Archives of Hygiene Sciences
Qom University of Medical Sciences

https://jhygiene.muq.ac.ir/
10.34172/AHS.12.4.5.284
Vol. 12, No. 4, 2023, 187-191

Orginal Article

# Environmental Risk Factors in the Outbreak of Avian Influenza Infection (H5N1): A Case Study in Qom, Iran

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## Abstract

**Background & Aims:** Based on reported evidence of an outbreak incidence of highly pathogenic avian influenza (HPAI) in Qom province, this study aimed to evaluate the environmental risk factors in the outbreak of avian influenza infection in this province to provide essential data for developing effective interventions in infection control.

**Materials and Methods:** The cross-sectional method was predicted and implemented in two specific phases. In the primary phase of the study, the necessary criteria were extracted using a questionnaire. In another part of the study, the characteristics and spread of the infection in Qom province were evaluated by DotMapper software.

**Results:** From a total of 175 investigated farms, 95 farm units (54%) were infected and were positive for AI. The results showed that at least one of the environmental risk factors was not controlled in 86% of laying poultry farms and 66% of broiler poultry farms, according to the questionnaire. The findings of statistical analyses for the evaluation of environmental risk factors affecting AI infection in poultry farm units indicate that sanitary land disposal of infected poultry carcasses, waste and manure of birds (odds ratio [OR] = 1.02), complete quarantine and installation of warning signs in contaminated areas (OR = 0.55), the existence of facilities and performance decontamination, as well as the use of effective disinfectants for the disinfection of ventilators, disinfection of poultry vehicles, and equipment and manure of birds (OR = 0.33) have a considerable association with AI infection on poultry farms in Qom province.

**Conclusion:** Our findings revealed that control and monitoring of environmental risk factors as part of an effective surveillance system for the AI virus are key processes for the propagation and contribute to the spread of the infection.

**Keywords:** Influenza in birds, Disease outbreaks, Infections, Environment, Risk factors, Qom, Iran

**Received:** October 7, 2023, **Accepted:** November 19, 2023, **ePublished:** December 29, 2023

## 1. Introduction

Acute avian influenza (AI) occurs in animal populations, especially poultry, and can be transmitted to humans. Therefore, not only does the virus infect humans and cause severe disease with a high mortality rate, but also it has the ability to adapt to humans. As a potential pathogen for humans or in combination with other human influenza viruses, AI gives rise to a pathogen capable of causing a pandemic [1–3]. Among the necessary measures to control this infection, implementing the environmental surveillance system program, which is a regular and continuous process of collecting data related to diseases, analyzing them with the aim of determining the disease status, and implementing appropriate measures to control the infection based on epidemiological indicators are inevitable [4–6]. Spatial analysis has become highly important in the control of human and animal diseases in surveillance systems [7–9]. Given the prevalence of this disease around the world and the impact of various environmental risk factors on the incidence of this disease, the use of spatial modeling in identifying high-risk sites of this disease can be effective in implementing control and prevention programs. Clustering and spatial spread of AI outbreaks may provide clues as to the causes of infection that are effective in disease control and prevention programs [10–13]. In a recent survey conducted on the subject of AI, environmental risk factors have been reported to have a highly important role in the spread of the infection. In their study about the prevalence and risk factors for the AI virus in Bangladesh, Islam et al found that disposal of waste, cleaning and disinfectant agents, access of dogs, and inadequate biosecurity measures have increased the risk of AI transmission in Bangladesh [14]. The latest findings on the subject strategies to manage an outbreak of avian flu pathogens in 2023 revealed that for approved confirmed case, containment and prevention actions must be in the infected poultry cases or infected materials. The prevention measures for confirmed cases include the sanitary slaughter of infected poultry, environmental disposal, and incineration and disinfection of affected poultry farms [15]. Accordingly, considering the existence of about 600 poultry breeding units in Qom province in the central part of Iran and the density and proximity of poultry farms to each other, as well as the specific environmental factors of Qom province (e.g., climate conditions and social and cultural infrastructure), it seems that it is one of the important factors in the spread of the disease [16,17]. Accordingly, this study sought to

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evaluate the environmental risk factors in the outbreak of AI infection in Qom province to provide essential data for developing effective interventions in infection control.

## 2. Materials and Methods

### *2.1. Study Setting*

Qom, the capital of Qom province, is located on the boundary of the central desert of Iran (Kavir Markazi) with geographical attributes of 34°38′24″N and 50°52′35″E. At the 2017 census, the population of this province was 1 200 000. In this study, the cross-sectional method was predicted and implemented in two specific phases from the end of 2018 to 2019 in all parts of the province. In the primary phase of the study, the required criteria were extracted by applying a questionnaire and standard checklists (questionnaire of control and environmental care of poultry farm units to control AI taken from the Center for Disease Management of the Ministry of Health in Iran). The reliability and validity of the questionnaire were evaluated and confirmed. Table 1 presents some of the main questions summarized in five sections. All poultry farms in the province that are registered in the Disease Monitoring and Care Information System of the Iran Veterinary Organization by means of a questionnaire have been evaluated in this study.

In this study, a stratified sampling method was performed based on the ratio of poultry breeding units in the districts of Qom province. The number of samples required for sampling (n = 175) was calculated based on the prevalence rate of 50%, accuracy of 5%, and a 95% confidence level (Figure 1). In another part of the study, the characteristics and spread of the infection in Qom province, including location, type and number of birds, longitude, latitude, and longitude, and other required data, were determined using DotMapper software based on the geographic information system, which is usually used to distribute the disease display [18].

### *2.2. Statistical Analysis*

The relationship between outbreak occurrence and environmental risk factors was determined by logistic regression models and odds ratios (ORs) using GraphPad Prism software (2019).

## 3. Results

The results of the study are provided based on the method described in Tables 2–3 and Figures 1–3. Tables 2 and 3 present the characteristics of poultry farms, outbreak cases, and evaluation of environmental risk factors for avian influenza in the outbreak of influenza

**Table 1.** Summarized Questionnaire of Environmental Risk Factors in the Outbreak of Avian Influenza Infection in Poultry Farm Units

| No. | Preparedness to Respond to Environmental Emergencies Before the Occurrence of the Infection |
|---|---|
| 1 | Have factors that cause the "indigenization" of disease in birds in a region, including the quality of the disease care system in birds, the movement of birds according to the necessity of biosecurity through trade or smuggling, or migration of birds, been visited and evaluated? |
| 2 | Have all the necessary materials and equipment, especially personal protective equipment such as general clothing, special masks, eye protection equipment, gloves, and rubber boots (or plastic covering for shoes) been prepared in advance? |
| 3 | Is the provision of effective disinfectants planned and stored in the right place? |
| 4 | Is there a trained manpower to form a special extermination team in the unit? |
| | **Evaluation of Measures Taken at the Time of Infection** |
| 5 | Have complete quarantine and prohibition of leaving the poultry unit without the permission of the veterinarian and extermination team been performed? |
| 6 | Has the entry of different people been prohibited at the bird farm? |
| 7 | Has the sign of the area infected with the avian influenza virus been installed in confirmed cases at a distance between 500 and 100 meters from the road leading to the poultry farm? |
| 8 | Have infected flock birds, waste, and consumables in the bird farm area and at a depth of at least 3 meters above the ground level and at least one meter above the underground water level been exterminated and destroyed? |
| 9 | Has the movement of birds been controlled in the protected area (with a radius of at least 3 kilometers) and the monitoring area (with a radius of at least 10 kilometers) around the contaminated area? |
| 10 | Have all materials that cannot be disinfected, such as dead birds, eggs, bedding, manure, fresh and frozen carcasses, as well as tools and equipment, been effectively and immediately destructed after placing them in impermeable plastic bags? |
| 11 | Are composted litter and manure protected for at least 60 days and buried carcasses for at least 4 months? |
| 12 | Have the poultry hall and the use of effective disinfectants in the form of aerosols, especially for the disinfection of ventilators, disinfection of poultry vehicles, equipment, and disinfection of worker houses, poultry offices, and the like, been decontaminated? |
| 13 | Is the preparation of minutes of the meeting and the preservation of documents related to the extermination and disposal of the carcass and its waste completely archived and preserved? |
| | **Evaluation of Environmental Health Facilities** |
| 14 | Are the facilities for the sanitary disposal of manure and waste in poultry breeding centers suitable? |
| 15 | Are the employees' health facilities, including toilets, bathrooms, lockers, and staff lockers, in suitable conditions? |
| 16 | Is the source of supply, including a well, a water storage tank, and the quality of the used water, approved? |
| 17 | Is the power and capacity of ventilation of the poultry unit suitable and capable of moving air at a rate of 10 times per hour? |

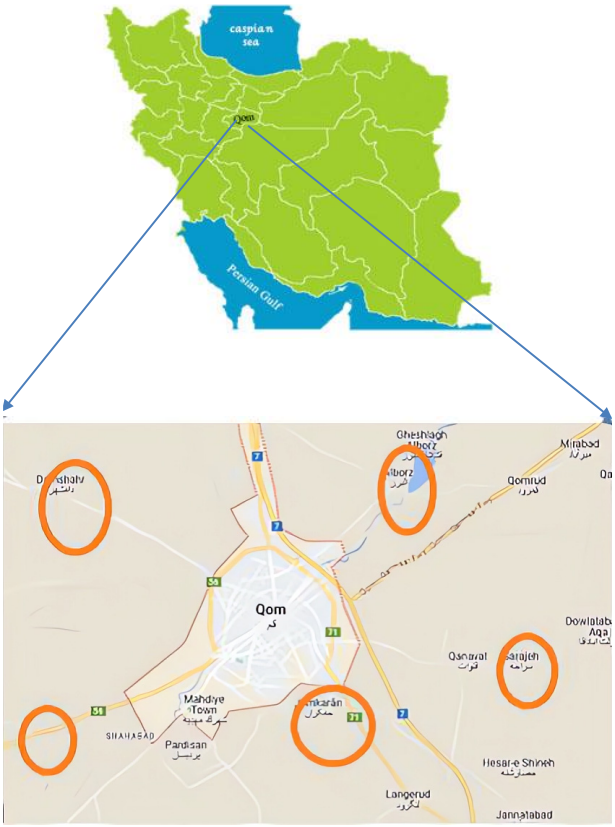


**Figure 1.** Location of the Study Area

infection in poultry farm units in the studied regions and districts in Qom province. Figures 2 and 3 display the geographic distribution, spread, and distribution map of AI based on control of environmental risk factors.

## 4. Discussion

According to the results (Table 2) regarding the characteristics of poultry farms, outbreak cases, and environmental risk factors, from a total of 128 investigated farms, 95 farm units (%54) were infected and were positive for AI. In the evaluation of how to manage environmental health risk factors, the results showed that at least one of the environmental risk factors was not controlled in 86% of laying poultry farms and 66% of broiler poultry farms, according to the questionnaire. The findings (Figure 3) demonstrated that, despite the control of environmental risk factors, the density and proximity of poultry units played a significant role in the spread of infection. Based on the findings of statistical analyses (Table 3), sanitary land disposal of infected poultry carcasses, waste and manure of birds (OR = 1.02), and complete quarantine and installation of warning signs in contaminated areas (OR = 0.55) were related to AI infection on poultry farms in Qom province. In addition, the existence of facilities and performance decontamination and the use of effective disinfectants for the disinfection of ventilators,

**Table 2.** Characteristics of Poultry Farms, Outbreak Cases, and Environmental Risk Factors

| Poultry Farm Type | Sum of Investigated Farms | Number of Infected Farms | The Number of Farms That Have Not Managed Environmental Risk Factors According to the Questionnaire in at Least One Case |
|---|---|---|---|
| Laying poultry farm | 73 | 34 | 29 (86%) |
| Broiler poultry farm | 78 | 41 | 27 (66%) |
| Turkey poultry farm | 6 | 5 | 3 (60%) |
| Hen poultry farm | 5 | 4 | 3 (75%) |
| Ornamental poultry farm | 6 | 5 | 3 (60%) |
| Quail poultry farm | 4 | 3 | 2 (66%) |
| Duck poultry farm | 3 | 3 | 3 (100%) |

**Table 3.** Evaluation of Environmental Risk Factor Affecting of Avian Influenza Infection in Poultry Farm Units

| Environmental Risk Factors | Odds Ratio | *P* Value |
|---|---|---|
| Preparedness and existence of a response plan to environmental emergencies for avian influenza infection | 0.018 | <0.001 |
| Complete quarantine and installation of warning signs in contaminated areas at a distance of 500 and 100 meters from the road leading to the poultry farm | 0.55 | <0.05 |
| Sanitary land disposal of infected poultry carcasses, waste, and manure of birds at a depth of at least 3 meters above the ground level | 1.02 | 0.033 |
| Existence of facilities and performance decontamination and the use of effective disinfectants for the disinfection of ventilators, disinfection of poultry vehicles, equipment, and manure of bird | 0.33 | <0.05 |
| Existence of suitable facilities, including toilets, bathrooms, and lockers for employees | 0.21 | 0.061 |
| Approval of the water supply system, water storage tank, and microbial quality of the water | 0.16 | 0.042 |
| Approval of power and capacity of ventilation of the poultry unit for moving displacement of air at the rate of 10 times per hour | 0.044 | 0.022 |

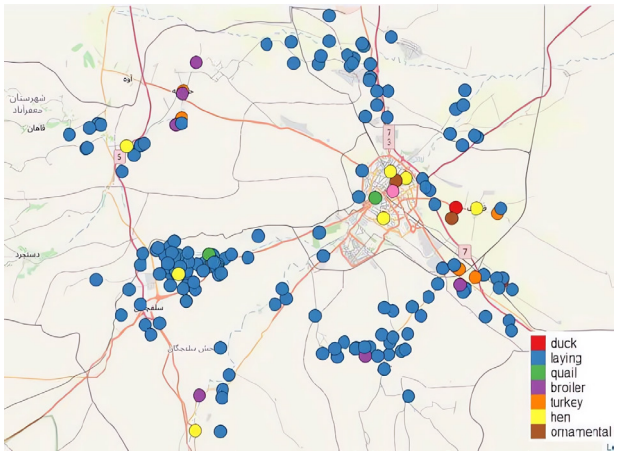


**Figure 2.** Geographic Distribution of Infected Poultry Farm Types in Districts of Qom Province

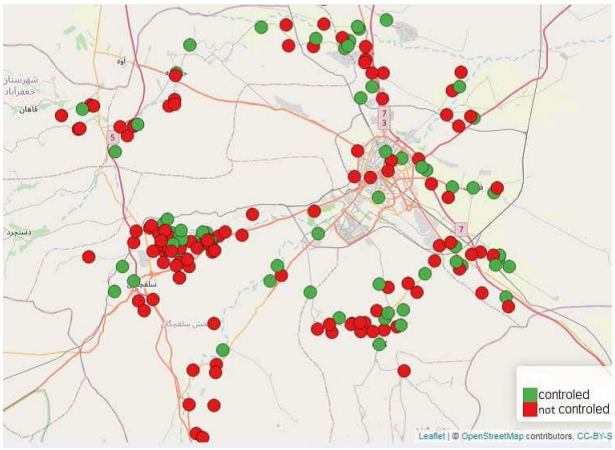


**Figure 3.** Spread and Distribution Map of Avian Influenza According to Control of Environmental Risk Factors in Poultry Farms in Qom, Iran

disinfection of poultry vehicles, equipment, and manure of birds (OR = 0.33) had a noticeable association with AI infection on poultry farms in this province. The results of the present study are important in comparison with those of studies evaluating environmental risk factors and outbreaks of AI. The findings of the study by Fang et al regarding the environmental factors and spread of H5N1 AI in mainland China indicated that environmental factors, including minimal distance to the nearest national highway, rate of annual precipitation, and the interaction between minimal distance to the nearest lake and wetland, are related to the spread of the infection [19]. Although the environmental variables and risk factors evaluated in the above-mentioned study contradict those of the present study, it should be noted that in both studies, attention has been paid to the role of environmental factors in the spread of infection. The results of a survey on the risk factors of AI on poultry farms in the meta-analysis study by Wang et al demonstrated that unsanitary water sources, infections on nearby farms, other livestock, and disinfection of farms have a significant association with AI infection on poultry farms [20]. The results of this study are in line with those of the present study. Based on the results of a predictive risk analysis for occurrences of AI (H5N1) by Si et al in wild birds in Europe, H5N1 occurrences were influenced by the availability of food resources, an increase in temperatures, and a decrease in precipitation [21]. This study also confirms the results of the current study with the approach of controlling environmental factors and improving the environment. One of the important results of this study is to pay attention to the issue of sanitation in the outbreak of AI. In the study of Wang et al, the sanitary condition in the poultry farms was a protective factor against AI [22], which is consistent with the results of the present study.

## 5. Study Limitations

Although environmental risk factors related to AI prevalence in Qom province were identified, this study has some limitations. A lack of an accurate environmental surveillance system for reporting positive cases on poultry farms in health centers and the lack of high participation of poultry owners in the interviews and questionnaire completion are among the limitations of this study.

## 6. Conclusion

Our findings indicated that control and monitoring of environmental risk factors as part of an effective surveillance system for the AI virus are key processes for the propagation and contribute to the spread of the infection.

### Acknowledgments

This study was financially supported by Qom University of Medical Science (IR.MUQ.REC.1398.162). We would like to thank the staff of the Health Center of Qom University of Medical Sciences.

### Authors' Contribution

**Conceptualization:** Yadollah Ghafuri, Ahmad Reza Yari.
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**Supervision:** Yadollah Ghafuri, Ahmad Reza Yari.
**Writing–original & draft:** Rahim Aali.

### Competing Interests

The authors of this article declare that they have no conflict of interests.

### Ethical Approval

This project has been approved by the Qom University of Medical Sciences Health Services.

### Funding

This project has been supported by the Qom University of Medical Sciences Health Services.

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