

# The Geography of Imported Malaria

## Literature Watch Review

Tatem AJ, Jia P, Ordanovich D, Falkner M, Huang Z, Howes R, et al. **The geography of imported malaria to non-endemic countries: a meta-analysis of nationally reported statistics.** *Lancet Infect Dis.* 2016 Oct 21. pii: S1473-3099(16)30326-7. doi: 10.1016/S1473-3099(16)30326-7.

Leder K, Chen LH. **Global malaria importations.** *Lancet Infect Dis.* 2016 Oct 21. pii: S1473-3099(16)30404-2. doi: 10.1016/S1473-3099(16)30404-2.

## Conclusion

- Patterns of malaria imported into non-endemic countries were heterogeneous and determined mainly by historical ties with endemic countries, the endemicity of malaria, and the flow of migrants and travelers.
- Importations were strongly skewed towards a small number of high-traffic routes with West Africa. Those routes accounted for 56% of all imported cases to non-endemic countries, with France and United Kingdom (U.K.) together receiving > 80% of the cases in this analysis—more than 4,000 per year on average.
- Migrants and migrants returning from visiting friends and relatives account for an increasing proportion of imported cases.
- Figure 1 of the article should be displayed in every travel clinic, although important flows to Canada from India and Pakistan appear to have been omitted.

## Abstract

More than 50 countries have eliminated malaria, but increasing travel to malaria-endemic countries ensures that imported cases of malaria remain common in non-endemic countries. Patterns of imported malaria vary by country and reflect several factors, notably the intensity of transmission in the endemic country and the number and behavior of people visiting that country. Most information on imported malaria is collected by national authorities where malaria is a notifiable disease. National data are often incomplete or may not be published; hence, regional reports may underestimate the problem. In 2010, World Health Organization (WHO) reported 6244 cases of imported malaria in Europe; the true figure may have been 6 times higher. Surveillance networks such as GeoSentinel and EuroTravNet play a role in identifying trends, tracking drug resistance, and documenting the changing profile of malaria risk at travel destinations.

This article describes the collection of nationally reported data on imported malaria and the geographic analysis of these data from 40 non-endemic countries during 2005-15, covering more than 50,000 individual cases. It maps the system of transmission and rates of flow from endemic to non-endemic countries and the species of malaria parasite by sending and receiving regions. Details of the construction of a library of imported malaria statistics and data extraction and processing are provided in an appendix. Briefly:

- Annual national summary reports were complemented by literature searches for imported malaria.
- For each endemic exporting country, all reported annual mean case numbers exported to non-endemic countries were aggregated to obtain proportions of parasite species exported.
- Origin-destination matrices for the average number of annual cases imported from endemic countries and regions to non-endemic countries were constructed.
- Non-endemic and endemic countries that showed strong links in terms of movement of infected travelers and that played similar roles within the imported malaria network were grouped into communities to better understand the patterns of importation.
- Existing parasite prevalence maps enabled simple comparisons to be made with the imported malaria statistics and provided a population-weighted mean *P. falciparum* and *P. vivax* prevalence for each endemic country.
- Data on bilateral migrations (migration flows) between each pair of endemic and non-endemic countries were obtained to enable comparisons to be made with the numbers of cases of imported malaria.

Results of this meta-analysis are presented quantitatively in maps and diagrams, making them easy to understand.

- During 2005-15, the movement of malaria followed specific routes. Figure 1A shows a world map with the numbers of

exported and imported cases of malaria by country. Countries with the most imported cases (cases per year on average) were France (n = 2169), U.K. (n = 1898), U.S. (n = 1511), Italy (n = 637), and Germany (n = 401).

- The majority (22,946/24,941 [92%]) of exported cases to non-endemic countries originated in West Africa (13,947 [56%]), India (4,988 [20%]), East Africa (3,242 [13%]), and Papua New Guinea (748 [3%]). Figure 1B shows a world map of *P. falciparum* endemicity overlaid with the routes between exporting and importing countries. The connections between France and West Africa and between U.K. and West Africa were the strongest, with movement of 2,492 cases per year on average. Many other routes produced an annual average of > 50 cases; these included U.S. and India (n = 149), U.S. and West Africa (n = 716), U.S. and Haiti (n = 52), Australia and Papua New Guinea (n = 97), and U.K. and Pakistan (n = 69).
- The structure of network communities was defined not so much geographically as by historical, economic, language, and cultural ties. For example, the French and U.K. communities included, but were not confined to, the French- and English-speaking African nations that were their former colonies.
- There were clear associations between the average annual number of outgoing *P. falciparum* cases from endemic to non-endemic countries, *P. falciparum* prevalence (parasite rate) in the endemic countries, and the migration flows to non-endemic countries (Figure 3). Other associations also played a part: demographics; levels of prophylaxis; and travel activities, notably visiting friends and relatives.
- There was much variation in *Plasmodium* species among malaria cases coming from different regions of the world. The mean percentage of cases of *P. falciparum* was 74.4% from Africa and the Caribbean, 13.1% from Central and South America, and 17.6% from Asia and Oceania. *P. vivax* dominated in cases imported from Central and South America, Asia, and Oceania. The species composition of cases in each non-endemic country reflected each country's connections to endemic regions and to their diagnostic capacity.

In an editorial comment, Karin Leder and Lin H Chen focus on the heterogeneity of patterns of imported malaria and the spatial clustering of malaria species. The robust methods of the study to overlay malaria data with travel and migration patterns and species breakdowns have provided a contemporary view of malaria importation. As patterns change, so travelers can serve as sentinels to provide information about disease activity in areas visited. This information may be collected through traveler surveillance networks such as GeoSentinel.

## Commentary

This is the most comprehensive review of the geography of imported malaria published in the past 20 years, and it benefits from new methods of data collection, analysis, mapping, and presentation. Several findings are of importance for travelers and their advisors. Importation of malaria frequently follows well established routes based on historical and contemporary links between endemic and non-endemic countries, creating communities of countries. The numbers of imported cases reflect malarial endemicity in the endemic country, the steadily increasing number of migrants and travelers, traveler behaviors, and the efficacy of preventive measures. The proportion of imported malaria cases in Europe due to migrants has increased during recent years from 14% to 83%. Migrants returning from visiting friends and relatives are 8 times more likely to be diagnosed with malaria than tourists. Children are at particular risk. New communities, based on southern and eastern European countries, for example, are emerging, but their characteristics are less clear. Guest workers traveling from India and Pakistan to the Middle East and Singapore present a singular problem.

Malaria cases imported into Canada were omitted from this analysis (about 4,000 cases over the duration of the study). The methods indicate that, for unclear reasons, only 2 literature reports were taken into account and no national public health data. While Figure 1 should be on the wall of every travel clinic and primary care waiting room, important major flows from West Africa and India to Canada should have been included.

*P. falciparum* is the dominant species in cases from Africa and the Caribbean, but *P. vivax*, *P. malariae*, and *P. ovale* are also endemic. Health care providers and laboratories need to be alert to them, as some rapid diagnostic tests or inexperienced technicians may miss them.

As more countries move towards national malaria elimination and plans for global malaria eradication proceed, the threat of drug resistance may increase. There may also be a risk of resurgence of malaria in recently eliminated countries where conditions for transmission persist, leading to a renewal of imported cases.

This is an open access article, and travel health advisors interested in imported malaria may wish to read it in full.

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