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Short communication

Prioritizing live bird markets at risk of avian influenza H5N1 virus contamination for intervention: A simple tool for low resource settings

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ABSTRACT

Live bird markets (LBMs) are at risk of contamination with the avian influenza H5N1 virus. There are a number of methods for prioritizing LBMs for intervention to curb the risk of contamination. Selecting a method depends on diagnostic objective and disease prevalence. In a low resource setting, options for prioritization are constricted by the cost of and resources available for tool development and administration, as well as the resources available for intervention. In this setting, tools can be developed using previously collected data on risk factors for contamination, and translated into prediction equations, including decision trees (DTs). DTs are a graphical type of classifier that combine simple questions about the data in an intuitive way. DTs can be used to develop tools tailored to different diagnostic objectives. To demonstrate the utility of this method, risk factor data arising from a previous cross-sectional study in 83 LBMs in Indonesia were used to construct DTs. A DT with high specificity was selected for the initial stage of an LBM intervention campaign in which authorities aim to focus intervention resources on a small set of LBMs that are at near-certain risk of contamination. Another DT with high sensitivity was selected for later stages in an intervention campaign in which authorities aim to detect and prioritize all LBMs with the risk factors for virus contamination. The best specific DT achieved specificity of 77% and the best sensitive DT achieved sensitivity of 90%. The specific DT had two variables: the size of the duck population in the LBM and the human population density in the LBM's district. The sensitive DT had three variables: LBM location, whether solid waste was removed from the LBM daily and whether the LBM was zoned to separate the bird holding, slaughtering and sale areas. High specificity or sensitivity will be preferred by authorities depending on the stage of the intervention campaign. The study demonstrates that simple tools utilizing DTs can be developed to prioritize LBMs for intervention to control H5N1-virus. DT tools are simple to apply, suitable for low-resource settings and can be tailored to the particular needs and stage of the disease control program.

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1. Background

The avian influenza A H5N1 virus is of global public health concern due to its high pathogenicity in birds, its current zoonotic capability and its pandemic potential (Briand and Fukuda, 2009). In virus endemic areas, live bird markets (LBMs) are vulnerable to contamination since bird populations coming into the LBM are dynamic and infected flocks may enter at any time. This increases the risk of virus transmission both to humans and animals in the LBM, and it increases the risk of propagating virus back into farms through the sale of infected live birds (Kung et al., 2003; Wang et al., 2006).

Previous research has shown that risk factors for H5N1-virus contamination in the LBM environment such as surfaces, floors and utensils include slaughtering birds in the LBM, lack of zoning in the poultry workflow and insufficient waste management (Bulaga et al., 2003; Garber et al., 2007; Indriani et al., 2010). In high resource settings, LBMs are managed through the enhanced application and monitoring of practices for good general hygiene and disease control (Lu, 1970; Mullaney, 2003; Trock et al., 2008). In low resource settings, there is limited capacity for hygiene and authorities do not have sufficient resources to intervene in all LBMs. Thus, the key question is 'how do authorities prioritize LBMs to invest their limited resources for disease control?'

Based on principles of screening and diagnostic testing for disease control (Wilson and Jungner, 1968), there are a number of methods for prioritizing LBMs for intervention (Table 1). Selecting a method depends on its fitness-for-purpose, including cost, sensitivity, specificity, speed, complexity as well as human and hardware resource requirements. In a low resource setting, options for prioritization are constricted by the cost of and resources available for tool development and administration, as well as the resources available for intervention. This decreases the feasibility of using laboratory-based tools and network analyses in LBMs as they are expensive to develop and administer, and mandate laboratory or statistical expertise (Table 1). Thus, other options need to be explored.

A number of low resource countries affected by the H5N1-virus have conducted cross-sectional surveys in LBMs to assess virus prevalence in birds and the LBM environment (Abdelwhab et al., 2010; Indriani et al., 2010; Jiang et al., 2010; Negovetich et al., 2011). Data from such studies can be used to develop tools to prioritize LBMs for intervention. Risk factor data can be translated into prioritization tools using prediction equations including classifiers such as decision tree (DTs). DTs categorize LBMs into groups, where those with the risk factors for contamination are deemed priority. These LBMs can then be targeted for public/veterinary health action, maximizing utilization of public health resources in low resource settings (World Health Organization, 2006).

DTs are quick and relatively simple to administer and interpret (Table 1). While DTs constitute one way of presenting and communicating results derived from prediction equations, well-established alternatives include logistic regression models that can be presented as predictive probabilities or as odds-ratios. The utility of any of these tools to veterinary and public health practitioners depends on the epidemiological considerations and the diagnostic criteria established. Using a previous cross-sectional study conducted in 83 LBMs in Indonesia as a case study, we explored DT options in tools for prioritizing LBMs for interventions based on different epidemiological considerations.

2. Methods

2.1. Data and problem formulation

The tools were developed for national authorities intervening in all LBMs in the three provinces reported in the Indriani et al. study: Banten, Jakarta and West Java. The Indriani et al. study assessed environmental contamination and risk factors for contamination in 83 LBMs randomly selected from the 300 LBM population. The Indriani et al. study found that at least one environmental site in 39 of the 83 LBMs (47%) tested were contaminated with the H5N1-virus. The ten risk factors identified from the univariate analysis were used to develop candidate DTs (Indriani et al., 2010). We also considered two variables known as risk factors for H5N1-virus spread in the three target provinces: density of farmed birds (chickens and duck) and human population density at district level (Loth et al., 2011). Details of the variables considered in the model development can be seen in Supplementary File 1.

2.2. Epidemiological considerations

Diagnostic objective and disease prevalence guided DT design.

2.2.1. Diagnostic objective

The stage of disease control and intervention resources available guide the decision to optimize diagnostic sensitivity or specificity. At the beginning of an intervention campaign, where authorities aim to reduce the overall level of contamination and virus circulation in LBMs, high specificity will limit the number of LBMs deemed priority and ensure that limited resources for intervention are allocated most efficiently. That is, if resources are available to intervene in only a proportion of LBMs, this tool allows us to maximize the number of infected LBMs in the sub-group receiving interventions. Even though this approach may yield low sensitivity, it is operationally more feasible based on constricted resources available for intervention. Further, unlike diagnostic tests in which outcomes may be catastrophic for the patient or for the unit receiving the intervention, the implications of a low sensitivity here are not dire for individual LBMs. In an intervention campaign, when levels of virus are reduced such that eradiation is a feasible objective, high sensitivity will ensure that all LBMs with the risk factors will be prioritized for intervention. Even though a tool with high sensitivity may risk low specificity, this may be acceptable to authorities since eradication is in near sight and the absolute number of LBMs deemed priority will be small.