likely to produce statistically robust results. Furthermore, some of the relevant factors that are needed to understand China's regional emissions, such as technological change and urbanization, are not included in the analysis. It is widely recognized that changes in the emissions intensity of a country or region are explained, at least in part, by the rate at which technological change occurs in the area, as rapid technical progress tends to reduce the share of emissions per unit of income. Furthermore, the impressive urban development in China over the past decades has largely accounted for the increased levels of emissions in the country. Lack of consideration of these factors in the study spoils the conclusions regarding the amount and the direction of the estimated emissions transfers.

Nevertheless, the study by Meng and colleagues[1] draws attention to the spatial distribution of carbon emissions within China and relates it to the level of economic development in the different areas. Their proposal of setting customized sub-goals for different regions based on their local situation is a sensible way to address the rising concerns about carbon dioxide emissions in China[4]. The technical and financial support from the east would allow the centre and the west to meet their abatement targets while fostering economic development where it is most needed. This proposed approach could also guide other countries that have a similar emissions profile and similar regional characteristics. ❐

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HEALTH

Wealth versus warming

The response of malaria distribution to climate change has been debated. Statistical models suggest that by 2050, increasing national wealth will limit the expansion of malaria risk caused by rising temperatures.

Krijn P. Paaijmans and Matthew B. Thomas

There has been much debate in recent years regarding the possible impact of climate change on malaria[1]. Although climatic factors clearly play a role in the dynamics and distribution of both the malaria parasites and the mosquito vectors, malaria is also a disease of poverty[2]. It is therefore unclear whether advances in the standard of living could mitigate the projected expansion of malaria. Writing in *Global Environmental Change*, Béguin and colleagues[3] use statistical modelling to show that under certain scenarios, economic growth could limit the rise in the number of people at risk from malaria owing to climate change by the middle of this century.

Malaria represents a substantial public-health burden. In 2009, there were an estimated 225 million malaria cases worldwide resulting in 781,000 deaths[4]. The current distribution of malaria is determined by a suite of factors categorized as 'intrinsic' and 'extrinsic'[5]. Intrinsic factors include environmental drivers such as temperature and rainfall: many malaria mosquitoes breed in standing water, and both mosquitoes and parasites develop faster under warmer conditions. The extrinsic drivers include a wide array of anthropogenic factors such as quality of housing, disease surveillance systems, access to health care, and mosquito-control interventions. These extrinsic controls are strongly determined by socio-economics; malaria and poverty go hand-in-hand, and malaria itself has been shown to slow economic growth[2]. The interplay of these intrinsic and extrinsic factors ultimately determines disease risk (Fig. 1). If the environment is too cold or too dry then there is little risk of malaria, irrespective of socio-economic status. Under warmer and wetter conditions, however, the extrinsic factors play a critical role in scaling malaria risk from high (as in regions of sub-Saharan Africa) to effectively zero (as in parts of the developed world such as Florida or northeast Australia).

So far, most studies on the effects of climate change on malaria have tended to consider intrinsic and extrinsic factors independently. Early studies[6] considered only climatic drivers, whereas a recent work[7] argued that the intrinsic relationship between climate and malaria became decoupled during the twentieth century, and that malaria distribution is now essentially determined by extrinsic factors alone. The reality is probably somewhere in between. The increase in climatic suitability for malaria that is anticipated to occur over the twenty-first century should indeed have little effect on the malaria burden in areas with high per capita gross domestic product (GDP). In areas that are poor, however, changes in climate suitability still matter. The challenge for improved prediction is to estimate the net effects when both intrinsic and extrinsic factors change simultaneously.


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Managing malaria: increased income affords interventions such as distributing mosquito netting, spraying residential areas and access to treatment.

Béguin and colleagues[3] aimed to quantify this effect by investigating the interaction of climatic and socio-economic factors on the global distribution of malaria in the future. Their statistical model included the mean temperature of the coldest month and the mean precipitation of the wettest month, which represent the intrinsic factors, and a square root transformation of per capita GDP to constrain the extrinsic factors. Their model accurately captured the current global geographical distribution of malaria.

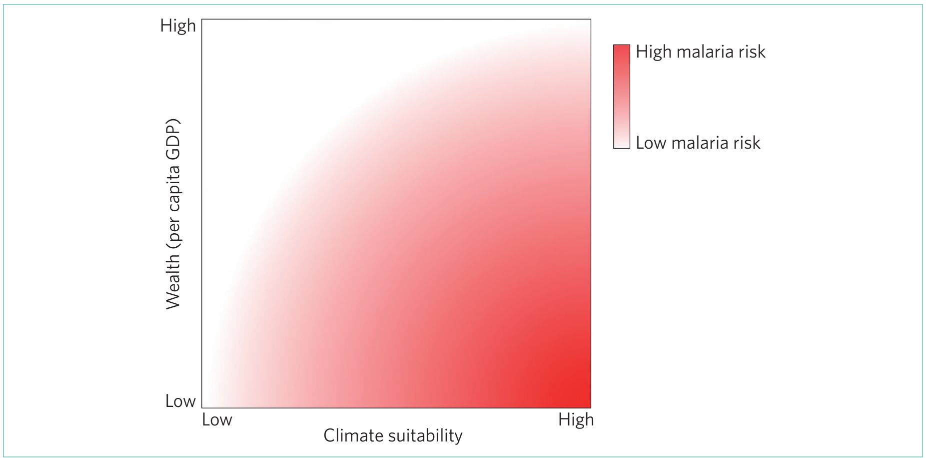

Figure 1 | Conceptual relationship between climatic factors and wealth for malaria risk. A shift to a more suitable climate for malaria will have minimal impact in areas with high wealth, as measured by per capita GDP. Climate change in lower-income regions will have a more pronounced effect, but climate and economic shifts are hard to unravel. Béguin and colleagues[3] have explored these combined effects in a statistical model, which shows that predicted economic growth should lessen the impact of malaria by 2050. However, climate change could counter some of the gains.

Béguin and colleagues then explored the change in malaria distribution up to the middle of this century. They combined the influence of economic growth under the Intergovernmental Panel on Climate Change A1B emissions scenario (which assumes a decrease in global inequity with policies focusing on economic growth and a balanced emphasis on all energy sources) with climatic projections from three general circulation models.

Their statistical model indicates that further economic development will cause the geographic incidence of malaria to continue to contract over the coming decades. Climate change, however, will counter this decrease to some extent; projections that only consider changes in GDP predict on average 1.74 billion people at risk of malaria by 2050, but adding the effect of climate increases this number by 200 million (or 11.5%). Interestingly, when the common approach to malaria prediction is employed, and only climatic effects are taken into account, the model suggests that 5.2 billion people would be at risk. Thus use of climate drivers alone grossly overestimates malaria risk, at least under these scenarios.

The authors acknowledge the limitations of their study, such as the fact that they look at very large temporal scales (averaging over decades), and consider the distribution of malaria only and not the prevalence in the areas where it occurs. It is also important to note that even under this optimistic economic-growth scenario, malaria is still projected to persist in sub-Saharan Africa. And under more pessimistic economic-growth scenarios, the effects of climate change would be much worse, leaving 6.27 billion people at risk by 2050. These slightly more sobering projections, combined with question marks over the sustainability of current control tools[8,9] and long-term donor commitment to fund control programmes[10], provide a cautionary note and highlight a need for ongoing research and policy aimed at combating this disease.

Nonetheless, the study by Béguin and colleagues[3] is a much-needed first step in understanding the interactions and complexities between intrinsic and extrinsic drivers of malaria into the future. Set against a number of earlier studies, the message that economic growth can substantially counter the impacts of climate change on the population at risk of malaria is an encouraging finding. ❐

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ADAPTATION

Conservation for any budget

Deciding where and how to allocate scarce funding to conserve plants and animals in a changing and uncertain climate is a thorny issue. Numerical modelling identifies the most effective mix of conservation measures based on the level of expenditure available.

Joshua J. Lawler

Strategies for reducing the impacts of climate change on ecological systems include suppressing fires, installing snow fences, designating preserves, removing dams and moving species to new locations. For many ecosystems under threat, more than one intervention could have positive impacts. However, climate projections are uncertain and ecological responses even more so, and as such there is little guidance on how to decide which effort to prioritize in the face of often limited funds. Writing in *Nature Climate Change*, Wintle and colleagues[1] use model