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Human Health Surveillance During Animal Disease Emergencies: Minnesota Department of Health Response to Highly Pathogenic Avian Influenza Outbreaks, 2015 and 2022–2023

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Abstract

Objectives: Highly pathogenic avian influenza (HPAI) poses an occupational risk for poultry workers, responders, and others in contact with infected birds. The objective of this analysis was to describe HPAI surveillance methods and outcomes, and highlight the challenges, successes, and lessons learned during the Minnesota Department of Health's (MDH's) public health response to HPAI outbreaks in Minnesota poultry flocks in the years 2015 and 2022–2023.

Methods: During both outbreaks, MDH staff attempted to contact all potentially exposed people and conduct a standardized interview. People were considered exposed and at risk if they had entered a barn with poultry on any HPAI test-positive premises. With their consent, exposed persons were entered into illness monitoring until 10 days from their last exposure. In 2015, MDH

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Disclaimer

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monitored the health of poultry workers only. In the 2022–2023 response, MDH monitored the health of poultry workers, backyard flock owners, responders, and private contract workers. In 2022–2023, interview responses were entered into a REDCap (Research Electronic Data Capture) database in real time, which automatically entered the person into monitoring if they consented. Through REDCap, they received an automated email with a unique link to a short survey asking about any symptom development. Where appropriate, interview responses from poultry workers collected in 2015 were compared to interview responses from poultry workers collected in 2022–2023.

Results: From March 3 to June 5, 2015, MDH epidemiologists interviewed and evaluated 375 (86%) of 435 poultry workers from 110 HPAI-infected flocks. From March 25, 2022 through December 31, 2023, MDH epidemiologists interviewed and evaluated 649 (65%) of 992 poultry workers, responders, contractors, and backyard flock owners associated with 151 HPAI-infected flocks. Among poultry workers, self-reported personal protective equipment (PPE) usage declined significantly from 2015 to 2022–2023 (full PPE usage 51.8% vs. 23.9%, $p < .01$).

Conclusion: MDH's long standing relationships with animal health officials and the poultry industry resulted in strong poultry worker participation rates in surveillance efforts during HPAI outbreaks in 2015 and 2022–2023. Self-reported PPE usage was low, particularly in 2022–2023. Improvements in PPE accessibility and technology are needed to protect workers and responders in the on-going HPAI outbreak.

Keywords

Highly pathogenic avian influenza; One Health; personal protective equipment; poultry workers; public health response

Introduction

Minnesota leads the United States in turkey production, with approximately 600 turkey farms that produce over 40 million turkeys annually.¹ Egg layers and broiler chickens are also important agricultural businesses in Minnesota. In 2022, the combined value of poultry production in Minnesota was estimated to be \$1.1 billion annually, involving an estimated 6,400 rural jobs.¹ The state is located on the Mississippi Flyway, making low and highly pathogenic avian influenza viruses carried by wild waterfowl a constant risk for Minnesota poultry industries.^{2,3} In 2015 and again in 2022–2023, Minnesota state animal health and human health agencies responded to two large highly pathogenic avian influenza (HPAI) outbreaks.

HPAI H5N2 in Minnesota, 2015

The first HPAI H5N2 infected flock in Minnesota was identified in March 2015. The virus spread to 110 premises (104 commercial turkey flocks, 5 chicken layer flocks, and 1 backyard flock) in 23 counties before the outbreak ended in mid-June 2015, making Minnesota the U.S. state with the greatest number of infected flocks during this HPAI outbreak. Over 8.8 million birds died or were depopulated to limit disease spread.^{4,5} Molecular analysis later showed that spread involved a combination of individual point source introductions of the virus from wild waterfowl and substantial farm-to-farm spread,

particularly later in the outbreak.^{3, 6–8} The economic burden due to the outbreak was over \$650 million, and 2,500 jobs in Minnesota were impacted.^{4,9} The emotional toll on producers, responders, and state animal and human health officials was immeasurably large.

HPAI H5N1 in Minnesota, 2022–2023

In 2022–2023, the Midwest was again the most affected region in the U.S. by HPAI. In Minnesota, HPAI H5N1 was identified in nearly every county of the state, with 115 commercial flocks (including 112 commercial turkey flocks, two chicken layer flocks, and one chicken broiler operation) and 36 backyard flocks infected from March 25, 2022 to December 31, 2023. Over 6.3 million birds died of the disease or were depopulated to prevent disease spread.¹⁰ Molecular analysis determined that cases in domestic poultry in 2022–2023 occurred almost entirely through individual introductions of the virus from wild birds to poultry flocks, rather than from farm-to-farm spread.^{11–13} This molecular evidence aligned with the extraordinary number of HPAI detections in wild birds and the large number of backyard flocks infected, which typically have more contact with wild birds than commercial flocks.^{14,15}

Minnesota's One Health approach to HPAI

Minnesota is known among affected states for its truly One Health approach to HPAI outbreak response in domestic poultry. The Minnesota Board of Animal Health (BAH), Minnesota Department of Agriculture (MDA), Minnesota Department of Natural Resources (DNR), Minnesota Department of Health (MDH), and United States Department of Agriculture (USDA) collaborate as full partners in HPAI response including real-time communication as events unfold. This manuscript describes the Minnesota Department of Health's (MDH) surveillance methods and outcomes, and public health response activities during the 2015 and 2022–2023 HPAI outbreaks, focusing on successes, challenges, and lessons learned that may be of value to other public health responders.

Methods

Role of Minnesota Department of Health

The most important role of MDH in the 2015 and 2022–2023 HPAI outbreaks was to protect human health, which was the source of the agency's statutory authority to act. HPAI is an animal disease emergency; therefore, MDH supported the responding animal health agencies and was not the lead agency in the joint response. In 2022–2023, to streamline information sharing, MDH's State Public Health Veterinarian (SPHV) and Deputy SPHV served as human disease surveillance officers on the Minnesota HPAI Incident Management Team (IMT) (Figure 1). Inclusion in the IMT was codified during multi-agency after-action reviews held after the 2015 HPAI outbreak to ensure more efficient access to situational information in real time going forward.

The basic functions of MDH during both outbreaks were to provide guidance on infection control and use of personal protective equipment (PPE); individually interview poultry workers, responders, and others in contact with infected birds for work duties, type of contact, PPE usage, and illness history; institute active human disease surveillance for

signs of avian influenza illness among exposed people, known as “monitoring;” test any symptomatic people for influenza; provide information about human health risk and disease prevention to poultry workers, industry partners, incident responders, and the public in multiple formats; and when appropriate, recommend human seasonal influenza vaccination.

Specifics of the MDH monitoring program

Minnesota Board of Animal Health (BAH) contacted the MDH Zoonotic Diseases Unit (ZDU) by email as soon as a flock was identified as presumptively positive for HPAI at the Minnesota Veterinary Diagnostic Laboratory, and before the flock was confirmed positive at the National Veterinary Services Laboratory. Starting in 2022, BAH case managers, usually the first responder on a HPAI-positive farm, distributed MDH’s “Health Information for Poultry Personnel” handout, which was created during the 2015 outbreak (Appendix 1). The handout provided guidance on recommended PPE inside the poultry buildings, information on monitoring, contact information for MDH, and mental health resources. It was translated into Spanish, Karen, Hmong, and Somali, and modified in 2022 for additional audiences including backyard flock owners, wildlife rehabilitators, and incident responders. Callers to the BAH Sick Bird Hotline (a telephone number provided to the public for reporting potential HPAI-infected backyard flocks) were verbally advised about MDH recommendations for PPE and emailed a “Health Information for Backyard Flock Owners” handout.

In 2015, MDH staff contacted the flock owner or manager to identify everyone who had contact with an infected flock. Starting in 2022, for company-owned commercial flocks (vs. independently-owned commercial flocks), MDH contacted the company’s occupational health or safety lead to obtain contact information for all employees associated with an affected premises. Participation in monitoring by workers was voluntary. However, when farm owners, managers, or company occupational health and safety leads were contacted by MDH, it was expected they would provide the names and contact information for personnel associated with an infected premise. ZDU staff then attempted to contact all potentially exposed people and conduct a standardized interview regarding their role on the farm, what type of contact they had with sick birds, what type of PPE they were using, whether they considered themselves to be immunocompromised, and answered any questions workers had. Interviews were conducted in the participant’s preferred language, either with native speakers employed at MDH or through a contracted interpreter service. Based on their interview, each person was evaluated for risk of severe disease with influenza by assessing their level of exposure to infected birds in the context of self-reported PPE usage and any immunocompromising conditions. People were considered exposed if they had entered a barn with poultry on an HPAI test-positive premises in the 2 days before the first indication of illness in the birds, or anytime thereafter (or) in the 2 days before the collection date of the first positive test samples, or anytime thereafter until depopulation was complete. This included people who worked with healthy flocks on the same premises. Anyone considered exposed was entered into monitoring with their consent. People who may have been on a test-positive premises but did not enter any of the poultry buildings were not considered at risk and were not monitored. In 2015, MDH monitored the health of poultry workers only and one backyard flock owner. In the 2022–2023 response, MDH monitored the health of

poultry workers; backyard flock owners; BAH, MDA, and USDA responders; and private contract workers, as well as tracked the number of different infected premises to which an individual was exposed during each outbreak.

During both time periods, the first interview was conducted via telephone. The monitoring period was 10 days from the last exposure, but the number of times MDH contacted the person during monitoring depended upon the person's role in the response and the level of exposure in the context of self-reported PPE usage. In 2015, monitoring was paper interview-based, data were maintained in an Excel spreadsheet, and texting was the default monitoring contact method. MDH ZDU public health graduate student workers texted poultry workers individually 7 days/week and sent personalized messages to each worker. In 2022–2023, in an effort to improve data integrity and the sustainability of the response in terms of staff hours, interview responses were entered into a REDCap (Research Electronic Data Capture) database in real time, which automatically entered the person into monitoring if they consented. Through REDCap, they received an automated email with a unique link to a two-question survey asking about any symptom development or further contact with a subsequent infected flock. Follow up by phone or text was also available by request.

During both outbreaks, full PPE use was defined as the continuous use of all the following elements of PPE: washable or disposable long-sleeved coveralls or Tyvek suit; rubber boots that could be disinfected or disposable plastic boots; washable or disposable head covering or Tyvek suit hood; latex or nitrile gloves; eye protection; and an N95[®] filtering facepiece respirator (N95[®]), or KN95[®] respirator if an N95[®] respirator was not available. Medical clearance and fit testing were encouraged. During the 2022–2023 response only, if an individual reporting missing or inconsistent PPE use, they were asked if they lacked access to necessary PPE components.

Individuals who were exposed to infected flocks, including being present in infected barns and/or physically touching birds or their environment, without full PPE and who self-identified as immunocompromised were referred to their healthcare provider to discuss antiviral prophylaxis. With the individual's consent, MDH facilitated the process by working with the individual's health care provider or the company occupational health department, which included providing CDC's current antiviral prophylaxis recommendations. CDC's threshold for recommending prophylactic antivirals after exposure to infected flocks was higher in 2022–2023 than in 2015, though in both outbreaks, prophylaxis could be considered after any unprotected exposure.^{16,17} Anyone who reported symptoms was referred to MDH's Vaccine Preventable Diseases Surveillance Unit for follow-up and testing, which was limited to Influenza A in 2015. In 2022–2023, testing was expanded to include a multi-pathogen respiratory panel. Evaluation and sampling of the individual was normally performed at a local primary care clinic and facilitated by MDH.

Statistical analysis

Data analyses were performed using SAS 9.4 (SAS Institute, Cary, NC, USA) statistical software. Descriptive statistics from the 2015 HPAI outbreak were analyzed and compared to descriptive statistics from the 2022–2023 HPAI response where appropriate. Study data were collected and managed using REDCap electronic data capture tools hosted at the

Minnesota Department of Health.^{18,19} During the 2022–2023 response, individuals were only interviewed once per response season (i.e., Spring 2022, Fall 2022, Spring 2023, Fall 2023). However, the same individual could have completed multiple interviews if they were exposed to poultry during subsequent seasons. Analyses were conducted on the differences in PPE utilization and vaccination rates among poultry workers in 2015 and 2022–2023, using the initial interview as their baseline. Dichotomous variables were analyzed using a chi-square test or Fisher's exact test as applicable. A p-value <.05 was considered significant.

Results

2015 occupational health monitoring

From March 3 to June 5, 2015, MDH ZDU epidemiologists interviewed, evaluated, and monitored 375 (85.8%) of 437 poultry workers from 110 infected flocks (Table 1). Of the workers interviewed, 198 (52.8%) individuals were recommended by MDH epidemiologists to take prophylactic oseltamivir based on their exposure to test-positive premises without the use of full PPE, or if they had risk of severe disease from influenza. Of these, 118 (59.6%) agreed to take prophylactic antivirals, and the remaining chose to refrain unless symptoms developed. An interpreter was utilized for 11 Karen-speaking and 10 Spanish-speaking poultry workers. Among poultry workers, 221 (59%) chose texting versus a telephone call or email for monitoring their health.

In 2015, 186 (51.8%) of 359 poultry workers reported consistently using all recommended PPE components, among those who did not, eye protection compliance was lowest (Table 2). When poultry workers employed in a turkey breeding facility, where use of full PPE is typically required, were removed from analysis, 96 (35.7%) of 269 poultry workers reported wearing full PPE (Table 2). A human seasonal influenza vaccination in the past season was reported by 132 (47.0%) of 281 poultry workers. There were 20 (5.3%) poultry workers who reported respiratory symptoms; 15 consented to medical evaluation and were tested only for Influenza A. Among those tested, no human infections with avian influenza were identified (Table 3).

2022–2023 occupational health monitoring

From March 25, 2022 to December 31, 2023, MDH ZDU staff interviewed and evaluated 649 (65.4%) of 992 poultry workers, state and federal responders, contractors (private environmental health company workers and poultry company depopulation teams), and backyard flock owners associated with 151 infected flocks (Table 1, Figure 2). Among the 343 (34.6%) individuals potentially at risk who refused an interview or were lost to follow-up, the greatest proportion were contractors (134 (61.4%) of 218 contractors), followed by poultry workers (196 [30.9%] of 635), and state and federal responders (13 [17.3%] of 75). All 64 backyard flock owners were contacted and agreed to be interviewed (Table 1).

Among the 649 interviews, 536 (82.6%) interviewees met the criteria for monitoring based on having entered poultry buildings on an infected premise. Of 514 interviewees who consented to monitoring, 134 (26.1%) elected to be contacted by text message instead of

the standard e-mail monitoring. Individuals were only interviewed once per response season (i.e., Spring 2022, Fall 2022, Spring 2023, Fall 2023), but the same individual could have completed multiple interviews, if they were exposed to poultry during subsequent seasons. During 2022–2023, there were 469 unique individuals involved in the outbreak, including 309 poultry workers, 60 contractors, 36 state and federal responders, and 64 backyard flock owners (Table 1, Figure 2). Contractors and state and federal responders who responded to multiple infected premises ($n = 50$) accounted for 10.7% of 469 at-risk people and 22.9% ($n = 218$) of 950 exposures (data not shown).

In 2022–2023, 134 (28.6%) of 469 at-risk individuals who met monitoring criteria reported wearing all recommended elements of PPE; among those who did not, eye protection was most often not used (Table 2). Among poultry workers specifically, 74 (23.9%) of 309 reported consistently using all recommended PPE components (Table 2). When poultry workers employed in a turkey breeding facility, where use of full PPE is typically required, were removed from analysis, 59 (23.0%) of 257 poultry workers reported wearing full PPE (Table 2). Among individuals who reported not using full PPE, 41 (12.2%) of 335 reported the reason for that being a lack of access to all components. A human seasonal influenza vaccination in the past season was reported by 102 (33.1%) of 308 poultry workers (Table 2).

In 2022–2023, 45 (8.4%) people reported illness with respiratory, ocular, or gastrointestinal (GI) symptoms, 37 (82.2%) of whom were recommended to undergo testing for respiratory and GI pathogens. Of those, 24 (64.9%) agreed to testing. While H5N1 HPAI was not detected, several other human respiratory viruses and GI pathogens were found (Table 3).

Discussion

Successes and lessons learned

Partnerships: For nearly 20 years, the SPHV and Deputy SPHV at MDH have served as full members of the Board of Animal Health’s Poultry Emergency Disease Management Committee (EDMC) to provide the human health perspective. MDH was automatically alerted to low and highly pathogenic avian influenza-positive flocks as soon as they occurred and was fully engaged during “peace time” in avian influenza response planning and related discussions with animal health agency colleagues and the poultry industry. Understanding the disease from the industry perspective and building trusted relationships with animal health officials and industry leaders was necessary for a successful, coordinated, One Health response.

Minnesota is one of few states to incorporate zoonotic disease subject matter experts from the state health department into the Incident Management Team of an animal-health emergency to coordinate human disease surveillance, follow-up, and response. Building a formal data sharing and communication agreement between animal health and human health agency partners into the incident command structure (ICS) is the strongest recommendation for other jurisdictions, and likely the most difficult to achieve. Building trust takes time and involves meeting the key stakeholders in advance of a crisis and working to understand regional animal agriculture industries, including their privacy concerns.

In 2022, when it became clear that raptors such as eagles, hawks, and owls were especially susceptible to this strain of HPAI, MDH increased its support for The Raptor Center, located at the University of Minnesota. As intake of ill raptors and other wild birds increased, the MDH ZDU Veterinary Infection Preventionist assisted in the creation of protocols and procedures to protect their permanent education raptor birds on site and maintain biosecurity during wildlife rehabilitation operations. This included reviewing biosecurity protocols for both the education birds and hospital patients, establishing an isolation triage area and intake protocols for new sick birds entering the hospital, and training staff on PPE donning and doffing. In 2022, The Raptor Center admitted over 200 HPAI test-positive raptors and was able to collect more than 75% of Minnesota's HPAI test-positive raptor data, greatly contributing to the state's overall wild bird surveillance activities.²⁰ The partnership provided an example of the growing importance of veterinary infection control as a specialty and its value in a variety of settings.

The first wild mammalian animals to be identified with HPAI H5N1 in Minnesota, in 2022, were fox kits with neurologic disease. The virus was subsequently identified in dozens of other wild species globally and has persisted in dairy cattle in the U.S.^{21–24} Partnerships with animal health colleagues were leveraged to address growing concerns about transmission from ill animals to workers in the dairy industry in Minnesota, further supporting the need for strong partnership prior to animal health emergencies to protect human health in occupational settings.

Personal relationships: In both 2015 and 2022–2023, potentially exposed people were interviewed by telephone. This initial personal contact was critical for understanding the situation on the ground at the farm and establishing a relationship with the poultry worker/backyard flock owner/responder that would carry into monitoring. The interview allowed for a discussion about PPE recommendations, including why protecting the eyes, nose, and mouth was so important, and affirmation that they had access to PPE. MDH ZDU's contact information was provided for health questions. MDH staff often lent emotional support because they understood the situation as few others could. The response from poultry workers was positive, especially in 2015, but still appreciably so in 2022–2023. Many interviewees expressed gratitude to have someone responsible for oversight of their personal health, particularly in 2015 when depopulation crews became overwhelmed, and producers witnessed thousands of their birds die of the disease in a matter of hours to days.

Challenges and lessons learned: In April and May of the 2015 response, Minnesota's SPHV was asked by USDA national command staff to investigate two clusters of human disease. In April 2015, there were five cases of *Campylobacter* enteritis among state and federal responders working on depopulation on farms in Minnesota. *Campylobacter* is commonly found in poultry feces and environments. During the investigation, MDH found responders were working very long hours, often without breaks. There were often no hand hygiene facilities or in some situations no bathroom facilities. USDA immediately provided a clean trailer for resting and eating. In May 2015, through MDH's routine sentinel-site influenza surveillance activities and reports from urgent care providers, 30 cases of Influenza B among Emergency Operations Center (EOC) responders were identified.

Concurrently, MDH was asked by USDA national command staff to investigate and control a respiratory disease outbreak among responders in two Minnesota EOCs. MDH recommended immediate medical evaluation, testing, oseltamivir treatment, and isolation of responders with influenza-like-illness, as well as influenza vaccination prior to deployment. These responders were office personnel in support of the response who did not have contact with poultry but were working together in crowded conference rooms for extended periods of time. They had been asked to self-monitor and report any respiratory symptoms to the Incident Safety Officer, who would then work with MDH. Lessons learned from these additional outbreak experiences resulted in a change in Minnesota's HPAI human disease monitoring plan that was endorsed by animal health colleagues and applied in 2022–2023. Everyone involved in the response, including poultry workers, backyard flock owners, responders, and contractors, who consented would be interviewed and entered into monitoring.

PPE and seasonal influenza vaccination: While the 2022–2023 HPAI H5N1 clade 2.3.4.4b virus was arguably of higher risk for transmission to humans than the 2015 HPAI H5N2 clade 2.3.4.4 virus,^{25–28} the proportion of poultry workers who reported using full PPE in the 2022–2023 HPAI outbreak was significantly lower than in the 2015 HPAI outbreak, even when those employed by the turkey breeder industry, where full PPE usage is typically required, were excluded from analysis (23.0% vs. 35.7%; $p < .01$). This may be a result of difficulties using full PPE during hot Minnesota summers and the extended length of the 2022–2023 outbreak; complacency because many of the same producers affected in 2022–2023 had experienced the 2015 outbreak in which no one became ill; and a decline in public health trust following the SARS-CoV-2 pandemic. MDH ZDU staff emphasized the need for everyone entering barns on infected premises to use full PPE during presentations to a variety of audiences, during multiple meetings and in multiple formats. Despite MDH's educational efforts and the support of animal health responders to increase PPE utilization on-the-ground, individual PPE usage may have been greatly influenced by factors such as PPE availability and, based on anecdotal reports collected during worker interviews: physical discomfort; safety, including heat exhaustion and impaired vision from fogging of goggles; concerns about being unable to complete work as assigned; inability to negotiate labor conditions; and incongruencies between actual risk and perceived risk. Further research to corroborate these anecdotal reports is needed to elucidate the factors impacting PPE usage during animal health emergencies. Advances in PPE technology are needed to address the real impediments to PPE use in the farm environment. In addition, federal policy allowing for allocation of PPE resources and a national requirement that all persons entering a HPAI-infected barn use full PPE could improve compliance.

The proportion of poultry workers who reported a seasonal influenza vaccination in the previous season was significantly lower during the 2022–2023 than in the 2015 HPAI outbreak (33.1% vs. 47.0%; $p < .01$). Though turkeys and swine have been shown to be susceptible hosts for human seasonal influenza strains,^{29–31} achieving widespread poultry and swine industry buy-in for vaccination of producers/workers has proven difficult, increasing the risk for reassortment events.²⁹

Sustainability: In 2015, MDH ZDU public health graduate student workers texted poultry workers for 2–3-hours/day, 7 days/week, and sent personalized messages to each worker. The SPHV, Deputy SPHV and five ZDU epidemiologists followed up with each positive premises and were available for consultation 7 days/week for the duration of the outbreak. Changes implemented to improve sustainability during the 2022–2023 HPAI outbreak appeared to reduce participation, specifically sending automatic emails rather than personalized texting and less frequent direct personal communication with flock managers and owners.

Another factor limiting sustainability was a lack of federal funding for human disease surveillance during an animal disease response. Particularly in 2015, but also in 2022–2023, volunteers from other units at MDH, the University of Minnesota College of Veterinary Medicine Public Health Residency, and others assisted with the response and helped maintain other critical ZDU public health surveillance functions, such as follow-up of potential rabies exposures. Relationships between human and animal health officials require substantial effort and time to build and maintain. Dedicated funding for public health personnel and allocation of resources for One Health responses during “peace time” would maintain critical expertise in zoonotic diseases and other issues at the human/animal interface.

Coordinating health and safety: Coordinating the ICS Safety Officer responsibilities and state health department human health surveillance responsibilities proved difficult during the 2015 response and again in 2022–2023. MDH was responsible for all human disease surveillance and response, and the ICS Safety Officer was responsible for injury and hazard mitigation; however, limited coordination occurred, and responders did not clearly understand how or to whom to report their health issues. In future responses, the relationship should be codified to clearly outline responsibilities and communication between the two response roles. Safety Officers have expertise in injury and emergency response and are privy to the situation on the ground. State health department epidemiologists are skilled in outbreak investigation and infectious disease prevention and control. Coordination and communication between the two roles are needed to effectively address all types of health hazards potentially encountered by responders.

Limitations

In 2015, as the outbreak rapidly grew, data management and analysis became increasingly more challenging. In 2022–2023, before the first infected flock was detected in Minnesota, MDH prepared a REDCap database, automatic email-based monitoring system, and response protocols to enhance data management and sustainability. As a result, many direct comparisons between the two responses were not possible. More turkey breeding facilities were impacted in 2015 than in 2022–2023, impacting PPE usage and influenza vaccine data because full PPE usage is standard and required, and influenza vaccine is provided to workers in the turkey breeding industry. We strove to mitigate this by excluding poultry workers employed in turkey breeding operations from the PPE by outbreak analysis, but it was not possible for the influenza vaccination comparison because the vaccine is not required, only supported. There was likely response bias, as individuals willing to

be interviewed and participate in monitoring may also be more likely to use PPE and participate in other protective behaviors such as vaccination. In 2022–2023, the largest proportion of workers/responders lost to follow-up were contractors. Some contract-workers, especially migrant workers, may have been reluctant to engage with government officials, thus impacting our findings, particularly on PPE usage, as contractors may have a higher likelihood of working in unsafe conditions that may include a lack of PPE or training on proper PPE use.³²

Conclusions

Influenza viruses are unpredictable and ever evolving, creating a complex disease ecology that threatens both people and animals. MDH has responded to two large highly pathogenic avian influenza (HPAI) outbreaks in Minnesota, the first in 2015 and the second that has been on-going since March 2022, allowing for a longitudinal perspective on occupational health surveillance and its sustainability. Public health responses to potentially zoonotic influenza outbreaks among domestic food animals require the cooperation and active participation of animal health officials and the affected animal agriculture industries. Relationships and trust between animal agriculture and public health agencies require substantial effort, time, and resources to build and maintain, and are especially important when livelihoods are at stake. Successful methods and approaches to human health monitoring during animal health emergencies are important to document. As data are collected to inform future occupational health surveillance efforts, public health departments should consider the complex sociopolitical factors, including PPE policies, availability, and usability, that may influence the actions of animal health responders and food animal producers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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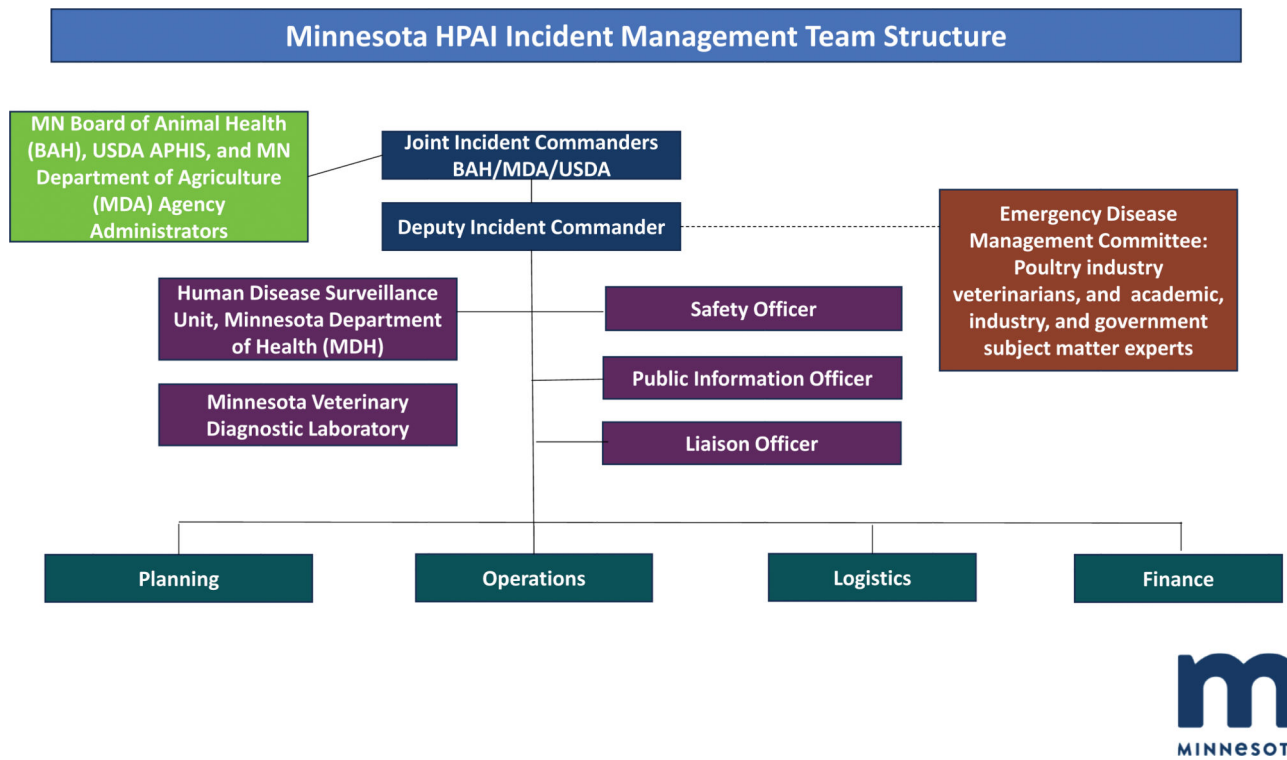


Figure 1.
Minnesota HPAI Incident Management Team Structure.

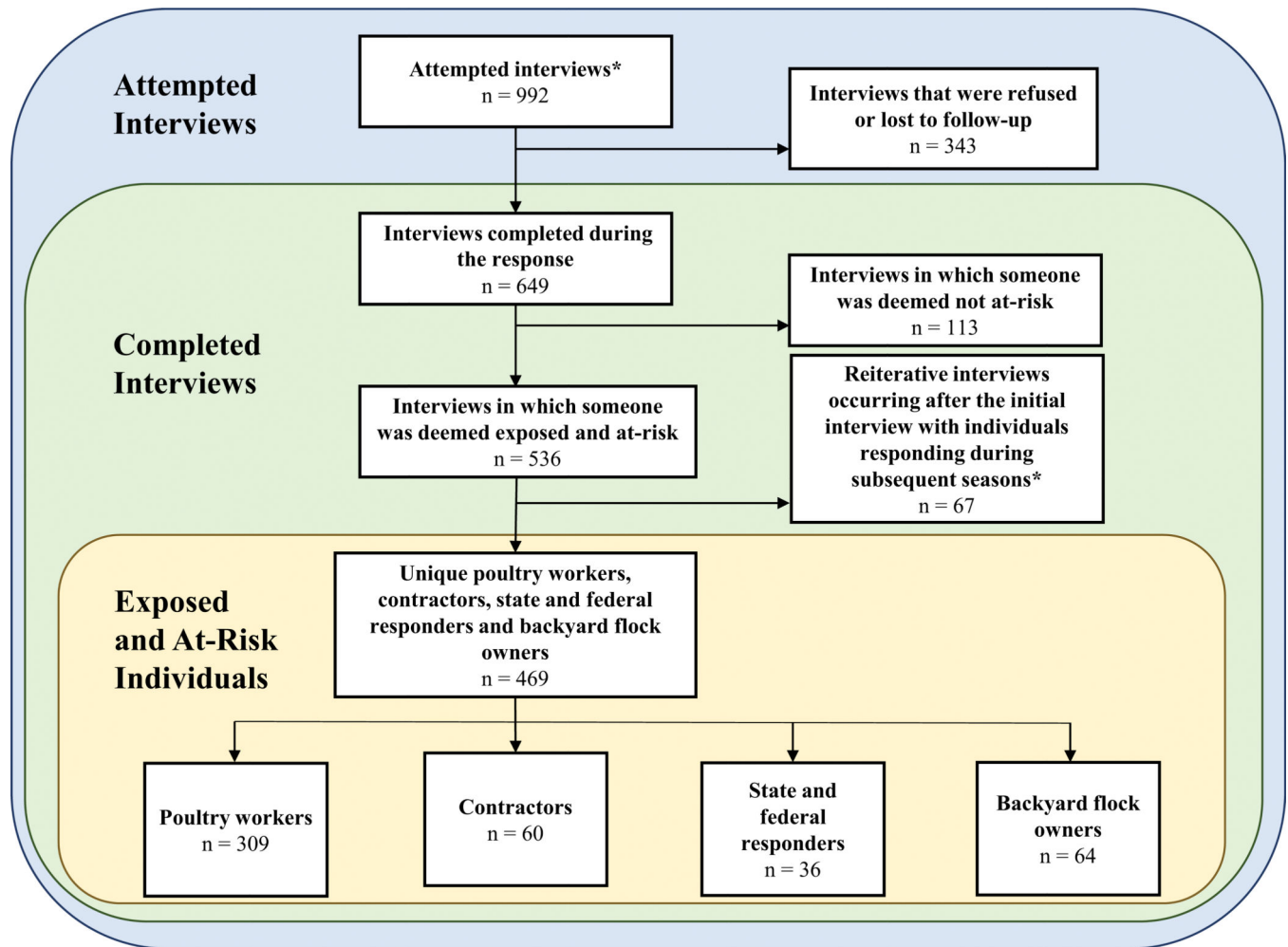


Figure 2.

Interview and exposure summary, HPAI H5N1 outbreak, Minnesota, 2022–2023.

*Individuals were only interviewed once per response season (ie. Spring 2022, Fall 2002, Spring 2003, Fall 2003). However, the same individual may have completed multiple interviews if they were exposed to poultry during subsequent seasons.

Table 1.
Occupational health monitoring, highly pathogenic avian influenza outbreaks, Minnesota, 2015 and 2022–2023.

Measure	2015 N (%)	2022–2023 N (%)	p-value ^e
Number of affected flocks	110	151	-
Number of birds that died of HPAI or were depopulated	8,894,004	6,337,820	-
Attempted Interviews	437	992	-
With poultry workers	435 (99.5)	635 (64.0)	-
With contractors	NA	218 (22.0)	-
With federal and state responders	NA ^a	75 (7.6)	-
With backyard flock owners	2 (0.5)	64 (6.4)	-
Lost to follow-up, refused, or unable to interview	60 (13.8)	343 (34.6)	<0.01
Poultry workers	60 (100.0)	196 (30.9)	<0.01
Contractors	NA ^a	134 (61.4)	-
Federal and state responders	NA ^a	13 (17.3)	-
Backyard flock owners	0 (0.0)	0 (0.0)	-
Completed Interviews	375 (85.8)	649 (65.4)	<0.01
Interviews in which the interviewee was deemed exposed and at risk ^{b,c,d,e}	375 (100.0)	536 (82.6)	-
Poultry workers	373 (99.4)	352 (65.7)	-
Contractors	NA ^a	71 (13.2)	-
State and federal responders	NA ^a	49 (9.1)	-
Backyard flock owners	2 (0.6)	64 (11.9)	-
English speaker interviews	310 (82.6)	535 (82.4)	0.92
Non-English speaker interviews	65 (17.3)	114 (17.6)	0.92
Spanish	35 (9.3)	102 (15.7)	<0.01
Karen	29 (7.7)	11 (1.7)	<0.01
Other language	1 (0.3)	1 (0.2)	0.80
Iterative re-interviews after the initial interview with individuals exposed on multiple premises (2015 only)	14	NA ^a	-
Iterative re-interviews occurring after the initial interview with individuals responding during multiple seasons (2022–2023 only)	NA ^a	67	-
Unique individuals deemed exposed and at risk	361 (86.2)	469 (52.7)	<0.01

^aData not available.

^q During the 2015 public health response, Minnesota Department of Health Zoonotic Diseases Unit (MDH ZDU) staff contacted, interviewed, and performed active disease surveillance (called “monitoring”) only for poultry workers. During the 2022–2023 response, MDH ZDU staff contacted, interviewed and monitored poultry workers, backyard flock owners, contract workers, and state and federal responders.

^c Interviewees were considered exposed and at risk if they had entered a barn with poultry on an HPAI test-positive premises in the 2 days before the first indication of illness in the birds or anytime thereafter (or) in the 2 days before the collection date of the first positive test samples or anytime thereafter.

^d During the 2015 public health response, MDH ZDU staff collected contact information only for the people who entered a poultry barn on an infected premise, and therefore everyone interviewed was categorized as “at risk.” During the 2022–2023 response, MDH ZDU staff received lists of all employees and others associated with an infected premise, including people who had not entered a poultry barn and were therefore categorized as “not at risk.”

^e Individuals were only interviewed once per response season (i.e. Spring 2022, Fall 2022, Spring 2023, Fall 2023). However, the same individual could have completed multiple interviews if they were exposed to poultry during subsequent seasons.

^e χ^2 or Fisher’s exact test used as appropriate for dichotomous variables. A p-value < .05 was considered significant.

Table 2.

Self-reported personal protective equipment (PPE) usage and seasonal flu vaccine among poultry workers and others exposed to infected birds, highly pathogenic avian influenza outbreaks, Minnesota 2015 and 2022–2023.

PPE component, Seasonal flu vaccine, or other occupational detail	Exposed poultry workers (2015) N = 359 n (%)	Exposed poultry workers (2022–2023) N = 309 n (%)	p-value ^d	All exposed individuals ^b (2022–2023) N = 469 n (%)
Coveralls	263 (73.3)	249 (80.6)	0.03	343 (73.1)
Gloves	291 (81.1)	239 (77.3)	0.24	376 (80.2)
Boots	297 (82.7)	285 (92.2)	<0.01	402 (85.7)
Mask or respirator of any kind	254 (70.8)	198 (64.1)	0.07	282 (60.1)
Eye protection	186 (51.8)	103 (33.3)	<0.01	168 (35.8)
Wearing full PPE ^c	186 (51.8)	74 (23.9)	<0.01	134 (28.6)
Wearing full PPE, excluding poultry workers employed by a turkey breeding facility ^d	N = 269 96 (35.7)	N = 257 59 (23.0)	<0.01	-
Seasonal Flu Vaccine	N = 281 132 (47.0)	N = 308 102 (33.1)	<0.01	N = 340 118 (34.7)

^a χ^2 used for dichotomous variables.

^b During the 2015 public health response, Minnesota Department of Health Zoonotic Diseases Unit (MDH ZDU) staff contacted, interviewed, and performed active disease surveillance (called “monitoring”) only for poultry workers. During the 2022–2023 response, MDH ZDU staff contacted, interviewed and monitored poultry workers, backyard flock owners, contract workers, and state and federal responders.

^c Full PPE use was defined as the consistent use of washable or disposable long-sleeved coveralls or Tyvek suit; rubber boots that could be disinfected or disposable plastic boots; washable or disposable head covering or Tyvek suit hood; latex or nitrile gloves; goggles; and an N95 respirator or KN95 respirator if an N95 respirator was not available.

^d Turkey breeding facilities typically require full PPE use, and thus were excluded from analysis.

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Table 3. Human respiratory disease testing, highly pathogenic avian influenza outbreaks, Minnesota, 2015 and 2022–2023.

	2015 ^a (n = 376)	2022–2023 ^b (n = 536)
Individuals reporting symptoms	20 (5.3)	45 (8.4)
Recommended testing	19 (95.0)	37 (82.2)
Individuals tested	15 (78.9)	24 (64.9)
Testing Results (+) H5 PCR	0	0
FluSC2		
Influenza A		
SARS-CoV-2 and Metapneumovirus	NA	1
SARS-CoV-2	NA	2
Respiratory Pathogen Panel		
Seasonal Coronavirus	NA	4
Bocavirus	NA	1
Rhinovirus/enterovirus	NA	2
Parainfluenza virus	NA	1
Stool culture		
<i>Campylobacter</i> spp.	NA	2

^aIn 2015, symptomatic interviewees who consented were tested only for Influenza A.

^bIn 2022–2023, symptomatic interviewees who consented were tested with a respiratory panel that included SARS-CoV-2 and Influenza A. All testing was performed at the Minnesota Department of Health Public Health Laboratory.