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Prevention and Control of Avian Influenza: A View from the Farm Household

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Overview

- **Avian influenza**
- **Poultry production**
- **Control measures**
- **Epidemiology**
- **Household behavior**
- **Conclusions**
- **Future directions**

Avian Influenza

- **Avian Influenza (AI) viruses occur naturally among wild birds and generally cause only minor symptoms from which the birds rapidly recover**
- **Many subtypes of AI that vary in pathogenicity and infectivity**
- **Classified by the combination of two proteins on the surface of the virus**
 - **Hemagglutinins (H1 through H16)**
 - **Neuraminidases (N1 through N9)**
- **Numerous strains generally categorized into**
 - **Low pathogenicity avian influenza (LPAI)**
 - ◆ **Generally causes only mild illness in birds**
 - **Highly pathogenic avian influenza (HPAI)**
 - ◆ **Extremely infectious, causes severe illness, and can reach mortality rates above 50% and often reaching 90-100% in domesticated poultry, often within 48 hours**
- **Certain birds, particularly migratory waterfowl, often carry the virus while showing no outward signs of illness, but shedding virus in saliva, nasal secretions, and feces**

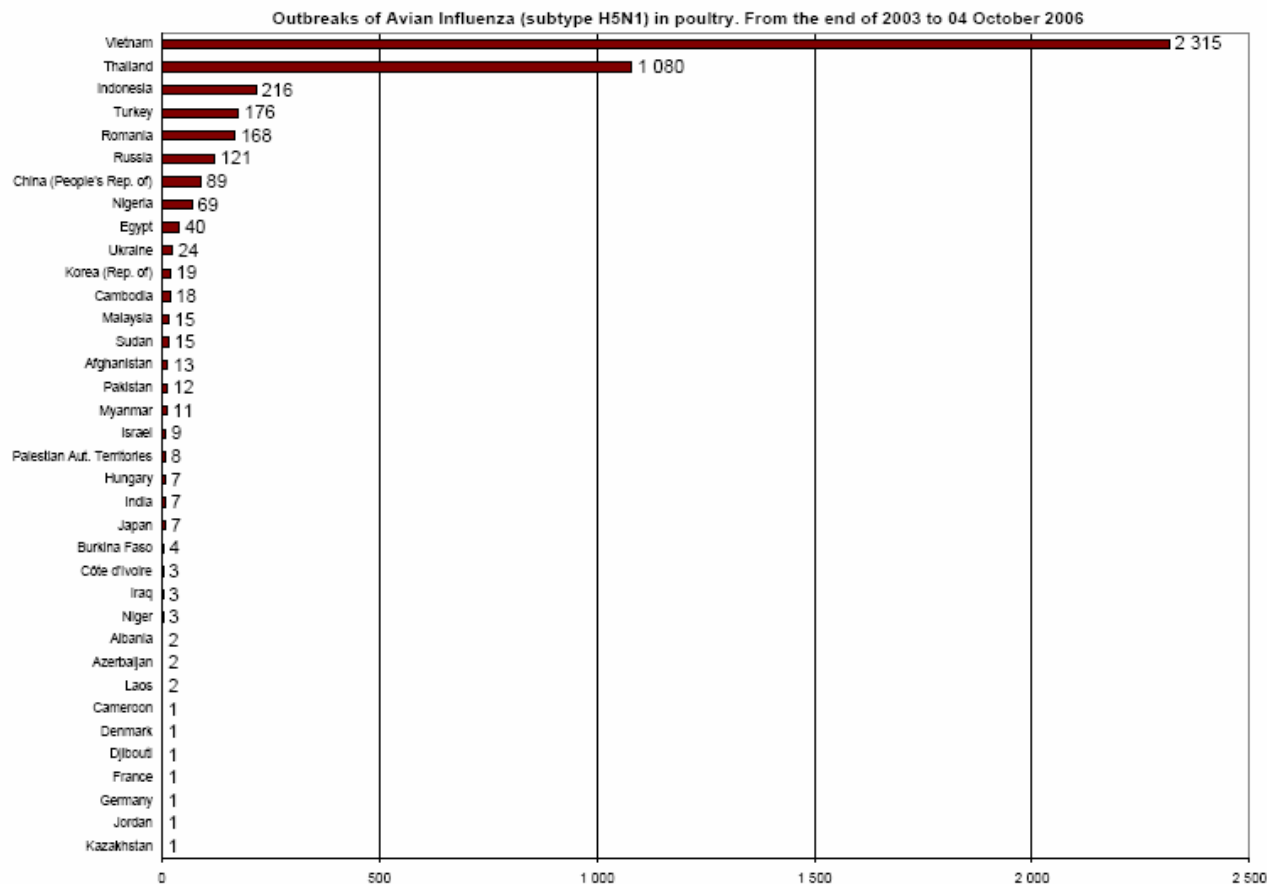
Strains of Avian Influenza

- **LPAI is endemic in wild birds and outbreaks in poultry are not unusual and have occurred in countries throughout the world**
- **However, some strains of LPAI (H5 and H7) can rapidly mutate and become highly pathogenic, especially when moving between bird species**
 - **Domestication of poultry has created species subtypes that can be infected by an AI virus adapted to waterfowl and have it mutate rapidly into a strain of HPAI**
- **Poultry can become infected through:**
 - **Primary introduction of HPAI**
 - ◆ **Contact with infected wild birds**
 - ◆ **Live bird markets**
 - **Contamination of people, equipment, or vehicles**
 - **Secondary transmission**
 - ◆ **Infectivity (amount of virus produced by infected flock)**
 - ◆ **Susceptibility (amount of virus needed to infect susceptible bird)**
 - ◆ **Amount of virus transferred during contact**
 - ◆ **Contact rate**
 - ◆ **Number of flocks that make contact**

Current Strain of H5N1

- **Recently, outbreaks of A(H5N1) or H5N1 have led to the death of tens of millions of birds through disease mortality or culling (primarily chickens and ducks on farms), primarily in Southeast Asia**
- **Adding to economic impacts are trade restrictions and negative demand shocks**
- **In addition, the disease has infected humans in 11 countries**
 - **251 confirmed human cases of H5N1 in humans since 2003 and 148 deaths (WHO, October 2006)**
- **There is concern that H5N1 could mutate into a form that could spread between humans, which could lead to a global pandemic**
 - **Estimates that millions of people would be killed (WHO, 2004) and global economic losses in the hundreds of billions or even trillions of dollars (e.g., McKibbin and Sidorenko, 2006)**

Outbreaks of H5N1 in Poultry



Poultry Production and Avian Influenza

Table 1. Classification of Poultry Production Systems

	Sector 1	Sector 2	Sector 3	Sector 4
System	Industrial integrated	Commercial	Commercial	Village or backyard
Biosecurity	High	Moderate to high	Low to minimal	Minimal
Bird and product marketing	Commercial	Usually commercial	Birds usually sold in live bird markets	Birds and products consumed locally

Source: FAO (2004).

- **Scale and production technology vary enormously between and within countries**
- **Sectors 3 and 4 generally considered to be more susceptible to infection due to low levels of biosecurity, although losses may be larger in the event of an infection in Sector 1 and concentration of birds may increase probability of virus circulation and mutation**

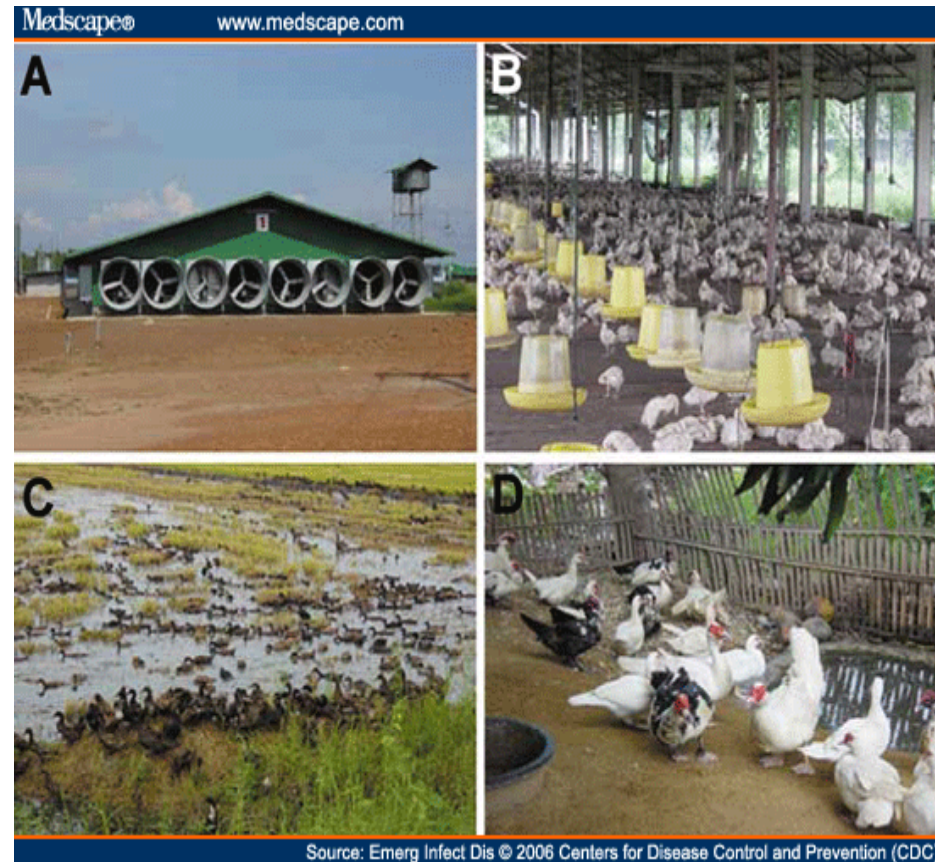
Poultry Systems in Southeast Asia

Country	Sector 1	Sector 2	Sector 3	Sector 4
Cambodia	Believed not to exist	~0.4 million poultry	0.4 million chickens 0.8 million ducks	99.9% of farms and 90% of poultry (12 million chickens and 2.7 million ducks)
Indonesia	9.7 million poultry, export oriented but large proportion for national consumption	58.2 million poultry for the national market	32.4 million poultry	174 million poultry
Lao PDR	Believed not to exist	Relatively insignificant	10% of poultry	90% of poultry
Thailand	70% of national production, important export market	20% of national production	36% of farms and 7% of production	61% of farms and 3% of production
Viet Nam	Relatively insignificant	20-25% of production, but very few producers	10-15% of production, but very few producers	65% of production with possibly 70% of the country's population involved

Source: Rushton et al. (2005).

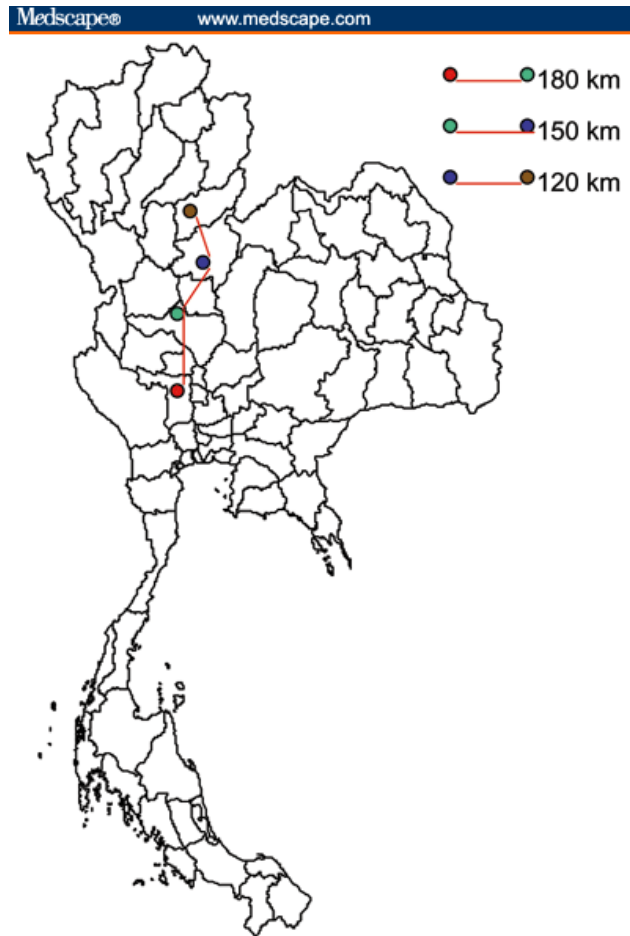
Duck Production Systems in Thailand

- **A) Closed system with high biosecurity, an evaporative cooling system, and strict entrance control.**
- **B) Open system but with netting to prevent entrance of birds. Biosecurity was not strictly enforced. This system is no longer approved for the raising of poultry.**
- **C) Free-grazing ducks. Biosecurity is never practiced in this system.**
- **D) Backyard Muscovy ducks; no biosecurity is practiced in this system**



Free-grazing duck husbandry in Asia

- Found to be important risk factor in spreading HPAI in duck-producing regions of Asia
- Ducks infected with H5N1 may show few clinical signs while shedding enough of the virus to form a potential reservoir for continued infections
- Frequently rotated between rice paddy fields after rice harvest to feed on leftover rice grains, insects, and snails
- Come into contact with wild birds and then brought together with other flocks of free-grazing ducks and other poultry as they are rotated



Source: Emerg Infect Dis © 2006 Centers for Disease Control and Prevention (CDC)

H5N1 in Thai Production Systems

- Songserm et al (2006) conducted tests for H5N1 during the 2004 outbreak in Thailand that resulted in 60 million poultry being killed
- Found no H5N1 in the closed industrial system (about 1% of every flock was sampled before slaughter, over 10,000 birds)
- H5N1 was found in all three open systems:
 - Open house system: 4/17 flocks (23.5%) tested positive
 - Free-grazing duck system: 28/61 flocks (45.9%) tested positive
 - ◆ 10 flocks studied in more detail; no evidence of H5N1 while they were in brooding houses but all 10 tested positive within 12-63 days of moving to rice fields
 - Backyard poultry: 56% of backyard chicken flocks and 27% of backyard duck flocks tested positive

Prevention and Control Measures

- Provision of information and technical assistance
- Disease surveillance
- Improved biosecurity practices
- Culling and disposal
- Vaccination

Information and Technical Assistance

- Poultry producers may not have sufficient information on HPAI and appropriate disease prevention and control strategies to make efficient decisions on adoption of control measures
- Backyard growers may not be aware of the potential severity of HPAI and could have more difficulty identifying an outbreak because villagers in many developing countries may accept significant poultry losses as “normal” (Rushton et al., 2004)
- Development and dissemination of this information lowers the private cost of control measures for producers by reducing the time and human capital required to identify and adopt appropriate actions, thereby increasing expected adoption

Disease Surveillance

- Another important measure for controlling the spread of disease is surveillance of poultry operations to monitor birds for disease and immediately report any suspected cases of AI
- Proper incentives are vital for inducing producers to report suspected outbreaks
 - In some Asian countries, low or no compensation for birds lost is a significant impediment to disease reporting
- As part of surveillance, it is important to understand the epidemiology, ecology, and economics of the disease and assess spatial and temporal patterns to improve the effectiveness of control programs

Improved Biosecurity Practices

- Strict biosecurity practices that prevent exposure to any animals or other items potentially contaminated with AI are vital for preventing and controlling the spread of disease
 - Closed poultry housing
 - Ensure wild birds cannot access poultry feed and water supplies
 - Isolate new birds or avoid their introduction into existing flocks
 - Limit access to poultry houses and thoroughly clean all clothing, shoes, equipment and vehicles before and after coming in contact with birds
 - Restrictions on transportation and marketing, especially at live bird markets

Culling and Disposal

- Culling infected birds as well as birds that may have come in contact with the sick birds has been a typical response to an HPAI outbreak and is often credited with limiting the spread of the disease, particularly in countries such as Hong Kong and Thailand, which moved quickly to quarantine and destroy potentially affected flocks
- Reduces flock infectivity by removing the flock altogether
- In conjunction with surveillance, early detection and culling reduces amount of virus produced by infected birds
- Compensation level is vital for producer cooperation

Vaccination

- Vaccination reduces the probability of infection and the amount of virus produced by an infected flock
- Currently being used in several countries, including China, which has instituted a major initiative to inoculate poultry in areas considered susceptible to AI infection
 - China inoculated 2.68 billion birds, primarily chickens, ducks, and geese between February 2004 through January 2005
- Potentially costly to administer
- Concerns that vaccination may suppress the symptoms of the virus for vaccinated birds that get infected, allowing it to continue spreading without notice

Epidemiology

- Probability of primary HPAI introduction into a poultry flock depends primarily on contact rate with infected wild birds and at live bird markets and probability of infection from contact
 - Function of vaccination status, level of biosecurity, number of poultry in the region, number of wild waterfowl in the region, and disease prevalence
- Epidemiological models often define an equilibrium reproductive ratio (R ; number of secondary infections resulting on average from each additional infectious host) to characterize the spread of disease
 - Infectivity (surveillance and early reporting, culling, vaccination)
 - Susceptibility (vaccination)
 - Contact rate (biosecurity, number of poultry)
- Region-level reproductive ratio depends on aggregate of farm-level decisions regarding time spent on surveillance, number of poultry, vaccination, and level of biosecurity

Farm-level behavior

- **Increase in risk of poultry production will provide incentives to shift away from poultry production towards non-poultry farm production and non-farm income, other things being equal**
- **Because of potential income losses (and the fact that human cases have generally been poultry workers in direct contact with live infected birds), there are clearly incentives for poultry farmers to take precautions against HPAI**
- **Nonetheless, there are externalities that will not be fully taken into account**

Adoption of Control Measures

- Producers adopt control measures to the point that the private marginal benefits are equal to the private marginal costs
 - Tend to underinvest relative to socially optimal level
 - Decision to invest in avoiding primary introduction depends on the farmer's ability to impact likelihood of introduction into region
 - ◆ For regions where HPAI is not yet present, producers may determine it is optimal not to invest in avoiding introduction into the area if they have little impact on probability of regional introduction

Responses to Outbreak in Viet Nam

- Delquigny et al. (2004) examined three outbreaks in Viet Nam and found highly varied responses
- In the first outbreak, the company notified the Vietnamese veterinary services of high death rates and the birds in the region were destroyed, although the level of destruction of birds and eggs varied across villages
- In a second outbreak that took place in a village with no official veterinary services, data collected on the fate of sick and apparently healthy birds showed that almost 29% of sick birds and 56% of healthy birds were consumed, 70% of sick birds and 8% of healthy birds were destroyed, and 1% of sick birds and 36% of healthy birds were sold
- The third outbreak took place on two commercial farms. In a 5,000 bird broiler farm, chickens began dying on day 1 with 50% mortality by the end of day 2. On day 3, the remaining birds were killed and buried using quicklime. In a 1,200 bird layer farm, 50% of hens died by the second day of the outbreak, but the farmer sold the rest to a trader. The farm also had 600 chicks that all died on the third day and were disposed of in a public rubbish area.
- Thus, in addition to the importance of incentives for reporting disease and ensuring that infected birds are destroyed, proper incentives are also necessary for encouraging adequate procedures for disposal of infected carcasses

Public Policy

- Providing information to improve private decision-making
- National surveillance program
 - Analyze the epidemiology, ecology, and economics of the disease and assess spatial and temporal patterns to improve the effectiveness of control programs.
- May be welfare-improving for government to compel or provide incentives for at least some producers (often largest) to adopt biosecurity (Hennessey, 2006)
- Once these producers have adopted, the probability that other farmers would be the source of introduction increases, which may make it optimal for them to adopt as well
- Similarly, vaccination of a certain fraction of the susceptible population by government may help avoid major epidemic
- In the event of an outbreak, government involvement in proper culling and disposal likely to be important

Compensation

- Producer compensation for losses is a major issue
- Too low
 - Less surveillance
 - Do not report suspected infections
- Too high
 - Little incentive for costly control measures to avoid HPAI
 - Possibly even incentive to get birds infected!
- Costly for governments to provide, but tool for reducing severity of outbreaks
- Varies widely
 - Thailand: 70-100% of market price
 - Viet Nam: 20-30% before being raised to 50-60% in November 2005
 - Cambodia: 0%
 - Canada: 100% market value after adjustments for age and salvage value
 - US: 100% of costs associated with eradication (for H5/H7 LPAI, those involved in the National Poultry Improvement Plan are also eligible for 100%, 25% for those that are not as of September 2006)

Conclusions

- Poultry producers play a vital role in containing HPAI
- Spatial dimension of agricultural production is important for infectious animal diseases
- There are averting and mitigating options available to farm households, but numerous barriers to adoption especially in smallholder systems
 - Information and resource constraints
 - Social and cultural barriers
 - Disease control efforts substitute for those of other producers in the region
 - Difficulty of monitoring and enforcement

Conclusions (2)

- Public policy design is very important for providing socially optimal incentives for infectious disease control
 - Provision of information
 - Compensation level for culled poultry
 - Compulsory vaccination or biosecurity vs. market incentives
- Comparisons between alternative control strategies need to reflect the incentive structures under each strategy
- Appropriately designed policies that account for producer response can help overcome the coordination failure that otherwise arises under market equilibrium conditions and improve household welfare
 - Government resource limitations
 - Difficulty in monitoring and enforcement
 - Implications for poultry production systems

Future Directions

- Empirical research to quantify implications of farm behavior for the spread of avian influenza, the distribution of impacts, the extent and cost of private disease prevention behavior, and the effectiveness of public disease control programs
 - Requires detailed farm household-level data from before and after the recent H5N1 outbreaks as well as information on outbreaks and local ecological and market conditions
 - Examination of producer responsiveness to incentives in reporting disease and cooperation with depopulation
- Incorporation of potential human health effects
- Integration with economy-wide modeling of impacts using CGE model