EMERGING DISEASE INSIGHTS

Research from the PREDICT Modeling & Analytics team

Mapping Hotspots of Emerging Zoonoses

Emerging diseases originating from wildlife represent a significant threat to global health, security and economic growth. Efforts to identify the geographic origins and underlying causes of disease emergence are essential to focus surveillance, prevention, and control programs so that we can contain these diseases at source and more effectively limit their spread and socioeconomic impacts. [1]

Previous work by the PREDICT team modeled the global occurrence of zoonotic diseases from wildlife species and non-wildlife species, drug-resistant infections, and vector-borne diseases [2]. This work showed that all types of emerging infectious diseases (EIDs) are associated with human population density, but that those emerging from wildlife correlate with the diversity of wildlife on our planet. It also identified hotspots for emerging diseases in largely tropical, developing countries.

Here, the PREDICT-2 Modeling & Analytics team advances this previous work, focusing on the mechanisms driving emergence of zoonoses from wildlife (these are the diseases most often responsible for pandemic risk). We examined a broader set of potential drivers, used updated and refined data sets, incorporated advanced machine-learning techniques, and developed new ways to estimate and account for reporting bias and uncertainty in the information available.

MAPPING DISEASE EMERGENCE RISK

Figure 1 shows the calculated relative risk of wildlife-origin zoonotic disease emergence. Regions with the largest areas of high relative risk include South and Southeast Asia, West and East-Central Africa. Smaller hotspots of high risk can be found in Europe and the Americas.

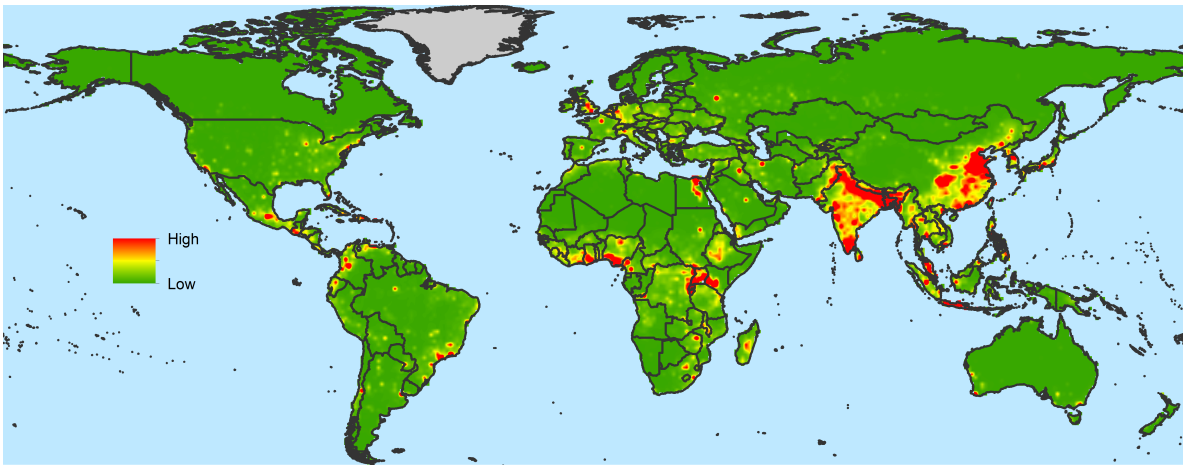

Figure 1: Heat map of predicted relative risk of zoonotic EID events, taking into account bias and under-reporting. Green indicates lowest risk, yellow mid-level risk, and red is the highest.

July 11, 2016

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UNDERSTANDING THE DRIVERS OF EMERGENCE

Biodiversity, land cover and land use were the most important factors determining where future emerging disease will originate, after accounting for observation bias and the baseline distribution of the human population (Figure 2). We found that disease emergence was more likely in areas of high mammal biodiversity and heavily forested areas. Weaker, but still important, factors included high levels of urbanization, and either very high or very low rates of land conversion to pasture (Figure 3).

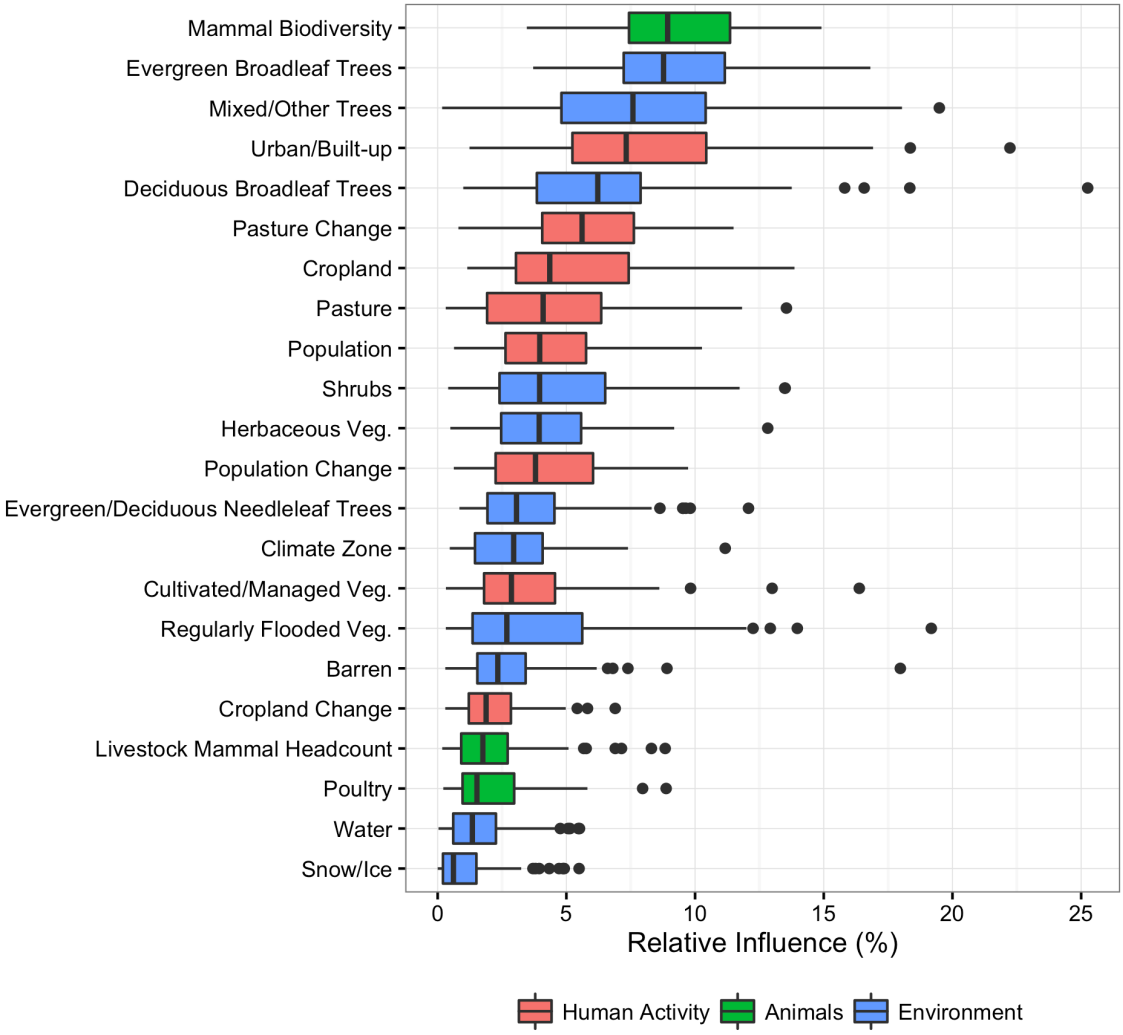

Figure 2: The relative influence of different variables on the likelihood that an emerging disease event might occur. The colored boxes show the range of relative influence to account for uncertainty in the locations of reported EID events.

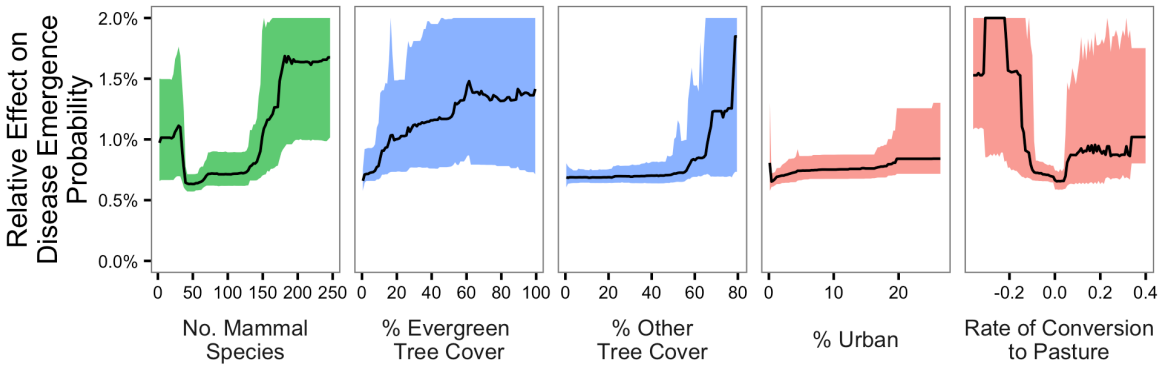

Figure 3: How key drivers influence the risk of new zoonotic disease emergence. Vertical axes show the relative importance of each factor on the risk of disease emergence and horizontal axes show the range of each driver. Graphs 1-4 show increasing risk of disease emergence with increasing levels of each driver. In graph 5, risk of disease emergence is highest at very high rates of land conversion to pasture (right of center), and high rates or from pasture (usually reforestation – left of center. Black lines show the average (median) effect on probability and coloured areas show the range of the calculated effects within 95% confidence intervals.

DISUSSION

Our analysis and our new map of EID hotspots shows that the highest risk of new zoonotic EID emergence is concentrated in tropical regions with high wildlife biodiversity, dense and growing human populations, and rapid land use change. These are the places where the next pandemic is most likely to originate, and therefore most valuable for surveillance in wildlife, livestock or people. These regions should be targeted for programs such as PREDICT and USAID's Emerging Pandemic Threat program that aim to identify novel pathogens in wildlife, and target high risk groups of people to develop mitigation programs that stop these new pathogens from emerging and spreading [3]. These programs will be most cost effective if they are targeted geographically to EID hotspots.

[1] S. Morse, Factors in the Emergence of Infectious Diseases. Emerg. Infect. Dis. 1 (1995) 7–15. doi:10.3201/eid0101.950102.

[2] K.E. Jones, N.G. Patel, M.A. Levy, A. Storeygard, D. Balk, J.L. Gittleman, et al., Global Trends in Emerging Infectious Diseases. Nature. 451 (2008) 990–993. doi:10.1038/nature06536.

[3] S.S. Morse, Public Health Surveillance and Infectious Disease Detection. Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science. 10 (2012) 6–16. doi:10.1089/bsp.2011.0088.