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# Editorial

## Can Modeling of Fine-Scale Spatial Patterns of Environmental Markers of Zoonotic Infections Enhance Disease Prevention and Clinical Outcomes?

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When evaluating patients with an undiagnosed infectious disease, physicians in general (and infectious disease specialists in particular) are trained to obtain a history of factors such as recent travel, location of residence, country of birth, occupation, and contact with animals. These factors are taken into account when generating a ranked differential diagnosis. For example, a history of work as a professional landscaper in the setting of a compatible clinical presentation would likely trigger specific diagnostic testing and presumptive treatment of tularemia.[1] Unfortunately, physicians generally lack the expertise to identify factors such as specific ecotones associated with risk of zoonotic infections. On the other hand, infectious disease ecologists and epidemiologists consider the role of the environment to be critical in vector-borne and zoonotic disease transmission,[2–4] and they are increasingly aware of the need to consider the effective range of transmission overlap of several pathogens, model the potential benefits of integrated control, and define the environmentally appropriate level for control efforts.[5,6]

In this issue, Eisen and others[7] report the development of a fine-scale model to predict the risk of plague and hantavirus infection in humans in northwestern New Mexico and northeastern Arizona. The environmental risk of plague was related to precipitation and distance to piñon-juniper ecotones, whereas the risk of hantavirus infection was related to precipitation and elevation; half the area had risk for both zoonotic infections. The authors suggest that fine-scale identification of areas of increased disease risk would be useful for targeting education activities, resulting in improved disease prevention and management.

Targeting disease prevention activities for these significant, rodent-borne infections should at a minimum lead to more efficient use of public health funding, which in turn could lead to more effective prevention activities. Education of healthcare providers also might lead to some improvement in disease management, but it is not clear whether targeted education with training on fine-scale identification of areas of increased disease risk or targeting training in areas of increased risk would be more effective than general, regional educational activities without this training.

Early initiation of appropriate antibiotic therapy for plague reduces mortality; management by an experienced critical care team in a tertiary care center, including extracorporeal membrane oxygenation (ECMO) in some centers, reduces mortality in severe hantavirus cardiopulmonary syndrome (HCPS), also known as hantavirus pulmonary syndrome.[8–10] Targeted, regional education of local providers might lead to earlier initiation of appropriate antibiotic therapy for bubonic plague and earlier recognition and emergent transfer of patients in the cardiopulmonary phase of HCPS, because both syndromes have relatively distinct, recognizable clinical presentations.[8–10] However, septicemic and pneumonic plague and the febrile prodrome of HCPS are difficult to differentiate from other causes of febrile illness, septicemia, and pneumonia based on clinical, radiologic, and routine laboratory criteria, which leaves the clinician with a broad differential diagnosis.[8–10] As a result, appropriate antibiotic management of septicemic and pneumonic plague in particular is often delayed, and HCPS is rarely recognized during the febrile prodrome. Finally, with an incubation period of 2 to 6 days for plague, an average incubation period of almost 3 weeks for HCPS, and with the potential for travel during the incubation period, patients may present to healthcare providers who have little awareness of these zoonotic diseases. Therefore, the impact of regional training is reduced.

In light of these challenges and physicians' general lack of awareness of the relative risk of different zoonotic diseases associated with different ecotones, is it realistic to think that the fine-scale identification of areas of increased disease risk would be useful for enhancing early recognition and improving management of these zoonotic diseases? Satellite data, geographic information systems (GIS), and spatial analysis are increasingly applied by public health practitioners and researchers to disease surveillance and control. Considering multiple diseases simultaneously is a logical step that is likely to be adopted further in the public health arena. On a more clinical level, we believe it would be feasible to develop a resource that could link fine-scale modeling to generation of a ranked differential diagnosis. The components of a resource that would make this feasible are largely available, but a significant challenge would be to link these components and make them easily accessible.

First, sophisticated fine-scale modeling, as evidenced by the study by Eisen and others is already in place, albeit in limited areas. With adequate funding, this type of modeling could be expanded to cover larger areas and to include other infectious diseases. Second, web-based resources such as GIDEON are available, which prompt the user for symptoms, signs, and factors such as geographic location to generate a syndrome-based, ranked differential diagnosis. However, information regarding geographic location in these resources lacks the fine-scale sophistication of the model reported by Eisen and others, and the current cost of these resources limits access. Third, resources such as the MMWR and ProMed provide open-access mechanisms for rapid dissemination of information about the occurrence of recognized and emerging pathogens. Finally, although it may be unrealistic to expect physicians to identify factors in the patient's exposure history that identify ecotones and other factors used in fine-scale modeling, data on ecotones, precipitation, elevation, and other factors could be linked to easily accessible information, such as local addresses or locations on web-based maps that could be identified by the patient.

Combining these tools depends on collaborative effort between ecologists, spatial modelers, clinicians, public health agencies, and other groups. To translate this ecological approach and improved predictive capability into clinical applications, we must determine whether the added complexity of fine-scale modeling improves the accuracy and, importantly, the ranking of potential diagnoses. If an approach of this type can be shown to improve diagnostic capabilities and outcomes, as well as targeting of public health resources and prevention programs, we urge that it be expanded and made widely available.

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