The effect of environmental degradation and land use change on malaria re-emergence in south Venezuela: a spatiotemporal modelling study

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Abstract

Background Malaria transmission is highly dependent on environmental conditions. The association between climatic variables and malaria transmission is well established, but the interaction between variations in climate and land use change, such as deforestation, is less well understood. Earth observation data provide a valuable and accessible resource to investigate these environment–malaria associations, in particular where little ground truth data are available. Progress towards malaria elimination in Latin America is being hindered by a surge of cases in Venezuela, a country that accounted for 53% of cases in the region in 2019. The country's economic and political crisis has fuelled economic migration to gold mining areas in the south, where extraction activities are expanding malaria vector habitats and sustaining disease transmission.

Methods In this spatiotemporal modelling study, we used multisource Earth observation data, including meteorological, land use change, and socioeconomic factors, and data on mining activity, to investigate how changes in the ecological landscape might have facilitated increases in the incidence of malaria in the past 20 years. We modelled spatiotemporal malaria case data for 1996–2016 using a Bayesian hierarchical mixed-model framework for Bolívar state in Venezuela, a malaria foci where approximately 60% of national cases occur annually. We examined how mining activities were associated with malaria hotspots and also considered the potential effects of climate variation, seasonality, and spatial dependency structures.

Findings We found that malaria risk was increased in mining hotspots, which were important in sustaining transmission in Bolívar state. We also found that the effect of temperature and rainfall variation differed depending on the level of deforestation in Bolívar, where the increased risk of malaria with temperature was greatest in areas that were more deforested.

Interpretation Our findings provide important evidence of environmentally driven re-emergence of malaria and highlight the advantages of using Earth observation data for understanding malaria dynamics in areas with sparse or incomplete data records.

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Contributors
IKF and RL conceived the study. IKF collated the data, fitted the models, analysed the results, and wrote the abstract. MEG helped conceive the study and provided interpretation and discussion of study results. JH-V and JEM provided the malaria case data. KJ and CD provided input on model formulation and discussion of results. RL reviewed and revised the abstract.

Declaration of interests
We declare no competing interests.