NEXT GENERATION CB HAZARD PREDICTION AND CONSEQUENCE ASSESSMENT WITH MULTI-ECHELON DECISION SUPPORT APPLICATIONS

Climate-based Forecasting Of Dengue Virus Cases And Vector Habitat Suitability In The United States

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Climate change is expected to affect the burden of vector-borne diseases across the globe, which would result in unanticipated risk to the United States and the Joint Force from diseases transmitted by mosquitos, ticks, and other vectors. Failing to account for the potential influence of climate change may increase disease risk in U.S. civilian and military populations, for instance by reducing response capacity and underestimating operational threats due to naturally-occurring pathogens. To better understand the degree to which climate change might affect risk from vector-borne disease in the U.S. Homeland, we undertook a statistical modeling effort to estimate: 1) future cases of dengue disease (dengue hereafter); and 2) the potential range of suitable habitats of the dengue virus (DENV) mosquito vectors. We used a combination of random forest and boosted regression tree models trained on historical dengue cases and vector presence, and projected over three climate change scenarios through 2100.

Overall, we predict a significant observed increase in dengue burden in the United States. Our models forecast an increase in both the number of counties experiencing locally acquired dengue cases (from 10s of counties to 1000s of counties per year) and the total number of locally acquired dengue cases (from 10s of cases to 1000s of cases per year) between 2024 and 2100. Affected locations are primarily in the Southern United States, though more severe climate change is projected to shift affected locations both northward and westward. These expected changes represent a sizeable shift in the locations at risk of local dengue transmission, in addition to an increase in incidence.

We also project a large increase in the U.S. population size residing in locations suitable for both dengue mosquito vectors (Aedes aegypti and Aedes albopictus). More than half of the U.S. population may reside in suitable habitats for Ae. aegypti by the end of the century, and, while most of the country already lives in areas suitable for Ae. albopictus, 80% may reside in Ae. albopictus-suitable habitats by 2100; these increases represent hundreds of millions of individuals residing in newly suitable habitats for dengue vectors, which can also carry other pathogens (e.g., Zika virus, Chikungunya virus). The degree of expansion in suitable vector habitats is mediated by climate change parameters, suggesting that large differences in projected suitable habitats depends on the severity of future climate change.

This work highlights the need to consider climate change in projections of risk to the United States and the Joint Force. We find clear relationships between climate variables and both dengue cases and vector habitat suitability; ignoring these relationships is likely to underestimate the future burden of vector-borne disease in the United States. Our methods can readily be applied to other countries and vectors, providing the ability to rapidly assess current and future risk in different environments. Our approach enables a more comprehensive understanding of how future climate change may affect vector-borne disease risk for civilian and military personnel, therefore promoting a more agile and responsive Joint Force.

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