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Review

The risk factors for avian influenza on poultry farms: A meta-analysis

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ABSTRACT

Background: Avian influenza is a severe threat both to humans and poultry, but so far, no systematic review on the identification and evaluation of the risk factors of avian influenza infection has been published. The objective of this meta-analysis is to provide evidence for decision-making and further research on AI prevention through identifying the risk factors associated with AI infection on poultry farms.
Methods: The results from 15 selected studies on risk factors for AI infections on poultry farms were analyzed quantitatively by meta-analysis.
Results: Open water source (OR = 2.89), infections on nearby farms (OR = 4.54), other livestock (OR = 1.90) and disinfection of farm (OR = 0.54) have significant association with AI infection on poultry farms. The subgroup analysis results indicate that there exist different risk factors for AI infections in different types of farms.
Conclusions: The main risk factors for AI infection in poultry farms are environmental conditions (open water source, infections on nearby farms), keeping other livestock on the same farm and no disinfection of the farm.

1. Introduction

Avian influenza is a severe infectious disease caused by the AI virus. Both humans and animals can be infected (Gao et al., 2013), and the mortality rate is high in both humans and poultry. Since the first human infected case, detected in 1997 during a poultry outbreak in Hong Kong SAR, China, there have been to date 380 deaths worldwide out of 641 cases caused by the H5N1 virus subtype (WHO, 2013). Thus, avian influenza could cause enormous health and economic losses worldwide, and it has been classified as a List A disease by the Office International Des Epizooties (OIE). AI has been known for more than 100 years, but its control measures remain limited. Disinfection, isolation and culling are the only measures available to prevent its spread. The WHO's monitoring data and many other relevant studies show that AIV can transmit from birds to people but not vice versa (Perdue and Swayne, 2005). Therefore, controlling AI in poultry is the first step in decreasing risks to humans. Some scholars have conducted epidemiological studies on risk factors for AI in poultry, but some of the results are inconsistent and even contradictory. Moreover, thus far, no one has conducted a systematic review of the association between AI and

Abbreviations: OR, odds ratio; AI, avian influenza; AIV, avian influenza virus; CI, confidence interval.

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production, management, environment and biological factors on poultry farms. By the retrieval, screening and comprehensive analysis of the published epidemiology studies on the identification of AI risk factors on poultry farms, this study attempts to adopt a systematic approach to identifying the risk factors for AI infection and to provide a basis for decision-making and for further research on AI prevention.

2. Materials and methods

2.1. Search strategy

Systematic research was performed on the literature about risk factors for AI on poultry farms. The databases included PubMed, Wiley, Elsevier, Springer and Cochrane Library. Based on the reported AIV subtypes in poultry (Alexander, 2007, 2000; Perdue and Swayne, 2005; Swayne, 2008), the basic logic relationship of keywords in the database retrieval was (risk) AND (avian influenza OR HPAI OR LPAI OR H5N1 OR H5N2 OR H5N3 OR H5N8 OR H7N1 OR H7N3 OR H7N4 OR H7N7 OR H7N9 OR H9N2), etc. Based on the earliest traceable report of AI (Swayne and Suarez, 2000), the retrieval dates were limited to the period from January 1955 to May 2013, and the retrieval language was limited to English. Finally, the authors searched the original articles, review articles and references cited from the retrieved articles.

2.2. Study selection

Under the premise of equilibrium between the studies' internal validity and extrapolation, based on Lichtenstein's 20 standards (Lichtenstein et al., 1987) and experts' discussion, the following literature inclusion and exclusion criteria were set.

Inclusion criteria: (1) The 1: N matched case-control studies were on AI risk factors in China and overseas. (2) The publishing date ranged from 1955 to 2013. (3) The respondent of study was on the farm level, not on the poultry level. (4) The definitions of exposures were clear and the same. (5) The sample size was specified. (6) The outcome was AI infection. (7) The associative indicator between exposure and outcome was OR, and either the original data provided OR values with 95% CIs or other data could be converted to ORs and their 95% CIs.

Exclusion criteria: (1) The sample size of the study's case or control group was less than 10. (2) The study had incomplete or inconsistent data. (3) Publications with results that have been published before.

Following the above criteria, the initial selection was made by two authors (Y.M.W. and P.L.) independently, and any disagreements were resolved by consensus.

2.3. Data extraction

The following data were extracted from the selected studies: the first author, publication year, country, sample source, case-control study time, type of farm, type of poultry, subtype of AIV and its pathogenicity, exposure factors, and number of exposed and nonexposed cases in the case-control study. To avoid misclassification caused by unclear definitions of exposure in various studies, some exposure factors were defined as follows: (1) confinement: farms were surrounded by fencing. (2) Visitors enter the farm: family and friends entered the farm without disinfection or cloths changing. (3) Shared equipment: the equipment, such as transportation and coops were also used by other farms. (4) Open water source: untreated ponds and rivers existed in the surrounding areas to which the poultry could have direct or indirect contact. (5) Near farm infection: there were cases of infection with avian influenza near the farm. (6) Backyard poultry: there were cage-free poultry on farm. (7) Bird contact: there were bird droppings or bird-damaged feed around farms without bird-proof facilities. (8) Other livestock on farm: there were other livestock, such as cattle or sheep on farm. (9) Hygiene manners of farm workers: farmers changed their clothes and shoes and washed hands when they went to work. (10) Disinfection of transportation: vehicles went in and out of the farm were disinfected (tires should be disinfected, too). (11) Disinfection of farm: disinfectants were regularly used to clean the yard, coops and so on. (12) Appropriate disposal of dead poultry: the safety measures used to dispose of ill and dead poultry, such as deep burial, incineration and composting.

In the process of data extraction, ambiguous and missing data were clarified and obtained by contacting the corresponding authors, and then, all data were extracted by double entry and validation.

2.4. Statistical analysis

The software Review Manager 5.2 was used to conduct meta-analysis of the extracted data. The merged effect was OR and its 95% CI, which reflected the strength of association between exposures and AI. The χ^2 test was used for the homogeneity test. In consideration of the facts that the quantity of selected studies was limited and the Q statistic's power was low, the significance level (α) was set to 0.10 to increase the power and reduce the probability of false negatives. Because the number of studies in this analysis was small, which limits the accuracy of the homogeneity test, we could not tell whether the studies were functionally equivalent (Borenstein et al., 2009; Xu, 1994); therefore, we used the random effect model to estimate the overall OR of all studies. At the same time, subgroup analysis was used to compare the change in heterogeneity before and after the selected studies being stratified by different farm types. Next, to analyze the sensitivity of the results, we used the one-removed study method to show the impact of each study on the overall OR. To detect publication bias, the fail-safe N method was used to calculate the number of studies that would have been needed to reverse the effect (Mai et al., 2006), and the Egger's regression test was used to investigate the association between sample size and effect size (OR value) and quantitatively detect the publication bias (Egger et al., 1997).