Overview of Avian Influenza and the U.S. Poultry Industry

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Protecting AI Responders – September 2007
Outline

- Avian Influenza Overview
  - Virus Characteristics and Transmission
  - Natural Reservoirs
  - Risks of AIV Transmission
- LPAI and HPAI Pathogenesis
- U.S. Commercial Poultry Industry
  - Meat-type Chickens (Broilers)
  - Meat-type Turkeys
  - Table egg birds (Layers)
Avian Influenza Overview

- Avian influenza (AI) - identified in the early 1900s
- Three HPAI (“Fowl Plague”) Outbreaks in the U.S.
  - 1924 – affected live bird markets in the Northeastern U.S.
  - 1983 – destruction of 17 million birds in commercial poultry in PA
  - 2004 – quickly contained to one poultry farm and eradicated in TX
- HPAI – causes rapid, infectious illness, \(\downarrow\) egg production, sudden death in birds.
- LPAI causes mild to no illness in birds.
- Vast majority of AI viruses found in birds do not represent a public health concern
Avian Influenza Overview

- Orthomyxovirus – RNA, single stranded, enveloped
- Major surface proteins – hemagglutinin (HA) and neuraminidase (NA).
- 144 different characterizations of the virus based on 16 H types and 9 N types.
- AI viruses mutate easily – only H5 and H7 viruses have the potential to mutate from LPAI to HPAI form.
- AI viruses vary widely in pathogenicity from strain to strain.
- Not all H5N1 subtypes are infectious for people or pathogenic to poultry.
Natural Reservoirs of Influenza A Viruses

- Wild aquatic birds
- Majority are represented by two Orders
  - Anseriformes (ducks, geese, swans)
  - Charadriiformes (gulls, terns, shorebirds)
- No clinical disease
  - Except: A/Turn/South Africa/61
  - HPAI H5N1 infection in wild birds in Europe, Asia
Ecology of Influenza

Genetic Reservoirs

Intermixing

Other Aquatic Birds?

Modified from D. Swayne
# Type A Influenza Surface Antigens

## Hemagglutinin (H) Subtypes:

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## Neuraminidase (N) Subtypes:

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Avian Influenza Viruses Change Frequently

- **Antigenic Drift**: Minor antigenic changes to HA protein caused by mutations in H gene
  - Continuous process
  - Limits cross – protective immunity

- **Antigenic Shift**: Replacement of H or N gene type
  - Emergence of novel (pandemic) strains
  - Genetic re-assortment (human and animal viruses)

- **Recombination**: Insertion of large portion of extraneous RNA near the HA cleavage site – virulence shift
Risks of AI Disease Transmission

- Risk of spread of LPAI in LBMS to commercial poultry operations.
- Risk of mutation of H5/H7 LPAI viruses to highly pathogenic viruses.
- Recent HPAI occurrences in poultry:
  - Euro-Asia/ Africa: 1997-2007 (H5N1)
  - Italy: 1999 - 2000 (H7N1)
  - Netherlands: 2003 (H7N7)
  - Chile: 2002 (H7N3)
  - British Columbia: 2004 (H7N3)
  - U.S.A. (Texas): 2005 (H5N2)
- Interruptions of international trade
Risk of AIV Transmission to Humans

Historically, H1, H2, H3 human pandemics have followed adaptation of AI viruses to swine

Recently, H5 and H7 human infections have resulted from direct transmission from poultry (Asia, The Netherlands, Canada)
Risks of AI Disease Transmission

Risk of undergoing re-assortment to an HPAI virus that becomes pathogenic to humans.

- 322 confirmed human HPAI H5N1* cases, 200 deaths
  - Azerbaijan: 8 cases, 5 fatal
  - Cambodia: 6 cases, 6 fatal
  - China: 21 cases, 14 fatal
  - Egypt: 14 cases, 6 fatal
  - Indonesia: 63 cases, 48 fatal
  - Iraq: 2 cases, 2 fatal
  - Thailand: 24 cases, 16 fatal
  - Turkey: 12 cases, 4 fatal
  - Vietnam: 93 cases, 42 fatal

- Case fatality rate is 61%

*10 September 2007 (WHO report)
Interspecies Transmission of Influenza A Viruses

Avian-human species barrier exists

$\alpha_2$-3 Receptors / $\alpha_2$-6 Receptors

Sialic acid receptors
Pathogenesis of AI

Replication at point of entry

LPAl strains

Trypsin enzyme

Respiratory / Intestinal replication

HA cleavage site has few dibasic amino acids
(B-X-X-R/)

Viremia

Systemic infection

HPAl strains

Ubiquitous enzymes

HA cleavage site has multiple dibasic amino acids
(B-X-B-R/)
## Clinicopathologic Forms of Avian Influenza

<table>
<thead>
<tr>
<th>Low Pathogenicity (LPAI)</th>
<th>Highly Pathogenic (HPAI)</th>
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<tr>
<td><strong>Localized infection</strong></td>
<td><strong>Acute, systemic disease</strong></td>
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<tr>
<td>No or mild disease</td>
<td>High mortality</td>
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<tr>
<td>Any subtype</td>
<td>H5 &amp; H7 subtypes</td>
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<tr>
<td>Waterfowl - intestines</td>
<td>Domestic birds - chickens, turkeys</td>
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<tr>
<td>Domestic birds - respiratory</td>
<td>Virus in muscle/eggs</td>
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<tr>
<td>No virus in muscle/eggs</td>
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LPAI: *Clinical Signs & Lesions*

- First sign: Drop in egg production (layers, breeders)
- Rough, misshapen eggs
- Hemorrhage in ovary

D. Swayne
LPAI: Clinical Signs & Lesions

- Huddling
- Depression
- Closed eyes
- Sinusitis
- Respiratory signs
LPAI: Clinical Signs & Lesions

- Yolk peritonitis
- Oviduct edema
- Urates in kidney
HPAI: Clinical Signs & Lesions

- Sudden onset and high mortality
- Rapid spread
- Severe depression, drop in feed/water consumption
HPAI: Clinical Signs & Lesions

External

- Edema of head
- Edema/necrosis of comb/wattle
- Subcutaneous hemorrhage of shanks
HPAI: Clinical Signs & Lesions

Internal

- Hemorrhage of trachea
- Visceral hemorrhage
- Petechial hemorrhage on heart
- Petechial (spray paint) hemorrhage on fat deposits

D. Senne
HPAI: Differential diagnosis

- Exotic Newcastle disease (Paramyxovirus)
- Avian cholera (Pasteurella)
- Duck plague (Herpes virus)
- Infectious Laryngotracheitis (ILT - Herpes)
- Infectious bronchitis (IBV - Coronavirus)
- Water deprivation
- Heat exhaustion
- Toxins – food or water borne
How is the AI virus spread among birds?

- Direct contact between healthy and infected birds
- Infected fecal matter
- On the unwashed egg shell surface from feces of infected birds
Methods of Spread: AI Infected Premises

- Infected Birds
- Fecal/oral (Feces, saliva, soil, water)
- Wind
- Wild Birds
- Insects
- Vehicles/Equipment
- Aerosol (Nasal secretions)
- Rodents

People
Emergence of HPAI

AIV in the natural reservoir is genetically stable and LPAI

Live-bird markets

Backyard Poultry

Commercial Poultry

H1-H16

H5 & H7 AIV

Host adaptation

Re-adaptation

Asian HPAI H5N1
HPAI outbreaks in poultry since 1959

25 outbreaks - 11 (H5), 14 (H7)

A/chicken/Scotland/59 (H5N1)
A/turkey/England/63 (H7N3)
A/turkey/Ontario/7732/66 (H5N9)
A/chicken/Victoria/76 (H7N7)
A/chicken/Germany/79 (H7N7)
A/turkey/England/199/79 (H7N7)
A/chicken/Pennsylvania/1370/83 (H5N2)
A/turkey/Ireland/1378/83 (H5N8)
A/chicken/Victoria/85 (H7N7)
A/turkey/England/50-92/91 (H5N1)
A/chicken/Victoria/1/92 (H7N3)
A/chicken/Queensland/667-6/94 (H7N3)
A/chicken/Mexico/8623-607/94 (H5N2)
A/chicken/Pakistan/447/94 (H7N3)
A/chicken/NSW/97 (H7N4)
A/chicken/Hong Kong/97 (H5N1)
A/chicken/Italy/330/97 (H5N2)
A/turkey/Italy/99 (H7N1)
A/chicken/Chile/2002 (H7N3)
A/chicken/Netherlands/2003 (H7N7)
A/chicken/SE Asia/2003 (H5N1)*
A/chicken/USA-Texas/2004 (H5N2)
A/chicken/Canada-BC/2004 (H7N3)
A/Ostrich/South Africa/2004 (H5N2)

* Largest outbreak in last 50 years
Compartmentalization
Top Broiler States

Georgia, Arkansas, Alabama, N. Carolina, Mississippi, DelMarVa, California

Tyson Foods, Gold Kist, Pilgrim’s Pride, Perdue Farms, Wayne Farms, Fieldale Farms
Vertical Integration in the Broiler Industry

- Primary Breeders → Multiplier Breeders
- Hatchery → Hatchery Supply Farms
- Flock Service → Grow Out Farms
  - Company & Contract
  - Processing Plant
  - Ready-to-Cook Whole Birds & Parts
  - Consumer
- Feed Mill
- Rendering Plant
- Further Processing Plant
- Further Processed Products
- Market Division
Poultry Industry Feed Production

- Companies often operate own feed manufacturing facilities and transport feed to farms
- Typical company may supply four to five different feeds throughout life of flock
Meat-type Chickens
Broiler Growers

- Newly hatched broiler chicks are transported to contract growers (or company growers)
- Growers care for and raise birds under supervision of technical service personnel
- Grower provides labor, properly equipped housing, and utilities
- Company provides birds, feed, medication, technical support and load-out crew
Broiler Industry-Summary

- Vertical Integration allows company control of product and costs of production
- Contract growers shift burden of production facilities away from company
- Development of value added products has increased cost of processing but stabilized market
Top Five Turkey States

Minnesota, N. Carolina, Arkansas, Virginia, Missouri

Jennie-O Foods, Butterball Turkey, Pilgrim’s Pride, Cargill North American, Carolina Turkey
Turkey Industry

- Primarily located in Southeast and Midwest
- Level of integration similar to broiler industry
- Turkeys grown in two or more facilities during live of flock
- Toms grown separately from hens
- Has a slightly higher cost of production facilities versus broiler industry
- Turkey industry has maintained commodity status and has greater fluctuations in supply and demand
Top Egg Production

Iowa, Ohio, Indiana, California, Pennsylvania, Indiana, Georgia

Cal-Maine Foods, Rose Acre Farms, Michaels Foods
Commercial Layers

- Production companies buy day-old pullets from genetic-line companies and raise in company owned cage facilities
- Raise pullets to production age (18 weeks)
- Transfer birds to concentrated layer facilities
- Many companies have million bird complexes
- Birds remain in production as long as 110 weeks
- Egg industry has remained a commodity supplier and is very much dependent on supply and demand for price of product
Questions?

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