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A spatial zero-inflated modelling approach for assessing the H5N1 surveillance system in Thailand

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In Thailand, the major epidemic lasted from July 2004 to May 2005. The H5N1 surveillance system has often been assumed to be very efficient during this epidemic. However, no quantitative assessment of the Thai H5N1 surveillance program has been so far undertaken. Here, we propose to use zero-inflated (ZI) models to analyze unilist capture-recapture surveillance data collected during the 2004 epidemic at subdistrict level, to identify the factors driving the presence/absence of the disease and those influencing the detection process. ZI models use the number of detections of infection in the different sites for estimating the total number of infected sites, including those where infection was never detected. We considered each subdistrict of the country as the epidemiological unit (site), and that each H5N1 outbreak notified during the 2004 epidemic constituted a detection of the disease in the site. Therefore, our count dataset focused on the number of detected outbreaks in each subdistrict. To derive the real number of infected sub-districts, we fitted a ZI Poisson model (ZIP) and a ZI negative binomial model (ZINB) to our dataset. We tested the residuals for spatial autocorrelation, proved it was significant and thus added a spatial autocorrelation term in the model. As expected, the spatial ZINB fitted the data better than the spatial ZIP, suggesting the presence of overdispersion in the counts of detections. Derived from the spatial ZINB model, we were able to estimate the real number of infected subdistricts during the epidemic and the sensitivity of detection at sub-district level. We also identified the most important factors that determine the presence/absence of the disease in subdistricts (density of human population and density of free grazing ducks), and influence the detection process (density of free grazing ducks and density of native chicken).