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An overview of the 2002 outbreak of low-pathogenic H7N2 avian influenza in Virginia, West Virginia and North Carolina

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Abstract

During the spring and summer of 2002, an outbreak of low-pathogenic H7N2 avian influenza virus (AIV) infected 210 flocks of chickens and turkeys in Virginia, West Virginia and North Carolina, and caused the destruction of more than 4.7 million birds. Although no epidemiologic link was established, the virus was related to the H7N2 virus circulating in the live-bird market system (LBMs) since 1994. An avian-influenza Task Force (TF), comprised of industry, state and federal personnel, was utilized in the control programme. The use of good safety and biosecurity practices was emphasized by TF commanders. Carcass-disposal options, which included burial in sanitary landfills, incineration and composting, proved to be problematic and caused delays in depopulation of infected premises. Surveillance activities focused on once-a-week testing of dead birds from all premises, biweekly testing of all breeder flocks and pre-movement testing. Additional surveillance carried out in backyard flocks and local waterfowl did not detect the H7 virus or specific antibodies to the virus. The outbreak emphasized the need to establish effective biosecurity barriers between the LBMs and commercial poultry.

Avian influenza (AI) is a viral disease that can affect many species of wild and domestic birds, including poultry. The AI virus (AIV) is comprised of 15 subtypes based on differences in antigenic nature of the surface haemagglutinin (HA) protein and is classified, based on pathogenicity, into low-pathogenic (LPAI) and highly pathogenic (HPAI) viruses (Swayne and Halvorson 2003). The natural reservoirs of avian influenza virus (AIV) are migratory waterfowl and shorebirds (Kawaoka et al. 1988; Slemons et al. 1974). However, the live-bird market system (LBMs) has been recognized as a significant man-made reservoir of poultry-adapted AIV and has been implicated in several outbreaks of AIV in commercial poultry in the United States (Committee on Transmissible Diseases of Poultry and Other Avian Species 2002; Davison et al. 2003).

The highly pathogenic form of AI is extremely contagious and lethal, causing sudden death in poultry, often without any warning signs of infection. Mortality in

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flocks infected with HPAI can often reach 100%. It has been documented that HPAI can evolve through the mutation of LPAI H5 or H7 precursor viruses after circulating for extended periods in unnatural hosts such as domestic poultry (Capua and Marangon 2000; Horimoto et al. 1995; Kawaoka, Naeve and Webster 1984; Webster 1998). Low-pathogenic strains of AI can also be highly contagious often resulting in subclinical infections, allowing the virus to spread undetected for a period of time.

In March 2002, a LPAI H7N2 virus similar to a strain of H7N2 virus known to be present in the LBMs in Northeast United States was found to be present in commercial poultry in Virginia, West Virginia and North Carolina. To reduce the possibility of the H7 virus mutating to HPAI, a control programme was implemented to eradicate the H7N2 virus from commercial poultry in the region. Agriculture authorities in Virginia initially took steps to control the H7N2 LPAI through diagnostic testing, quarantines, surveillance, and depopulation and disposal of infected poultry. However, the rapid increase in the number of positive cases quickly overwhelmed the State's capacity to manage the outbreak. Consequently, the Commonwealth of Virginia asked the USDA for assistance in controlling the outbreak. This paper will provide an overview of the outbreak and methods used to control the outbreak.

Keywords: avian influenza; outbreak; surveillance; bird disposal

The poultry industry at risk in the Shenandoah Valley and North Carolina

The Shenandoah Valley, located in Northwest Virginia, is situated between the picturesque Blue Ridge mountain range to the east and Shenandoah Mountains to the west. The Valley is approximately 20-30 miles wide and stretches nearly 100 miles, north to south. At the time of the outbreak of low-pathogenic H7N2 AI, there were over 1,000 premises and more than 56 million commercial turkeys and chickens present in the Valley. Of the 1,000 premises, there were approximately 400 premises each with broilers and meat turkeys, 175 broiler breeder flocks, 50 turkey breeder flocks and 3 table-egg layer flocks.

North Carolina shares its northern boarder with Virginia. The state produces about 700 million broilers, 40 million turkeys and 1.4 million turkey breeders annually. This production represents about 30% of the nation's turkey hatching eggs and ranks second in meat-turkey production. The high density of poultry in the Shenandoah Valley and North Carolina provided the ultimate challenge to regulatory officials to control a highly contagious disease such as AI.

Chronology of the outbreak in Virginia and West Virginia

Clinical signs of respiratory disease and a drop in egg production were first observed on March 7, 2002 in a turkey breeder flock near Harrisonburg, Virginia. A diagnosis of H7N2 LPAI was confirmed by the National Veterinary Services Laboratories (NVSL), Ames, Iowa on March 12. One day prior to the appearance of clinical disease, some birds were moved from the affected house to another location for forced molting. Within the next few days, clinical disease was observed in several additional turkey breeder premises owned by the same company. It is believed that movement of infected birds and the use of a common rendering truck to pick up dead birds were responsible for tracking the infection from one breeder's premises to another. On March 21 it became apparent that this was not just a localized outbreak

when a turkey grow-out farm located 30 miles north of the index farm and belonging to a different company, was diagnosed as positive. By March 28, 20 positive flocks were identified.

By April 12, 2002, more than 60 flocks were positive, with about half of the positive flocks awaiting depopulation. The poultry companies in the Valley insisted on depopulation of positive flocks; therefore, the State of Virginia began issuing 24-hour destruction orders for positive flocks. The State of Virginia also requested USDA assistance and on April 14 a joint Task Force (TF) comprised of State, Federal and Industry representatives was established, with headquarters located in Harrisonburg. Because an official 'state of emergency' was never declared, either at the state or federal level, all TF activities were carried out under state authorities to quarantine and order depopulation of infected flocks without indemnity. This was the first time the federal government participated in the control of LPAI in the United States. The control of LPAI in the United States is currently the responsibility of the state governments.

One of the most successful activities initiated by the TF was the 'barrel surveillance' programme that accomplished 100% coverage of all commercial poultry flocks once each week. This programme was started during the last week of April, 2002 and continued throughout the outbreak. Producers were required, at prearranged times, to place up to 10 dead birds per house in sealed garbage cans at the end of the driveway for sampling by the TF. Tracheal-swab pools (from up to 5 birds) were collected for laboratory testing. This activity facilitated collection of samples without compromising on-farm biosecurity procedures, thus limiting the spread of disease through surveillance activities. This practice proved to be very effective in detecting positive flocks that were infected but not showing clinical signs or where there may have been under-reporting of clinical disease by producers.

The last positive case in Virginia was identified on July 2, 2002, four months after the first case was diagnosed, and the final quarantine of positive premises was lifted on October 9, 2002. A total of 197 flocks, representing approximately 20% of the 1000 area commercial poultry farms, were infected with the H7N2 virus. Approximately 4.7 million birds, or 8.4% of the estimated 56 million birds at risk, were destroyed to control the outbreak. Turkeys accounted for 78% of the positive farms and included 28 turkey breeder flocks and 125 commercial meat-turkey flocks. Twenty-nine chicken broiler breeder flocks, 13 chicken broiler flocks and 2 of the 3 chicken egg-layer flocks in the Valley were also infected.

In addition to the infected flocks in Virginia, one flock in West Virginia was infected with the H7N2 virus. The poultry industries in Virginia and West Virginia are contiguous and it is suspected the disease was introduced into West Virginia from Virginia.

Although the USDA approved the use of an autogenous killed H7N2 vaccine, it was not used in this outbreak primarily because of company and allied industry concerns related to negative impacts on trade and to facilitate rapid eradication of the H7N2 virus from commercial poultry, thus reducing the opportunity for virus mutation that could lead to increased virulence.

The source of infection for the index flock was never established. However, the H7N2 strain responsible for this outbreak was shown to be genetically identical to the strain that caused recent outbreaks in Pennsylvania and that has been found in the LBMs in the Northeast United States since 1994. To assess the likelihood that wild waterfowl or backyard birds could have introduced the infection into commercial poultry, surveillance was carried out on more than 90 backyard flocks and 300

resident Canada geese from 23 sites in close proximity to infected poultry farms. Surveillance of waterfowl and backyard flocks yielded no positive isolations or serologic evidence of H7N2; antibodies to H6N2 AI virus were detected in some geese.

Federal compensation payments totalling $52.65 million were paid to growers and owners for the birds that were destroyed and for cost of bird disposal. The payments were made based on 75% of the appraised market value of the birds. An additional $13.5 million was spent on operational expenses for the outbreak TF. However, figures upward of $149 million have been used to reflect the total negative impact of the outbreak on the poultry industry and allied industries.

Chronology of events in North Carolina

During March and April, 2002, a total of 12 premises with over 60,000 birds were diagnosed positive for AI H7N2 in North Carolina. Of the 12 positive flocks, three were commercial turkey and quail flocks and 9 backyard flocks. The index case was detected on March 6, when the North Carolina Department of Agriculture and Consumer Services was notified that a North Carolina turkey flock processed in Virginia was positive for AI antibodies in serum collected at slaughter. During the following two weeks, surveillance detected H7N2 infection in one additional turkey flock and one quail flock at a nearby shooting preserve. Seven premises were identified as having received birds from the positive quail farm and four were confirmed as being infected. Investigations showed that the owner of one of the positive trace-back farms made regular trips to markets in Pennsylvania to sell goats; this activity could have been a source for the H7N2 virus for the outbreak. All infected premises in North Carolina were depopulated by the state without federal assistance.

Task-Force operations

A Task Force (TF) was established in Harrisonburg, Virginia and served as a headquarters for approximately 200 personnel at any given time. The mission of the TF was to assist the state of Virginia in control efforts by identifying and eliminating foci of infection and preventing spread of disease. Priorities identified by TF commanders included safety of TF personnel as well as adherence to strict biosecurity measures. All TF personnel were required to receive training in proper safety and biosecurity procedures before being assigned to an activity unit. During the outbreak, approximately 800 people from various federal and state agencies rotated through the TF. Personnel came from 46 states and several foreign countries.

Laboratory tests and surveillance

At the beginning of the outbreak only two testing modalities were available, the agar-gel immunodiffusion antibody test (AGID) at the state laboratory in Harrisonburg, Virginia and virus isolation in embryonated chicken eggs at the USDA's National Veterinary Services Laboratories (NVSL) in Ames, Iowa. Because of the time delays inherent in both of these test methods, days for seroconversion to occur after infection of a flock and days for results from virus isolation, additional test methods were sought that would provide rapid results to aid in the management of the outbreak. This led to the rapid adoption of the Directigen^{TM} FLU A (Becton, Dickinson

and Company, Sparks, Maryland) membrane-based antigen-capture immunoassay and the real-time reverse-transcriptase polymerase chain reaction (RRT-PCR) test. A flock was diagnosed positive if clinical signs consistent with AI infection (respiratory signs, drop in egg production etc.) were present along with at least one positive laboratory test result. In the absence of clinical signs, positive results on two different types of tests were required to designate a flock as positive.

Early in the outbreak, swab specimens were tested by three methods: Directigen™ test, virus isolation and RRT-PCR. As the outbreak progressed, the increased number of samples generated created a severe strain on the state and federal laboratories leading to changes in testing procedures. Results of a comparison of the three virus/antigen detection methods on over 3,500 specimens showed that the sensitivity and specificity of the AI RRT-PCR was 95% and 99% respectively when compared to virus isolation at the submission (farm) level. The Directigen™ test was shown to be 80% sensitive and 99% specific compared to virus isolation. Therefore, the decision was made to stop testing by virus isolation and test only by Directigen™ at the Harrisonburg laboratory and RRT-PCR at the NVSL. This marked the first poultry-disease outbreak in the United States where a molecular method was used as the primary diagnostic test for an eradication programme. Midway through the outbreak, equipment for the RRT-PCR was purchased for the Harrisonburg laboratory and personnel trained so that rapid, sensitive monitoring and surveillance for AI could occur locally. Timeliness of test turnaround was found to be absolutely critical to the successful management of the outbreak.

Prior to the outbreak, Virginia and North Carolina routinely conducted AGID tests to detect antibodies to AI virus from chicken and turkeys at processing plants and from breeders as part of the monitoring programme for the National Poultry Improvement Plan (NPIP). No evidence of AIV was detected in surveillance samples preceding the outbreak.

Antibody surveillance for AI was significantly increased during the outbreak and following the outbreak. In addition to antibody surveillance, breeder flocks were tested for AI virus antigen by the Directigen™ and RRT-PCR tests at regular intervals. All meat birds going to slaughter were required to be Directigen™ and RRT-PCR-negative before being moved. Over 96,000 serum samples and 40,000 swab specimens were tested during the outbreak.

Methods of bird disposal

Bird disposal proved to be a major issue during the outbreak in Virginia. Public protests following the burial of the index flock in plastic-lined pits on the farm of origin prompted the State Department of Environmental Quality to stop this practice unless land owners recorded such burial pits on the property deed and agreed to install long-term monitoring wells. These requirements made burial on the farm an unacceptable option as a disposal method. As a result, alternative methods for disposal were used, including air-curtain incineration, burial in large sanitary landfills, and composting. The use of ‘mega-landfills’, those landfills with the capacity and equipment to handle thousands of tons of carcasses per day, proved to be the most economical, despite sometimes having to transport the birds over long distances. Following euthanasia with carbon dioxide gas, carcasses were placed in sealed, leak-proof trucks for transport to the landfills. Task Force personnel monitored cleaning and disinfection of vehicles carrying dead birds from infected premises and prior to

leaving disposal sites. No evidence of disease-spread was attributed to transportation of carcasses to landfills or incinerators.

Outcomes and lessons learned

A number of lessons were learned from this outbreak and response. The H7N2 viruses isolated from commercial poultry in Virginia, North Carolina and West Virginia were shown to be genetically similar to the H7N2 virus that has been circulating in the live-bird market system in the Northeastern United States since 1994. Therefore, greater effort must be made to establish barriers between commercial poultry and the live-bird markets and their suppliers to prevent tracking AI virus from these sources into commercial production facilities.

Epidemiologic studies showed that the spread of the H7N2 virus was primarily by people, fomites and contaminated equipment. There was very little evidence of air-borne spread. The transport of dead birds (daily mortality) from the farm to rendering facilities for disposal was an especially high-risk activity.

Every outbreak is unique, and as such, flexibility and creative decision-making will be needed to solve problems that may arise. In addition, environmental considerations will figure prominently in disposal options.

This outbreak showed that multiple state and federal agencies can work effectively with industry and producers to quickly stamp out an outbreak of a highly contagious disease. The biosecurity measures used and methods for sample collection, euthanasia and disposal in this control programme did not contribute to further spread of the virus to other geographic areas.

Finally, trade considerations do play an important role in determining response policies such as stamping out, vaccination and disposal.

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