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Biosecurity Factors and the Introduction and Spread of HPAI: Findings from Epidemiological Studies

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Introduction

Since the expansion of highly pathogenic avian influenza (HPAI) viruses into commercial poultry occurred in January 2015, APHIS Veterinary Services (VS) has initiated a number of epidemiologic and laboratory based investigations to better understand the factors associated with HPAI virus transmission. Two observational studies, a case series and a case-control, were led by APHIS. This report identifies specific biosecurity factors identified through these studies that may be associated with higher risk of HPAI initial introductions or lateral transmission. Mitigating these factors, in conjunction with strict attention to biosecurity in general, may reduce a producer's risk of infection.

Turkeys

A case series study conducted by APHIS described 81 turkey farms in IA, MN, ND, SD, and WI with infections of highly pathogenic avian influenza (HPAI): 63 meat production farms (grow and/or brood), 11 breeder farms, 6 farms that raised breeder candidate birds to breeding age, and 1 turkey farm that did not provide information on production type. Birds on these farms developed clinical signs of HPAI between March 30 and May 2, 2015. The median farm capacity was 46,000 birds and the median number of barns per farm was four.

Turkey farms typically follow biosecurity protocols, which are established by the company with which they work. Common procedures include: spraying vehicle tires with disinfectant at the farm entrance, requiring visitors and employees to wear coveralls and disposable boot covers (or dedicated footwear) before entering the barns, using disinfectant footbaths at barn entrances, using rodent control, and caring for younger birds before caring for older birds. The objective is to establish a clean-dirty line where outside contaminants are not carried into the barn. Showering before entering the barn is commonly required on breeding farms.

In this case series, 46% of farms had a wash/spray area for vehicles, 73% used dedicated coveralls for workers before entering each house, 100% used boots or boot covers for workers, and 99% had footbaths at barn entrances. The most commonly used footbath disinfectants were phenolic compounds (e.g., Pheno-Tek), oxidizing agents (e.g., Virkon-S, Accel) and iodophors. A few farms used quaternary ammonium compounds or chlorine compounds in footbaths. For washing vehicles, most farms used oxidizing agents or chlorhedixine.

Importantly, only 43% of case farms reported that biosecurity audits or assessments were conducted on the farm by the company or a third party. Farms can decrease their HPAI risk by verifying that biosecurity procedures are being followed properly.

People are potential fomites for transmitting HPAI, particularly if they move from farm to farm on the same day. None of the farms in this case series had employees who worked at multiple farms, and 94% had rules restricting workers from having contact with backyard poultry. These findings are typical for the turkey industry. However, 16% had family members who were employed by other poultry operations. This is not surprising considering the density of poultry operations in the area. Several steps of virus transfer would be required for disease to pass from farm to farm via family members who work at different farms, so the risk for this transmission route is likely to be fairly low.

Equipment sharing is very common in the poultry industry. In the majority of cases, feed trucks, live haul loaders, pre-loaders, and other items were shared by multiple farms. Equipment is typically disinfected between farms, but not all items are easy to disinfect (e.g., vehicles). In addition, disinfectants need sufficient contact time, and are less effective if organic matter and feces are present. Respondents were asked to describe their cleaning and disinfection procedures for pre-loaders. Most respondents described power washing followed by a disinfectant. If done correctly, this procedure should be very effective at inactivating HPAI. The power washing stage to remove all organic matter is particularly important, and is sometimes done inadequately in actual practice. A few respondents noted the importance of removing organic material, manure, and feathers. Equipment sharing makes economical and logistical sense, but it also increases the risk of lateral spread of HPAI between farms. Fomites, such as equipment, are probably playing a role in this outbreak.

Movements of manure and dead birds have both caused transmission of AI in previous outbreaks (Halvorson, 2009). When litter and carcasses are transported, infectious material may be spread to nearby farms as trucks travel down the road. In this case series, 89% of farms disposed of litter off-farm, and 47% used off-site disposal for carcasses (e.g., renderer, landfill. Litter that was moved off site was most often applied to cropland or fields, while some farms moved litter off-site to be used as fuel at a power plant.

Farm visitors are potential fomites for transmitting HPAI, particularly if they move from farm to farm on the same day. About half of farms (53%) had a visitor log, and 68% provided outer clothing for visitors. For each farm, visitor and vehicle traffic in the 3 to 10 days before HPAI clinical signs began was examined because HPAI probably arrived on the farm during this time frame. There were no unusual patterns in visitors or vehicle traffic. The most common visitors/vehicles entering the farms were feed delivery vehicles and renderers. Because of the frequency of these visitors, and because they usually service more than one farm, they should be further explored as potential fomites for HPAI spread. Other vehicles or visitors may have been important in HPAI spread in this case series of farms, but information was not available on every type of visitor.

For most farms, it was not possible to definitively identify the specific mechanism by which HPAI was transmitted to the farm. However, for a few farms, a particular transmission route was highly likely. The likely transmission mechanisms are listed below. The numbers in parentheses indicate number of days between the potential exposure event and the start of clinical signs on the exposed farm.

- A person who traveled back and forth between two farms (10-11 days).
- A piece of equipment that was borrowed from a pre-clinical positive farm (10 days).
- Two farms in close proximity that shared equipment and vehicles daily (11 days).
- Two farms in close proximity that shared a mortality bin. Farm 1 may have become infected due to waterfowl in standing water near the barn. Farm 2, which shared a mortality bin with Farm 1, developed clinical signs 7 days after Farm 1 (7 days).

- Five farms in a single State used the same company for rendering and/or load out services. These farms all developed clinical signs within a 10-day period.

These findings demonstrate potential important fomites in lateral transmission of HPAI – including equipment, vehicles, and people. The time periods in parentheses (7 to 11 days) are longer than the expected 3-5 day incubation period for some AI viruses. The incubation for this virus appears to be longer than 3-5 days based on experimental work conducted by the ARS, SEPRL. In addition, fomites might carry the virus around an exposed farm for several days before it reaches the birds.

One farm employs workers who commute together with other workers to a crowded communal housing facility that they rent together. These workers who live in the same house work for multiple poultry operations in the area. Virus would need to survive several transfer steps (farm 1 (infected) → worker 1 → house surfaces at shared housing → worker 2 → survive biosecurity measures such as coveralls and footbaths → farm 2) for disease transmission to occur via this route, making it fairly unlikely, but not impossible. Certain practices by the workers could make this route more likely – such as having gross fecal contamination on shoes they wear home, or sharing clothing/shoes/fomites with other workers. These details were not available.

<u>Layers</u>

The study included all detected case farms as of May 15, 2015, in Iowa or Nebraska. Control farms were recruited from the surrounding geographic area for each case farm. A 28-page questionnaire was sent to each participating farm with a follow-up interview conducted in person or via telephone. The questionnaire focused on the 2-week period leading up to the detection of disease on a case farm (either via clinical signs/increased mortality or through active surveillance). This 2-week period was defined as the reference period. Participants with control farms responded for the reference period of the matched case survey. Analysis of data was conducted at both the farm and barn level.

Farm Level

Five variables were statistically significant in the final multivariable model. Being located in an existing control zone was highly associated with farm status. Half of case farms were located in an existing control zone compared to only 10% of control farms (OR=28.8, p=0.002). Rendering dead birds was a risk factor; 39% of case farms (compared to 13% of control farms) reported that the renderer came onto the farm. Additionally, 29% of case farms (and only 3% of control farms) reported that rendering trucks came near the barns (OR=21.4, p=0.0001). Although a similar percentage of case and control farms reported that garbage trucks come to the farm, 61% of case farms (compared to 23% of control farms) reported that the garbage trucks come near the barns (OR=14.0, p=0.0003). Having visitors change clothing was protective (OR=0.10, p=0.01).

Visits in the past 14 days (see prior report for the definitions of time periods for data collection) by a company service person was associated with farm status: 50% of case farms and 19% of control farms had a company service person visit (OR=4.3, p=0.0004). Additionally, 43% of case farms and 16% of control farms reported that the service person entered the barn. We note that causation relative to infection cannot be determined via this study; therefore, we can't know whether the increased risk was due to the company service person's visit, or if this variable is a proxy for another risk, such as the initiating reason for the request for a service person visit.

Barn Level

Three variables remained statistically significant in the final multivariable model. Having a hard surface barn entry pad that was cleaned and disinfected was protective when compared with all other levels combined (i.e., not having a hard surface, or no cleaning or no disinfection) (adjusted OR=0.16, p=0.01). Control barns (53.6%) were nearly twice as likely as case barns (28.6%) to have hard surface entry pads that were cleaned and disinfected.

Dead bird disposal within 30 yards of a barn remained a statistically significant risk factor (adjusted OR=2.78, p=0.012). Case barns (60.7%) were much more likely to have dead disposal within 30 yards than were control barns (35.5%). This is consistent with results in the farm level analysis, where we found higher risk of farm infection when rendering trucks entered the farm and came near barns.

When ventilation type was dichotomized into two levels, ceiling/eaves versus all other types, where other types included tunnel, curtain and sidewall ventilation, we found the ceiling/eaves type to be protective (adjusted OR=0.33, p<0.001). Control barns were more likely to have ceiling or eaves inlets (67.7%) compared with case barns (48.2%).

One variable, access to a shower by employees, was strongly associated with a barn being a case in the univariate analysis, and remained statistically significant in our multivariable models. Because employees having access to a shower appears to impart significant risk, and because this risk appears contradictory to biosecurity convention, we explored this effect further. The wording of the question ("employees have access to a shower") does not imply required, enforced or validated use of the shower by employees. We also found that "having access to a shower" was strongly correlated with the age of the barn where barns older than 10 years were significantly less likely to have showers (p=0.006). We determined that, were we to include employee shower access in multivariable models, we would need to include a variable for the interaction with the barn's age. Given our limited sample size we were not able to fully explore interaction terms or stratified analyses in current multivariable models.