

Title: Evaluation of influenza dynamics in exhibition swine at jackpot shows
- **NPB #17-101**

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Industry Summary:

Pigs play a critical role in the ecology and epidemiology of influenza A viruses (IAVs) by serving as a source of novel reassortant viruses infecting humans. Agricultural fairs and livestock exhibitions create an environment conducive to zoonotic IAV transmission by commingling pigs and people for a prolonged period, resulting in a dramatic increase in the number of documented variant influenza A cases in people during 2011-2018. The epidemiological investigations into the 306 reported human cases of variant H3N2 influenza A (H3N2v) that occurred in 2012 linked the majority of them to human-swine exposure occurring at fairs. Research conducted by this study team provided molecular confirmation of zoonotic H3N2v transmission at county fairs in addition to evidence that IAV infections are common among apparently healthy swine at agricultural fairs.

H3N2v outbreaks in 2011-2016 show that swine infected with IAV at fairs and livestock exhibitions are a public health threat. Reducing zoonotic transmission of IAV between pigs and people is crucial to both agriculture and public health. Swine industry leaders and public health officials are seeking strategies to reduce intra- and inter- species transmission of IAV at swine exhibitions. The ultimate objective of this project was to provide new knowledge and insight into the dynamics of IAVs circulating in exhibition swine that can be used to make evidence based recommendations to prevent cases, outbreaks, epidemics, and/or pandemics caused by swine-to-human transmission of IAV occurring at agricultural fairs and livestock exhibitions. In order to achieve this objective, three specific aims were investigated:

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1) Estimate influenza A virus prevalence in exhibition swine at jackpot shows.

The scientific community currently has limited data about IAV activity among exhibition swine at jackpot shows. Last year we hypothesized that the prevalence of IAV at jackpot shows would be <5%, but overall we detected a 12% IAV prevalence in 3,754 pigs sampled across 21 jackpot shows during 2016. Interestingly, in one jackpot show we detected IAV in 47% of the pigs tested. While we found a higher IAV prevalence than expected, findings cannot be interpreted as normal or abnormal without additional data. Detecting 461 IAVs during the first year of this project indicates one year of surveillance is simply inadequate to estimate the IAV prevalence in exhibition swine at jackpot shows. In addition to providing insights into this understudied portion of the exhibition swine lifecycle, this aim aids the influenza research community by contributing data from active IAV surveillance in clinically healthy pigs, an identified gap in current swine IAV surveillance programs.

2) Evaluate influenza A virus evolution and transmission in exhibition swine.

Previous work has demonstrated that it is common to find similar IAVs at several fairs across a large geographic area. We suspect that pigs are becoming infected with IAV at jackpot shows, start shedding virus after the show, perpetuate viral transmission between additional naïve exhibition swine at future jackpot shows which eventually leads to index cases at local fairs. We hypothesized the IAV strains found in pigs at jackpot shows would be genomically similar to those strains found in pigs at agricultural fairs during the same year. Sequences of the IAV isolates recovered from pigs during Aim 1 are being used to test this hypothesis. While we are still performing the sequencing of viral isolates recovered during 2016, we have identified a H3N2 virus from a pig at a June 2016 jackpot show that is 99.95% identical (i.e. the same) to two of the 2016 human H3N2v cases. This isolate was recovered approximately one month prior to the start of the fair where the humans became infected, indicating the jackpot show likely played a role in propagating and disseminating the virus. It appears that controlling IAV at jackpot shows could have a major impact on IAV transmission within the exhibition swine population. Thus, decreased IAV transmission during jackpot shows would likely reduce the IAV prevalence at downstream agricultural fairs providing protection to public health.

3) Evaluate compliance with recommendations from animal and public health officials.

This new aim for 2017 is based on the feedback received from the Public Health Committee. The National Assembly of State Animal Health Officials and National Association of State Public Health Veterinarians have released several recommendations for swine exhibitors and show organizers in a document entitled *Measures to Minimize Influenza Transmission at Swine Exhibitions*. We hypothesize that while recommendations are being made, swine exhibitors are either unaware or reluctant to adopt the changes in recommended swine management practices. Understanding exhibitors' perception of the recommendations and barriers to adoption is critical because exhibitor compliance with proposed mitigation strategies is key to decreasing the disease burden in swine, thus reducing the risk of IAV transmission from pigs to people.

In order to estimate the prevalence of IAV among swine at jackpot shows, nasal wipes were collected from 53-600 pigs per show at 22 selected jackpot shows, resulting in 3,665 samples. Nasal wipes were used in this study because, although not as sensitive as nasal swabs, they provide a sample collection method without the need for pig restraint. Based on the estimated distribution of exhibition swine in the Midwestern United States, jackpot shows occurring in Iowa, Illinois, Indiana, Ohio, Kentucky, and Michigan were included. The shows will never be identified by name and will not appear by name in any publication. Exhibitor identities were not collected thus results could never be traced back to any of the animals, individuals, or farms.

Overall, 5% of samples tested from swine at jackpot shows were positive for viable influenza A virus. In comparison, 9.5% of exhibition swine tested during the 2017 agricultural fair season were shedding active influenza A virus. The reduced prevalence of IAV in pigs within the jackpot circuit as compared to agricultural fairs could be due to the shortened period of time in which the pigs are co-mingled. A majority of jackpot shows are one to two days, with many pigs being housed within trailers rather than exhibition barns to minimize contact with other animals and their infectious diseases. A decrease in IAV prevalence due to the shortened show duration could be extrapolated as the effects of implementing a 72 hour rule at agricultural fairs, as is recommended in the “Measures to Minimize Influenza at Swine Exhibitions” document. Disseminating related data through relationships built through sample collection activities could elicit change throughout the swine exhibition network as individuals see the impact paradigm shifts could have on animal and public health at their local swine exhibitions.

For more information regarding the outcome of this study please visit our website at www.go.osu.edu/vetfluresearch

Keywords: influenza A virus, exhibition swine, nasal wipe, transmission, zoonotic

Scientific Abstract:

Pigs play a critical role in the ecology and epidemiology of influenza A viruses (IAVs) by serving as a source of novel reassortant viruses infecting humans. Agricultural fairs and livestock exhibitions create an environment conducive to zoonotic IAV transmission by commingling pigs and people for a prolonged period of time, resulting in a dramatic increase in the number of documented variant influenza A cases in people during 2011-2017. The epidemiological investigations into the 306 reported human cases of variant H3N2 influenza A (H3N2v) that occurred in 2012 linked the majority of them to human-swine exposure occurring at fairs. Research conducted by this study team provided molecular confirmation of zoonotic H3N2v transmission at county fairs in addition to evidence that IAV infections are common among apparently healthy swine at agricultural fairs.

H3N2v outbreaks in 2011-2017 show that swine infected with IAV at fairs and livestock exhibitions are a public health threat. Reducing zoonotic transmission of IAV between pigs and people is crucial to both agriculture and public health. Swine industry leaders and public health officials are seeking strategies to reduce intra- and inter- species transmission of IAV at swine exhibitions. The ultimate objective of this project was to provide new knowledge and insight into the dynamics of IAVs circulating in exhibition swine that can be used to make evidence based recommendations to prevent cases, outbreaks, epidemics, and/or pandemics caused by swine-to-human transmission of IAV occurring at agricultural fairs and livestock exhibitions.

In order to estimate the prevalence of IAV among swine at jackpot shows, nasal wipes were collected from 53-600 pigs per show at 22 selected jackpot shows, resulting in 3,665 samples. Overall, 5% of samples tested from swine at jackpot shows were positive for viable influenza A virus. In comparison, 9.5% of exhibition swine tested during the 2017 agricultural fair season were shedding active influenza A virus. The reduced prevalence of IAV in pigs within the jackpot circuit as compared to agricultural fairs could be due to the shortened period of time in which the pigs are co-mingled. A majority of jackpot shows are

one to two days, with many pigs being housed within trailers rather than exhibition barns to minimize contact with other animals and their infectious diseases. A decrease in IAV prevalence due to the shortened show duration could be extrapolated as the effects of implementing a 72 hour rule at agricultural fairs, as is recommended in the “Measures to Minimize Influenza at Swine Exhibitions” document.

In an effort to mitigate risk associated with exposure to IAV in swine through these events, the recommendation document “Measures to Minimize Influenza Transmission at Swine Exhibitions” was developed to be used by show organizers, volunteers, and exhibitors. These recommendations are updated and released each year; however, it is not clear if youth swine exhibitors are aware of the recommendations; support the recommendations; and would be willing to practice recommended behaviors. Therefore, a cross-sectional survey method was used to understand swine exhibitor perceptions and their adoption of swine production practices aimed at reducing the transmission of IAV at the human-animal interface. The instrument created consisted of 11 recommendations put forth in the “Measures...” document. Each statement was followed by three to six statements regarding the participant’s perception of the recommendation, their opinion of their ability to implement the recommendation, and their current behavior related to the recommendation. In addition, the survey asked participants their state of residence and the number of shows they would attend in 2017. In all, 155 participants who showed swine on a regular basis (\bar{x} =11 shows per year), from at least 18 states within the US, completed the survey. At least 67% of participants believed each statement was a good recommendation, with 6 of 11 recommendations being supported by >90% of participants. When asked if recommendations could be implemented, 65-94% of respondents agreed, and 21-89% of participants had already implemented each recommendation, respectively. Although significant efforts have been made to increase signage at swine exhibitions warning of risks associated with eating/drinking in animal areas, a majority of respondents report eating/drinking in the barn and are unwilling to change their behaviors. This study provides evidence that developing and disseminating static recommendations to reduce zoonotic disease transmission is not enough to change human behavior and interactive methods must be deployed to preventive future variant IAV infections associated with swine exhibitions.

Introduction:

Zoonotic transmission of influenza A virus (IAV) threatens economies and public health worldwide. In United States, seasonal strains of IAV commonly cause epidemics of acute respiratory disease in the human population resulting in an estimated 200,000 hospitalizations and 36,000 deaths annually (1). The emergence of novel IAV strains with pandemic potential present an even greater risk to public health. Interspecies transmission of IAV is believed to a principal mechanism contributing to emergence of novel IAV strains that threaten public health (2, 3); therefore, controlling IAV in animal populations is critical to protecting public health.

The negative-sense, single-stranded, segmented RNA genomes of IAV allow for continual antigenic drift and antigenic shift to occur. While antigenic drift is a

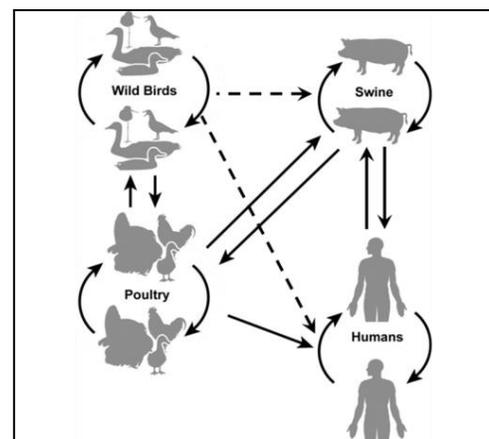


Fig. 1. Reassortment between avian, swine and human influenza A viruses can occur in pigs, and thus pigs have been labeled as a “mixing vessel” for influenza A viruses. Additionally, swine-origin influenza A viruses are capable of infecting humans.

- Solid lines between species:**
Confirmed interspecies transmission
- Solid lines within species:**
Intraspecies maintenance cycle
- Dotted lines between species:**
Suspected interspecies transmission

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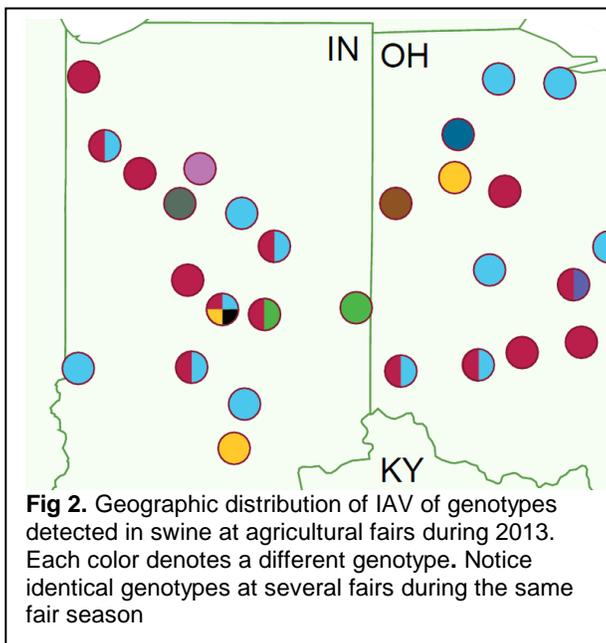
gradual evolutionary process, antigenic shift, caused by genomic reassortment, can result in the rapid emergence of novel IAVs. Influenza A viruses can infect a wide range of hosts including humans, pigs, and many avian species, but due to their susceptibility to multiple IAV strains pigs, as depicted in Figure 1, have been called ‘mixing vessels’ for IAVs (4). If a pig is simultaneously infected with greater than one IAV strain, reassortment and a novel strain generation can occur (5). Novel IAV strains produced by genomic reassortment in pigs could be potentially maintained in swine and/or transmitted to humans or another host species (6).

Swine-to-human transmission of IAV has been documented periodically worldwide (7) and has recently received considerable publicity following the H3N2 variant IAV (H3N2v) outbreaks of 2011-2014. Transmission of IAV between pigs and people generally requires a swine-human interface that allows for close contact between swine and humans. In North America, approximately 150 million people attend agricultural fairs each year (International Association of Fairs & Expositions, personal communication) making these settings the most heavily human populated swine-human interfaces in the world. Fairs and exhibitions allow many people from diverse backgrounds, whom would not otherwise have any exposure to swine, to have direct and indirect contact with pigs and the pathogens they might harbor.

Agricultural fairs and livestock exhibitions are locations where pigs from various production systems (backyard to commercial) are comingled and concentrated at one site. Factor in the large number of people who are exposed to pigs at fairs and it becomes apparent that the swine-human interface at livestock exhibitions has increased potential for zoonotic transmission of influenza A virus. During 2012, 306 cases of H3N2v were documented (8) with thousands more believed to have gone unreported (9). Most of the people who became infected with H3N2v had significant swine exposure occurring at agricultural fairs and livestock exhibitions. Data from the H3N2v outbreaks show children have the highest risk of infection with H3N2v (10), which is particularly concerning because the vast majority of exhibition pigs are being shown as part of youth agricultural education programs (4-H and FFA). While human-to-human transmission of H3N2v was limited,

people infected at livestock exhibitions may serve as a pathway to disseminate swine-origin influenza A viruses in their local community (11).

As depicted in Figure 2, ongoing surveillance of IAV in exhibition swine at agricultural fairs over the past 6 years has frequently detected genetically related IAV strains at several geographically disperse fairs within a single fair season (12, 13). The nearly simultaneous appearance of such similar strains at several fairs suggests a common source of IAV, rather than fair-to-fair-to-fair dissemination of virus. Identifying a common source(s) of the virus may allow for the implementation of pre-fair interventions to limit the introduction of IAV to agricultural fairs and ultimately protect public health.



Objectives:

Swine infected with IAV at agricultural exhibitions are a public health threat, as demonstrated by previous zoonotic transmission occurring in these settings. Thus, decreasing the overall IAV prevalence in exhibition swine is paramount to protecting public health. Exhibition swine are shown at agricultural fairs but may also be shown multiple times across locations at exhibitions that are open to all competitors (also known as ‘jackpot shows’). The vast majority of previous IAV surveillance in exhibition swine has focused on agricultural fairs but little surveillance has occurred at jackpot shows, creating a major gap in understanding IAV dynamics in exhibition swine. The central hypothesis of this project is that IAV is circulating among pigs exhibited at jackpot shows, and that these exhibitions represent critical control points for limiting IAV in the life cycle of exhibition swine. The following three aims were proposed to gather scientific data regarding IAV dynamics at jackpot shows to develop improved mitigation strategies to protect public health.

1) Estimate influenza A virus prevalence in exhibition swine at jackpot shows.

The scientific community currently has limited data about IAV activity among exhibition swine at jackpot shows. Last year we hypothesized that the prevalence of IAV at jackpot shows would be <5%, but overall we detected a 12% IAV prevalence in 3,754 pigs sampled across 21 jackpot shows during 2016. Interestingly, in one jackpot show we detected IAV in 47% of the pigs tested. While we found a higher IAV prevalence than expected, findings cannot be interpreted as normal or abnormal without additional data. Detecting 461 IAVs during the first year of this project indicates one year of surveillance is simply inadequate to estimate the IAV prevalence in exhibition swine at jackpot shows. In addition to providing insights into this understudied portion of the exhibition swine lifecycle, this aim aids the influenza research community by contributing data from active IAV surveillance in clinically healthy pigs, an identified gap in current swine IAV surveillance programs.

2) Evaluate influenza A virus evolution and transmission in exhibition swine.

Previous work has demonstrated that it is common to find similar IAVs at several fairs across a large geographic area. We suspect that pigs are becoming infected with IAV at jackpot shows, start shedding virus after the show, perpetuate viral transmission between additional naïve exhibition swine at future jackpot shows which eventually leads to index cases at local fairs. We hypothesized the IAV strains found in pigs at jackpot shows would be genomically similar to those strains found in pigs at agricultural fairs during the same year. Sequences of the IAV isolates recovered from pigs during Aim 1 are being used to test this hypothesis. While we are still performing the sequencing of viral isolates recovered during 2016, we have identified a H3N2 virus from a pig at a June 2016 jackpot show that is 99.95% identical (i.e. the same) to two of the 2016 human H3N2v cases. This isolate was recovered approximately one month prior to the start of the fair where the humans became infected, indicating the jackpot show likely played a role in propagating and disseminating the virus. It appears that controlling IAV at jackpot shows could have a major impact on IAV transmission within the exhibition swine population. Thus, decreased IAV transmission during jackpot shows would likely reduce the IAV prevalence at downstream agricultural fairs providing protection to public health.

3) Evaluate compliance with recommendations from animal and public health officials.

This new aim for 2017 is based on the feedback received from the Public Health Committee. The National Assembly of State Animal Health Officials and National Association of State Public Health Veterinarians have released several recommendations for swine exhibitors and show organizers in a document entitled *Measures to Minimize Influenza Transmission at Swine Exhibitions*. We hypothesize that while recommendations are being made, swine exhibitors are either unaware or reluctant to adopt the changes in recommended swine management practices. Understanding exhibitors' perception of the recommendations and barriers to adoption is critical because exhibitor compliance with proposed mitigation strategies is key to decreasing the disease burden in swine, thus reducing the risk of IAV transmission from pigs to people.

Materials & Methods

Objective 1-2

In order to estimate the prevalence of IAV among swine at jackpot shows, nasal wipes were collected from 53-600 pigs per show at 22 selected jackpot shows, resulting in 3,665 samples. Nasal wipes were used in this study because, although not as sensitive as nasal swabs (17), they provide a sample collection method without the need for restraint to fill this critical knowledge gap. Based on the estimated distribution of exhibition swine in the Midwestern United States, jackpot shows occurring in Iowa, Illinois, Indiana, Ohio, Kentucky, and Michigan were included. The shows will never be identified by name and will not appear by name in any publication. Exhibitor identities were not collected thus results could never be traced back to any of the animals, individuals, or farms.

Samples were frozen at -80°C and held for 30 days post-show before testing was conducted. This protocol is designed to lessen negative implications of the test results (i.e., the show season is over and any threat is already long gone by the time results are available). Samples were screened with the USDA validated rRT-PCR protocol and positive samples (Ct≤40) were inoculated into MDCK cells for virus isolation (19). All hemagglutinating agents were screened for the presence of IAV using a commercially available rapid antigen detection kit. Influenza A virus isolates were submitted to the J. Craig Venter Institute for full-length genomic sequencing using previously described protocols (20).

Objective 3

Instrumentation

The instrument created consists of 11 recommendations put forth in the "Measures..." document. Example statements include: *Clean and disinfect all tack, feeders, waterers, and show supplies between shows; Wash your hands with soap and water when you leave the barn; and No food or drink in animal areas*. Each statement is followed by three to six statements regarding the participant's perception of the recommendation, their opinion of their ability to implement the recommendation, and their current behavior related to the

recommendation. In addition, the survey asks participants which state they reside, and the number of shows they will attend in 2017.

Validity of Instrument

Face and content validity were established by a review of a panel of virology experts and young adults involved in public health and agricultural education. Panel members with expertise in virology and agricultural education reviewed the instrumentation to ensure the content measured characteristics it was intended to measure; content validity. All panel experts reviewed for face validity, or the overall appearance of the instrument. Panel of Experts included:

1. Dr. Andrew Bowman – Virology and veterinary medicine expert to assess scientific background
2. Ms. Sarah Lauterbach - Virology and veterinary medicine expert to assess scientific background
3. Dr. Josh Lorbach – Virology and veterinary medicine expert to assess scientific background
4. Ms. Elena Mircoff – Masters of Public Health Student to assess public health relatedness
5. Ms. Sarah Nelson – Virology and veterinary medicine expert to assess scientific background
6. Ms. Hannah Cochran – Young adult involved in agricultural education to determine age level appropriateness
7. Ms. Rachel Patton– Young adult involved in agricultural education to determine age level appropriateness

Study Sample

Surveys were collected from jackpot swine exhibitors, ages 3-21, regarding their perceptions and behaviors related to recommendations in the “Measures to Minimize Influenza Transmission at Swine Exhibitions” document.

Data Analysis

Deductive reasoning was used to determine if themes of support in accordance with recommendations exist among swine jackpot exhibitors. Content analysis was used to gain insight in the perceptions and behaviors of jackpot swine exhibitors. Frequencies were calculated using SPSS and used to compare the number of shows attended and the state distributions of respondents.

Results

Objective 1

Jackpot show organizers, including jackpot circuit organizers, were contacted at the onset of the this project period to explain the objectives of the project; to discuss the benefits of gaining knowledge regarding the presence of IAV in swine shown at jackpot shows; and to devise sampling protocols appropriate for each individual show event. In all, 22 jackpot show events agreed to participate in the study including two national shows sponsored by the National Swine Registry, one national show sponsored by Team Purebred,

eight Ohio shows included in the OH-Pig circuit, six shows included in the Michigan Swine Youth Challenge, and five shows held in Indiana. At each show event, study team members collected nasal wipes from individual pigs along with the zip code of the pig owner. A total of 3,665 nasal wipes were collected resulting in 585 (16%) rRT-PCR positives ($cT \leq 40$) and 187 (5%) IAV isolates.

Objective 2:

All isolates recovered from objective one activity have been submitted for full-length genomic sequencing completion to identify the viral genotypes present at jackpot shows participating in this study. Sequencing is ongoing for the influenza A viral isolates. Upon completion, these sequences will be used to support or refute the hypothesis that IAV strains circulating in exhibition swine during the jackpot show season will match those IAV strains circulating in exhibition swine during the agricultural fair season.

Objective 3

In all, 155 jackpot show participants in the OH-Pigs jackpot circuit, the Showpigs.com All-Star camp, and World Pork Expo who showed swine on a regular basis ($\bar{x} = 11$ shows per year), from at least 18 states within the US, completed the survey (Table 1). At least 58.7% of participants believed each statement was a good recommendation, with 5 of 11 recommendations being supported by >85% of participants. When asked if recommendations could be implemented, 54-82% of respondents agreed, and 36-93% of participants had already implemented each recommendation, respectively. Recommendations that have been widely adopted by respondents include; avoidance of sick pigs or people attending shows (90%) and disinfecting equipment between shows (88%). The recommendations not being implemented commonly by respondents include; not eating and drinking in animal areas (19%), reporting sick pigs to show organizers (36%), and isolating animals when they are taken home after a show (45%). Details for the responses to each survey item are listed in Table 2.

Table 1. Number of survey respondents representing each state included in the study.

State	No. Surveys
Arkansas	2
Arizona	5
California	1
Florida	4
Georgia	2
Iowa	1
Idaho	1
Illinois	2
Indiana	4
Kansas	1
Michigan	5
Minnesota	2
Missouri	6
Nebraska	1
Ohio	99
Oklahoma	9
Texas	5
West Virginia	1
Unknown	4
Grand Total	155

Table 2. Summary of swine jackpot exhibitor perceptions and opinions of the recommendations put forth in the Measures to Minimize Influenza Transmission at Swine Exhibitions document.

Survey Question	Yes/Total (%)	No/Total (%)
<i>Clean and disinfect all tack, feeders, waterers, and show supplies between shows.</i>		
I think this is a good recommendation	137/155 (88.4)	3/155 (1.9)
I can implement this recommendation	125/155 (80.6)	9/155 (5.8)
I disinfect all equipment between shows	74/155 (47.7)	70/155 (45.2)

Wash your hands with soap and water when you leave the barn.

I think this is a good recommendation	135/155 (87.1)	5/155 (3.2)
I can implement this recommendation	124/155 (80)	11/155 (7.1)
I wash my hands after I have contact with pigs	106/155 (92.3)	37/155 (23.9)

No food or drink in animal areas.

I think this is a good recommendation	91/155 (58.7)	45/155 (29)
I can implement this recommendation	89/155 (57.4)	45/155 (29)
I eat and/or drink in animal areas	115/155 (74.2)	30/155 (19.4)

Allow at least 7 days of “down time” (i.e. on-farm quarantine) after returning from a previous show before showing a pig or pen-mates, to reduce the risk of spreading influenza.

I think a 7 day down time is a good recommendation	110/155 (71)	26/155 (19.1)
I can implement a 7 day downtime	83/155 (53.5)	45/155 (29) 55/155
My pigs are at home for at least 7 days in between shows	76/155 (49)	(35.5)
I think it is a good day to isolate pigs returning home	112/155 (72.3)	20/155 (12.9)
I can implement isolation for pigs returning home	90/155 (58.1)	40/155 (25.8)
I do isolate pigs for at least 7 days when they return home	69/155 (44.5)	68/155 (43.9)

Discuss the use of swine influenza vaccines with a veterinarian and check the show rules for any requirements.

I think this is a good recommendation	130/155 (83.9)	7/155 (4.5)
I can implement this recommendation	121/155 (78.1)	11/155 (7.1)
My pig (s) were vaccinated for influenza	111/155 (71.6)	22/155 (14.2)
I have/will attend a show that requires influenza vaccination for pigs	94/155 (60.6)	29/155 (18.7)

Consult a veterinarian to help outline and implement applicable biosecurity and swine health practices at home.

I think this is a good recommendation	133/155 (85.8)	5/155 (3.2)
I can implement this recommendation	117/155 (75.5)	10/155 (6.5)

A veterinarian has visited my farm in the last 12 months

16/155
(10.3)

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Sick pigs and sick people need to stay home so they do not risk infecting other pigs or people.

I think this is a good recommendation	139/155 (89.7)	3/155 (1.9)
I can implement this recommendation	127/155 (81.9)	11/155 (7.1)
I have taken a sick pigs to a show	29/155 (18.7)	101/155 (65.2)
I have gone to a show when I've been sick myself	52/155 (33.5)	79/155 (51)

Avoid sharing tack with other exhibitors, but if you must, clean and disinfect in-between uses.

I think this is a good recommendation	123/155 (79.4)	18/155 (11.6)
I can implement this recommendation	110/155 (71)	22/155 (14.2)
I have shared tack at shows	88/155 (56.8)	43/155 (27.7)
I disinfect shared tack	71/155 (45.8)	62/155 (40)

No sleeping in animal areas.

I think this is a good recommendation	103/155 (66.5)	35/155 (22.6)
I can implement this recommendation	87/155 (56.1)	44/155 (33.6)
I sleep in animal areas	71/155 (45.8)	64/155 (41.3)

Report sick pigs to exhibition organizers

I think this is a good recommendation	129/155 (83.2)	16/155 (10.3)
I can implement this recommendation	109/155 (70.3)	20/155 (12.9)
I have reported sick pigs to show organizers	56/155 (36.1)	74/155 (47.7)

Become familiar with the clinical signs of influenza and other illnesses in pigs.

I think this is a good recommendation	136/155 (87.7)	1/155 (0.6)
I can implement this recommendation	123/155 (79.4)	8/155 (5.2)
I can recognize influenza in pigs	100/155 (64.5)	40/155 (25.8)

Discussion

This project directly addresses National Pork Board's call for research focused on producer/public health and zoonotic disease (Influenza section, priorities c). The pork industry knows that exhibition swine comprise a small subset of the U.S. swine population and for the most part are not representative of the commercial pork industry. However, fairs and exhibitions often serve as the face of agriculture to the general public and for many people there are the only opportunities to see, touch, and interact with pigs. Many consumers cannot and do not differentiate show pigs from commercial swine; thus, exhibition swine are a very visible image of the overall swine industry. Repeated swine-to-human IAV transmission in these settings damages the public perception of the industry and causes consumers to question if pork is wholesome, healthy, and safe. Large-scale erosion of consumer confidence can have significant financial ramifications for U.S. pork.

While the potential for financial damage from zoonotic IAV transmission at agricultural fairs presents an immediate threat to the pork industry, the long term impacts of repeated variant influenza linked to exhibition swine hit a little closer to home. To date, the bulk of the variant influenza A cases have been swine exhibitors, many of whom are relatives and/or friends of pork producers. Agricultural education programs such as 4-H and FFA serve as a great way to introduce youth to pork production and establish an interest in the industry. It is highly likely that today's youth swine exhibitors will be the next generation of U.S. pork producers and are the future of the industry. Given the unprecedented level of swine-to-human IAV transmission that occurred at fairs during 2011-2016, several public health officials have called for a total ban on swine exhibitions to protect public health, as seen in poultry exhibition in 2015 due to the threat of avian influenza. The loss of swine exhibitions will decrease youth interest in pork production as a career and will further separate the public from agriculture. We agree that the public health threat from swine-to-human transmission of IAV at fairs is significant and concerning, but we propose a moderated approach to improve public health while still protecting the educational value of agricultural fairs. This project sought to better understand IAV dynamics among exhibition swine in order to suggest proactive management changes to ensure the continuation of swine exhibitions in a responsible manner.

Swine jackpot shows included in the study occurred in the late spring/early summer, largely prior to the start of the agricultural fair season. Unlike fairs, jackpot shows are not attended by the public but rather by individuals involved in breeding, raising, and showing exhibition swine, thus reducing the public health threat of IAV circulating in these pigs. Transmission of influenza A viruses, or other pathogens, within this population of exhibition swine could allow for widespread dissemination of infectious agents to local swine populations. Identifying the vast swine movement occurring within this exhibition network indicates the impact a virus of interest could have on localities across the US. Gaining better understanding of the exhibition network and the virus that are circulating within the network could lead to mitigation strategies which could reduce viral load present at agricultural fairs.

The reduced prevalence of IAV in pigs as shown in 2016 and 2017, within the jackpot circuit as compared to agricultural fairs could be due to the shortened period of time in which the pigs are co-mingled. A majority of jackpot shows are one to two days, with many pigs

being housed within trailers rather than exhibition barns to minimize contact with other animals and their infectious diseases. A decrease in IAV prevalence due to the shortened show duration could be extrapolated as the effects of implementing a 72-hour rule at agricultural fairs, as is recommended in the “Measures to Minimize Influenza at Swine Exhibitions” document. Disseminating related data through relationships built through sample collection activities could elicit change throughout the swine exhibition network as individuals see the impact paradigm shifts could have on animal and public health at their local swine exhibitions.

Understanding the opinions and perceptions of swine exhibitors toward recommendations to mitigate disease is essential in directing further mitigation. Swine jackpot participants and their parents were the target population for this study because they generally were more heavily involved in the show swine industry. Individuals show pigs at the county fair level, likely have very few pigs and attend only 1-2 shows per year however, the families included in this study reported attending an average of 11 shows per year, with a range of 2 to 37 shows (Bliss, 2017). This increased level of show activity allows more opportunity for these individuals to adopt mitigation strategies recommended by animal and public health officials. It also increases their risk for exposure to zoonotic disease, potentially increasing their favoritism toward mitigation. Thus, the results found in this study may be skewed toward being a more positive view of the recommendations, as compared to individuals who only compete at local fairs.

Besides targeting this population based on the number of shows they attend, swine jackpot participants were also targeted because they are considered experts at the local level and local show pig enthusiasts seek after their advice. If the experts consider the recommendations favorable and adopt the practices, they are more likely to encourage local level showman to do the same. This trickle down approach to knowledge dissemination saves time and resources by spreading the information rapidly across large geographic areas. Individuals who show at the local level may be more willing to adopt practices that reduce disease transmission if they are recommended by other swine producers rather than regulatory or university personnel.

Variant influenza A virus cases have not been reported in swine jackpot participants, as they have been reported in county fair swine exhibitors (Schicker, 2016). This could be attributed to many factors including; increased biosecurity, increased knowledge, shortened length of show exposure, or differences in the viruses circulating within the swine populations. It has been shown in a fair setting, that the prevalence of swine shedding IAV is <30% at 72 hours post arrival whereas IAV prevalence can be over 90% by the seventh day of the fair (Bowman, unpublished data). Because jackpot shows typically last 1 -3 days, the prevalence of IAV in the pigs stays relatively low during the show, thus decreasing the exposure jackpot participants may have to IAV. However, these individuals are also more likely to be raising swine full time, rather than purchasing only a few head to show at a local fair, and therefore may have exposures during animal husbandry away from show atmospheres. In addition, the strains of IAV circulating among swine at jackpot shows is genetically nearly identical to virus strains circulating among fair pigs, therefore the difference in variant cases is likely not due to viral strain (Bowman, unpublished data). The differences seen are then likely due to increased biosecurity or knowledge of the risks associated with zoonotic diseases.

The “Measures to Minimize...” document has been disseminated across the country through extension and health officials; however, the breadth of impact it has made is currently unknown. Survey results indicate that 19 – 92% of respondents have already

implemented the respective recommendations included on the questionnaire. Whether they implemented these practices because they saw the specific recommendation in the “Measures...” document or because they gained, knowledge through some other venue is still unknown, however it is important to document the practices currently being followed by the show swine industry. This knowledge can be used to lead further investigation into behavior changes that could prevent animal – human transmission of zoonotic diseases.

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