development goals: a road map for neglected tropical diseases 2021–2030. 2020.

12 The WHO Control of Neglected Tropical Diseases Team. Ending the neglect to attain the sustainable development goals: a road map for neglected tropical diseases 2021-2030. 2020.

13 World Health Organization. Egypt is certified malaria-free by WHO. 2024. Available: https://www.who.int/news/item/20-10-2024-egypt-is-certified-malaria-free-by-who

14 Wickramage K, Ito C, Hilali M, et al. Migrants in the Middle East and North Africa during the COVID-19 pandemic. J Travel Med 2023;30:1–2.

15 Al-Awadhi M, Ahmad S, Iqbal J. Current Status and the Epidemiology of Malaria in the Middle East Region and Beyond. Microorganisms 2021;9:338.

16 Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71.

17 Seedat F, Evangelidou S, Abdellatifi M, et al. Defining indicators for disease burden, health outcomes, policies and barriers and facilitators to health services for migrant populations in the Middle East and North African region: a protocol for a suite of systematic reviews. BMJ Open 2024;14:e083813.

18 Glossary on migration international migration law N° 34. 2019.

19 International Organization for Migration. Migration factsheet No. 2-Migrants. 2020.

20 International Organization for Migration. Migration to, from and in the Middle East and North Africa1 Data snapshot. 2015.

21 Rayyan: AI-powered systematic review management platform. Available: https://www.rayyan.ai/ [Accessed 14 Dec 2024].

22 Faculty of Health and Medical Sciences The University of Adelaide. Critical appraisal tools. JBI. Available: https://jbi.global/critical-appraisal-tools [Accessed 09 Mar 2024].

23 Tyndall J. AACODS checklist. 2010.

24 R: the R project for statistical computing. Available: https://www.r-project.org/ [Accessed 19 Sep 2024].

25 Al-Rumhi A, Al-Hashami Z, Al-Hamidhi S, et al. Influx of diverse, drug resistant and transmissible Plasmodium falciparum into a malaria-free setting in Qatar. BMC Infect Dis 2020;20:413.

26 Iqbal J, Al-Awadhi M, Ahmad S. Decreasing trend of imported malaria cases but increasing influx of mixed P. falciparum and P. vivax infections in malaria-free Kuwait. PLoS ONE 2020;15:e0243617.

27 Al-Kuwari MG. Epidemiology of imported malaria in Qatar. J Travel Med 2009;16:119–22.

28 Abdalal SA, Yukich J, Andrinoplous K, et al. An insight to better understanding cross border malaria in Saudi Arabia. Malar J 2023;22:37.

29 Elgoraish AG, Elzaki SEG, Ahmed RT, et al. Epidemiology and distribution of Plasmodium vivax malaria in Sudan. Trans R Soc Trop Med Hyg 2019;113:517–24.

30 El Mekki M, Aburas N, Alghaithy A, et al. Prevalence and Molecular Identification of Malaria Parasite in Displaced Camps in Khartoum State, Sudan. Egyptian Academic Journal of Biological Sciences, E Medical Entomology & Parasitology 2012;4:7–12.

31 Saeed IE, Ahmed ES. Determinants of acquiring malaria among displaced people in Khartoum state, Sudan. East Mediterr Health J 2003;9:581–92.

32 Farag E, Bansal D, Chehab MAH, et al. Epidemiology of Malaria in the State of Qatar, 2008-2015. Mediterr J Hematol Infect Dis 2018;10:e2018050.

33 Nilles EJ, Alosert M, Mohtasham MA, et al. Epidemiological and clinical characteristics of imported malaria in the United Arab Emirates. J Travel Med 2014;21:201–6.

34 Khan FY, Lutof AK, Yassin MA, et al. Imported malaria in Qatar: A one year hospital-based study in 2005. Travel Med Infect Dis 2009;7:111–7.

35 Hawash Y, Ismail K, Alsharif K, et al. Malaria Prevalence in a Low Transmission Area, Jazan District of Southwestern Saudi Arabia. Korean J Parasitol 2019;57:233–42.

36 Anderson J, Doocy S, Haskew C, et al. The burden of malaria in post-emergency refugee sites: A retrospective study. Confl Health 2011;5.

37 El-Malky M, Aldosari MS, Elsendiony A, et al. IMPORTED MALARIA TO MAKKAH DISTRICT, SAUDI ARABIA: IS THERE ANY RISK OF LOCAL TRANSMISSION? J Egypt Soc Parasitol 2016;46:461–5.

38 Eshag HA, Elnzer E, Nahied E, et al. Molecular epidemiology of malaria parasite amongst patients in a displaced people's camp in Sudan. Trop Med Health 2020;48:3.

39 Khan FY. Malaria Cases Presenting at Hamad General Hospital in Doha-Qatar 2000-2002. Qatar Med J 2006;2006.

40 Memish ZA, Alzahrani M, Alhakeem RF, et al. Toward malaria eradication in Saudi Arabia: evidence from 4-year surveillance in Makkah. Ann Saudi Med 2014;34:153–8.

41 Amin TT, Al-Mohammed HI, Kaliyadan F, et al. Cutaneous leishmaniasis in Al Hassa, Saudi Arabia: epidemiological trends from 2000 to 2010. Asian Pac J Trop Med 2013;6:667–72.

42 Abdalla NM, Abdelgani AM, Osman AA, et al. Demographical and population dynamics impact on public health of cutaneous Leishmaniasis in Al-Madinah Almonawra, Saudi Arabia. Afr Health Sci 2019;19:2421–30.

43 Alraey Y, Alhweti R, Almutairi H, et al. Molecular Characterization of Leishmania Species among Patients with Cutaneous Leishmaniasis in Asir Province, Saudi Arabia. Pathogens 2022;11:1472.

44 Alhawarat M, Khader Y, Shadfan B, et al. Trend of Cutaneous Leishmaniasis in Jordan From 2010 to 2016: Retrospective Study. JMIR Public Health Surveill 2019;6:e14439.

45 Sami Amr Z, Kanani K, Shadfan B, et al. Cutaneous leishmaniasis among syrian refugees in Jordan: A retrospective study. Bull Soc Pathol Exot 2018;11:295–300.

46 Abdulla QB, Shabila NP, Al-Hadithi TS. An An outbreak of cutaneous leishmaniasis in Erbil governorate of Iraqi Kurdistan Region in 2015. J Infect Dev Ctries 2018;12:600–7.

47 Alawieh A, Musharrafieh U, Jaber A, et al. Revisiting leishmaniasis in the time of war: the Syrian conflict and the Lebanese outbreak. Int J Infect Dis 2014;29:115–9.

48 Saroufim M, Charafeddine K, Issa G, et al. Ongoing epidemic of cutaneous leishmaniasis among Syrian refugees, Lebanon. Emerg Infect Dis 2014;20:1712–5.

49 Sulaiman A, Elmadhoun W, Noor S, et al. An outbreak of cutaneous leishmaniasis among a displaced population in North Sudan: Review of cases. J Family Med Prim Care 2019;8:556.

50 Farah Z, Saleh M, Abou El Naja H, et al. Communicable Disease Surveillance in Lebanon during the Syrian Humanitarian Crisis, 2013–2019. Epidemiologia 2023;4:255–66.

51 Hassanein RAM, El-Shemi AG, Albalawi BM. Cutaneous leishmaniasis in Tabuk, Saudi Arabia: epidemiological trends from 2006 to 2021. Pan Afr Med J 2023;45:11.

52 Lehlewa AM, Khaleel HA, Lami F, et al. Impact of Modifiable Risk Factors on the Occurrence of Cutaneous Leishmaniasis in Diyala, Iraq: Case-Control Study. JMIRx Med 2021;2:e28255.

53 Abu-Madi MA, Behnke JM, Doiphode SH. Changing trends in intestinal parasitic infections among long-term-residents and settled immigrants in Qatar. Parasites Vectors 2010;3:98.

54 Abu-Madi MA, Behnke JM, Doiphode SH. Intestinal parasitic infections among long-term-residents and settled immigrants in Qatar in the period 2005 to 2011. Am J Trop Med Hyg 2013;88:1185–95.

55 Abu-Madi MA, Behnke JM, Boughattas S, et al. Helminth infections among long-term-residents and settled immigrants in Qatar in the decade from 2005 to 2014: temporal trends and varying prevalence among subjects from different regional origins. Parasites Vectors 2016;9.

56 Abu-Madi MA, Behnke JM, Ismail A, et al. Assessing the burden of intestinal parasites affecting newly arrived immigrants in Qatar. Parasit Vectors 2016;9:619.

57 Abu-Madi MA, Behnke JM, Ismail A, *et al*. Comparison of intestinal parasitic infection in newly arrived and resident workers in Qatar. *Parasit Vectors* 2011;4:211.

58 Dafalla AIA, Almuhairi SASO, AlHosani MHJ, *et al*. Intestinal parasitic infections among expatriate workers in various occupations in Sharjah, United Arab Emirates. *Rev Inst Med Trop Sao Paulo* 2017;59:e82.

59 Imam NaglaaFA, Abdulbaqi Z, Fahad R. The prevalence of intestinal parasitic infections among foreign workers in Madinah, Kingdom of Saudi Arabia. *Saudi J Med Med Sci* 2015;3:112.

60 Hassan AO, Mero WMS. The Prevalence of Ectoparasites among Displaced People Living in Displacement Camps: Duhok Province, Iraqi Kurdistan. *IJRP* 2020;24:7897–905.

61 Humphrey JM, Al-Absi ES, Hamdan MM, *et al*. Dengue and chikungunya seroprevalence among Qatari nationals and immigrants residing in Qatar. *PLoS ONE* 2019;14:e0211574.

62 Alshabi A, Marwan A, Fatima N, *et al*. Epidemiological screening and serotyping analysis of dengue fever in the Southwestern region of Saudi Arabia. *Saudi J Biol Sci* 2022;29:204–10.

63 Farag EA, Jaffrey S, Daraan F, *et al*. Dengue Epidemiology in Qatar from 2013-2021: A Retrospective Study. *Trop Med Infect Dis* 2022;7:329.

64 Ahmed A, Elduma A, Magboul B, *et al*. The First Outbreak of Dengue Fever in Greater Darfur, Western Sudan. *Trop Med Infect Dis* 2019;4:43.

65 Alqassim AY, Badedi M, Muaddi MA, *et al*. Shifting spatial, temporal and demographic patterns of dengue incidence and associated meteorological factors in Jazan Region of Saudi Arabia from 2015–2020. *J Vector Borne Dis* 2024;61:444–51.

66 Al-Awadhi M, Iqbal J, Ahmad S. An Update on the Epidemiological Features of Imported Schistosomiasis and Cystic Echinococcosis in Kuwait, 2010-2018. *Med Princ Pract* 2021;30:138–45.

67 Mohammad KA. Prevalence of Schistosomiasis in Al-Baha Province, Saudi Arabia in Years 2012 and 2013 : Prospective and Comparative Study. *JESP* 2014;44:397–404.

68 Balahbib A, Amarir F, Bouhout S, *et al*. Retrospective study on imported schistosomiasis in Morocco between 2005 and 2017. *Trop Doct* 2020;50:317–21.

69 Sanders AM, Abdalla Z, Elshafie BE, *et al*. Prevalence of trachoma within refugee camps serving South Sudanese refugees in White Nile State, Sudan: Results from population-based surveys. *PLoS Negl Trop Dis* 2019;13:e0007491.

70 Macleod CK, Binnawi KH, Elshafie BE, *et al*. Unimproved water sources and open defecation are associated with active trachoma in children in internally displaced persons camps in the Darfur States of Sudan. *Trans R Soc Trop Med Hyg* 2019;113:599–609.

71 Javaloy J, Ferrer C, Vidal MT, *et al*. Follicular conjunctivitis caused by Chlamydia trachomatis an infant Saharan population: Molecular and clinical diagnosis. *Br J Ophthalmol* 2003;87:142–6.

72 Alsamara AM, Alobaidi AHA. Scabies in displaced families: Health care problem that need urgent action. *Our Dermatol Online* 2017;8:250–4.

73 Prevalence of Scabies in Duhok Province and Duhok Refugees' Camps- Kurdistan Region of Iraq. *JSTR* 2020.

74 Alberfkani MI, Mero WMS. The Incidence of Scabies and Head Lice and Their Associated Risk Factors among Displaced People in Cham Mishko Camp, Zakho City, Duhok Province, Iraq. *Pol J Microbiol* 2020;69:463–9.

75 Al-Mutairi N, Al-Doukhi A, Ahmad MS, *et al*. Changing demography of leprosy: Kuwait needs to be vigilant. *Int J Infect Dis* 2010;14:e876–80.

76 Assiri A, Yezli S, Tayeb T, *et al*. Eradicating leprosy in Saudi Arabia: Outcome of a ten-year surveillance (2003–2012). *Travel Med Infect Dis* 2014;12:771–7.

77 Al-Awadhi M, Iqbal J, Ahmad S. Cysticercosis, a Potential Public Health Concern in Kuwait: A New Diagnostic Method to Screen Taenia solium Taeniasis Carriers in the Expatriate Population. *Med Princ Pract* 2020;29:347–53.

78 Haddad N, Shaheen Y, Abunaib M, *et al*. Neurocysticercosis in non-endemic regions: The experience of Qatar. *Front Neurol* 2023;14.

79 Iqbal J, Sher A. Determination of the prevalence of lymphatic filariasis among migrant workers in Kuwait by detecting circulating filarial antigen. *J Med Microbiol* 2006;55:401–5.

80 Gautret P, Cramer JP, Field V, *et al*. Surveillance and outbreak reports Infectious diseases among travellers and migrants in Europe. *EuroTravNet* 2010.

81 Guido G, Frallonardo L, Cotugno S, *et al*. Prevalence of neglected tropical diseases among migrants living in Europe: A systematic review and meta-analysis. *Travel Med Infect Dis* 2025;64:102823.

82 Oommen GZ. South Asia-Gulf migratory corridor: emerging patterns, prospects and challenges. *Migr Dev* 2016;5:394–412.

83 Asundi A, Beliavsky A, Liu XJ, *et al*. Prevalence of strongyloidiasis and schistosomiasis among migrants: a systematic review and meta-analysis. *Lancet Glob Health* 2019;7:e236–48.

84 Abdul-Ghani R, Mahdy MAK, Al-Eryani SMA, *et al*. Impact of population displacement and forced movements on the transmission and outbreaks of Aedes-borne viral diseases: Dengue as a model. *Acta Trop* 2019;197:105066.

85 Owoaje ET, Uchendu OC, Ajayi TO, *et al*. A review of the health problems of the internally displaced persons in Africa. *Niger Postgrad Med J* 2016;23:161–71.

86 Zheng J-X, Liu Y, Guan S-Y, *et al*. Global, regional, and national burden of neglected tropical diseases and malaria in the general population, 1990-2021: Systematic analysis of the global burden of disease study 2021. *J Adv Res* 2025.

87 Piperaki ET, Daikos GL. Malaria in Europe: emerging threat or minor nuisance? *Clin Microbiol Infect* 2016;22:487–93.

88 Guidelines on prevention of the reintroduction of malaria EMRO Technical Publications Series 34. 2007.

89 World Health Organization. Neglected tropical diseases 2019. Geneva, 2019.

90 Giménez L, Evangelidou S, Gresle A-S, *et al*. Living labs for migrant health research: the challenge of cocreating research with migrant population and policy makers. *BMJ Glob Health* 2024;9:e014795.