VALIDATION OF A SPATIAL MULTICRITERIA DECISION ANALYSIS OF THE RISK OF HIGHLY PATHOGENIC AVIAN INFLUENZA H5N1 IN THAILAND AND ITS APPLICATION IN CAMBODIA

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ABSTRACT. Highly Pathogenic Avian Influenza H5N1 (HPAI) virus is now considered endemic in several Asian countries as well as in Egypt. In Cambodia, the virus has been circulating in poultry population since 2004, with a dramatic effect on farmers' livelihoods. HPAI H5N1 is also a public health threat as 56 human cases (including 39 deaths) have been identified so far in this country. In Thailand, no outbreaks have been recently reported, but surveillance and control are still important to prevent any new HPAI H5N1 incursion. Risk maps may efficiently inform disease surveillance and control systems. However, in countries with a lack of primary care systems, their production can be hampered by lack of reliable disease data. In such situations, knowledge-driven modeling methods including spatial multicriteria decision analysis (MCDA) have been identified as an alternative to classical statistical approaches. However, these methods can appear somehow subjective and poorly connected to real data. Validation of knowledge-driven maps is therefore an essential and challenging task. The present study used MCDA to map HPAI H5N1 risk in domestic poultry in Southeast Asia. In a first step, 3 MCDA models (2 with weights calculated from literature review, and 1 with weights attributed by experts) were built and applied to Thailand, where reliable HPAI H5N1 data exist. In a second step, the best model was applied to Cambodia where the number of poultry cases is under-estimated due to poor reporting by farmers. For each country, the same set of 10 predictors was selected. Predictors included density of farm and free-grazing ducks, backyard chicken density, proportion of rice fields and number of rice crops in a 2- and 5-km radius, wetlands density, altitude, human population density and proximity to major cities. 14 and 11 experts were contacted in Thailand and Cambodia, respectively. They were asked i) to choose a relationship between each selected variable and the risk of HPAI H5N1 and ii) to fill a pairwise comparison matrix, where each variable was compared with the others, relative to its importance, on a scale from 1 ("extremely less important") to 9 ("extremely more important"). Weights for each variable were computed from this matrix through an Analytical Hierarchy Process. All variables values were standardized on a scale from 0 to 1 before aggregation, which was realized using weighted linear combination (WLC). A sensitivity analysis based on the one-factor-at-a-time method was then performed to assess the robustness of the results with respect to expert choices. The predictive ability of each of the 3 models was quantitatively evaluated in Thailand by calculating the Area Under the Curve (AUC) from ROC analysis, based on actual HPAI H5N1 data. Analysis was implemented using the ArcGIS, IDRISI, and R softwares. Results showed that the expert-based model had an excellent prediction capacity in Thailand (AUC = 0.97, CI 95: 0.96-0.97), which was significantly higher to literature-based models (AUC ranging from 0.74 to 0.77). Applied to Cambodia, the expert-based model pointed out a higher

risk of HPAI H5N1 in the surroundings of the Tonlé Sap Lake, as well as in provinces located in the lower Mekong basin bordering Vietnam. Visual inspection of the map showed that high risk areas were consistent with places where poultry outbreaks have been reported. These two high risk areas could correspond to distinct epidemiological mechanisms, with high densities of free grazing ducks participating to virus maintenance in the lakesides and transboundary poultry movements favoring periodic virus introductions from Vietnam. Results suggest that expert opinion could be used to produce risk maps in countries with limited outbreaks data, and that these maps could be a starting point to define risk-based surveillance programs.