The Landscape Epidemiology of Seasonal Clustering of Highly Pathogenic Avian Influenza (H5N1) in Domestic and Wild Birds

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Background
Highly pathogenic avian influenza subtype H5N1 (H5N1) has contributed to substantial economic loss for small and large scale poultry farmers since 1997. While the global distribution of domestic H5N1 outbreaks is extensive, features of the landscape, including variations by season, conferring greatest risk remain uncertain.

Methods
World Organization for Animal Health surveillance data was used to:
1) Delineate areas at greatest risk for H5N1 epizootics among domestic poultry,
2) Identify those abiotic and biotic features of the landscape associated with outbreak risk, and
3) Examine patterns of epizootic clustering by season. Inhomogeneous point process models were used to predict the intensity of H5N1 outbreaks and describe the dependencies between them.

Results
In October-March, decreasing precipitation, increasing isothermality, and the presence of H5N1 in wild birds were significantly associated with increased risk of domestic H5N1 epizootics. Conversely, increasing precipitation and decreasing isothermality were associated with increased risk in April-September. Increasing temperatures, high density of domestic poultry, presence of H5N1 in wild birds, and proximity to surface water were significantly associated with the increased risk of H5N1 domestic poultry H5N1 epizootics throughout the year. In April-September, H5N1 outbreaks exhibited no clustering at small scale once accounting for landscape factors.

Conclusions
We identified seasonal differences in risk and clustering patterns of H5N1 outbreaks in domestic poultry, and may suggest strategies in high risk areas with features amenable to intervention such as controlling domestic bird movement in areas of high poultry density or preventing contact between poultry and wild birds and/or surface water. Non-permanent water bodies and timing of freeze-up and beak-up at higher latitudes could play a role in transmission by affecting flyways and contact between domestic and wild birds. Thus, inclusion of data of spatio-temporal distribution of open water on the landscape in future analyses could provide additional insights on H5N1 transmission and outbreaks.

Figures 1 and 2: Global distribution of H5N1 outbreaks in domestic birds between 2005-15. Fig. 1 displays outbreaks that occurred during October–March overlaying their kernel density estimates (KDE) in red, while Figure 2 shows outbreaks during April–September.

Figure 3: Global distribution of surface water type across Africa, Europe and Asia.

Figure 4: Predicted intensity of highly pathogenic avian influenza H5N1 outbreaks in domestic poultry during the period October through March (scale ranges from 0 to ≥10 outbreaks per 5 square km).

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