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JSHAP SPOTLIGHT

Dr Daniel Linhares

Iowa State University

Dr Daniel Linhares earned a DVM ('03) from Universidade Federal de Goias, an MBA ('07) from Fundacao Getulio Vargas, and a PhD ('13) from the University of Minnesota. Dr Linhares is currently an Associate Professor and the Director of Graduate Education at Iowa State University. In these roles, he interacts with the swine industry and graduate students to develop and evaluate strategies to prevent, detect, or manage infectious diseases affecting swine populations under field conditions. Dr. Linhares is pleased to serve on the JSHAP Editorial Board and has learned a lot through interaction with the JSHAP team and reviewers. He encourages contributing authors to remember the JSHAP target audience – practicing veterinarians and producers thirsty for applied science and evidence-based recommendations.

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We're all in this together!

I am writing this message just after returning from the AASV Annual Meeting in Indianapolis. It was great to greet old friends and colleagues, and even more exciting to meet new friends and colleagues. It is these friends and colleagues that many of us reach out to and rely upon for professional and personal support. Throughout life we have all had people who have made a special effort to support us through both good and challenging times. This support can come in many forms depending on the situations of both those giving and receiving the support.

Support can come in the form of a mentor, or an experienced and trusted adviser. Most think of a mentor in the classic term of someone who is older than the mentee. While this is often the case, a mentor can be anyone with a specific skill or experience that the mentee would like to develop under their guidance. In the spirit of lifelong learning, many choose to specialize, or gain increased knowledge in specific areas. These learnings can be more formalized such as a graduate degree or certification program, or informal self-study. No matter what approach you choose, the presence of an experienced, engaged mentor is key to success. A trusted mentor must be a good listener to best understand the goals of the individual while asking questions that challenge potentially limiting assumptions. A mentor should be empathetic, and at the same time, provide encouraging, honest feedback. How do you find a mentor? Usually it is up to the individual to identify someone they feel would be a good mentor, and then contact them. This can be intimidating, especially if there is not an existing relationship. Asking for an introduction from a mutual peer may help lessen the anxiety of the process. Fortunately, the AASV Early Career Committee has started to formalize a plan to establish a mentorship program. Consider participating and share your knowledge and experiences with others within AASV.

The impact of various stressors on our mental health is a real challenge, and not unique to our profession. For many individual reasons, the ability to openly discuss our own mental health, or the mental health of another with family or colleagues is uncomfortable. The American Psychiatric Association states that more than half of people with mental illness do not receive help for their disorders, often due to concerns about being treated differently or fear of losing their employment.[1] This is because stigma against those with mental illness is still a problem. How do we as an organization continue the discussion and move towards removing this stigma? Stigma usually comes from lack of understanding or fear of what we do not understand. Research shows that knowing or having contact with someone with mental illness is one of the best ways to reduce stigma.[1] Although these conversations are uncomfortable and difficult, sharing with a peer makes it less uncomfortable for the person sharing, and now more relatable and real for the person listening. We need to continue to have conversations regarding mental health including educational opportunities as an organization so that these conversations continue to become more normal. Both the AASV and AVMA have well-being resources available to begin increasing your personal knowledge that I have found to be very helpful, and I encourage you to review them.

"Reach out, be willing to listen, and give back. Remember, we're all in this together!"

aasv.org/Resources/Wellbeing/index.php

avma.org/resources-tools/wellbeing

The peer support that I have received from members of AASV has been invaluable to me personally and professionally. From my first mentor, Dr David Schoneweis inviting me to ride along to my first AASP meeting in Minneapolis, to other mentors and many of you who have always been there to talk or listen when needed, thank you for always being there. I am sure many of you also can describe similar experiences of tremendous peer support that members of AASV have provided to you. Reach out, be willing to listen, and give back. Remember, we're all in this together!

Mike Senn, DVM, MS
AASV President

Reference

1. Stigma, prejudice and discrimination against people with mental illness. American Psychiatric Association. August 2020. Accessed March 14, 2022. **https://www.psychiatry.org/patients-families/stigma-and-discrimination**

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1: Perri A et al. An investigation of iron deficiency and anemia in piglets and the effect of iron status at weaning on post-weaning performance. JSHAP. 2016;24:10–20.

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3: Olsen, C. (2019) The economics of iron deficiency anemia on US swine production: An annual impact of 46-335 million US dollars. American Association of Swine Veterinarians. Orlando. Florida.

* Industry Standards for Blood Hb Levels (g/L)

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PHARMACOSMOS

PM-060-00

Fist bumps and hugs

The 53rd AASV Annual Meeting is all in, all done. Well, that is not quite true. We still must wrap up all the statistics and get everyone paid, but at least our time in Indianapolis is over for 2022. It was great to see everyone in person! While I think the 2021 virtual format was a very effective mechanism for the exchange of scientific information, it certainly lacked the personal interaction that we all value so much at the Annual Meeting. That is why we all show up, right?

The feedback we received during the meeting was very positive. Yes, there were a few glitches and disruptions. There always are. Our goal as staff is to keep those behind the scenes and minimize the distraction for you, the attendees. I hope that we accomplished that for the most part. Everyone seemed happy and eager to catch up with old friends.

The AASV Annual Meeting has been fortunate through the COVID-19 outbreak. As you will recall, we left Atlanta in 2020 just as COVID-19 hit the United States and a few short days before everything shut down. In 2021, we went virtual like everyone else; we did not really have a choice. So, as we planned to return to an in-person format in 2022, we were unsure what attendance would look like.

We felt confident, however, that our membership was anxious to get off Zoom and experience a real-world happy hour again.

The contracts for our Annual Meeting are negotiated years in advance. At that time, we commit to a certain number of room nights and a food and beverage minimum based on projected attendance. If we do not meet the room night or food and beverage quotas, the AASV can be charged for the difference. It is always a guessing game. The contract for the 2022 meeting was signed in 2018, when attendance at the meeting was showing a steady increase year over year and attendance projections were based on that trend. Then, COVID-19 hit in 2020 and everyone knows the impact that had on large gatherings and travel.

Unfortunately, not everyone was able to attend this year's meeting in person due to illness, concern about exposure, or travel restrictions. Travel restrictions significantly impacted our international attendance, which normally accounts for approximately 22% of our overall meeting participants. Although 16 countries were represented this year, international attendance was less than 10%. In addition, we do not receive credit for room nights when attendees choose to book hotel rooms outside of our negotiated room block. While we were pleased with the attendance (approximately 880 total attendees), all these factors contributed to lower attendance than projected.

While we may not have met our projected attendance numbers, I think the meeting was a rousing success. The Program Planning Committee, under the direction of AASV President-elect Dr Mike Senn, put together an excellent series of scientific sessions highlighting new techniques and technologies. The information presented during the Monday and Tuesday General Sessions and afternoon concurrent sessions was inspirational, thought-provoking, and cutting edge. As always, the students did an excellent job presenting well-designed and useful scientific studies. In addition, attendees genuinely seemed to enjoy spending time together with our family of colleagues.

"We are already gearing up to do it all again in Colorado in about 11 months."

So, we are back home now. It has been almost a month since the meeting ended and we are still trying to wrap everything up. We are already gearing up to do it all again in Colorado in about 11 months. I want to thank everyone that took part in this year's meeting. Your participation and positive attitude made the meeting a success. One of the biggest challenges at this year's meeting was do we fist bump, elbow touch, or just hug. I saw a lot of the latter. I don't know if that was because there was more hugging, or I just noticed it more having not really seen it since 2020. I am looking forward to doing it all again in 2023 (or at least I am sure I will be soon). I hope you will come join us!

Harry Snelson, DVM
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My life with JSHAP and AASV

After sending in my notice for retirement, I went back to my personal journal and read my entry from October 26, 2001 – "Got job as Publications Manager of JSHAP – exciting and scary." After working in pig barns for 15 years, it was quite a turnaround to be contacting people from all over the world. When manuscripts are submitted to the journal, they are given a tracking number. At the time I started, submitted manuscripts were being assigned numbers in the low 300s; 20 plus years later they are in the 1300s. Nearly 500 of those manuscripts have been published during my tenure.

At the time I started with JSHAP, I was a technician for Dr Cate Dewey at the University of Guelph, which is how the connection began. When Cate retired as Executive Editor, Dr Terri O'Sullivan was hired, and fortunately for me, it was a smooth transition to working with Terri. I have learned a great deal from both women and have been honored to contribute to their commitment to a solid scientific journal for the swine industry.

The greatest joy and the greatest challenge in my job has been the review process. I am constantly amazed at the willingness of our membership to help again and again by serving as reviewers. The time and effort put into reviewing papers is humbling. I hope readers realize the depth of work that goes into getting a paper published, not including the work that ultimately resulted in the writing of the paper. Watching a paper develop over the review process, the editorial process, and graphic design is amazing and should make all of us proud of the publication that is produced for our readership.

Although most of my communication is electronic (even before COVID), it has definitely been the people who have made the job so special to me. The JSHAP and AASV staff became not only work colleagues but friends as well. The Editorial Board members, more reviewers than I can count, the many officers, the translators, and ancillary writers (National Pork Board and years of What's your Interpretation, Practice Tips, and Diagnostics Notes) became a part of my life. I wish I could mention the many people who are and will continue to be important to me, but the word count will not allow. I only hope I get the opportunity to personally connect with you again. I am sure you have often groaned when my emails popped up, as they undoubtedly were asking for help and reminding you of due dates looming on papers, messages, reviews, etc. Admit it, it is true!

As publications manager I have had the privilege of being the person with the most contact with authors and reviewers and, although it is strictly through email, it has been wonderful to be in touch with swine specialists all over the world. That is why attending the AASV Annual Meeting every year has been so important to me. It is my one opportunity to put a face to a name and, as is attested to every year when we thank our reviewers, it is quite a few people.

The first AASV Annual Meeting I attended was in Kansas City in 2002, and I have attended in-person every year through 2020 and virtually in 2021. It has been a delight every year to attend the AASV Annual Meeting and get to meet the people (and their families) who I communicate with throughout the year. To be able to spend time with my colleagues and the Editorial Board members and meet authors, reviewers, new officers, as well as renew connections from past years was always the highlight of my year.

"Watching a paper develop over the review process, the editorial process, and graphic design is amazing and should make all of us proud of the publication that is produced for our readership."

The AASV's commitment to students has been one of its greatest strengths. My 20 years with JSHAP and AASV has afforded me the opportunity to see students give professional talks, present posters, participate in the podcasts, and the many activities offered to them. It has been touching to see the veterinary students who have made their careers and marks in the swine industry over the time I have been associated with the journal. The AASV should be proud of the mentorship that they have given to the future generations.

I cannot express what it has meant to be connected to the journal and the AASV. It has broadened my life and given me the advantage for continual learning (another touchstone goal of AASV). I cannot say how much I will miss my work and my friends. I will be forever grateful that I was offered and accepted that exciting and scary opportunity to become the JSHAP Publications Manager.

Karen Richardson
Publications Manager

Antimicrobial susceptibility of *Actinobacillus pleuropneumoniae, Bordetella bronchiseptica, Pasteurella multocida,* and *Streptococcus suis* isolated from diseased pigs in the United States and Canada, 2016 to 2020

Michael T. Sweeney, MS; Lacie A. Gunnett, BS; Dipu Mohan Kumar, MVSc, PhD; Bryce L. Lunt, PhD; Lucina Galina Pantoja, DVM, PhD; Donald Bade, BS; Chandra Machin, BS

Summary

Objective: To report the *in vitro* susceptibility to veterinary antimicrobials of *Actinobacillus pleuropneumoniae, Bordetella bronchiseptica, Pasteurella multocida*, and *Streptococcus suis* isolated from diseased pigs in the United States and Canada from 2016 to 2020.

Materials and methods: *In vitro* broth microdilution susceptibility testing for minimal inhibitory concentration values were performed using ten antimicrobials (ampicillin, ceftiofur, danofloxacin, enrofloxacin, florfenicol, penicillin, tetracycline, tilmicosin, trimethoprim-sulfamethoxazole, and tulathromycin) with *A pleuropneumoniae* (n = 250), *B bronchiseptica* (n = 602), *P multocida* (n = 874), and *S suis* (n = 1223) following methods and susceptibility breakpoints approved by the Clinical and Laboratory Standards Institute.

Results: *Actinobacillus pleuropneumoniae* isolates were 100% susceptible to ceftiofur, florfenicol, and tulathromycin and *P multocida* isolates were 100% susceptible to ceftiofur. High rates of susceptibility (95% to > 99%) were observed for *A pleuropneumoniae* to tilmicosin; for *P multocida* to ampicillin, enrofloxacin, florfenicol, penicillin, tilmicosin, and tulathromycin; for *S suis* to ampicillin and florfenicol; and for *B bronchiseptica* to tulathromycin. Tetracycline exhibited low susceptibility rates against *A pleuropneumoniae* (0% to 10.6%), *P multocida* (23.2% to 38.2%), and *S suis* (0.8% to 2.1%). No susceptibility of *B bronchiseptica* to ampicillin (0%) and low rates of susceptibility to florfenicol (3.9% to 15.2%) were also observed.

Implications: Under the conditions of this study, the predominant pathogens associated with swine respiratory disease in the United States and Canada, *A pleuropneumoniae, B bronchiseptica, P multocida,* and *S suis* collected during 2016 to 2020, display high rates of susceptibility to most veterinary antimicrobials.

Keywords: swine, surveillance, antimicrobial susceptibility, respiratory disease

Received: August 2, 2021
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Resumen - Susceptibilidad antimicrobiana de *Actinobacillus pleuropneumoniae, Bordetella bronchiseptica, Pasteurella multocida,* y *Streptococcus suis* aislados de cerdos enfermos en los Estados Unidos y Canadá, 2016 a 2020

Objetivo: Reportar la susceptibilidad *in vitro* a los antimicrobianos veterinarios de *Actinobacillus pleuropneumoniae*, *Bordetella bronchiseptica*, *Pasteurella multocida*, y *Streptococcus suis* aislados de cerdos enfermos en los Estados Unidos y Canadá de 2016 a 2020.

Materiales y métodos: Se realizaron pruebas de susceptibilidad por microdilución en caldo *in vitro* para valores de concentración inhibitoria mínima utilizando diez antimicrobianos (ampicilina, ceftiofur, danofloxacina, enrofloxacina, florfenicol, penicilina, tetraciclina, tilmicosina, trimetoprim-sulfametoxazol, y tulatromicina) con *A pleuropneumoniae* (n = 250), *B bronchiseptica* (n = 602), *P multocida* (n = 874), y *S suis* (n = 1223) siguiendo métodos y puntos de corte de susceptibilidad aprobados por el Instituto de Estándares Clínicos y de Laboratorio.

Resultados: Los aislados de *A pleuropneumoniae* fueron 100% sensibles a ceftiofur, florfenicol, y tulatromicina y

MTS, LAG, DMK, BLL: Zoetis, Kalamazoo, Michigan.

LGP: Zoetis, Parsippany, New Jersey.

DB, CM: Microbial Research, Inc, Fort Collins, Colorado.

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Sweeney MT, Gunnett LA, Kumar DM, Lunt BL, Galina Pantoja L, Bade D, Machin C. Antimicrobial susceptibility of *Actinobacillus pleuropneumoniae*, *Bordetella bronchiseptica*, *Pasteurella multocida*, and *Streptococcus suis* isolated from diseased pigs in the United States and Canada, 2016 to 2020. *J Swine Health Prod*. 2022;30(3):130-144. **https://doi.org/10.54846/jshap/1282**

los aislados de *P multocida* fueron 100% sensibles a ceftiofur. Se observaron altos porcentajes de susceptibilidad (95% a > 99%) de *A pleuropneumoniae* a la tilmicosina; para *P multocida* a ampicilina, enrofloxacina, florfenicol, penicilina, tilmicosina, y tulatromicina; para *S suis* a ampicilina y florfenicol; y para *B bronchiseptica* a tulatromicina. La tetraciclina mostró bajos porcentajes de susceptibilidad frente a *A pleuropneumoniae* (0% a 10.6%), *P multocida* (23.2% a 38.2%), y *S suis* (0.8% a 2.1%). No se observó susceptibilidad de *B bronchiseptica* a ampicilina (0%), y también se observaron bajos porcentajes de susceptibilidad a florfenicol (3.9% a 15.2%).

Implicaciones: Bajo las condiciones de este estudio, los patógenos predominantes asociados con la enfermedad respiratoria porcina en los Estados Unidos y Canadá, *A pleuropneumoniae*, *B bronchiseptica*, *P multocida*, y *S suis* recolectados durante 2016 a 2020, muestran altos porcentajes de susceptibilidad a la mayoría de los antimicrobianos.

Résumé - Sensibilité aux antimicrobiens d'*Actinobacillus pleuropneumoniae, Bordetella bronchiseptica, Pasteurella multocida*, et *Streptococcus suis* isolés de porcs malades aux États-Unis et au Canada, de 2016 à 2020

Objectif: Rapporter la sensibilité *in vitro* aux antimicrobiens vétérinaires d'*Actinobacillus pleuropneumoniae*, *Bordetella bronchiseptica*, *Pasteurella multocida*, et *Streptococcus suis* isolés chez des porcs malades aux États-Unis et au Canada de 2016 à 2020.

Matériels et méthodes: Des tests de sensibilité par microdilution en bouillon *in vitro* pour les valeurs de concentration minimales inhibitrices ont été effectués à l'aide de dix antimicrobiens (ampicilline, ceftiofur, danofloxacine, enrofloxacine, florfénicol, pénicilline, tétracycline, tilmicosine, triméthoprime-sulfaméthoxazole, et tulathromycine) avec *A pleuropneumoniae* (n = 250), *B bronchiseptica* (n = 602), *P multocida* (n = 874), et *S suis* (n = 1223) selon les méthodes et les seuils de sensibilité approuvés par le Clinical and Laboratory Standards Institute.

Résultats: Les isolats d'*A pleuropneumoniae* étaient sensibles à 100% au ceftiofur, au florfénicol, et à la tulathromycine, et les isolats de *P multocida* étaient sensibles à 100% au ceftiofur. Des taux élevés de sensibilité (95% à > 99%) ont été observés pour *A pleuropneumoniae* à la tilmicosine; pour *P multocida* à l'ampicilline, l'enrofloxacine, le florfénicol, la pénicilline, la tilmicosine, et la tulathromycine; pour *S suis* à l'ampicilline et au florfénicol; et pour *B bronchiseptica* à la tulathromycine. La tétracycline présentait de faibles taux de sensibilité contre *A pleuropneumoniae* (0% à 10.6%), *P multocida* (23.2% à 38.2%), et *S suis* (0.8% à 2.1%). Aucune sensibilité de *B bronchiseptica* à l'ampicilline (0%) et de faibles taux de sensibilité au florfénicol (3.9% à 15.2%) ont également été observés.

Implications: Dans les conditions de cette étude, les agents pathogènes prédominants associés aux maladies respiratoires porcines aux États-Unis et au Canada, *A pleuropneumoniae*, *B bronchiseptica*, *P multocida*, et *S suis* recueillis de 2016 à 2020, affichent des taux élevés de sensibilité à la plupart des antimicrobiens.

Antimicrobials are critical to treat, control, and prevent disease in swine and other food animals. Responsible and timely antibiotic intervention is vital in controlling and mitigating disease incidence and spread, such as in swine respiratory disease (SRD) complex, which can endanger herd health and a sustainable food supply resulting in economic and commercial loss.[1] Of all the diseases that affect growing and finishing pigs, SRD is the most economically important as it is highly prevalent among indoor production facilities and can be difficult to treat and control. The treatment and control of SRD requires an understanding of the complexities and interaction between the organisms that are present as well as management of the environment in which the pigs are raised.[2] Primary pathogens for SRD complex may include *Mycoplasma hyopneumoniae*, *Actinobacillus pleuropneumoniae*, and *Bordetella bronchiseptica*, as well as viral agents. Common secondary pathogens include *Pasteurella multocida*, *Streptococcus suis*, *Glaesserella parasuis*, *Actinobacillus suis*, and *Salmonella* Choleraesuis. These primary and secondary multi-etiologic pathogens act together to increase the severity and duration of SRD.[3]

Antimicrobial surveillance among veterinary bacterial pathogens obtained from clinical specimens provides a platform from which to detect emergence of resistance in animal populations. While veterinary diagnostic laboratories throughout North America and Europe provide important antimicrobial susceptibility information for clinical isolates submitted by the attending veterinarian or animal caretaker, the susceptibility results are not typically examined. Few surveillance programs monitor susceptibility in swine pathogens nationally or internationally.[4-6] Portis et al[4] reported minimal inhibitory concentration (MIC) values for 7 antimicrobials against *A pleuropneumoniae*, *P multocida*, and *S suis* isolated from diseased swine in the United States and Canada over a 10-year period (2001-2010) and concluded that most isolates showed high rates of susceptibility to all antimicrobials tested. Additionally, Sweeney et al[5] reported MIC values for 10 antimicrobials against *A pleuropneumoniae*, *B bronchiseptica*, *P multocida*, and *S suis* isolated from diseased swine in the United States and Canada over a 5-year period (2011-2015) and concluded that most isolates showed high rates of susceptibility to all antimicrobials tested except tetracycline.

Continuing this surveillance program, we report the percentages of *A pleuropneumoniae*, *B bronchiseptica*, *P multocida*, and *S suis* pathogens isolated from swine in the United States and Canada that were susceptible to the veterinary antimicrobials ampicillin, ceftiofur, danofloxacin, enrofloxacin, florfenicol, penicillin, tetracycline, tilmicosin, trimethoprim-sulfamethoxazole (TMP-SMX), and tulathromycin. This paper presents the findings of the most contemporaneous 5-year surveillance period on SRD pathogens collected in North America from 2016 to 2020.

Animal care and use

Diagnostic submission data from clinical submissions were used in this study, therefore no animal use protocol was required.

Materials and methods

Laboratory participants and isolate characterization

Veterinary diagnostic laboratories from the United States and Canada participated in this surveillance study. The regions from which isolates were obtained are shown in Table 1.

Table 1: Origin and number of bacterial isolates per year by region for a 5-year study (2016-2020) of antimicrobial susceptibility of *Actinobacillus pleuropneumoniae*, *Bordetella bronchiseptica*, *Pasteurella multocida*, and *Streptococcus suis* from pigs in the United States and Canada*

Region and Year	2016	2017	2018	2019	2020	Total
A pleuropneumoniae						
Canada	22	10	6	2	0	40
Northeast	2	2	0	3	1	8
Midwest	30	28	30	27	32	147
South	8	5	6	7	4	30
West	1	6	5	9	4	25
Total	**63**	**51**	**47**	**48**	**41**	**250**
B bronchiseptica						
Canada	34	36	24	32	32	158
Northeast	2	3	4	5	7	21
Midwest	105	88	71	65	56	385
South	4	6	3	5	3	21
West	0	3	4	5	5	17
Total	**145**	**136**	**106**	**112**	**103**	**602**
P multocida						
Canada	53	66	32	59	49	259
Northeast	5	4	2	2	6	19
Midwest	119	124	100	98	78	519
South	9	8	8	3	7	35
West	8	13	5	12	4	42
Total	**194**	**215**	**147**	**174**	**144**	**874**
S suis						
Canada	86	87	56	74	83	386
Northeast	9	5	6	13	10	43
Midwest	155	155	138	132	130	710
South	8	9	13	8	6	44
West	6	11	7	11	5	40
Total	**264**	**267**	**220**	**238**	**234**	**1223**

* Provinces and states that submitted isolates originating from within the regions include Canada (Alberta, British Columbia, Manitoba, Nova Scotia, Ontario, Prince Edward Island, Quebec, and Saskatchewan); Northeast (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont); Midwest (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin); South (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia); West (Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming).

All *A pleuropneumoniae*, *B bronchiseptica*, *P multocida*, and *S suis* isolates were recovered from diseased or dead pigs. Laboratories selected isolates based on their own protocols and were requested not to use antimicrobial susceptibility as a criterion for selection. Laboratories were also requested to submit no more than eight isolates per quarter year to prevent over-representation from any one geographic area. Each participating laboratory was also requested to send no more than one isolate of each bacterial species from a herd each quarter year to prevent the over-representation of bacterial clones from one region.[4,5]

Bacterial isolates were identified to the species level by each participating laboratory before shipment to a central laboratory for susceptibility testing and the species identifications were confirmed at Zoetis (Kalamazoo, Michigan) using Matrix Assisted Laser Desorption Ionization Time-of-Flight Mass Spectrometry (MALDI-TOF MS; Bruker). All isolates were stored in approximately 1.0 mL trypticase soy broth (BD Biosciences) supplemented with 10% glycerol and stored at approximately -70°C until tested.

Determination of MIC values

In vitro susceptibility data were generated annually by performing MIC testing at a central laboratory (Microbial Research Inc) and followed Clinical and Laboratory Standards Institute (CLSI) standardized methods and quality control guidelines during susceptibility testing.[7] The MIC values for all isolates were determined using a dehydrated broth microdilution system (Sensititre System; Thermo Fisher Scientific) which conforms to CLSI standards for testing of veterinary pathogens.[7] Additionally, the central laboratory followed all manufacturer instructions for quality assurance and quality control when using the Sensititre plates. Direct colony suspensions were used and prepared at a final bacterial concentration of approximately 5×10^5 colony forming units/mL. Custom-made 96-well microtiter panels included serial doubling dilutions of the antimicrobials ampicillin, ceftiofur, danofloxacin, enrofloxacin, florfenicol, penicillin, tetracycline, tilmicosin, TMP-SMX, and tulathromycin. All concentration ranges for antimicrobials were chosen to encompass appropriate quality control ranges and published clinical breakpoints, and appropriate quality-control organisms were included with each testing date.[8]

Results

Quality control

The quality control organisms used in this study included *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, *Enterococcus faecalis* ATCC 29212, *Staphylococcus aureus* ATCC 29213, *Streptococcus pneumoniae* ATCC 49619, and *A pleuropneumoniae* ATCC 27090. Although not shown for this study, MIC values for all appropriate quality control organisms were acceptable when all study isolates were tested against antimicrobials on each date of testing.

A pleuropneumoniae

The MIC distributions, MIC_{50} values, and MIC_{90} values for 10 antimicrobials tested against *A pleuropneumoniae* (n = 250) are reported in Table 2. The CLSI has established clinical breakpoints for *A pleuropneumoniae* against ampicillin, ceftiofur, enrofloxacin, florfenicol, tetracycline, tilmicosin, and tulathromycin. *Actinobacillus pleuropneumoniae* susceptibility to ampicillin increased overall from 85.7% in 2016 (susceptible breakpoint ≤ 0.5 µg/mL) to 97.6% in 2020, but decreased to 83% in 2018. The percentage of isolates susceptible to ceftiofur over the 5-year study period was 100% (susceptible breakpoint ≤ 2 µg/mL) and the MIC_{90} values were ≤ 0.03 µg/mL. The percentage of susceptibility to enrofloxacin was very high (100% in 2016 and 2018-2020; breakpoint ≤ 0.25 µg/mL), and the MIC_{90} values over the study period were 0.06 to 1 µg/mL; florfenicol was 100% susceptible (breakpoint ≤ 2 µg/mL), with MIC_{90} values at 0.5 µg/mL. *Actinobacillus pleuropneumoniae* susceptibility to tetracycline (breakpoint ≤ 0.5 µg/mL) was very low, with a susceptibility range of 0% to 10.6%, while tilmicosin susceptibility (breakpoint ≤ 16 µg/mL) ranged from 96.8% in 2016 to 100% in 2020. There was 100% percent susceptibility of *A pleuropneumoniae* to tulathromycin (breakpoint ≤ 64 µg/mL) and MIC_{90} values ranged from 32 to 64 µg/mL. While CLSI-approved susceptible breakpoints have not been established for danofloxacin, penicillin, or TMP-SMX, the MIC_{90} values were determined as 0.06 to 1 µg/mL, 0.5 to ≥ 32 µg/mL, and ≤ 0.06 to 0.12 µg/mL, respectively, from 2016 to 2020.

B bronchiseptica

The MIC distributions, MIC_{50} values, and MIC_{90} values for 10 antimicrobials tested against *B bronchiseptica* (n = 602) are reported in Table 3. The CLSI has established clinical breakpoints for *B bronchiseptica* against ampicillin, florfenicol, and tulathromycin. *Bordetella bronchiseptica* isolates in this study had no *in vitro* activity to ampicillin (0% susceptibility; susceptible breakpoint ≤ 0.5 µg/mL) in which MIC_{90} values were 8 to ≥ 16 µg/mL. *Bordetella bronchiseptica* susceptibility to florfenicol (breakpoint ≤ 2 µg/mL) was low and ranged from 3.9% to 15.2% in which MIC_{90} values were 4 to 8 µg/mL over the 5-year study period. The percentage of *B bronchiseptica* susceptible to tulathromycin was 99.2% to 100% (breakpoint ≤ 16 µg/mL) and the MIC_{90} value was 8 µg/mL. While CLSI-approved susceptible breakpoints were not available, the MIC_{90} values were determined as ≥ 8 µg/mL for ceftiofur, 1 µg/mL for danofloxacin, 1 µg/mL for enrofloxacin, ≥ 32 µg/mL for penicillin, 1 to 2 µg/mL for tetracycline, 32 to ≥ 64 µg/mL for tilmicosin, and 8 to ≥ 16 µg/mL for TMP-SMX.

P multocida

The MIC distributions, MIC_{50} values, and MIC_{90} values for 10 antimicrobials tested against *P multocida* (n = 874) are reported in Table 4. The CLSI has established clinical breakpoints for *P multocida* against ampicillin, ceftiofur, enrofloxacin, florfenicol, penicillin, tetracycline, tilmicosin, and tulathromycin. *Pasteurella multocida* susceptibility to ampicillin was very high (95.5%-100%; susceptible breakpoint ≤ 0.5 µg/mL) from 2016 to 2020, while the percentage of susceptibility to ceftiofur was 100% (breakpoint ≤ 2 µg/mL), with MIC_{90} values at ≤ 0.03 µg/mL. *Pasteurella multocida* was 100% susceptible to enrofloxacin in 2016 and 2019 to 2020 (breakpoint ≤ 0.25 µg/mL) with MIC_{90} values at 0.03 µg/mL, and *P multocida* isolates were highly susceptible to florfenicol (> 98%; breakpoint ≤ 2 µg/mL), penicillin (97.7%-100%; breakpoint ≤ 0.25/per mL), tilmicosin (97.6%-100%; breakpoint ≤ 16 µg/mL), and tulathromycin (99.5%-100%; breakpoint ≤ 16 µg/mL) in which the tulathromycin MIC_{90} value ranged from 2 to 4 µg/mL. Clinical and Laboratory Standards Institute-approved susceptible clinical breakpoints have not been established for danofloxacin or TMP-SMX, but MIC_{90} values were determined as 0.03 µg/mL and 0.12 µg/mL, respectively.

S suis

The MIC distributions, MIC_{50} values, and MIC_{90} values for 10 antimicrobials tested against *S suis* (n = 1223) are reported in Table 5. The CLSI has established clinical breakpoints for *S suis* against ampicillin, ceftiofur, enrofloxacin, florfenicol, penicillin, and tetracycline.

Table 2: Summary of MIC values and frequency distributions for 10 antimicrobials tested with *Actinobacillus pleuropneumoniae* (n = 250) isolated from swine in the United States and Canada from 2016 to 2020*

Year	Isolates, No.	MIC_{50} (µg/mL)	MIC_{90} (µg/mL)	S, %	MIC frequency distribution (% of isolates)								
Ampicillin					**≤ 0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**
2016	63	0.12	≥ 16	85.7	17.5	42.8	23.8	1.6	0	0	0	1.6	12.7
2017	51	0.25	0.25	92.1	3.9	35.3	51	1.9	0	0	0	0	7.8
2018	47	0.12	≥ 16	83	12.7	44.7	21.3	4.3	0	0	0	2.1	14.9
2019	48	0.25	0.25	97.9	2.1	43.7	52.1	0	0	0	0	0	2.1
2020	41	0.12	0.25	97.6	0	53.6	44	0	0	0	0	0	2.4
Ceftiofur					**≤ 0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**≥ 8**
2016	63	≤ 0.03	≤ 0.03	100	95.2	4.8	0	0	0	0	0	0	0
2017	51	≤ 0.03	≤ 0.03	100	98	2	0	0	0	0	0	0	0
2018	47	≤ 0.03	≤ 0.03	100	97.8	2.8	0	0	0	0	0	0	0
2019	48	≤ 0.03	≤ 0.03	100	95.8	4.2	0	0	0	0	0	0	0
2020	41	≤ 0.03	≤ 0.03	100	100	0	0	0	0	0	0	0	0
Danofloxacin					**≤ 0.016**	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**≥ 4**
2016	63	0.12	0.25	NA	0	0	36.6	50.7	7.9	3.2	1.6	0	0
2017	51	0.12	1	NA	0	0	29.4	56.9	0	0	13.7	0	0
2018	47	0.06	0.12	NA	0	2.1	74.6	17	2.1	4.2	0	0	0
2019	48	0.06	0.12	NA	0	2.1	60.4	37.5	0	0	0	0	0
2020	41	0.06	0.06	NA	0	24.4	70.7	4.9	0	0	0	0	0
Enrofloxacin					**≤ 0.008**	**0.016**	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**≥ 2**
2016	63	0.06	0.12	100	0	15.9	71.4	6.3	4.8	1.6	0	0	0
2017	51	0.06	1	82.3	0	17.6	62.8	2	0	0	17.6	0	0
2018	47	0.03	0.06	100	6.3	51.3	36.1	2.1	2.1	2.1	0	0	0
2019	48	0.06	0.06	100	0	0	35.4	60.4	4.2	0	0	0	0
2020	41	0.03	0.06	100	0	7.4	56	36.6	0	0	0	0	0
Florfenicol					**≤ 0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**
2016	63	0.5	0.5	100	0	1.6	47.6	49.2	1.6	0	0	0	0
2017	51	0.25	0.5	100	2	2	74.5	21.5	0	0	0	0	0
2018	47	0.25	0.5	100	0	4.3	74.4	21.3	0	0	0	0	0
2019	48	0.5	0.5	100	0	0	18.8	81.2	0	0	0	0	0
2020	41	0.5	0.5	100	0	0	22	75.6	2.4	0	0	0	0
Penicillin					**≤ 0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**≥ 32**
2016	63	0.25	≥ 32	NA	14.3	44.4	25.4	1.6	0	0	0	0	14.3
2017	51	0.5	1	NA	9.8	15.6	51.2	15.6	0	0	0	0	7.8
2018	47	0.5	≥ 32	NA	12.8	31.9	34.1	4.2	0	0	0	4.2	12.8
2019	48	0.5	1	NA	2.1	25	60.4	10.4	0	0	0	0	2.1
2020	41	0.25	0.5	NA	7.2	51.2	36.8	2.4	0	0	0	0	2.4

Table 2: Continued

Year	Isolates, No.	MIC_{50} (µg/mL)	MIC_{90} (µg/mL)	S, %	MIC frequency distribution (% of isolates)								
Tetracycline					**≤ 0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**		
2016	63	≥ 16	≥ 16	3.2	0	3.2	17.5	4.7	0	22.3	52.3		
2017	51	≥ 16	≥ 16	3.9	0	3.9	7.8	0	0	25.6	62.7		
2018	47	≥ 16	≥ 16	10.6	0	10.6	14.9	0	4.2	16.8	53.5		
2019	48	≥ 16	≥ 16	0	0	0	29.2	6.2	0	33.3	31.3		
2020	41	8	≥ 16	7.3	0	7.3	17.1	0	0	31.7	43.9		
Tilmicosin					**≤ 0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**≥ 64**
2016	63	8	16	96.8	0	0	0	0	1.1	49.7	46	0	3.2
2017	51	16	16	98	0	0	0	4	0	43.1	50.9	0	2
2018	47	8	16	97.9	0	0	0	0	2.1	44.7	51.1	2.1	0
2019	48	16	16	97.9	0	0	0	0	6.3	29.1	62.5	0	2.1
2020	41	4	8	100	0	0	2.4	0	83	14.6	0	0	0
Trimethoprim-Sulfamethoxazole					**≤ 0.06**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**
2016	63	≤ 0.06	0.12	NA	80.1	18.3	0	1.6	0	0	0	0	0
2017	51	≤ 0.06	≤ 0.06	NA	90.2	9.8	0	0	0	0	0	0	0
2018	47	≤ 0.06	≤ 0.06	NA	97.8	2.2	0	0	0	0	0	0	0
2019	48	≤ 0.06	≤ 0.06	NA	95.8	4.2	0	0	0	0	0	0	0
2020	41	≤ 0.06	≤ 0.06	NA	92.7	7.3	0	0	0	0	0	0	0
Tulathromycin					**≤ 0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**≥ 128**
2016	63	32	32	100	0	0	0	0	3.2	20.6	69.8	6.4	0
2017	51	32	32	100	0	0	0	1.9	1.9	17.9	74.5	3.8	0
2018	47	32	64	100	0	0	0	0	2.1	15	63.8	19.1	0
2019	48	32	64	100	0	0	0	0	4.2	20.8	54.2	20.8	0
2020	41	16	32	100	0	0	0	0	12.2	75.6	12.2	0	0

* Vertical red lines indicate the CLSI-approved breakpoint for susceptible, intermediate, and resistant in that swine respiratory disease pathogen; numbers in the lowest concentration of the tested antibacterial drug range represent the percentage of isolates that had MICs less than or equal to the lowest drug concentration tested per year, while numbers above the highest antibacterial drug concentration represent the percentage of isolates that had MICs greater than the highest drug concentration tested that year. Percent MIC frequency rows may not add to 100% due to rounding.

MIC = minimal inhibitory concentration; MIC_{50} = antibacterial drug concentration that inhibits 50% of the bacterial population; MIC_{90} = antibacterial drug concentration that inhibits 90% of the bacterial population; S = isolates that are susceptible to the antibacterial drug using CLSI criteria; NA = not applicable since there are no CLSI-approved clinical breakpoints for susceptibility in that swine respiratory disease pathogen; CLSI = Clinical and Laboratory Standards Institute.

Table 3: Summary of MIC values and frequency distributions for 10 antimicrobials tested with *Bordetella bronchiseptica* (n = 602) isolated from swine in the United States and Canada from 2016 to 2020*

Year	Isolates, No.	MIC_{50} (µg/mL)	MIC_{90} (µg/mL)	S, %	MIC frequency distribution (% of isolates)								
Ampicillin					**≤ 0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**
2016	145	16	≥ 16	0	0	0	0	0	0	0	0.7	2.1	97.2
2017	136	≥ 16	≥ 16	0	0	0	0	0	0	0	2.2	0	97.8
2018	106	16	≥ 16	0	0	0	0	0	0	1.9	3.9	1.8	93.4
2019	112	16	≥ 16	0	0	0	0	0	0	0	10.7	0	89.3
2020	103	8	8	0	0	0	0	0	0	0.9	3.9	89.3	5.9
Ceftiofur					**≤ 0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**≥ 8**
2016	145	≥ 8	≥ 8	NA	0	0	0	0	0	0	0	0	100
2017	136	≥ 8	≥ 8	NA	0	0	0	0	0	0	0	0	100
2018	106	≥ 8	≥ 8	NA	0	0	0	0	0	0	0	0	100
2019	112	≥ 8	≥ 8	NA	0	0	0	0	0	0	0	0	100
2020	103	≥ 8	≥ 8	NA	0	0	0	0	0	0	0	0	100
Danofloxacin					**≤ 0.016**	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**≥ 4**
2016	145	1	1	NA	0	0	0	0	1.4	5.6	90.9	0.7	1.4
2017	136	1	1	NA	0	0	0	0	0.7	2.1	96.5	0.7	0
2018	106	1	1	NA	0	0	0	0.9	3.7	16.2	74.5	4.7	0
2019	112	1	1	NA	0	0	0	0.9	0.9	4.5	90.1	0	3.6
2020	103	1	1	NA	0	0	0	0	0.9	8.7	89.5	0	0.9
Enrofloxacin					**≤ 0.008**	**0.016**	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**≥ 2**
2016	145	0.5	1	NA	0	0	0	0	0	2.7	63.6	31.7	2
2017	136	1	1	NA	0	0	0	0	0	2.2	30	67.8	0
2018	106	0.5	1	NA	0	0	0	0	4.7	0	59.4	35	0.9
2019	112	0.5	1	NA	0	0	0	0	1.8	0	56.2	38.4	3.6
2020	103	1	1	NA	0	0	0	0	0.9	0	88.5	9.7	0.9
Florfenicol					**≤ 0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**
2016	145	4	4	6.9	0	0	0	0	0	6.9	87.6	5.5	0
2017	136	4	8	5.1	0	0	0	0	0.7	4.4	83.1	11.8	0
2018	106	4	8	9.4	0	0	0	0	2.8	6.6	75.5	15.1	0
2019	112	4	8	15.2	0	0	0	0	0.9	14.3	48.2	20.5	16.1
2020	103	4	4	3.9	0	0	0	0	0	3.9	92.2	3.9	0
Penicillin					**≤ 0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**≥ 32**
2016	145	≥ 32	≥ 32	NA	0	0	0	0	0	0	0	0	100
2017	136	≥ 32	≥ 32	NA	0	0	0	0	0	0	0	0	100
2018	106	≥ 32	≥ 32	NA	0	0	0	0	0	0	0	0.9	99.1
2019	112	≥ 32	≥ 32	NA	0	0	0	0	0	0	0	0	100
2020	103	≥ 32	≥ 32	NA	0	0	0	0	0	0	0	0	100

Table 3: Continued

Year	Isolates, No.	MIC_{50} (µg/mL)	MIC_{90} (µg/mL)	S, %	MIC frequency distribution (% of isolates)								
Tetracycline					**≤ 0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**		
2016	145	1	1	NA	0	45.5	44.8	6.3	3.4	0	0		
2017	136	1	2	NA	0	13.2	74.3	3.7	8.1	0	0.7		
2018	106	0.5	1	NA	0.9	49	40.6	3.8	3.8	0	1.9		
2019	112	0.5	2	NA	1.8	58	28.6	5.3	4.5	0	1.8		
2020	103	0.5	2	NA	0	73.8	11.7	4.8	2.9	0	6.8		
Tilmicosin					**≤ 0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**≥ 64**
2016	145	32	≥ 64	NA	0	0	0	0	0	2.8	11	62.7	23.5
2017	136	32	≥ 64	NA	0	0	0	0	0.7	0.7	5.9	81.6	11.1
2018	106	32	≥ 64	NA	0	0	0.9	0	3.7	0	16	63.4	16
2019	112	32	32	NA	0	0	0	0	0.9	0.9	17	73.2	8
2020	103	16	32	NA	0	0	0	0.9	0	18.4	68	11.8	0.9
Trimethoprim-Sulfamethoxazole					**≤ 0.06**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**
2016	145	8	8	NA	6.2	1.4	0.7	0	0	5.5	18.6	65.5	2.1
2017	136	8	8	NA	5.9	0	0	0	0.7	0.7	8.9	77.9	5.9
2018	106	8	≥ 16	NA	4.7	0	0	0	2.8	1.9	10.4	64.1	16.1
2019	112	8	8	NA	5.4	0	0	0.9	0.9	1.8	33.8	54.5	2.7
2020	103	8	8	NA	6.8	0	0	0	0	0	32	57.3	3.9
Tulathromycin					**≤ 0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**≥ 128**
2016	145	8	8	100	0	0	4.1	26.2	63.5	6.2	0	0	0
2017	136	8	8	99.2	0	0.8	1.6	19.5	76.5	0.8	0.8	0	0
2018	106	8	8	100	1.8	1.8	0.9	33.2	62.3	0	0	0	0
2019	112	8	8	100	0.9	0.9	0	32.1	63.4	2.7	0	0	0
2020	103	8	8	100	0	0.9	0	41.9	56.3	0.9	0	0	0

* Vertical red lines indicate the CLSI-approved breakpoint for susceptible, intermediate, and resistant in that swine respiratory disease pathogen; numbers in the lowest concentration of the tested antibacterial drug range represent the percentage of isolates that had MICs less than or equal to the lowest drug concentration tested per year, while numbers above the highest antibacterial drug concentration represent the percentage of isolates that had MICs greater than the highest drug concentration tested that year. Percent MIC frequency rows may not add to 100% due to rounding.

MIC = minimal inhibitory concentration; MIC_{50} = antibacterial drug concentration that inhibits 50% of the bacterial population; MIC_{90} = antibacterial drug concentration that inhibits 90% of the bacterial population; S = isolates that are susceptible to the antibacterial drug using CLSI criteria; NA = not applicable since there are no CLSI-approved clinical breakpoints for susceptibility in that swine respiratory disease pathogen; CLSI = Clinical and Laboratory Standards Institute.

Table 4: Summary of MIC values and frequency distributions for 10 antimicrobials tested with *Pasteurella multocida* (n = 874) isolated from swine in the United States and Canada from 2016 to 2020*

Year	Isolates, No.	MIC_{50} (µg/mL)	MIC_{90} (µg/mL)	S, %	MIC frequency distribution (% of isolates)								
Ampicillin					**≤ 0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**
2016	194	0.12	0.12	99.5	36.1	61.3	2.1	0	0	0	0	0	0.5
2017	215	0.12	0.12	99.1	18.1	74.8	6.1	0	0	0	0.5	0	0.5
2018	147	0.12	0.12	100	42.8	55.8	1.4	0	0	0	0	0	0
2019	174	0.12	0.25	98.3	17.6	66.8	13.3	0.6	0	0	0	0	1.7
2020	144	0.12	0.12	97.9	49.3	45.8	2.8	0	0	0	0	0.7	1.4
Ceftiofur					**≤ 0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**≥ 8**
2016	194	≤ 0.03	≤ 0.03	100	97.9	1.6	0.5	0	0	0	0	0	0
2017	215	≤ 0.03	≤ 0.03	100	100	0	0	0	0	0	0	0	0
2018	147	≤ 0.03	≤ 0.03	100	99.3	0.7	0	0	0	0	0	0	0
2019	174	≤ 0.03	≤ 0.03	100	96.6	2.2	0.6	0.6	0	0	0	0	0
2020	144	≤ 0.03	≤ 0.03	100	94.4	3.5	1.4	0.7	0	0	0	0	0
Danofloxacin					**≤ 0.016**	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**≥ 4**
2016	194	0.03	0.03	NA	49	44.9	4.6	1	0.5	0	0	0	0
2017	215	0.03	0.03	NA	41.4	54.4	3.7	0	0	0.5	0	0	0
2018	147	≤ 0.016	0.03	NA	65.3	27.2	5.4	0.7	0.7	0.7	0	0	0
2019	174	≤ 0.016	0.03	NA	63.2	31	5.2	0.6	0	0	0	0	0
2020	144	≤ 0.016	0.03	NA	71.5	25.7	2.1	0.7	0	0	0	0	0
Enrofloxacin					**≤ 0.008**	**0.016**	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**≥ 2**
2016	194	0.016	0.03	100	15.5	69	12.9	2.1	0.5	0	0	0	0
2017	215	0.016	0.03	99.5	11.6	65.6	21.5	1.4	0	0	0.5	0	0
2018	147	0.016	0.03	99.3	28.6	53.7	12.2	4.1	0	0.7	0.7	0	0
2019	174	0.016	0.03	100	16.1	63.2	16.7	4	0	0	0	0	0
2020	144	0.016	0.03	100	43	44.4	11.9	0	0.7	0	0	0	0
Florfenicol					**≤ 0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**
2016	194	0.5	0.5	100	0	0	3	95.5	1.5	0	0	0	0
2017	215	0.5	0.5	100	0	0	0.9	94	5.1	0	0	0	0
2018	147	0.5	0.5	100	0	0	2.7	94.6	2.7	0	0	0	0
2019	174	0.5	0.5	98.9	0	0	2.9	93.7	2.3	0	0	1.1	0
2020	144	0.5	0.5	100	1.4	2.1	22.9	70.1	3.5	0	0	0	0
Penicillin					**≤ 0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**≥ 32**
2016	194	≤ 0.12	≤ 0.12	98.9	97.9	1	0	0	0.5	0	0	0	0.5
2017	215	≤ 0.12	≤ 0.12	99.1	95.3	3.8	0	0	0	0.5	0	0	0.5
2018	147	≤ 0.12	≤ 0.12	100	100	0	0	0	0	0	0	0	0
2019	174	≤ 0.12	0.25	97.7	82.7	15	0.6	0	0	0	0	0	1.7
2020	144	≤ 0.12	≤ 0.12	97.9	96.5	1.4	0	0	0	0.7	0	0	1.4

Table 4: Continued

Year	Isolates, No.	MIC_{50} (µg/mL)	MIC_{90} (µg/mL)	S, %	MIC frequency distribution (% of isolates)								
Tetracycline					**≤ 0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**		
2016	194	2	≥ 16	25.3	2.1	23.2	14.4	33.5	2.6	2.6	21.6		
2017	215	2	≥ 16	23.2	1.3	21.9	20.5	32.8	6.5	2.6	14.4		
2018	147	2	≥ 16	36.1	2.8	33.3	9.5	31.9	3.4	2.8	16.3		
2019	174	1	≥ 16	27	4.6	22.4	26.4	26.4	9.2	3	8		
2020	144	1	8	38.2	10.4	27.8	13.9	25.7	5.6	6.9	9.7		
Tilmicosin					**≤ 0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**≥ 64**
2016	194	4	16	99	0	0.5	6.2	20	31.4	22.2	18.7	0.5	0.5
2017	215	4	16	98.5	0	0	1.5	18.6	30.7	25.6	22.1	0.5	1
2018	147	4	16	100	0.7	0	10.9	23.1	30.6	24.5	10.2	0	0
2019	174	4	16	97.6	0	0	4.4	20.7	29.9	30.4	12.2	1.2	1.2
2020	144	2	4	97.9	2.8	9	26.4	29.1	27.8	1.4	1.4	0.7	1.4
Trimethoprim-Sulfamethoxazole					**≤ 0.06**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**
2016	194	≤ 0.06	0.12	NA	67.5	25.8	4.6	0.5	0	0	0	0	1.6
2017	215	≤ 0.06	0.12	NA	76.3	20.1	1.3	0.5	0.9	0	0	0	0.9
2018	147	≤ 0.06	0.12	NA	78.9	17.7	2	0	0.7	0	0	0	0.7
2019	174	≤ 0.06	0.12	NA	89.1	8.6	2.3	0	0	0	0	0	0
2020	144	≤ 0.06	0.12	NA	81.2	11.8	4.2	0.7	0.7	0	0.7	0	0.7
Tulathromycin					**≤ 0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**≥ 128**
2016	194	1	4	100	51.5	32	15.5	0.5	0.5	0	0	0	0
2017	215	1	4	99.5	21.4	30.7	37.7	9.2	0	0.5	0	0	0.5
2018	147	1	2	100	36	21.8	38.1	3.4	0.7	0	0	0	0
2019	174	2	2	100	47.1	47.1	5.8	0	0	0	0	0	0
2020	144	1	2	98.6	23.6	36.8	36.1	2.1	0	0	0	0	1.4

* Vertical red lines indicate the CLSI-approved breakpoint for susceptible, intermediate and resistant in that swine respiratory disease pathogen; numbers in the lowest concentration of the tested antibacterial drug range represent the percentage of isolates that had MICs less than or equal to the lowest drug concentration tested per year, while numbers above the highest antibacterial drug concentration represent the percentage of isolates that had MICs greater than the highest drug concentration tested that year. Percent MIC frequency rows may not add to 100% due to rounding.

MIC = minimal inhibitory concentration; MIC_{50} = antibacterial drug concentration that inhibits 50% of the bacterial population; MIC_{90} = antibacterial drug concentration that inhibits 90% of the bacterial population; S = isolates that are susceptible to the antibacterial drug using CLSI criteria; NA = not applicable since there are no CLSI-approved clinical breakpoints for susceptibility in that swine respiratory disease pathogen; CLSI = Clinical and Laboratory Standards Institute.

Table 5: Summary of MIC values and frequency distributions for 10 antimicrobials tested with *Streptococcus suis* (n = 1223) isolated from swine in the United States and Canada from 2016 to 2020*

Year	Isolates, No.	MIC_{50} (µg/mL)	MIC_{90} (µg/mL)	S, %	MIC frequency distribution (% of isolates)								
Ampicillin					**≤ 0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**
2016	264	≤ 0.06	≤ 0.06	99.2	90.5	6	1.9	0.8	0.4	0	0	0.4	0
2017	267	≤ 0.06	0.12	97.8	87.6	6	3.4	0.8	0.4	1.2	0.4	0.4	0
2018	220	≤ 0.06	0.06	98.6	89.1	6.8	1.6	1.3	0.8	0	0.4	0	0
2019	238	≤ 0.06	≤ 0.06	99.2	83.6	10.5	3.8	1.3	0	0.8	0	0	0
2020	234	≤ 0.06	0.12	97.9	88	7.4	2.1	0.4	0.4	1.7	0	0	0
Ceftiofur					**≤ 0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**≥ 8**
2016	264	0.12	2	95.5	5.3	33.3	29.5	5.7	7.6	8.4	5.7	1.5	3
2017	267	0.12	1	94.8	8.2	32.2	29.6	3.4	7.9	9.7	3.8	0.7	4.5
2018	220	0.12	1	97.7	2.3	34.5	27.3	8.6	12.3	8.6	4.1	0.9	1.4
2019	238	0.12	2	91.2	4.6	30.7	26.5	11.3	7.6	5.5	5	1.7	7.1
2020	234	0.06	2	93.2	5.1	44.9	13.3	10.7	7.7	7.7	3.8	1.7	5.1
Danofloxacin					**≤ 0.016**	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**≥ 4**
2016	264	0.5	1	NA	0	0	0	3	13.3	47	34.1	1.5	1.1
2017	267	0.5	1	NA	0	0	0	0.4	12.4	43.8	39.3	1.9	2.2
2018	220	0.5	1	NA	0	0	0.8	2.3	16.4	51.4	26.8	0	2.3
2019	238	0.5	1	NA	0.4	0	0.4	2.4	18.9	53.4	22.9	0.4	1.2
2020	234	0.5	1	NA	0	0	0.4	0.8	15.4	48.7	31.1	1.6	2
Enrofloxacin					**≤ 0.008**	**0.016**	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**≥ 2**
2016	264	0.5	1	89.4	0	0	0.4	0.4	5.3	25.7	57.6	8.7	1.9
2017	267	0.5	1	87.3	0	0	0	0	3	21	63.3	10.5	2.2
2018	220	0.5	0.5	92.7	0	0	0	0.9	5	28.6	58.2	5	2.3
2019	238	0.5	0.5	94.1	0	0.4	0.4	1.2	6.3	28.2	57.6	4.7	1.2
2020	234	0.5	1	89.3	0	0	0	0	3.8	32.9	52.6	7.7	3
Florfenicol					**≤ 0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**
2016	264	2	2	97.7	0	0	0.4	1.5	23.5	72.3	1.1	0	1.1
2017	267	2	2	97.7	0	0	0	3.4	26.5	67.8	1.9	0	0.4
2018	220	2	2	96.4	0	0.4	1.2	6.4	25.2	63.2	3.6	0	0
2019	238	2	2	97.5	0	1.2	0.8	13	26.2	56.3	0.8	0	1.7
2020	234	1	2	100	0	0.4	0.8	6.5	42.7	49.6	0	0	0
Penicillin					**≤ 0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**≥ 32**
2016	264	≤ 0.12	1	81.8	76.9	4.9	4.2	4.2	4.2	5.6	0	0	0
2017	267	≤ 0.12	2	79.4	74.2	5.2	4.9	1.9	4.5	5.2	2.6	1.5	0
2018	220	≤ 0.12	1	80	74.1	5.9	5.5	5.5	4.5	1.8	2.3	0.4	0
2019	238	≤ 0.12	2	78.6	70.2	8.4	2.5	5.5	5	6	1.6	0.8	0
2020	234	≤ 0.12	2	78.6	70.5	8.1	3.8	4.2	6.5	3	1.3	2.6	0

Table 5: Continued

Year	Isolates, No.	MIC_{50} (µg/mL)	MIC_{90} (µg/mL)	S, %	MIC frequency distribution (% of isolates)								
Tetracycline					**≤ 0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**		
2016	264	≥ 16	≥ 16	0.8	0.4	0.4	0	0.4	1.9	1.9	95		
2017	267	≥ 16	≥ 16	1.1	0	1.1	0.7	1.9	4.2	0.7	91.4		
2018	220	≥ 16	≥ 16	0.9	0.4	0.4	1.6	1.6	3.8	0.8	91.4		
2019	238	≥ 16	≥ 16	1.7	1.3	0.4	0.8	2.4	4.3	3.8	87		
2020	234	≥ 16	≥ 16	2.1	1.3	0.8	0.8	0.4	5.2	1.3	90.2		
Tilmicosin					**≤ 0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**≥64**
2016	264	≥ 64	≥ 64	NA	0	0.4	0	0	7.5	9.5	0.8	0.4	81.4
2017	267	≥ 64	≥ 64	NA	0.4	0	0.4	0	9.7	20.2	0	0	69.3
2018	220	≥ 64	≥ 64	NA	0	0	0	0.4	12.7	7	0.4	0	79.5
2019	238	≥ 64	≥ 64	NA	0	0	0.4	0.8	9.2	13.2	1.2	0.4	74.8
2020	234	≥ 64	≥ 64	NA	0	0	3.4	14.9	9.2	0.4	0.8	0.4	70.9
Trimethoprim-Sulfamethoxazole					**≤ 0.06**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**≥ 16**
2016	264	≤ 0.06	0.25	NA	62.9	25.3	4.2	2	0.8	1.2	0.4	0.4	2.8
2017	267	≤ 0.06	0.25	NA	64.4	21.9	4.5	2.4	0.4	1.6	1.2	0.8	2.8
2018	220	≤ 0.06	0.12	NA	70.9	21.5	0.8	1.2	0.8	0	1.2	1.2	2.4
2019	238	≤ 0.06	0.12	NA	76.9	14.7	0	0.8	1.2	1.6	0.8	1.6	2.4
2020	234	≤ 0.06	0.12	NA	76.1	15.5	2	1.2	0.8	1.2	1.6	0	1.6
Tulathromycin					**≤ 0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**≥ 128**
2016	264	≥ 128	≥ 128	NA	0	1.1	9.1	7.7	0	0	1.5	3	77.6
2017	267	≥ 128	≥ 128	NA	0.8	2.8	7.1	17.5	2.4	0.4	0	2	67
2018	220	≥ 128	≥ 128	NA	0	1.2	10.9	9.9	0	0	1.6	3.2	73.2
2019	238	≥ 128	≥ 128	NA	0.4	1.2	7.1	13.9	2.4	0	1.2	2.8	71
2020	234	≥ 128	≥ 128	NA	0.4	5.1	10.2	10.7	2.6	2.6	1.3	3	64.1

* Vertical red lines indicate the CLSI-approved breakpoint for susceptible, intermediate and resistant in that swine respiratory disease pathogen; numbers in the lowest concentration of the tested antibacterial drug range represent the percentage of isolates that had MICs less than or equal to the lowest drug concentration tested per year, while numbers above the highest antibacterial drug concentration represent the percentage of isolates that had MICs greater than the highest drug concentration tested that year. Percent MIC frequency rows may not add to 100% due to rounding.

MIC = minimal inhibitory concentration; MIC_{50} = antibacterial drug concentration that inhibits 50% of the bacterial population; MIC_{90} = antibacterial drug concentration that inhibits 90% of the bacterial population; S = isolates that are susceptible to the antibacterial drug using CLSI criteria; NA = not applicable since there are no CLSI-approved clinical breakpoints for susceptibility in that swine respiratory disease pathogen; CLSI = Clinical and Laboratory Standards Institute.

Streptococcus suis susceptibility to ampicillin was very high (susceptible breakpoint ≤ 0.5 µg/mL) and ranged from 97.8% to 99.2%, while the percentage of susceptibility to ceftiofur was also high (91.2%-97.7%; breakpoint ≤ 2 µg/mL) over the 5-year study period in which MIC_{90} values ranged from 1 to 2 µg/mL. The percentage of *S suis* susceptible to enrofloxacin (breakpoint ≤ 0.5 µg/mL) ranged from 87.3% to 94.1% in which MIC_{90} values were 0.5 to 1 µg/mL. The percentage of *S suis* susceptibility to florfenicol was very high (breakpoint ≤ 2 µg/mL) and increased from 97.7% in 2016 to 100% in 2020, in which MIC_{90} values were 2 µg/mL. The percentage of *S suis* susceptibility to penicillin (breakpoint ≤ 0.25 µg/mL) decreased slightly from 81.8% in 2016 to 78.6% in 2020 in which MIC_{90} values ranged from 1 to 2 µg/mL. *Streptococcus suis* susceptibility to tetracycline was very low and ranged from 0.8% in 2016 to 2.1% in 2020. Susceptible breakpoints were not available for danofloxacin, tilmicosin, TMP-SMX, or tulathromycin, but MIC_{90} values were determined as 1 µg/mL, ≥ 64 µg/mL, 0.12 to 0.25 µg/mL, and ≥ 128 µg/mL, respectively.

Discussion

The prevalence of *A pleuropneumoniae, B bronchiseptica, P multocida,* and *S suis* pathogens associated with SRD emphasizes the importance of maintaining high levels of susceptibility to antimicrobials that are available to veterinarians for treatment of these pathogens.[9] Surveillance and monitoring studies for antimicrobial resistance in pathogenic bacteria of animal origin are necessary to understand any rates of change in the susceptibility of bacteria to antimicrobials, thereby serving as one component among many to help guide practitioners to select the most appropriate antimicrobial for treatment of disease.[10]

Antimicrobial resistance surveillance programs support antibiotic stewardship principles which require all antibiotic prescribers (for animals and humans) to assure good prescribing decisions that mitigate the emergence of resistance to preserve the effectiveness of antibiotics for veterinary and human medicine. Additionally, selecting the proper course of antimicrobial treatment for an animal, whether it is over-the-counter, prescribed, or through a Veterinary Feed Directive, should correlate with the Animal Medicinal Drug Use Clarification Act.

A limited number of surveillance studies have investigated *in vitro* susceptibilities of specific antimicrobials used to treat swine pathogens associated with respiratory disease on a national and international basis.[4-6,11-14] The SRD surveillance program reported herein has continuously obtained swine pathogens for over 20 years from North American veterinary diagnostic laboratories that have then been tested for antimicrobial susceptibility. The purpose for this ongoing surveillance study was to summarize the antimicrobial susceptibility profiles of 2949 isolates from 4 different pathogenic bacterial species associated with SRD collected from laboratories in the United States and Canada over a 5-year period from 2016 to 2020. To our knowledge, when coupled with our published SRD surveillance data from 2001 to 2010 and 2011 to 2015, this is the only surveillance program that has collected and published 20 years of SRD susceptibility data against a total of 11,992 isolates from the United States and Canada.[4,5]

Retrospective studies have been published that investigated the antimicrobial susceptibility of *A pleuropneumoniae* isolates from swine. Pangallo et al[15] showed high antimicrobial susceptibility for 354 isolates of *A pleuropneumoniae* from Italy to penicillins, fluoroquinolones, tetracyclines, and ceftiofur while low rates of susceptibility were observed for florfenicol. Holmer et al[16] reported the antimicrobial susceptibilities of *A pleuropneumoniae* from Danish pigs in which high susceptibility (> 95%) to ceftiofur, florfenicol, tulathromycin, tilmicosin, penicillin and tetracycline was observed for 135 isolates. Susceptibility data for *A pleuropneumoniae* from our 2001 to 2010 SRD surveillance program reported 100% susceptibility to ceftiofur, florfenicol, and tulathromycin and susceptibility data from our 2011 to 2015 SRD surveillance program reported 100% susceptibility to ceftiofur and florfenicol with high levels of susceptibility (> 90% to 100%) to enrofloxacin and tulathromycin.[4,5] This current report shows 100% susceptibility to ceftiofur, florfenicol, and tulathromycin along with high levels of susceptibility (> 95%) to tilmicosin, and low levels of susceptibility (0%-10.6%) to tetracycline for 250 *A pleuropneumoniae* isolates from 2016 to 2020. *Actinobacillus pleuropneumoniae* MIC values have remained high for tetracycline since 2001 and may be due to distribution of tetracycline resistance genes associated with plasmids which have been previously reported.[17,18]

For *B bronchiseptica*, El Garch et al[6] reported high susceptibility to amoxicillin-clavulanate (95.8%) and tulathromycin (99.2%) and lower susceptibility to florfenicol (52.5%). In our previous study we reported ≥ 99% susceptibility to tulathromycin, no susceptibility (0%) to ampicillin, and low susceptibility (5.4%-23.5%) to florfenicol against 572 *B bronchiseptica* isolates from 2011 to 2015.[5] This current report shows ≥ 99% susceptibility to tulathromycin, 0% susceptibility (100% resistance) to ampicillin, and low susceptibility (3.9%-15.2%) to florfenicol against 602 *B bronchiseptica* isolates from 2016 to 2020.

For *P multocida* isolated from swine, El Garch et al[6] reported 100% susceptibility to amoxicillin-clavulanate, ceftiofur, enrofloxacin, and tulathromycin and 65.8% susceptibility to tetracycline for 152 isolates. Susceptibility data from 2001 to 2010 for our SRD surveillance program reported 100% susceptibility to ceftiofur with high rates of susceptibility (> 90%-100%) to enrofloxacin, florfenicol, tilmicosin, and tulathromycin and data from our 2011 to 2015 SRD surveillance program reported 100% susceptibility to ceftiofur, enrofloxacin, and florfenicol and high levels of susceptibility (> 90%-100%) to ampicillin, penicillin, tilmicosin, and tulathromycin, with low levels of susceptibility (22.3%-35.3%) to tetracycline for 855 *P multocida* isolates.[4,5] This current report shows 100% susceptibility to ceftiofur along with high levels of susceptibility (> 95%) to ampicillin, enrofloxacin, florfenicol, penicillin, tilmicosin, and tulathromycin and low levels of susceptibility (23.2%-38.2%) to tetracycline for 874 *P multocida* isolates from 2016 to 2020.

For *S suis,* El Garch et al[6] reported high susceptibility (96%-100%) to amoxicillin-clavulanate, ceftiofur, enrofloxacin, and florfenicol and 4% susceptibility to tetracycline when tested against 151 isolates. Additionally, other studies have shown high rates of resistance among *S suis* isolates against tetracycline (75%-100% resistance) while the year 2 report from the US Department of Agriculture's Animal and Plant Health Inspection Service pilot project showed that of 167 *S suis* isolates, 2.4% were resistant to ceftiofur and enrofloxacin, 0.6% were resistant to ampicillin, 15.6% were resistant to penicillin, and 98% were resistant to tetracycline.[19,20] Susceptibility data from our 2001 to 2010 SRD surveillance program reported high rates of susceptibility (> 90%-100%) to ceftiofur and florfenicol and susceptibility data from our 2011 to 2015 report showed high levels of susceptibility (> 90%-100%) to ampicillin,

ceftiofur, and florfenicol, with low levels of susceptibility (0%-1.3%) to tetracycline against 1201 *S suis* isolates.[4,5] This current report shows > 90% susceptibility to ampicillin, ceftiofur, and florfenicol, low levels of susceptibility (0.8%-2.1%) to tetracycline, and moderate rates of resistance among *S suis* to penicillin (18.2%-21.4% resistance) for 1223 *S suis* isolates from 2016 to 2020. Due to the inability to genetically characterize these *S suis* isolates, some may belong to other bacterial species, and thus the resistance rates could be affected.

Numerous authors have highlighted the challenges of surveillance programs and the potential biases that may be encountered.[5,6,21,22] While there is no "gold standard" for evaluating the antimicrobial surveillance of animal pathogens, a report is available that offers guidance on areas in which harmonization can be achieved in veterinary antimicrobial surveillance programs with the intent of facilitating comparison of data among surveillance programs.[23] All surveillance studies still have certain biases and limitations to consider when interpreting susceptibility data. For this current study, 2949 clinical isolates were collected from 2016 to 2020 and analysed, but this number of clinical isolates is still small when considering the number of SRD cases in North America over the last 5 years. As the isolates in this current study originated from many veterinary diagnostic laboratories, the methods of sample selection, collection, and submission varied among laboratories. To help decrease regional sampling bias in this study, the number of isolates of a target species from any herd was restricted to one isolate during any quarter year period.[4,5] Biases reported in other programs, such as a passive surveillance design, no consideration in differences between livestock farm types and sizes, or prior treatment of animals with antibacterial agents, are acknowledged in this and other studies.[4-6] Furthermore, the lack of clinical breakpoints or interpretive criteria for certain antibacterial agents against pathogens to determine rates of susceptibility continue to be a limitation to veterinary surveillance. A greater collaborative effort among academic and industrial veterinary groups should be made to identify what gaps exist for available breakpoints and then establish CLSI-endorsed clinical breakpoints if a standardized approach is used.

The data presented from this current study, especially data that show a continued lack of susceptibility to certain antimicrobials such as tetracycline, should serve to underscore the importance of prudent use of these drugs when treating SRD. Although tetracycline has traditionally served as the class representative agent for *in vitro* susceptibility testing for veterinary tetracyclines, extrapolation of tetracycline susceptibility results may not necessarily be predictive of activity or clinical outcome for other tetracycline agents, such as oxytetracycline or chlortetracycline, due to differences in blood and lung-tissue concentrations and differences in bioavailability. Even though there are CLSI-established clinical breakpoints for tetracycline that were used in evaluating data in this study, these breakpoint values were derived partly from oxytetracycline pharmacokinetic data.[8]

Management practices used in modern pig farming such as manure management, age-segregation of pigs, and nutritional and metabolic awareness have profound influences on microbial interactions which may result in decreased disease among swine.[24] The high levels of antimicrobial susceptibility observed in this study and others may be attributed to specific health management practices within swine herds such as the all-in, all-out management practice system. Another management practice that may be contributing to overall high antimicrobial susceptibility rates is multi-site production where contained groups of pigs spend their production life in different facilities appropriately designed for each age group (site I: breeding herd; site II: nursery; site III: finishing, all of which are located at separate geographical locations to minimize disease transmission). Future studies may be able to determine if these management practices influence antibiotic resistance changes over time, and if resistance reduction can be achieved through alterations in further enhanced housing and cleaning practices.

The results of this surveillance study when using standardized susceptibility testing methods show high percentages of antimicrobial susceptibility among the major respiratory tract pathogens isolated from swine across the United States and Canada, except for tetracycline, and results from this 5-year SRD surveillance study are similar to those previously published.[4,5] This surveillance study continues to be useful in identifying the development of antimicrobial resistance among SRD target pathogens which is crucial for the prudent use of antimicrobials in veterinary medicine. Additionally, understanding the *in vitro* susceptibility of SRD pathogens isolated in the United States and Canada continues to be an important component of antimicrobial stewardship and One Health.

While this study shows high rates of susceptibility for antimicrobials against SRD pathogens, public perceptions and regulatory pressures continue to drive the need for newer, alternative treatment options which may include novel antibacterial classes, re-evaluation of older or discontinued antibacterial agents, posology, and alternative approaches such as bacteriophages and peptides.[25]

Implications

Under the conditions of this study:

- Susceptibility rates of SRD pathogens were high to key antimicrobials approved for SRD treatment.
- Antimicrobial stewardship benefits from susceptibility monitoring.

Acknowledgments

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Conflict of interest

Authors Sweeney, Gunnett, Kumar, Lunt, and Galina Pantoja were employed by Zoetis and authors Bade and Machin were employed by Microbial Research, Inc at the time this study was planned and performed.

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Peer reviewed **Brief communication**

Characterization of changes in productivity parameters as breeding herds transitioned through the 2021 PRRSV Breeding Herd Classification System

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Summary

Using retrospective data from 6 breed-to-wean herds over 4 years, porcine reproductive and respiratory syndrome virus (PRRSV) statuses were assigned by week according to the 2021 American Association of Swine Veterinarians PRRSV classification. Productivity changes were characterized as herds transitioned through status categories. Overall, productivity improved as farm status improved.

Keywords: swine, classification, American Association of Swine Veterinarians, productivity, monitoring

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Resumen - Caracterización de los cambios en los parámetros de productividad a medida que las piaras reproductoras hicieron la transición a través del sistema de clasificación de granjas reproductoras para el PRRSV 2021

Usando datos retrospectivos de 4 años de 6 hatos de gestación-maternidad, los estatus del virus del síndrome respiratorio y reproductivo porcino (PRRSV) se asignaron por semana de acuerdo con la clasificación del PRRSV de la Asociación Americana de Veterinarios de Cerdos de 2021. Los cambios de productividad se determinaron a medida que las piaras pasaron por las diferentes categorías de estatus. En general, la productividad mejoró a medida que mejoró el estatus de las granjas.

Résumé - Caractérisation des changements dans les paramètres de productivité lors de la transition des troupeaux reproducteurs dans le système de classification du PRRSV 2021 des troupeaux reproducteurs

À l'aide de données rétrospectives de six troupeaux de type saillie-au-sevrage sur une période de 4 ans, les statuts du virus du syndrome reproducteur et respiratoire porcin (PRRSV) ont été attribués par semaine selon la classification PRRSV 2021 de l'American Association of Swine Veterinarians. Les changements de productivité ont été caractérisés comme les troupeaux passaient d'une catégorie de statut à l'autre. Dans l'ensemble, la productivité s'est améliorée à mesure que le statut de l'exploitation s'améliorait.

The American Association of Swine Veterinarians (AASV) classification of breeding herds for the porcine reproductive and respiratory syndrome virus (PRRSV) helped facilitate PRRSV prevention, control, and elimination efforts. The standard terminology aided better information interchange between producers and veterinarians as to herd health status and intervention decisions, facilitated strategic biosecurity planning and execution, furnished researchers with standardized data, helped with assigning PRRSV infection status to herds, and helped to better understand market value of weaned pigs.[1]

Considering the emergence and widespread adoption of population-based sampling methods in the United States[2] and certain drawbacks associated with the classification scheme in use, for example, inconsistently weaning truly negative pigs from herds classified as PRRSV stable, the AASV proposed a modified PRRSV status classification scheme for breeding herds, hereafter defined as the AASV 2.0 PRRSV Classification System.[3]

The modified classification system relies solely on laboratory evidence. Therefore, there is no guarantee that there would be significant productivity differences between any 2 statuses, or how significant these differences would be. There has not been any study characterizing productivity differences between the PRRSV-positive unstable low-prevalence status just introduced (status 1B) and status 1A or 2vx.

The objective of this study was to characterize the changes in productivity of breeding herds as they transitioned between PRRSV status categories as defined by the AASV 2.0 PRRSV Classification System.

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Osemeke OH, Donovan T, Dion K, Holtkamp DJ, Linhares DCL. Characterization of changes in productivity parameters as breeding herds transitioned through the 2021 PRRSV Breeding Herd Classification System. *J Swine Health Prod*. 2022;30(3):145-148. **https://doi.org/10.54846/jshap/1269**

Animal care and use

An animal use protocol was not required as this was a retrospective cohort study that used available laboratory diagnostic data, PRRSV outbreak information, and weekly productivity parameters.

Materials and methods

Overview

Six breed-to-wean farms belonging to a single production system in the southeastern United States were conveniently selected for the study. These sow farms were routinely exposed to PRRSV modified live virus (MLV) vaccines. Two of these six farms had no laboratory evidence of wild-type PRRSV shedding all through the study period (2017 to 2020). The remaining 4 farms had laboratory evidence of PRRSV shedding at one point or another, sufficient for herd placement into any of the AASV 2.0 PRRSV categories (1A, 1B, or 2vx). The reverse transcription polymerase chain reaction (RT-PCR) tests on samples to determine shedding status were carried out in an accredited veterinary diagnostic laboratory located in the United States. The following weekly productivity parameters were obtained from the system's production records:

- Total pigs born per litter (TBL)
- Pigs born alive per litter (BAL)
- Pigs weaned per sow (PWS)
- Preweaning mortality percentage (PWM)
- Neonatal losses per litter (NL; derived by subtracting BAL from TBL)

The farms used multiple sample types for RT-PCR testing to monitor PRRSV shedding including processing fluids, ear blood swabs, family oral fluids, fetal tissues, pig tissues, and sow tissues. The farms used these sample types individually or in combination.

Observational units and eligibility criteria

The observational unit was week, defined as a given calendar week for each study herd. To be eligible each week, the farm had to be void of perceived activity of other disease outbreaks that impact breeding herd productivity, including porcine epidemic diarrhea, transmissible gastroenteritis, and porcine delta coronavirus. Weeks without sufficient diagnostic information for assigning PRRSV status, according to the protocol described herein, were also excluded from the analysis.

AASV 2.0 PRRSV classification

The AASV 2.0 PRRSV Classification System was used to assign a status to each week based primarily on laboratory evidence of PRRSV activity over defined time periods for certain sample types and attenuated PRRSV vaccine use in the breeding herds. The full details of the AASV 2.0 PRRSV Classification System are described by Holtkamp et al.[3]

In summary:

Category 1A included PRRSV unstable, high prevalence herds evidenced by high viremia or viral shedding. A herd falls into this category if it does not meet conditions for any of the other categories.

Category 1B included PRRSV unstable, low prevalence herds evidenced by low viremia or viral shedding. To enter this category, herds required 3 of 4 tests in 90 days for sera or 10 of 13 weekly tests (using population-based aggregate samples) with zero detection of wild-type PRRSV RNA in weaning age pigs.

Category 2vx included PRRSV stable herds that were vaccinated. This is the best-case scenario for vaccinating herds. To enter this category, herds required all tests in a 90-day period have zero detection of wild-type PRRSV in weaning age pigs. Either 6 pools of 10 sera each or 6 pools of 5 sera each together with one pooled processing fluid sample is considered the minimum sample set to be tested for a herd to be promoted to this category.

This study was conducted on herds controlling PRRSV through MLV vaccine exposure. As such, no weeks were eligible for placement into AASV 2.0 PRRSV categories 2, 3 or 4, representing PRRSV stable, provisionally negative, and negative, respectively.

An additional analysis was implemented to characterize trends during the first 10 weeks of category 1A following diagnostic confirmation of a PRRSV outbreak as compared to the rest of the 1A weeks. This was based on a study where the median time to recover baseline productivity for herds using attenuated PRRSV vaccine was 10 weeks.[4]

For this study, any week where multiple samples were submitted, any positive result, regardless of sample type, was considered diagnostic evidence for a positive PRRSV herd test for that week.

Data analysis

A linear mixed regression analysis was performed with each productivity parameter as the response variable, the PRRSV status as a fixed effect, and farm ID and season of the year as random effects. The least-squares mean analysis was performed using the Kenward-Roger degrees of freedom method, 0.95 confidence level, Šidák method for confidence level adjustment, and Tukey method for *P*-value adjustment. These analyses were performed using the lme4 package[5] in R program.[6] Univariate analyses were chosen over multivariate as there was little to no correlation between most of the parameters measured.

Standardized residuals were plotted against fitted values for each model to assess heteroscedasticity and nonlinearity using the plot() function in base R.[6] The base R qqplot() function was used to evaluate the normality of residuals. There was a log transformation of the response variable to correct for violations in model assumptions wherever observed; this step sufficed. Outliers were assessed and confirmed to be valid data observations; no observations were removed.

Results

A total of 1125 weeks had sufficient information for category placement and data analysis. Overall, productivity improved as weeks improved PRRSV classification status (Table 1).

Discussion

This study aimed to investigate and describe the trends in selected productivity parameters as the study population changed AASV 2.0 PRRSV status categories. Data for 1125 weeks from 6 breed-to-wean farms in a single production system from 2017-2020 were included in the study. Each week was identified with productivity data and PRRSV status according to diagnostic test results, vaccination history, and PRRSV outbreak history. All study herds used attenuated PRRSV-vaccination as a control strategy during this time frame and, therefore, were classified as 1A, 1B, or 2vx. Routine PRRSV vaccination of the breeding female population is a common practice in some US swine herds and the results of this study will be informative to several other systems. There were no statistical differences across groups in the average TBL, which includes the total BAL and NL (mummified fetuses and still births).

Table 1: Least-squares means (SE) of productivity parameters for each AASV 2.0 PRRSV status classification*

	AASV 2.0 PRRSV classification			AASV 2.0 PRRSV classification - further categorization of 1A			
Parameter/wk	1A	1B	2vx	1A - first 10 weeks	1A - 11th week through promotion to 1B†	1B	2vx
Total born/litter, No. (SE)	14.3 (0.22)[a]	14.4 (0.21)[a]	14.4 (0.22)[a]	14.6 (0.24)[a]	14.3 (0.22)[b]	14.4 (0.23)[ab]	14.4 (0.21)[ab]
Born alive/litter, No. (SE)	12.6 (0.20)[a]	13.1(0.21)[b]	13.2 (0.20)[b]	12.1 (0.22)[a]	12.7 (0.20)[b]	13.1 (0.20)[c]	13.2 (0.19)[c]
Neonatal losses/ litter, No. (SE)	1.58 (0.12)[a]	1.23 (0.01)[b]	1.18 (0.10)[b]	2.46 (0.20)[a]	1.44 (0.11)[b]	1.23 (0.09)[c]	1.19 (0.09)[c]
Pigs weaned/sow, No. (SE)	10.7 (0.20)[a]	11.3 (0.21)[b]	11.5 (0.20)[c]	9.6 (0.21)[a]	10.9 (0.20)[b]	11.3 (0.20)[c]	11.5 (0.19)[c]
Preweaning mortality, % (SE)	14.0 (1.36)[a]	13.0 (1.29)[a]	12.1 (1.16)[b]	19.9 (2.08)[a]	12.9 (1.29)[b]	13.0 (1.32)[b]	12.2 (1.20)[b]

* The AASV 2.0 PRRSV status classification[3] categories assigned to herds in this study include 1A = positive unstable, high prevalence; 1B = positive unstable, low prevalence; 2vx = positive stable with vaccination.

† This period begins on the 11th week of a herd being classified as 1A status post-PRRSV outbreak and ends when the herd was promoted to 1B status.

[a,b,c] Different superscripts on compared statuses for each productivity parameter indicate statistical differences (α = .05).

PRRSV = porcine reproductive and respiratory syndrome virus

Provided there is not significant early gestation reproductive failures attributable to PRRSV, this parameter is expected to be about the same across categories. Differences between statuses would lie in the proportions of the component parameters that make up TBL. Records of other productivity parameters such as breeding repeats and number of aborts were not available for analyses; we therefore could not characterize reproductive disorders or prenatal losses attributable to PRRSV.

Neonatal losses per litter, BAL, PWS, and PWM improved as these herds improved PRRSV status. These results are similar to those observed in Torrents[7] where BAL and PWM had relatively better numbers when herds were PRRSV stable. Torrents[7] study was conducted in Spain with farms naturally exposed to PRRSV-1, while the farms in this study were naturally exposed to PRRSV-2.

As seen from the first few weeks following a PRRSV outbreak, the impact on productivity can be short lived relative to the time the virus is actively being shed and susceptible animals infected in herds. This demonstrates that productivity levels should not be used as a proxy of PRRSV circulation. It would also be economically beneficial for vaccinated herds to keep implementing best practices until their herds attain and maintain PRRSV stability; a low PRRSV-prevalence status should not be a comfortable destination for herds aiming to control PRRSV.

Considering that the parameters measured in this study are only a subset of those important for measuring productivity losses attributable to PRRSV, this study does not attempt to fully characterize the economic differences between PRRSV statuses, rather, to characterize differences in the averages of the mentioned parameters. Some liberty was taken in promoting herds from 1B to 2vx, in that, even though these herds demonstrated a lack of PRRSV shedding for several months using at least three sample types weekly, these samples were not exactly as described in the AASV 2.0 PRRSV classification scheme. To the best of our knowledge, this is the first study that has evaluated changes in productivity parameters as breeding herds transitioned through the AASV 2.0 PRRSV status categories. Therefore, there is a need for similar studies on PRRSV-negative herds and herds targeting elimination to characterize changes in productivity parameters for other AASV 2.0 PRRSV categories not included in this study (ie, categories 2, 3, and 4).

Complementary studies in this line will provide useful data for evaluating and choosing best intervention strategies (control versus elimination) at farm, production company, and regional levels.

Implications

Under the conditions of this study:

- Productivity improved as AASV 2.0 PRRSV classification status improved.
- Productivity can approach baseline even when a herd is actively shedding PRRSV.

Acknowledgments

Conflict of interest

None reported.

Disclaimer

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* Non-refereed reference.

Senecavirus A: Frequently asked questions

Alexandra C. Buckley, DVM, PhD; Kelly M. Lager, DVM, PhD

Summary

Senecavirus A (SVA) has been demonstrated to be a causative agent for vesicular disease in swine. It is clinically indistinguishable from other agents that cause vesicular disease such as foot-and-mouth disease virus (FMDV), which is a reportable foreign animal disease (FAD). Thus, an investigation is initiated to rule out FMDV every time a vesicle is observed. Senecavirus A has now been reported across the Americas and Asia, and it appears the ecology of this virus has changed from sporadic infections to an endemic disease in some areas. In addition to vesicular disease, there have also been reports of increased neonatal mortality on affected sow farms. Knowledge about the pathogenesis of SVA in swine can provide many benefits to the swine industry. Understanding how long the virus can be detected in various sample types after infection can aide in choosing the correct samples to collect for diagnosis. In addition, the duration of virus shedding can help determine measures to control virus spread between animals. Prevention of SVA infection and disease with an efficacious vaccine could improve swine welfare, minimize SVA transmission, and reduce the burden of FAD investigations.

Keywords: swine, Senecavirus A, Seneca Valley virus, epidemiology, pathogenesis

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Resumen - Senecavirus A: Preguntas frecuentes

Se ha demostrado que el Senecavirus A (SVA) es un agente causal de enfermedad vesicular en cerdos. Es clínicamente indistinguible de otros agentes que causan enfermedades vesiculares como el virus de la fiebre aftosa (FMDV), que es una enfermedad exótica (FAD) de los animales y de declaración obligatoria. Por lo tanto, cada vez que se observa una vesícula, se inicia una investigación para descartar la presencia del FMDV. Actualmente se ha reportado la presencia del Senecavirus A en las Américas y Asia, además parecería que la ecología de este virus ha cambiado de infecciones esporádicas a una enfermedad endémica en algunas áreas. Además de la enfermedad vesicular, también se ha reportado un aumento de la mortalidad neonatal en las granjas de cerdas afectadas. El conocimiento sobre la patogénesis del SVA en cerdos puede proporcionar muchos beneficios a la industria porcina. Entender durante cuánto tiempo se puede detectar el virus en varios tipos de muestras después de la infección puede ayudar a elegir las muestras correctas a colectar para su diagnóstico. Además, la duración de la diseminación del virus puede ayudar a determinar las medidas para controlar la propagación del virus entre los animales. La prevención de la infección por SVA y la enfermedad mediante una vacuna eficaz podría mejorar el bienestar de los cerdos, minimizar la transmisión del SVA y reducir la carga de las investigaciones de FAD.

Résumé - Sénécavirus A: Foire aux questions

Le sénécavirus A (SVA) s'est avéré être un agent causal de maladie vésiculeuse du porc. Il est cliniquement impossible de le distinguer des autres agents responsables de maladie vésiculeuse, comme le virus de la fièvre aphteuse (FMDV), qui est une maladie animale exotique à déclaration obligatoire (FAD). Ainsi, une enquête est initiée pour écarter la fièvre aphteuse à chaque fois qu'une vésicule est observée. Le SVA a maintenant été signalé dans les Amériques et en Asie, et il semble que l'écologie de ce virus soit passée d'infections sporadiques à une maladie endémique dans certaines régions. En plus de maladie vésiculeuse, on a également signalé une augmentation de la mortalité néonatale dans les élevages de truies touchés. La connaissance de la pathogenèse de SVA chez le porc peut apporter de nombreux avantages à l'industrie porcine. Comprendre combien de temps le virus peut être détecté dans divers types d'échantillons après l'infection peut aider à choisir les bons échantillons à prélever pour le diagnostic. De plus, la durée de l'excrétion du virus peut aider à déterminer des mesures pour limiter la propagation du virus entre les animaux. La prévention de l'infection et de la maladie causées par SVA avec un vaccin efficace pourrait améliorer le bien-être des porcs, minimiser la transmission de SVA et réduire le fardeau des enquêtes sur les FAD.

Senecavirus A (SVA) is the only member of the genus *Senecavirus* in the family Picornaviridae.[1] The virus was first discovered in 2002 at a laboratory in Maryland as a cell culture contaminant in PER.C6 cells and was named Seneca Valley virus-001 (SVV-001).[1] It was speculated the contamination could have been introduced by either porcine trypsin or fetal bovine serum, both commonly used in cell culture.[2] The National Veterinary Services Laboratory isolated twelve picornavirus-like viruses

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between 1988 and 2005 from swine exhibiting a variety of clinical signs and from multiple states across the United States.[3] Sequencing highlighted the close relationship of these isolates with SVV-001, and neutralizing antibodies were found in swine serum samples supporting swine as a natural host. Two of these historical isolates were used to inoculate pigs, but they did not develop any specific clinical disease.[3]

What clinical signs are observed during SVA infection?

Prior to 2014, SVA had only been detected in North America, and in a few cases, detection of virus was associated with an idiopathic vesicular disease in mature swine. In one report, market weight pigs being transported from Canada to the United States in 2007 arrived with vesicular lesions on the snouts and coronary bands.[4] Samples from these animals tested negative for the top differentials for swine vesicular disease: foot-and-mouth disease virus (FMDV), swine vesicular disease virus (SVDV), vesicular stomatitis, and vesicular exanthema of swine; but, these animals did test polymerase chain reaction (PCR) positive for SVA.[4] Subsequently, in 2011 a boar from Indiana with vesicular lesions also tested PCR positive for SVA.[5] Due to evidence that SVA infected swine, a competitive enzyme-linked immunosorbent assay (ELISA) test was developed using serum generated from experimentally inoculated pigs.[6] Inoculated pigs did not develop clinical disease, though they did generate an antibody response. Thus, experimental infection with SVA failed to reproduce any consistent clinical disease, but evidence from field cases supported an association of SVA infection with vesicular disease in swine.

Beginning in late 2014, reports of vesicular lesions in swine along with an increase in neonatal mortality observed in piglets less than a week of age were spreading across the swine producing regions of Brazil.[7] The mortality observed in piglets was given the name epidemic transient neonatal losses (ETNL), and piglets displayed inconsistent clinical signs prior to death including lethargy, wasting, neurologic signs, and diarrhea.[7] Samples collected from these cases tested PCR and virus isolation (VI) positive for SVA.[8] Not only were these the first reports of SVA infection outside of North America, they also described a different character of the field infections. Instead of sporadic, limited infections in a swine herd, the Brazilian reports describe an epidemic wave of vesicular disease in sows and ETNL in piglets through a swine dense region. In summer 2015, cases of vesicular disease in finishing pigs and sows with an increase in neonatal mortality were observed in US swine. Similar to field cases in Brazil, SVA was detected in the affected animals and genetic analysis found a 97.7% to 98.0% nucleotide identity to the isolates from Brazil.[9-11] Using 2015 SVA isolates from the United States, research groups were able to experimentally reproduce vesicular disease in 3-, 9-, and 15-week-old pigs,[12-14] confirming that SVA was a causative agent for vesicular disease in swine.

Since multiple groups were able to experimentally reproduce disease with the 2015 US SVA isolates, questions remain as to why previous attempts with historical isolates were unsuccessful. In retrospect, some previous animal inoculation reports provided limited information about methods including number of pigs inoculated, age, etc, so it is difficult to make direct comparisons to recent animal inoculations. Experimental studies with US isolates suggest lesions may be more difficult to see on younger animals or they may not develop at all, thus there may be age-related differences to expression of clinical disease. To date, all pigs experimentally inoculated with what is believed to be an infectious dose of SVA are susceptible to infection, but not all inoculated animals develop clinical disease leading to speculation that an individual pig may harbor different resistance/susceptibility traits. Beyond questions about the susceptibility of the host, there are questions about potential differences in pathogenicity of viruses or the requirement of a novel cofactor to explain possible differences in disease expression.

Although the first SVA cases reported in the Midwest involved pigs from county fairs and late finishing pigs with vesicular lesions on the coronary bands and snout, the virus was also quickly identified at sow farms reporting increases of neonatal mortality ranging from 30% to 70% along with a diverse range of adult animals exhibiting vesicular disease.[15] One study reported that 2 of 6 SVA-affected breeding herds did not report vesicular lesions in sows.[16] In Brazil, similar findings were reported consisting of neonatal mortality ranging from 5% to 60% and mixed reports on the number of affected farms that also observed vesicular lesions on the sows.[17] A study comparing clinically affected sows to nonclinically affected sows on a farm experiencing an SVA outbreak demonstrated similar PCR-positive samples and antibody responses between both groups.[18] Therefore reiterating that not all animals infected with the virus develop vesicular disease and infected farms may be under reported, thus contributing to the spread of SVA.

What is the frequency of SVA detection?

Shortly after the 2015 outbreak began, 441 diagnostic cases including oral fluid samples from the United States tested via PCR had approximately 1% SVA prevalence.[19] During 2017, 444 diagnostic lab submission samples showed a 5.4% positive rate.[20] In addition, SVA antibodies in US swine were measured from samples collected in 2016 to better understand herd-level seroprevalence in both growing pigs and sows, and in the samples tested they estimated seroprevalence of 12.2% in growing pigs and 34% in sows.[21] In Brazil, serum samples prior to the 2014-2015 outbreak were negative for SVA antibodies while 34.6% of post-outbreak samples were positive, supporting that SVA had not been circulating in Brazil prior to 2014 and that seroprevalence was similar to US sow farms.[22] These levels of seroprevalence could also be suggestive of infections that went undetected due to missed clinical signs or lack of clinical signs.

How is SVA transmitted?

Epidemiologic investigations assigned employee entry, carcass disposal, and cull sow removal as high-risk events for SVA introduction to a farm, but also mentioned rodents, feed delivery, and semen entry as high risk.[16] Live virus has been isolated from environmental samples, mouse feces, and mouse small intestine from an affected farm; and virus was also detected via PCR in flies collected from both affected and unaffected farms, thus providing evidence that these pests may play a role in the spread of SVA between farms.[23] Recently, feed has been suspected as a vector to transport virus between countries.[24,25] Senecavirus A remained infectious in many feed ingredients tested in a simulated trans-Pacific Ocean journey and was shown to be the most stable of all the viruses studied.[26] Senecavirus A has been

detected in feed ingredients and complete feed samples collected from two feed mills in Brazil, but further research is needed to determine the risk of transmission through feed.[27] In addition, the daily trafficking of animals to slaughter plants provides abundant opportunity for virus spread between slaughter plants and trucks and back to farms or collection points. Trucks have been shown to play a role in the spread of viruses as demonstrated by studies with porcine epidemic diarrhea virus.[28,29] Recently, risk factors reported for SVA-positive pigs arriving at a slaughter plant included suppliers that raised pigs indoors and suppliers with pigs originating from multiple sites.[30]

Semen is a known risk for transmitting classical swine fever virus, porcine reproductive and respiratory syndrome virus (PRRSV), and pseudorabies (PRV) virus,[31] and with the detection of SVA PCR-positive semen, there is the potential for viral transmission during breeding.[11] Little objective data has been collected regarding cull sow movements; but one study found a significant number of sows entered multiple collection points prior to reaching a slaughter facility and traveled on average over 240 km from their site of origin, making the cull sow network a likely area of pathogen transmission.[32] Environmental samples from an assembly yard in Canada have tested positive for SVA.[33] In addition, samples from collection points in North Carolina from animals headed to slaughter tested PCR positive suggesting that SVA circulates in secondary and cull sow markets and most likely contributes to the spread of SVA.[19]

Pig-to-pig transmission has been observed both in the field and experimentally. Piglets weaned from an SVA-negative sow farm comingled with piglets from an SVA-positive sow farm tested positive for SVA in serum suggesting SVA spread among pigs during comingling, which is a common practice in the swine industry.[34] In experimental studies, sows that farrowed around 45 days after a challenge with SVA were still able to transmit virus to their piglets.[35] Unpublished research from our laboratory has demonstrated transmission of SVA to naïve contact sows from primary inoculated sows on 7 and 14 days post inoculation (dpi), but not on 21 or 28 dpi, so movement of infected animals can also play a role in SVA transmission. Live virus has been isolated from oral/nasal secretions and feces; therefore, fecal-oral transmission is likely an important route of transmission in addition to direct contact.[14]

What countries have reported SVA infection in swine?

Since the 2015 outbreaks reported in Brazil and the United States, vesicular disease cases due to SVA have been found across the globe including China,[36] Canada,[33] Colombia,[37] Thailand,[38] and Vietnam.[39] In March 2015, SVA was discovered and isolated in China with farms reporting vesicular lesions in sows and acute death in neonates.[40] In October 2015, sows transported to the United States from Canada had vesicular lesions on arrival which initiated a foreign animal disease (FAD) investigation. Tracebacks to the herd of origin detected SVA that was genetically similar to isolates found in China.[33] In February 2016, a breeding farm in Colombia broke with vesicular disease, and phylogenetic analysis of the SVA isolate clustered the Colombian strain with contemporary isolates from the United States (98.5%-98.9% nucleotide identity) rather than strains from Brazil (97.7%).[37] Senecavirus A was first detected in Thailand in October 2016 with lesions in market-weight pigs. At a genomic level, this virus was most closely related (98.2%) to the first Canadian strain from 2011.[38] Saeng-Chuto et al[41] suggested the SVA introduction to Thailand may not have been recent, but that the virus had evolved in the Thai swine population and remained undetected due to the presence of other pathogens that cause similar clinical disease, like FMDV. Finally, in January 2018, a group of pigs from Vietnam diagnosed with FMDV also tested positive for SVA, and the sequence shared high homology with isolates collected from China in 2015 and 2016.[39] This case and others highlight the difficulties faced by countries with FMDV and SVA cocirculating in swine herds to understand virus spread and mount control responses to each virus.

How genetically similar are SVA isolates?

Brazilian isolates appear to have originated from a common source, since they are genetically similar and group together in a clade separate from most US isolates from the same time period.[42] Surprisingly, early SVA isolates from China (2015-2016) tended to cluster together near Canadian and Brazilian isolates, while isolates from 2016-2017 began to cluster within the 2015 US isolates.[43-48] Of note, one report commented that earlier isolates more closely related to Brazilian isolates caused acute death in neonates, while the more recent strains clustering with the US isolates did not cause mortality in piglets.[49] Clusters of Chinese isolates branch throughout SVA phylogenetic trees with little relationship to region or year of isolation and could imply multiple introductions into China or undetected circulation and adaptation in Chinese swine herds.[50,51] The genetic distance between the US and Brazilian isolates was reported to be 2.71%, while the distance between the US and China isolates was 2.48%, and 2.8% between Brazilian and Chinese isolates.[52] The overall genetic divergence of contemporary isolates was 2.8%, but the genetic divergence between contemporary isolates (2011-2017) and historical isolates (1988-2010) was 6.32%.[52] Another wave of outbreaks was reported in Brazil during the second half of 2018 in many of the same states that experienced outbreaks in 2015. Although the clinical disease presentation seemed more severe, phylogenetic analysis suggested the 2018 strains were not significantly different from those strains sequenced in 2015-2016 in Brazil.[53]

Is there evidence of recombination in swine?

There have been multiple reports of recombination events with Chinese SVA strains. A few events involving Chinese isolates from 2016-2019 showed parental strains from 2015 US isolates, SVV-001, a 2016 isolate from Colombia, and other Chinese isolates.[54-58] Thus, there is evidence of SVA recombination in China dating back to at least 2016. These events have been found to occur across the SVA genome.[57] Senecavirus A's RNA-dependent RNA polymerase has been shown to play a central role in SVA replicative recombination, and mutation rate was linked to recombination rate.[59] Though more research is needed in this area, evidence of recombination events has been reported in other picornaviruses, including FMDV, and can play a key role in virus evolution.[60]

How long are vesicular lesions observed?

Vesicular lesions in swine can be found on the coronary bands, intradigital space, snout, lips, and tongue.[61] Lesions can begin with erythematous areas or blanched areas of the skin progressing to vesicles with varying levels of fluid

that rupture leaving an erosion on the skin that crusts over and resolves.[14] Histologically, areas of separation between the dermis and epidermis with clefts are noted containing edema, fibrin, necrotic debris, and inflammatory infiltrates (neutrophils, lymphocytes, and plasma cells).[14,62] Development of vesicular lesions on the coronary bands have been observed in as little as 48 hours in market-weight animals, but most animals develop vesicular lesions 3 to 6 days after experimental challenge and heal within 7 to 14 days.[12-14,63,64] Snout lesion development has been described as delayed compared to the appearance of coronary band lesions and heals more quickly.[35,63] In addition, some studies have reported seeing fewer snout lesions compared to coronary band lesions.[62,65] Other clinical signs that have been reported intermittently in pigs inoculated with SVA include fever, lameness, lethargy, and decreased feed intake.[49,66]

Although most experimental infection studies with contemporary SVA strains have resulted in most animals developing vesicular lesions, field reports have described varying levels of incidence.[8,11,16,34] It is not understood why some animals develop vesicular lesions and others do not.[67] Exposure dose may play a role considering most experimental studies with swine have used inoculum doses between 10^7 and 10^8 median tissue culture infectious dose/mL, which may be higher than exposure levels in the field. Experiments with FMDV in swine have shown altered infection dynamics and a shorter time to clinical signs with higher doses of inoculum.[68,69] There has also been speculation surrounding age dependency of lesion development. One study, using an SVA isolate from China, inoculated pigs around 1, 2, and 3 months of age. The oldest pigs were the only pigs to develop vesicles on their coronary bands and snout while the two groups of younger pigs did not develop any visible lesions.[65] Differences in lesion development could also be affected by density of the SVA receptor, anthrax toxin receptor 1, on susceptible cells in the epithelium of the coronary band and snout, which could be dependent on age or genetics of the pig.[70]

How long do pigs replicate and shed SVA?

Viremia after experimental challenge lasts between 1 and 10 dpi with peak levels around 2 to 4 dpi.[12,71,72] Live virus has been isolated from serum on 2 to 3 dpi, but not later in infection.[61,72] Interestingly, it has been noted in recent experimental studies that not all challenged animals develop a viremia.[64] Oral, nasal, and rectal swabs typically test PCR positive from 1 to 21 dpi, but there are sporadic positive samples detected at an additional week or more with oral and nasal swabs often testing PCR positive longer than rectal swabs.[35,62] Virus isolation performed on swab samples was successful most reliably during the first week after inoculation, which coincides with peak RNA levels measured by PCR; although much less frequent, VI-positive oral and fecal swabs have been detected up to 21 dpi.[14,61,64]

Studies of SVA outbreaks in the field support observations from experimental studies. Shedding dynamics during a natural infection at a sow farm over 9 weeks post onset of clinical signs demonstrated vesicular lesions for approximately 2 weeks and viremia for approximately 1 week, but rectal and tonsil swabs from both piglets and sows were PCR positive for SVA at 6 weeks post outbreak.[34] Following an outbreak, a sow farm found PCR-positive rectal and tonsil swabs at least 6 weeks after the onset of clinical signs.[18] For diagnostics in the field with unknown infection status, swabs may be a more reliable sample than serum due to the greater longevity of SVA detection in swabs compared to serum. But, swabs of acute vesicular lesions are the best sample for the diagnosis of SVA due to the high levels of virus compared to other samples, however viral levels will likely decrease as lesions begin to heal.[63]

Does stress have an impact on SVA infection?

The role of stress and its effect on SVA pathogenesis and disease manifestation has been of interest following the first reports of SVA in the United States involving show pigs and finishing pigs being transported to market. Since experimental inoculation in the past had been unsuccessful, it was hypothesized that stress may be a required cofactor for clinical manifestation of SVA infection. This hypothesis was also supported by the fact that the virus had been found in healthy pigs without vesicular disease.[19,67] One early experimental inoculation with SVA treated half the pigs with an immunosuppressive regimen of dexamethasone prior to the challenge. Both groups developed vesicular lesions and had similar infection dynamics, although a greater percentage of dexamethasone-treated pigs showed clinical signs approximately 24 hours earlier than those not treated.[62] Similarly, animals that were transported prior to challenge developed lesions slightly earlier than animals not transported prior to challenge, but viremia, shedding dynamics, and neutralizing antibody response were similar between both groups.[35] Thus, these studies support stress is not required for lesion development, but it may accelerate development.

Can SVA recrudesce in previously infected animals?

There had also been speculation of stress causing SVA to recrudesce or to renew active replication. Recrudescence has been reported to occur in other viruses that infect swine including the herpesvirus PRV.[73,74] A field study observed an increase in the percentage of piglets positive for SVA in serum at weaning almost 3 weeks after the virus had been cleared from the serum of most piglets.[34] An unconfirmed field report suggested that pigs without lesions present during marketing showed up to the slaughter plant approximately 12 hours later with lesions. Lesions were not observed on other animals from the farm of origin leading to speculation of recrudescence. Experimental work to test this theory challenged three groups of pigs with SVA and 46 days after infection applied a stressor event: transportation, dexamethasone treatment, or parturition. No lesions were observed after the stressor, but intermittent viremia and shedding was detected in all groups.[35] Of note, shedding detected by PCR was still reported in some animals at the stressor event from the initial SVA challenge.[35]

Can SVA cause persistent infection in swine?

The extended shedding seen in some animals infected with SVA could be attributed to persistence of the virus in tonsils. Live virus has been isolated from a tonsil 60 days after initial challenge, and *in situ* hybridization (ISH) localized the virus to both tonsillar epithelial cells as well as lymphoid tissues.[35] Double-stranded RNA (dsRNA) was detected by

immunofluorescence assay (IFA) in tonsils indicating a potential mechanism for persistence that has been shown for other viruses including PRRSV.[75,76] In addition, dsRNA is also a product of positive-sense RNA viral replication, so the dsRNA could also represent continued replication of SVA in the tonsillar tissue. Sows that farrowed approximately 46 days after initial exposure to SVA were able to transmit virus to their piglets supporting continued replication in animals long after the resolution of clinical signs.[35] Although piglets were found positive for SVA, the piglets did not demonstrate any clinical signs. Unpublished work from our group where neonates were experimentally challenged with SVA also did not result in any clinical signs, which further perpetuates the mystery surrounding ETNL in the field and the inability to reproduce that syndrome experimentally.

How does SVA infection impact neonates?

Piglets in Brazil have been reported to have ulcerative lesions on the snout, tongue, and coronary bands in SVA-affected farms; however, those lesions have not been reported frequently in piglets in the United States.[77,78] Brazil also had more reports of neurologic disease in neonates, which was supported by immunolabeling of SVA found in the choroid plexus of the brain and the surrounding endothelium cells of blood vessels of piglets that died on SVA-affected farms.[77] In addition, piglets submitted to a diagnostic lab in Brazil for ETNL had atrophic enteritis with positive immunolabeling in apical enterocytes as well as transmission electron microscopy evidence of viral particles similar in size and morphology to that of picornaviruses in the apical enterocytes.[79] Senecavirus A was also detected in urinary epithelium by immunohistochemistry (IHC) with ballooning degeneration of the transitional epithelium.[80] Histology and IHC demonstrated a multi-systemic infection of SVA in piglets; and quantification by PCR had demonstrated that the lymphoid organs had the highest levels of virus, which has also been observed in older swine after an experimental challenge.[62,81] Lesions and virus in the urinary and enteric tracts suggest that urine and feces could be a mode of horizontal transmission of SVA. Detection of SVA by IHC in tissues from 1- to 2-day-old piglets also suggests vertical transmission of the virus from sows.[80]

Are contemporary isolates more pathogenic than historical isolates?

Due to the inability of early studies to reproduce clinical disease with an experimental SVA challenge, we hypothesized that older isolates were less pathogenic than contemporary SVA isolates. Our work showed that both contemporary and historical isolates, including SVV-001, were able to cause vesicular disease in swine.[82] In contrast, another study reported that pigs challenged with SVV-001 did not develop vesicular lesions, while the group challenged with a 2015 isolate did develop clinical disease.[64] Both groups developed cross-neutralizing antibodies and cross-neutralizing T-cell responses suggesting conserved antigenic determinants, which was also supported by the cross-neutralizing titers in our study.[64,82] Another group compared the pathogenicity of two contemporary Chinese isolates (2016 vs 2017) and found one isolate to be more pathogenic in pigs than the other, with the 2016 isolate most closely related to Canadian isolates not causing vesicular disease in a group of finishing pigs.[71] Recent cell culture work with 5 different Chinese isolates located in different SVA phylogenetic clusters also showed small differences in viral growth kinetics in swine testicular cells.[83] Therefore, more research is necessary to correlate SVA genomic differences with pathogenic differences in SVA strains.

What is the humoral and cell-mediated immune response to infection?

Neutralizing antibody titers have been measured in pigs as early as 3 to 5 days after experimental infection, which has been correlated with VP2- and VP3-specific IgM responses.[12,14,63,72] This rise in neutralizing antibodies corresponds with the decline in viremia. Immunoglobulin G antibody response to infection follows IgM with titers beginning around 10 dpi.[14,62] Surface protein VP2-specific IgG antibodies were detected longer than VP1 and VP3.[72] Neutralizing antibodies have been found in animals up to 5 months after initial exposure, but further research must be performed to determine the protective titer. Critical for antibody production, $CD4^+$ helper T cells were detected by 7 dpi, while $CD8^+$ and $CD4^+$ $CD8^+$ T cells (effector/memory) increased after 10 dpi.[72] Aforementioned VP2-specific responses were highly suggestive that VP2 contains important B-cell and T-cell epitopes.[72]

What diagnostics are available for SVA?

An invaluable tool for virus detection and SVA diagnosis is PCR. Both SYBR Green and TaqMan-based real-time reverse transcriptase-PCR (qRT-PCR) assays have been developed with probes targeting different regions of the virus, including VP1 and 3D.[84-86] In addition, a nested-PCR assay has been developed to amplify a fragment of VP1, which was able to identify SVA RNA in samples considered negative by reverse transcriptase-PCR (RT-PCR).[87] A real-time reverse transcription loop-mediated isothermal amplification (RT-LAMP) assay was developed to provide a cheaper option for SVA detection.[88] The RT-LAMP procedure has also been combined with a lateral flow dipstick for rapid visualization of results.[89] Finally, an RNA RT-droplet digital PCR was also developed to allow quantification without the need for standard curves and is resistant to inhibitors present in different sample types.[90]

Not only is it important to be able to detect the virus in swine via PCR, it is equally important to be able to measure the antibody response to infection. As opposed to PCR, serology can provide information on SVA exposure over time. To identify SVA antibodies in swine, SVA VP1 and VP2 recombinant protein indirect ELISAs have been developed, which are more rapid and convenient for diagnostic labs versus assays that involve cell culture, like virus neutralization (VN) assays and indirect IFA.[18,91] One group found antibody responses to VP2 were higher than VP1 and VP3 and had higher binding affinity in the ELISA, which correlates with data that VP2-specific IgG antibodies were shown to last the longest in experimentally challenged pigs.[72,91] Indirect ELISAs can have high-cross reactivity, so a competitive ELISA has also been developed.[6,92] Although the scalability of the ELISA assay is favored by diagnostic labs, VN and IFA assays are excellent confirmatory assays with high sensitivity and specificity and often used in research settings.[14,92] Recently an enhanced green fluorescent protein tagged recombinant SVA has been developed to facilitate reading VN assays.[93]

Both ISH and IHC assays have been developed to detect SVA within tissues.[78,80] Immunohistochemistry assays detect

viral antigen and require antibodies against the virus of interest, which in the case of SVA can be difficult to obtain commercially. In contrast, for RNAScope (ISH), a probe is ordered to a target genomic region of interest for virus detection in tissues.[14,78] Although it is rarely used for clinical diagnosis, electron microscopy has also been used to identify particles with picornavirus morphology in animals infected with SVA.[79]

How can SVA be differentiated from other vesicular disease-causing viruses?

The ability to differentiate between viruses that cause vesicular disease in swine is important since they are clinically indistinguishable. This is especially significant for FMDV, since it is on the World Organization for Animal Health list of notifiable diseases.[94] To this end, a multiplex qRT-PCR assay was developed for quick differentiation of FMDV and SVA.[20] Multiplex assays are particularly vital for those countries that have multiple endemic viruses that cause vesicular disease in swine because the ability to track different viruses will be critical to understanding viral epidemiology to develop control and prevention plans. Of equal importance to differentiation is the speed at which the diagnosis can be made. In countries free of FMDV, there is a halt to swine movement when a vesicle is observed until FMDV has been ruled out. Pen-side testing allows quicker results and could contribute to faster continuity of animal movements. To this end, a field-deployable RT-insulated isothermal PCR (RT-iiPCR) has been developed that can detect SVA in the field.[95] Unfortunately, this test can diagnose SVA, but it does not provide information about FMDV status.

For countries with FMDV-negative status, identifying FMDV would have severe economic ramifications including production loss, trade restrictions, control measures, and the cost of regaining FMDV-free status.[96] Due to the significant consequences involved with an FMDV-positive diagnosis, testing for FMDV is highly regulated. In the United States, when a vesicle is observed in swine, a foreign animal disease investigation (FADI) is instigated. Trained personnel collect a set of standard samples in duplicate to be sent to both the Foreign Animal Disease Diagnostic Lab and a National Animal Health Laboratory Network lab to rule out FMDV. Therefore, even though pen-side diagnostic tests for FMDV have been produced (RT-iiPCR and lateral flow device), governments may be reluctant to approve these platforms due to ramifications of false-positive/negative results.[97-99] For example, a false-negative result could lead to the movement of positive animals and contribute to the spread of FMDV, which is considered one of the most highly contagious animal diseases.[100]

What disinfectants and inactivation techniques work against SVA?

Disinfectants have shown differing levels of success at inactivating SVA on different surfaces at various temperatures. In one study, bleach (sodium hypochlorite) at a 1:20 dilution was most effective at inactivating the virus, with a quaternary ammonium disinfectant demonstrating intermediate success depending on surface and temperature, and a phenolic disinfectant performing the worst.[101] Accelerated hydrogen peroxide at 1:20 for 10 minutes was also an effective disinfectant against SVA, as well as FMDV and SVDV.[102] Ultraviolet-C (254 nm wavelength) can also be used as an inactivation method, though it may be best suited as a redundant biosecurity measure because it was seen to be less effective with nonenveloped viruses and required greater than 3000 J/L for viral inactivation of SVA.[103]

Trypsin was suspected to be the source of contamination when SVA was discovered as a cell culture contaminant due to evidence of swine being the natural host for SVA and since porcine trypsin is used commonly in cell culture work. Some swine vaccines are grown in cell culture, thus raising concern for SVA contamination during the vaccine manufacturing process. Vaccine distribution nationally and around the globe could serve as a route for dissemination of SVA. Two lots of trypsin that had received 25 to 40 kGy of gamma-irradiation tested PCR positive for SVA and also VI positive indicating live virus.[104] Of note, after the trypsin samples received a second round of gamma-irradiation, SVA was inactivated. Thus, animal biologic manufacturers using porcine trypsin should add SVA to their exogenous agent testing to ensure that SVA is not inadvertently being spread through swine biologics.

What vaccines are available to protect swine against SVA infection?

Multiple vaccine platforms have been evaluated for efficacy against an SVA challenge. A whole-virus inactivated vaccine made from a Chinese SVA isolate mixed with an adjuvant given in one dose provided protection against a homologous challenge by preventing the development of clinical signs and viremia.[105] Similarly, unpublished work from our research group has shown the efficacy of a whole-virus inactivated vaccine (2015 US SVA isolate) in both weaned pigs and sows. In addition, piglets suckling immunized dams were protected against an SVA challenge. Also, a recombinant SVA strain used as a live attenuated vaccine given in a single dose induced a robust antibody response; and after a challenge with SVA, animals did not develop any clinical disease, had reduced viremia, and had reduced viral shedding compared to nonvaccinated animals.[106] Interestingly, an inactivated vaccine tested in the same study did not produce detectable neutralizing antibodies until after a second dose was given; and after the challenge, the inactivated SVA vaccine did not protect against the development of vesicular disease.[106]

Recently, a virus-like particles (VLP) vaccine for SVA has been tested in swine against an SVA challenge. A VLP vaccine consists of viral structural proteins that spontaneously self-assemble into particles antigenically indistinguishable from the native virus.[107] An advantage of VLP vaccines is they present viral antigens in a more authentic conformation compared to typical subunit vaccines with recombinant proteins.[108] Pigs vaccinated with SVA VLP and challenged with a 2017 Chinese isolate did not develop clinical disease or viremia. This study also showed similar efficacy of a one-dose inactivated virus vaccine. Having an effective commercial vaccine for SVA could reduce the occurrence of SVA-related vesicular disease, thus reducing the economic burden of FADIs in FMDV-free countries and viral load of SVA in endemic regions.

What are the next steps?

The change in SVA ecology from rare infections detected in the United States and Canada to small epidemics in Brazil, then the United States, and subsequently other countries around the

world, produced many questions about this virus. Since the fall of 2015, when SVA was demonstrated as a causal agent of vesicular disease in swine, several questions about the biology and pathogenesis of the virus have been addressed through research conducted in many laboratories and will continue to be addressed with future research. However, questions remain about why the SVA paradigm changed around 2015. Are the SVA epidemics reported around the world related? Have properties of the virus changed? What is the relationship between SVA and neonatal morbidity and mortality in the field?

As SVA spreads around the globe it will continue to present challenges due to its clinical similarity with FMDV. If SVA becomes endemic in FMDV-free regions, there is danger of the swine industry becoming complacent in reporting vesicular lesions by assuming these lesions are due to SVA. Improving knowledge through research about the epidemiology, viral evolution, and pathogenesis of SVA may help focus swine industry efforts directed at controlling the spread of SVA and future elimination efforts.

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Conflict of interest

None reported.

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Infection of a naïve sow herd with *Mycoplasma hyopneumoniae*

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Summary

A 2500-sow herd previously free of, and unvaccinated for, *Mycoplasma hyopneumoniae* (MHP) became infected. Both MHP and influenza A H1N1pdm09 virus were identified in sows showing clinical signs. Coughing lasting 2 to 4 days was observed in approximately 10% of sows and 26 sows died over the course of the outbreak. There was no apparent impact on performance indicators. Polymerase chain reaction and serological results showed that MHP progression within the herd was fast and that infection may have occurred within a few weeks. An elimination program was quickly implemented so that sale of negative animals could resume.

Keywords: swine, *Mycoplasma hyopneumoniae*, epidemiology, elimination

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Resumen - Infección de una piara de cerdas libre con *Mycoplasma hyopneumoniae*

Una piara de 2500 cerdas previamente libre y no vacunada contra *Mycoplasma hyopneumoniae* (MHP) se infectó. Tanto el MHP como el virus de la influenza A H1N1pdm09 fueron identificados en cerdas que mostraban signos clínicos. Se observó tos que duró de 2 a 4 días en aproximadamente el 10% de las cerdas, 26 cerdas murieron durante el transcurso del brote. No hubo un impacto aparente en los parámetros de producción. La reacción en cadena de la polimerasa y los resultados serológicos mostraron que el movimiento del MHP dentro de la piara fue rápido y que la infección pudo haber ocurrido en unas pocas semanas. Rápidamente se implementó un programa de eliminación para que pudiera reanudarse la venta de animales negativos.

Résumé - Infection d'un troupeau de truies naïves par *Mycoplasma hyopneumoniae*

Un troupeau de 2500 truies précédemment exemptes et non vaccinées contre *Mycoplasma hyopneumoniae* (MHP) a été infecté. *Mycoplasma hyopneumoniae* et le virus de la grippe A H1N1pdm09 ont été identifiés chez des truies présentant des signes cliniques. Une toux d'une durée de 2 à 4 jours a été observée chez environ 10% des truies et 26 truies sont mortes au cours de l'éclosion. Il n'y a pas eu d'impact apparent sur les indicateurs de performance. La réaction d''amplification en chaîne par la polymérase et les résultats sérologiques ont montré que la progression de MHP au sein du troupeau était rapide et que l'infection pouvait s'être produite en quelques semaines. Un programme d'élimination a été rapidement mis en place afin que la vente des animaux négatifs puisse reprendre.

Infection of naïve herds with *Mycoplasma hyopneumoniae* (MHP) can be associated with significant clinical signs and losses.[1] Transmission of this organism is often slow compared to other pathogens like porcine reproductive and respiratory syndrome virus and influenza A virus in swine (IAV-S).[2-4] This case report describes a naïve sow herd infected with MHP where clinical signs in most animals were mild, a low percentage of sows were affected, and within farm transmission may have occurred at a faster rate than what is commonly observed.[3] The elimination program and diagnostic results are also discussed.

Animal care and use

The animals in the case herd were adequately housed, and humanely cared for.

Case description

Clinical signs, interventions, and timing of infection

The 2500-sow, high-health herd had remained negative to MHP since the farm was populated in 2007. The herd had not been vaccinated for this organism. The negative status was based on absence of clinical signs and lesions consistent with MHP infection in the sow herd and their progeny, no identification of the organism in diagnostic material submitted to the laboratory, and on monthly negative serological testing of the sow herd for 13 years. Table 1 summarizes observations and testing completed before and after the first clinical signs were noticed. An H1N1 IAV-S strain had been identified in the herd in the past, but not the 2009 novel influenza A virus (H1N1pdm09). Coughing was first observed among the sows on February 22, 2020, and 3 to 4 new sows per day began coughing thereafter. Clinical signs gradually decreased after the herd was treated with medication on April 12 and completely stopped by May 10. Overall, between 250 and 300 sows were

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Table 1: Observations and diagnostic test results made before and after appearance of clinical signs for *Mycoplasma hyopneumoniae* (MHP)

Date	Observations	Results
12/30/2019 & 02/04/2020	No clinical signs; 20 blood samples from sows for each date	All negative for MHP*
01/01/2020 to 02/12/2020	3 groups of 400 gilts sold at weaning; tested extensively after delivery on remote locations	All negative for MHP*†
02/22/2020	A few lactating sows coughing	No tests conducted
02/27/2020	Nasal swabs from 5 coughing sows, 2 pools	Both pools positive for MHP† and Influenza A H1N1pdm09 virus‡
03/04/2020	20 blood samples on sows	1 of 20 positive for MHP*
03/09/2020	Tracheobronchial swabs from a coughing sow and the sow that was seropositive on March 4, and lungs of 2 suckling piglets from one litter with dyspnea	Sow swabs positive for MHP†; lungs of piglets only positive for Influenza A H1N1pdm09 virus‡
03/24/2020	31 blood samples from females which had not shown clinical signs	22 positive for MHP*
03/24/2020	170 gilts that were in isolation are introduced in the herd; 20 had been serologically tested before introduction	All tested negative for MHP*
04/07/2020	30 gilts introduced on March 24 tested with tracheobronchial swabs, 12 pools of 2 or 3	11 of 12 pools positive for MHP†
03/18/2020 to 04/11/2020	26 sows reported to have died of the respiratory condition	No autopsy performed

* Enzyme-linked immunosorbent assay (*M hyo* Ab test; IDEXX).
† Real-time polymerase chain reaction assay (Swinecheck *M hyopneumoniae* PCR; Biovet).
‡ Real-time polymerase chain reaction assay (Swinecheck Influenza A virus PCR; Biovet).

coughing that, for most animals, lasted 3 or 4 days with or without treatment. Approximately 20% of the coughing animals also had reduced appetite and were treated with tulathromycin (Draxxin; Zoetis). The manager reported that a total of 26 sows died of their respiratory condition between March 18 and April 11. All these sows reportedly died rapidly, within two days of starting to show a deep cough and anorexia, and most were in late gestation between 2 to 3 weeks and 2 to 3 days of their farrowing date. All the females that died had farrowed at least one previous litter. No apparent impact was observed on performance indicators such as wean-to-estrus interval, farrowing rate, born alive, preweaning mortality, and number weaned per litter in the months during or after clinical signs were observed (data not shown).

Considering the time needed to produce a detectable serological response, approximately 3 weeks or more, it seems reasonable to assume that a large proportion of the sows present in the herd at the time of infection had been infected with MHP by early March.[1,5] Similarly, most of the gilts introduced on March 24 were MHP positive by April 7 as shown by polymerase chain reaction (PCR). These gilts had not shown clinical signs while in isolation and tested serologically negative before their introduction into the sow herd.

Elimination program

As soon as the MHP infection was confirmed, the decision was made to eliminate it from the sow herd so that sale of MHP-negative animals could resume. The herd was closed after transferring the 170 gilts from the quarantine barn to the sow herd on March 24. Clinically affected (coughing) sows were placed strategically within the gilt area to encourage rapid transmission of MHP. No medication other than individual treatments was used at the time so as not to reduce organism transmission within the herd. The PCR testing conducted on April 7 suggested that a large percentage of gilts had already come in contact with MHP. Coupled with the March 24 results, it appeared that most, and perhaps all, females present in the herd at the time of infection had apparently come in contact with the organism. Therefore, it was decided to start medication treatment on April 12. Tylvalosin (Aivlosin, Pharmgate) was added to the feed for 9 weeks at a dose of 2.125 mg/kg of live weight. Tulathromycin (Draxxin, Zoetis) was used on piglets at the time of processing and at 12 days of age for a period of 6 weeks starting one month after sows were medicated. The whole breeding herd was vaccinated with an MHP vaccine on April 13 and again on August 3 and September 1.

On June 22, 7 days after sow medication had concluded, 220 tracheobronchial samples were collected to determine if the organism could still be detected by PCR. Animals positive or suspicious on June 22 were retested until all were found to be negative on October 26. Table 2 shows the results that were obtained over time. Because two gilts were suspicious or positive on August 17, a 1-month feed medication period

(September 26 to October 26) was added with the same product and dosage as previously used. The practitioner elected to add a third feed medication period (November 7 to December 7) as an extra precaution, again using the same product and dosage.

Because of cost and labor concerns, only a subset of females found negative on June 22 were retested (data not shown in Table 2). Fifteen gilts found negative on June 22 were retested on August 17 and all were negative. Twenty-four animals found negative on July 12 were retested on August 17 and found negative. Finally, 33 and 41 gilts introduced on March 24 but had not yet been tested were sampled on October 26 and January 18, respectively, and none were positive. Given these results it seems reasonable to suggest that most if not all animals found negative on June 22 would likely have remained negative on subsequent testing dates.

Discussion

Some findings associated with this case were considered unexpected or original. First, the low number of animals that showed clinical signs was unexpected given that the herd was totally naïve to the organism at the time of infection. A second observation from the case was the very short period during which animals showed clinical signs. Coughing lasted only 2 to 4 days and most affected animals recovered without significant losses. When pigs are experimentally infected with MHP at the same time, pigs begin to cough about 2 weeks post infection, peak about 2 weeks later, and then coughing gradually declines.[1,5] Because both MHP and IAV-S were identified in coughing sows and no necropsy was performed, it is difficult to determine the respective role that each organism played or if something else could have contributed to the problem. Typically IAV-S will cause coughing for only a few days to a week in an individual animal, while MHP can cause coughing that often lasts weeks.[1,5-7] In this respect, the short period of coughing in affected animals in this case would suggest IAV-S rather than MHP, but the long period where coughing was present in the herd (February 22 to May 10) seems more likely to be associated with MHP than with IAV-S. Also, no sows died of the condition after medication was administered to the sow herd on April 12, which again may suggest the role MHP played. It is also possible that both pathogens contributed to the outbreak. It has been reported that animals infected with both organisms may have more severe lesions and losses than those infected with only one of them.[8,9] Studies have also shown that, as for most swine pathogens, strains of MHP can vary in virulence.[10,11] The low mortality and number of clinically affected animals, lack of impact on performance indicators, and that two known respiratory pathogens were identified in sick animals emphasize the apparent low virulence of the MHP strain involved in the current case.

Another finding that differed from what is often seen in MHP cases is the rapid speed of the organism transmission within the herd. Other authors have reported how slow the transmission of this organism within a population of naïve animals can be.[2-4] In a recent study, only 27% of the naïve animals placed in contact with an infected gilt had become infected 8 weeks post exposure.[3] In the case herd most animals present had become infected within a few weeks. Following experimental infection, it is estimated to take approximately 2 weeks or more for animals to begin coughing and 3 weeks or more to seroconvert.[1,5] As a working hypothesis, this suggests that most females present in the herd at the time of infection came in contact with MHP between early February and early to mid-March. The last batch of quarantined gilts was introduced on March 24, and by April 7, 11 of 12 pools of tracheobronchial samples obtained from 30 of the 170 introduced gilts were positive. This last batch of gilts would have been exposed to the organism between late March and early to mid-April, about 3 to 4 weeks after the rest of the herd.

The difference between the percentage of positive or suspicious recently introduced gilts and that of the rest of the herd after the elimination program was implemented was of interest. According to the samples taken on June 22, a 3- to 4-week delay in the time of infection resulted in a percentage of MHP-positive and MHP-suspicious gilts that was 4.8 times higher than for the other females in the herd. This percentage was 31.3 times higher for samples taken on July 12. Pieters et al[6] reported that 18 of 18 gilts (100%) were MHP-positive 94

Table 2: Number and percent of tested females already present in the herd at the time of infection and gilts introduced on March 24, 2020 that were found positive/suspicious over time by PCR on tracheobronchial samples

	Date tested			
	06/22/2020	07/12/2020	08/17/2020	10/26/2020
Tested females in the herd, No.	147	13*	1*	0*
Females positive/suspicious, No.†	13	1	0	0
Females positive/suspicious, %‡	8.8	0.7	0	0
Tested gilts introduced on March 24, No.	73	29*	16*	2*
Gilts positive/suspicious, No.†	31	16	2	0
Gilts positive/suspicious, %‡	42.5	21.9	2.7	0
Ratio of positive/suspicious gilts:females, %	4.8	31.3	-	-

* Only animals testing positive/suspicious on the previous test were retested on this date.

† Cycle threshold (Ct) values < 35 were considered positive and Ct = 35-38 were considered suspicious.

‡ All percentages based on the number of sows (147) and gilts (73) initially tested on June 22; it was assumed that animals negative on June 22 would remain negative afterwards.

days post experimental infection and it took 254 days for gilts to test negative for the organism. The reason for such a large difference between the last introduced gilts and the rest of the females in the case herd is unknown. One possible hypothesis could be that animals with immune systems that had been more completely stimulated by earlier exposure to the organism would better respond to the medication and vaccination program and more rapidly clear the pathogen from their respiratory system. This could mean that in herds where elimination of the organism is the goal, ensuring that all females come in contact with the organism as soon as possible would be important. If, as is often the case, MHP-negative gilts are introduced in the sow herd, this hypothesis would suggest that efforts may have to be made to ensure that gilts are infected before or soon after introduction.

In North America, the strategies used to eliminate MHP in sow herds have usually involved a herd closure of several months coupled with a medication period of 3 to 4 weeks or more in sows and piglets.[12,13] An 8-month herd closure is frequently recommended and different antimicrobials have been used in sows and piglets.[12,13] The rationale for such a long herd closure is the study where it took 240 days for experimentally infected animals to stop infecting negative sentinels placed in contact.[6] In elimination programs, the medication period is usually applied towards the end of the closure period.[12,13] In the case herd described here, the initial medication of the sow herd lasted 9 weeks and began only 20 days after the last gilts were introduced into the herd, at a time when some animals were still showing clinical signs. It was hypothesized that the longer medication period and the product and dose used could allow reproductive animals to eliminate the infectious organism, without including a closure period in the elimination program.

The results obtained showed that on August 17, none of the PCR-tested females (147) that were already present in the herd when infection occurred were MHP positive or suspicious. Furthermore, 5 weeks earlier on July 12, only 1 (0.7%) of these 147 females was weakly positive (cycle threshold = 34.2) and it is not known if this represented infectious MHP. This could mean that 4 or 5 months (mid-March to mid-July or August) following infection of the last female already present in the herd, the organism may have been eliminated from this group of animals. Other laboratory results suggest that the farm may have started to produce uninfected pigs at that time. Twenty-five pigs from a batch of about 3000 piglets born around July 27 were tested serologically at about 9 weeks of age (September 28) and found to be negative. Twenty of the same pigs were tested again when they were 23 weeks of age (January 6) and found to be negative. This is of particular interest because 21.9% of the gilts introduced on March 24 and tested on July 12 were MHP positive. Many of the recently introduced gilts had farrowed before the end of July since insemination had started while they were in isolation.

The diagnostic results and case interpretation suggest that the elimination program did succeed at least to an undetectable or low prevalence. For gilts introduced in March 2020 and had not yet been tested, 33 and 41 gilts were sampled using tracheobronchial catheters in October 2020 and January 2021, respectively. Between October 2020 and April 2021, tracheobronchial samples (average of 29 samples) were obtained 12 times either at weaning or at the end of the nursery period. In March and April 2021, 30 pigs from 4 different finishing units were tested at the end of the finishing period by both tracheobronchial samples and serology. Thirty negative sentinel gilts introduced in the sow herd in January 2021 were tested in April by tracheobronchial samples and serology, and 20 were retested by serology in May and June. In February, March, and April 2021, between 1200 and 1400 gilts were sold at weaning each month. Thirty of these gilts were tested by PCR (tracheobronchial samples) at 4- and 7-weeks post delivery. All these test results were negative. No evidence of MHP infection has been detected in the nursery and finishing units that received pigs from the case herd since July 2020.

If these elimination results were repeatable in other situations and with different strains, it could suggest that herd closure periods shorter than the 8 months often proposed in North America may be sufficient to eliminate MHP from sow herds. This would be consistent with other reports where elimination was achieved with very short or no herd closure.[13-15] Given the increasing interest in MHP elimination programs, more work is needed to identify the programs that are more likely to succeed at the lowest cost and with the least impact on production results.

The PCR test used in this study also detected *Mycoplasma hyorhinis*. While the strategy used in the case herd was successful at eliminating MHP, *M hyorhinis* could still be identified in the weeks and months following termination of the program. Most nursery pigs tested between October 2020 and February 2021 were found to be *M hyorhinis*-positive by PCR (data not shown). Finally, an epidemiological investigation was undertaken to determine the source of MHP infection for the herd described in this case report, but none could be identified with certainty.

Implications

Under the conditions of this study:

- An infected MHP-naïve herd had mild clinical signs and rapid transmission.
- Clearance of the organism by medication can depend on timing of infection.
- Elimination of MHP may require a shorter herd closure period than commonly used.

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Conflict of interest

None reported.

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Performance of a *Mycoplasma hyopneumoniae* serum ELISA for antibody detection in processing fluids

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Summary

The diagnostic performance of a commercial *Mycoplasma hyopneumoniae* (MHP) serum enzyme-linked immunosorbent assay (ELISA) was evaluated for MHP antibody detection in processing fluids (n = 494) using samples from three commercial swine farms. Based on historical monitoring, one farm was considered MHP positive and two were considered MHP negative. Samples were tested at a 1:10 dilution and diagnostic sensitivities and specificities estimated for specific ELISA sample-to-positive (S:P) cutoffs. At S:P ≥ 0.40, diagnostic sensitivity and specificity were estimated as 97.6% and 100.0%, respectively. Overall, the results suggest that processing fluids can be used for MHP antibody surveillance in breeding herds.

Keywords: swine, *Mycoplasma hyopneumoniae*, processing fluid, enzyme-linked immunosorbent assay, diagnostic performance

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Resumen - Comportamiento de un ELISA para suero de *Mycoplasma hyopneumoniae* para la detección de anticuerpos en fluidos de proceso

Se evaluó el comportamiento diagnóstico de un ensayo inmunoabsorbente ligado a enzimas (ELISA) en suero de *Mycoplasma hyopneumoniae* (MHP) comercial para la detección de anticuerpos contra MHP en fluidos de proceso (n = 494) utilizando muestras de tres granjas porcinas comerciales. Con base en el monitoreo histórico, una granja se consideró positiva para MHP y dos negativas para MHP. Las muestras se analizaron a una dilución de 1:10, y las sensibilidad y especificidad de diagnóstico se estimaron para los puntos de corte específicos de muestra a positivo (S:P) de ELISA. Con S:P ≥ 0.40, la sensibilidad y especificidad diagnóstica se estimaron en 97.6% y 100.0%, respectivamente. En general, los resultados sugieren que los fluidos de proceso se pueden utilizar para la vigilancia de anticuerpos MHP en hatos reproductores.

Résumé - Performances d'un ELISA sérique pour la détection d'anticorps envers *Mycoplasma hyopneumoniae* dans les fluides de procédures

Les performances diagnostiques d'une épreuve immuno-enzymatique (ELISA) sérique commerciale envers *Mycoplasma hyopneumoniae* (MHP) ont été évaluées pour la détection d'anticorps MHP dans les fluides de procédures (n = 494) à l'aide d'échantillons provenant de trois fermes porcines commerciales. Sur la base de la surveillance historique, une ferme a été considérée comme positive au MHP et deux ont été considérées comme négatives au MHP. Les échantillons ont été testés à une dilution de 1:10 et les sensibilités et spécificités diagnostiques ont été estimées pour des seuils ELISA spécifiques échantillon-à-positif (S:P). À S:P ≥ 0.40, la sensibilité et la spécificité diagnostiques ont été estimées à 97.6% et 100.0%, respectivement. Dans l'ensemble, les résultats suggèrent que les fluides de procédures peuvent être utilisés pour la surveillance des anticorps MHP dans les troupeaux reproducteurs.

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Magtoto R, Armenta-Leyva B, Dizon-Magtoto P, Cheng T-Y, Clavijo MJ, Johnson C, Lopez W, Baum D, Zimmerman J, Giménez-Lirola LG. Performance of a *Mycoplasma hyopneumoniae* serum ELISA for antibody detection in processing fluids. *J Swine Health Prod*. 2022;30(3):165-170. **https://doi.org/10.54846/jshap/1265**

Mycoplasma hyopneumoniae (MHP), the etiological agent of enzootic pneumonia[1] and a major player in the porcine respiratory disease complex,[2] is one of the most economically important pathogens of swine, costing the US swine industry approximately $400 million annually.[3] Sow herd stability is key to the reduction of MHP losses in growing pigs because piglets are born MHP-free and become infected by contact with sows shedding the microorganism.[4] For this reason, control programs typically focus either on enhancement of sow herd immunity (vaccination or intentional gilt exposure) or complete elimination of MHP. Regardless of the approach, testing for MHP-specific DNA or antibody is needed to establish the status of the breeding herd population.[5,6] Because each diagnostic approach has its advantages and disadvantages, the choice is determined by which best fits the farm's MHP control strategy and yet is practical in terms of sampling and testing.

Processing fluid (PF), the serosanguineous fluid recovered from testicles and tails at the time of piglet processing (3-5 days of age), is an easily collected specimen with high diagnostic utility.[7-10] Sow herd surveillance using PF was first reported[11] in 2010 and has been widely adopted by the industry, eg, the Iowa State University Veterinary Diagnostic Laboratory performed approximately 395 diagnostic tests on processing fluids in 2017; 11,790 tests in 2018; 22,411 tests in 2019; 22,163 tests in 2020; and 26,075 tests in 2021 (Dr Giovani Trevisan, DVM, email, January 15, 2022). Although Boettcher et al[11] reported the detection of MHP-specific (colostral) antibody in PF collected from piglets ≤ 7 days of age, there are no reports substantiating or expanding upon this initial report. Therefore, the purpose of this study was to evaluate the diagnostic performance (ie, sensitivity and specificity) of a commercial enzyme-linked immunosorbent assay (ELISA) for the detection of MHP antibodies using PF samples.

Methods

Design

Processing fluid samples (n = 494) from 3 commercial farms were tested for the presence of MHP antibodies using a commercial MHP indirect serum antibody ELISA at a 1:10 dilution. Based on intervention program and historical monitoring, one farm was considered MHP positive (246 PF samples) and two farms were considered MHP negative (248 samples). Receiver operating characteristic (ROC) curve analysis was used to analyze diagnostic performance using farm MHP status as a proxy of sample status. From this analysis, diagnostic sensitivity and specificity and 95% CI were estimated over a range of cutoffs.

PF samples

Samples were collected from 3 commercial swine farms from 2018 through 2020 for the purpose of monitoring porcine circovirus type 2 (PCV2) and porcine reproductive and respiratory syndrome virus (PRRSV). The criteria to establish MHP status corresponded to the MHP status of gilts used for the original stocking at each farm. The status of the MHP-negative farms was established based on their stocking history (ie, stocked with confirmed naïve gilts) and syndromic and routine surveillance. The latter consisted of monthly serum collection tested by MHP ELISA. Neither MHP-negative farm implemented MHP vaccine for piglets, gilts, or sows. The MHP-positive herd was stocked with MHP-positive gilts (confirmed at stocking via MHP ELISA on serum) that received commercial MHP vaccine at weaning (4 weeks of age; 2 mL Circumvent PCV-M; Merck Animal Health USA) and again at prebreeding (20 weeks of age; 2 mL Circumvent PCV-M). There was no mass vaccination of the sow herd and the piglets did not receive any MHP vaccine prior to weaning. Clinical signs of MHP in that herd were only identified sporadically in the gilt development unit in gilts 15 to 20 weeks of age, including mild coughing for 2 to 3 weeks with no noticeable performance impact (no mortality or average daily gain concerns).

Sample collection was performed by farm personnel using procedures previously described.[9] In brief, PF samples were collected at the time of piglet processing (ie, castration and tail docking) by placing testicle and tail tissues on gauze suspended over the top of a plastic container, thereby allowing the tissue exudate to pool in the bottom of the container. Each PF sample included tissues from 14 to 56 litters of 3- to 5-day-old piglets. At the end of processing, the liquid was transferred to a tube, stored at approximately 4°C, sent to the Iowa State University Veterinary Diagnostic Laboratory for PCV2 and PRRSV PCR testing, and then stored at -20°C until tested for MHP antibody.

MHP indirect antibody ELISA

The MHP ELISA (*M hyo* Ab test; Idexx Laboratories Inc), an assay designed to detect anti-P46 antibodies in serum, was used in the study. Samples were thawed, allowed to reach room temperature, and briefly vortexed. Thereafter, samples were tested for the presence of MHP antibodies following the instructions provided by the manufacturer with the exception that samples were tested at a 1:10 dilution rather than the 1:40 dilution described for serum.

To perform the test, samples were diluted 1:10 by adding 15 µL of sample to 135 µL of kit diluent in a dilution plate. Thereafter, 100 µL of diluted samples were transferred to plate wells, after which the plates were incubated (30 minutes, 22°C) on a plate heater (16-Position Microtiter Plate Heater; J-KEM Scientific) and then washed four times with 350 µL of wash solution on a plate washer (ELx405 Biotek Instruments Inc). Then 100 µL of kit conjugate was added to each well and the plate incubated (30 minutes, 22°C). The wash cycle was then repeated, 100 µL of 3,3',5,5'-Tetramethylbenzidine substrate was added to each well, the plates incubated (15 minutes, 22°C), and then 100 µL of stop solution was added into each well. Plates were read on an ELISA reader (EMax Plus Microplate Reader; Molecular Devices) using SoftMax pro 7.0 Software (Molecular Devices) and optical density (OD) results converted to sample-to-positive (S:P) ratios:

$$\text{MHP ELISA S:P} = \frac{\text{(Sample OD – Negative control mean OD)}}{\text{(Positive control mean OD – Negative control mean OD)}}$$

Statistical analysis

Diagnostic sensitivities and specificities for specific ELISA S:P cutoffs were estimated by ROC analysis using R software[12] (version 4.0.3; The R Foundation) and pROC package.[13] To perform the analysis, MHP ELISA S:P results with negative values were truncated to zero and sample status (positive, negative) was assumed to match farm status (MHP positive or MHP negative). Estimation of 95% CI for diagnostic sensitivity and specificity for every ELISA S:P cutoff was performed using a nonparametric stratified bootstrapping method with 10,000 iterations.[13,14]

Results

A frequency distribution of MHP ELISA S:P responses by farm status is given in Figure 1 and a summary of test responses by farm and year is given in Table 1. Among all samples from the two MHP-negative farms (n = 248), 246 (99.2%) had S:P values < 0.20 and all 248 (100%) had S:P values < 0.40. Among samples from the MHP-positive farm (n = 246), 240 (97.6%) had S:P values ≥ 0.40. Table 2 lists the diagnostic sensitivity and specificity estimated for specific MHP ELISA S:P cutoffs and 95% CI.

Discussion

Routine surveillance based on DNA and antibody detection is crucial for tracking MHP in commercial herds.[15] In sow herds, serum antibody testing is a common approach, but serum-based MHP surveillance is constrained both by the labor required for collecting blood samples and the number of samples required for statistically valid surveillance.[15] However, other specimens have been described to contain detectable levels of MHP antibody and could potentially be used for surveillance, eg, colostrum, milk, muscle tissue exudates (meat juice), and processing fluids.[11,16-18] In this regard, processing fluids are of particular interest because they are easily collected[10] and achieve better detection at the population level at a lower cost than individual pig sampling.[7,10,19]

The use of processing fluid antibody testing for sow herd surveillance was first reported in 2010 and has since been described for the nucleic acid- or antibody-based surveillance of a variety of pathogens, including hepatitis E,[7] influenza A virus,[11] MHP,[11,20] PRRSV,[9,11,21,22] PCV2,[8,22,23] porcine delta coronavirus,[22] and *Salmonella enterica*.[11]

On a diagnostic timeline, processing fluids were preceded by use of meat juice samples and the two are similar in derivation, ie, both are tissue exudates. Like processing fluids, meat juice contains detectable antibodies against a variety of pathogens, eg, *Toxoplasma gondii*,[24] pseudorabies virus,[25] *Salmonella enterica*,[26] PRRSV,[27] porcine epidemic diarrhea virus,[28] *Yersinia enterocolitica*, and *Actinobacillus pleuropneumoniae*.[17] Pertinent to the current study, Meemken et al[17] reported a 91% diagnostic sensitivity and 96% specificity for MHP antibody detection in meat juice when compared to serum antibody.

Processing fluids and meat juice differ in the source of the antibody in the sample. Antibody in meat juice is derived from the pig from which the sample was collected and indicates that the pig had been infected by, or vaccinated for, the pathogen of interest.[29] In contrast, antibody in processing fluids from 3- to 5-day-old piglets primarily represents circulating maternal antibody (primarily IgG). That is, colostral IgG is transported from the piglet's intestinal tract and into the lamina propria by nonselective endocytosis, then enters the intestinal lymphatic system, and finally, the circulatory system.[30] Therefore, antibody detection in processing fluid samples provides the means to surveil sow herd MHP antibody status - not the piglet humoral immune response against MHP infection.

Consistent with the report by Boettcher et al,[11] the commercial MHP ELISA used in this study was performed using a processing fluid sample dilution of 1:10 rather than the 1:40 dilution used in serum testing. The initial study of MHP antibody in 181 sows and processing fluids from their litters described strong agreement in MHP ELISA results at the herd level.[11] However, surveillance requires the use of assays with known diagnostic performance. The present study determined that the manufacturer´s recommended cutoff (S:P ≥ 0.40) provided 97.6% (95% CI, 95.5%-99.2%) and 100.0% (95% CI, 100%-100%) diagnostic sensitivity and specificity, respectively. However, since

Figure 1: Frequency distribution of MHP antibody ELISA (IDEXX Laboratories Inc) S:P responses by farm MHP status. MHP = *Mycoplasma hyopneumoniae*; ELISA = enzyme-linked immunosorbent assay; S:P = sample-to-positive ratio.

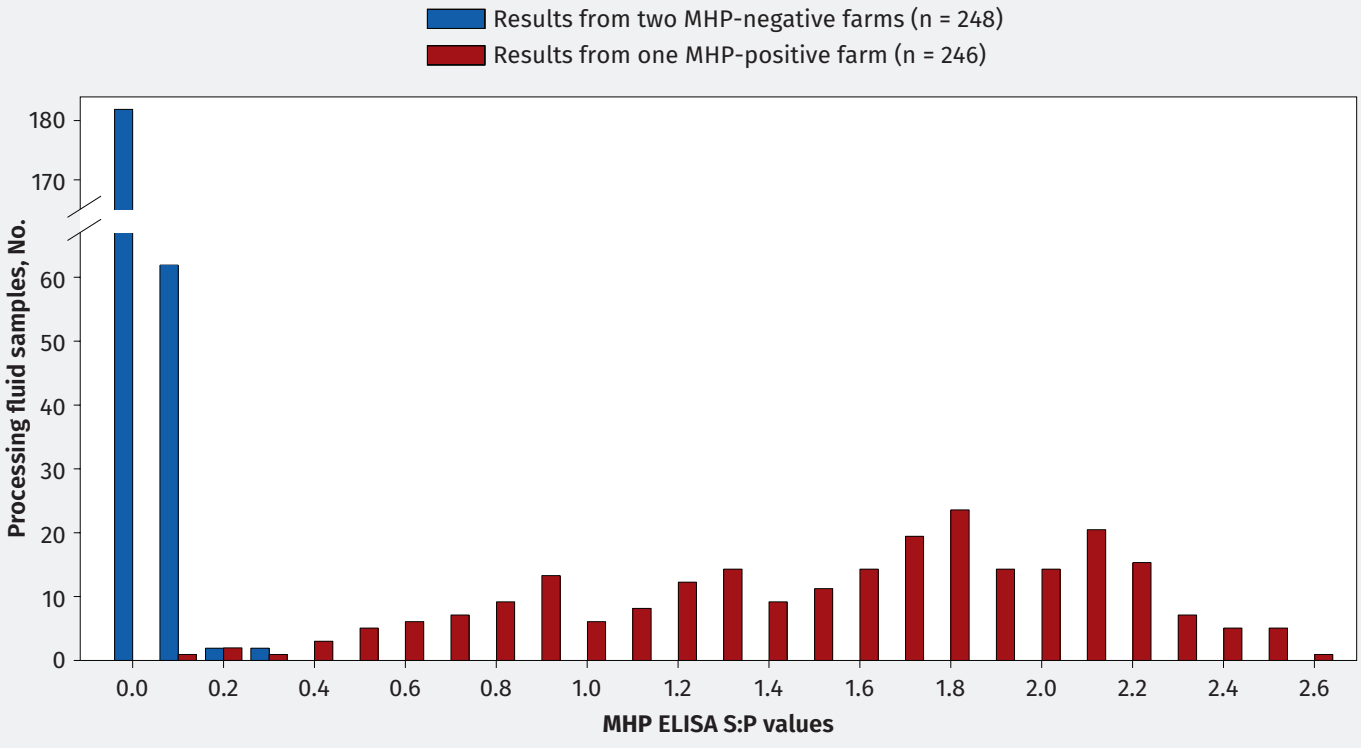

Table 1: Summary of MHP antibody ELISA* processing fluid sampling and testing data by farm

Farm (MHP status)	Year	No. samples	MHP ELISA mean S:P (min, max)
1 (positive)	2018	39	0.80 (0.10, 1.40)
	2019	143	1.51 (0.24, 2.61)
	2020	64	2.11 (1.18, 2.73)
	Total	**246**	**1.55 (0.10, 2.73)**
2 (negative)	2018	33	0.01 (0.0, 0.06)
	2019	122	0.03 (0.0, 0.28)
	2020	49	0.03 (0.0, 0.14)
	Total	**204**	**0.03 (0.0, 0.28)**
3 (negative)	2018	38	0.03 (0.0, 0.13)
	2019	6	0.05 (0.02, 0.09)
	Total	**44**	**0.03 (0.0, 0.13)**

* *M hyo* Ab test (IDEXX Laboratories Inc) with processing fluid samples tested at a 1:10 dilution.

MHP = *Mycoplasma hyopneumoniae*; ELISA = enzyme-linked immunosorbent assay; S:P = sample-to-positive ratio.

Table 2: Processing fluid MHP antibody ELISA* diagnostic sensitivity and specificity by S:P cutoff†

S:P cutoff	Sensitivity, % (95% CI)	Specificity, % (95% CI)
0.1	99.6 (98.8-100)	94.4 (91.5-97.2)
0.2	**99.2 (98.0-100)**	**99.2 (98.0-100)**
0.3	**98.8 (97.2-100)**	**100 (100-100)**
0.4	97.6 (95.5-99.2)	100 (100-100)
0.5	95.5 (92.7-98.0)	100 (100-100)
0.6	93.9 (90.7-96.7)	100 (100-100)
0.7	90.7 (87.0-93.9)	100 (100-100)
0.8	88.6 (84.6-92.3)	100 (100-100)
0.9	83.7 (78.9-88.2)	100 (100-100)
1.0	79.7 (74.8-84.6)	100 (100-100)

* *M hyo* Ab test (IDEXX Laboratories Inc) with processing fluid samples tested at a 1:10 dilution.

† Diagnostic sensitivity and specificity point estimates derived from ROC analysis using R software[12] (version 4.0.3) and pROC package.[13] A 95% CI was calculated using a nonparametric stratified bootstrapping method with 10,000 iterations.[13,14]

MHP = *Mycoplasma hyopneumoniae*; ELISA = enzyme-linked immunosorbent assay; S:P = sample-to-positive ratio.

near-perfect diagnostic specificity to minimize false-positive results is important for surveillance,[31] users may elect to use a higher cutoff using the cutoffs and associated diagnostic sensitivities and specificities provided in Table 2.

One limitation of the study was that sample classification was based on farm status rather than individual sow status. Two distinctly different MHP antibody response patterns were observed in samples from MHP-negative vs MHP-positive farms, but it is possible that samples from the MHP-positive sow herd were negative for MHP antibodies. Notably, four samples from the MHP-positive herd had S:P values < 0.40 (Figure 1). The overall impact of this small number of misclassified samples on the analysis would be to slightly underestimate the diagnostic sensitivity of the ELISA, but this will have little impact on the utility of this population-based surveillance tool. Still, the lack of detection in the MHP-negative dataset suggests a high level of specificity of this sample type and test. The MHP ELISA cannot differentiate between vaccine or acquired antibodies. Thus, positive processing fluid samples used from this study may have resulted from the use of vaccine in the breeding herd and not maternal antibodies derived from natural infection. This point will need to be considered for routine surveillance of vaccinated but antigen-free herds.

Overall, this study demonstrated that processing fluids could be used for detection of MHP-specific antibodies. The diagnostic performance of the sample type in known status samples revealed a high level of accuracy. The convenience and low-cost nature afforded by processing fluids, combined with its potentially high herd sensitivity, make it highly promising for monitoring naïve herds. Future investigation would need to determine the sensitivity of this sample type compared to serum or deep tracheal swabs for timely detection of MHP antibodies in MHP-naïve herds.

Implications

Under the conditions of this study:

- The MHP antibody ELISA discriminated between negative and positive sow herds.
- An S:P cutoff ≥ 0.40 provided 98.8% sensitivity and 100% specificity.
- Processing fluids could be used for surveillance of MHP-naïve herds.

Acknowledgments

Conflict of interest

Dr Zimmerman serves as a consultant to Idexx Laboratories, Inc. The terms of the consulting arrangement have been reviewed and approved by Iowa State University in accordance with its conflict of interest policies. No other conflicts reported.

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Conversion tables

Weights and measures conversions

Common (US)	Metric	To convert	Multiply by
1 oz	28.35 g	oz to g	28.35
1 lb (16 oz)	0.45 kg	lb to kg	0.45
2.2 lb	1 kg	kg to lb	2.2
1 in	2.54 cm	in to cm	2.54
0.39 in	1 cm	cm to in	0.39
1 ft (12 in)	0.3 m	ft to m	0.3
3.28 ft	1 m	m to ft	3.28
1 mi	1.6 km	mi to km	1.6
0.62 mi	1 km	km to mi	0.62
1 in^2	6.45 cm^2	in^2 to cm^2	6.45
0.16 in^2	1 cm^2	cm^2 to in^2	0.16
1 ft^2	0.09 m^2	ft^2 to m^2	0.09
10.76 ft^2	1 m^2	m^2 to ft^2	10.8
1 ft^3	0.03 m^3	ft^3 to m^3	0.03
35.3 ft^3	1 m^3	m^3 to ft^3	35.3
1 gal (128 fl oz)	3.8 L	gal to L	3.8
0.26 gal	1 L	L to gal	0.26
1 qt (32 fl oz)	0.95 L	qt to L	0.95
1.06 qt	1 L	L to qt	1.06

Temperature equivalents (approx)

°F	°C
32	0
50	10.0
60	15.5
61	16.1
65	18.3
70	21.1
75	23.8
80	26.6
82	27.7
85	29.4
90	32.2
102	38.8
103	39.4
104	40.0
105	40.5
106	41.1
212	100.0

°F = (°C × 9/5) + 32
°C = (°F - 32) × 5/9

Conversion calculator available at: amamanualofstyle.com/page/si-conversion-calculator

Conversion chart, kg to lb (approx)

Pig size	Lb	Kg
Birth	3.3-4.4	1.5-2.0
Weaning	7.7	3.5
	11	5
	22	10
Nursery	33	15
	44	20
	55	25
	66	30
Grower	99	45
	110	50
	132	60
Finisher	198	90
	220	100
	231	105
	242	110
	253	115
Sow	300	136
	661	300
Boar	794	360
	800	363

1 tonne = 1000 kg
1 ppm = 0.0001% = 1 mg/kg = 1 g/tonne
1 ppm = 1 mg/L

Industry unites to promote AgView as part of comprehensive FAD preparedness

When it comes to working together to help protect the US pork industry, collaboration is critical. That is why the National Pork Board (NPB), along with the National Pork Producers Council (NPPC), the American Association of Swine Veterinarians (AASV), and the Swine Health Information Center (SHIC) continue to work cross-functionally to ensure complete alignment on strategies and tactics to help prevent and prepare for foreign animal diseases such as African swine fever (ASF).

"Along with our partners at USDA and US Customs and Border Protection, the pork industry is united in its commitment to do everything it can to help keep our country free of foreign animal disease," says Dr Dustin Oedekoven, chief veterinarian at NPB. "We are also excited to have tools such as AgView that can help reduce the negative impact of a disease, such as ASF, by providing critical real-time information to state animal health officials when it is most needed."

Dr Paul Sundberg, executive director of SHIC, agrees that AgView is a vital new tool. "As SHIC monitors swine disease outbreaks around the globe, we see the need for technology such as AgView as part of a preparedness/response strategy for foreign animal disease threats to the domestic swine herd. Learning from those who have faced disease challenge better equips the US pork industry to respond if needed and AgView puts needed resources in place."

Echoing Sundberg's sentiments, Dr Liz Wagstrom, NPPC's chief veterinarian, says "To effectively respond to a foreign animal disease, we will need to know where pigs are, where they came from, and where they are moving. AgView allows us to visualize sites and movements and having producers use it now brings us another step closer to being prepared for a potential outbreak."

The optimism in the swine veterinary community is also high for AgView. Dr Harry Snelson, AASV executive director, says "AASV member veterinarians can help ensure business continuity in the swine industry by encouraging their clients to participate in the National Pork Board's AgView platform. Veterinary clinics can also facilitate a rapid disease response by utilizing the Account Management Partner (AMP) feature of AgView, which enables near real-time access to client data and laboratory results. Rapid data access and sharing is critical to effectively responding to a foreign animal disease outbreak."

AgView's AMP feature offers additional utility to veterinarians

While the overall function of AgView will remain focused on foreign animal disease mitigation and business continuity, the National Pork Board will be announcing additional AgView features in 2022, including the Account Management Partner (AMP) feature, which offers veterinarians quick access to future AgView capabilities such as near real-time lab results. In addition, key features include the ability to upload swine premises data, Secure Pork Supply documents and pig movements. This allows for a custom analysis of this information as well when producer-clients have granted their veterinarian access.

Plans for future AgView functionality include allowing veterinarians to access client diagnostic data once permission is granted. This will offer a single location to analyze even more data for improved response time. In the interim, the most recent AgView information can be found by going to **porkcheckoff.org/agview**. For additional information, contact Dr Patrick Webb, DVM, at **pwebb@pork.org** or 515-223-3441.

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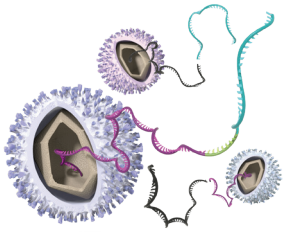

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AASV installs 2022 officers

Dr Michael Senn was installed as president of the American Association of Swine Veterinarians on March 1, 2022, during the association's 53rd Annual Meeting in Indianapolis, Indiana. He succeeds Dr Mary Battrell, who is now immediate past president. Dr William Hollis has ascended to president-elect. The newly elected vice president is Dr Angela Baysinger.

AASV President Dr Michael Senn (KSU '91) was involved in agriculture as a youth and raised on a diversified livestock and crop farm in Kansas, where he continues as the 4th generation involved with the farm. Dr Senn credits his participation in 4-H and FFA as a youth with his passion for volunteerism and leadership. He has served AASV with two terms on the board of directors, as a committee member, as chair of the Foreign Animal Disease Committee, and as a student presentation judge. During his career, he has worked as a mixed-animal practitioner, swine production veterinarian, and as a technical services veterinarian, providing technical support for products and focused on clinical research, antimicrobial resistance monitoring, antibiotic regulatory issues, and emerging infectious disease surveillance. He continues to work as an independent consultant. Dr Senn lives in Newton, Kansas with his wife, Stephanie, and children Annika and Jakob.

When asked to comment on his thoughts about the future of AASV and his tenure as president, Dr Senn said, "Through the challenges that we all have faced in recent years, I'm impressed with the continued focus and tenacity of the membership to continue to meet the mission of AASV. As we look ahead, it is important to continue to recruit new members through mentoring students and professional development of recent graduates, while creating a welcoming and inclusive experience for all members."

AASV President-elect Dr William Hollis (Illinois '96) is currently a partner and veterinarian of Carthage Veterinary Service and serves as the president of Professional Swine Management, the Carthage swine service management company. Dr Hollis was named the AASV Swine Practitioner of the Year in 2019. He is a Pork Quality Assurance Plus Advisor, served on the National Pork Producers Council Animal Health Food Security Policy Committee, and served on the National Pork Board Swine Health Committee. He has served on the American Veterinary Medical Association House of Delegates representing AASV, and on the AASV Board of Directors representing District 5. Dr Hollis is an active participant in the National Pork Board Operation Main Street program giving local presentations to raise awareness about modern pork production.

AASV officers (left to right) Dr Mike Senn (President), Dr William Hollis (President-elect), Dr Angela Baysinger (Vice President), Dr Mary Battrell (Past President).

AASV news continued on page 175

Build a productive herd with a healthy gut.

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AASV news continued from page 173

AASV Vice President Dr Angela Baysinger (Missouri '92) grew up on a livestock and grain farm near Martinsburg, Missouri. She currently serves as the North American Animal Welfare Lead for all species for Merck Animal Health. Dr Baysinger completed her undergraduate studies in animal science and her doctor of veterinary medicine at the University of Missouri. She received a master's of science in epidemiology from the University of Nebraska. Additionally, she received a master's of science in international animal welfare, ethics, and law in December of 2021 from the University of Edinburgh, which was partially funded by the AASV Foundation Alex Hogg Memorial Scholarship she was awarded in 2018. Dr Baysinger was honored with the AASV Meritorious Service Award in 2021. She has served on multiple AASV committees as a member and chair and on the AASV Board of Directors representing District 8. She has represented the AASV on the American Veterinary Medical Association (AVMA) Clinical Practitioners Advisory Committee, the AVMA Council on Biologics and Therapeutic Agents, the AVMA Animal Welfare Committee, and on the Professional Animal Auditor Certification Organization (PAACO) board. Further, she has served as a member of the welfare committees for the National Pork Board and the North American Meat Institute. Finally, she is a cochair of the recently established National Institute for Animal Agriculture Sustainability Council.

Commenting on her upcoming role as vice president, Dr Baysinger said, "I am honored to expand my service to the AASV and the swine industry in the role of vice president. The opportunity to work with the members of AASV is exciting, and I look forward to the challenges."

Dr Baysinger lives near Bruning, Nebraska with her family.

AASV Past President Dr Mary Battrell (ISU '95) has worked for Smithfield Hog Production since 2000, where she is currently a staff veterinarian for Smithfield Hog Production's Central Region and is responsible for the health and well-being of 92,000 sows farrow-to-finish. She has been actively involved in the development of the Smithfield Animal Care Program and their contingency plan for a foreign animal disease outbreak. Dr Battrell has served on the AASV Pig Welfare and Pharmaceutical Issues Committees and was the 2018 recipient of the AASV Swine Practitioner of the Year award.

AASV proceedings and seminar papers online

Were you unable to attend the AASV Annual Meeting? Or perhaps you could not attend all of the presentations you were interested in. Good news: the conference proceedings are available online to all AASV members at **aasv.org/library/proceedings/** (2022 membership dues-paid status required).

The proceedings papers are available in several formats:

- "Big book" of the papers for the regular meeting sessions in a single PDF file with a linked table of contents
- Seminar booklets - PDF file for each seminar
- Individual papers in the Swine Information Library (**aasv.org/library/swineinfo**)

Happy reading!

AASV "defines its future" at the 53rd Annual Meeting in Indianapolis

The American Association of Swine Veterinarians (AASV) held its 53rd Annual Meeting in Indianapolis, Indiana, February 26–March 1, 2022, at the JW Marriott Indianapolis. The conference program, themed "Defining Our Future," was chaired by AASV President-elect Dr Mike Senn.

As reported during the annual AASV business meeting on March 1st, the meeting drew 880 total attendees, including 459 paid registrants and 81 veterinary students from 16 universities. The total attendance also included 252 exhibit representatives from 90 companies and organizations. Including the United States, 16 countries were represented.

The meeting participants enjoyed the opportunity to listen to 213 speakers and poster presenters by attending numerous educational sessions, including 11 preconference seminars, 2 general sessions, 3 break-out sessions, 1 Research Topics session, 3 Industrial Partners sessions, the Student Seminar, and a poster session featuring posters from students, researchers, and industrial partners.

Preconference seminars included topics about influenza, pharmacology, feed risk, applied field research, nutrition, leadership, and the swine veterinarian's toolbox in 2032. Saturday's Diagnostics: Opportunities, Advancements, and Implementation and Sunday's Data-Driven Decision Making preconference seminars drew the most preregistered attendees. As always, the Swine Medicine for Students preconference seminar was well attended by veterinary students. The ever-popular practice tips session, Practice Tips: Learn from the Past and Shape our Future, was judged by volunteers Drs Chelsea Hamilton, Clark Huinker, and Terri Specht, and chaired by Dr Melissa Billing. Dr Thomas Gillespie's presentation "Ghost piglets" received the top prize, followed by Dr Jeff Harker's "Learning to work with yourself" and Dr Jessica Risser's "Tips and tricks for interpreting PRRS whole genome sequencing." Sunday afternoon, veterinary students highlighted their research and experience to a large crowd during the Student Seminar.

Dr Angela Baysinger, North American animal welfare lead for all species for Merck Animal Health, 2021 AASV Meritorious Service Award recipient, and AASV's newly elected vice-president, opened the Monday general session with the Howard Dunne Memorial Lecture. During her presentation titled "Leaping into the future: Sit down, buckle up, and hang on," she acknowledged that members do not always have to agree but should strive to be open minded. Dr Baysinger closed with a statement inspired by a quote from Martin Luther King, Jr. She left the audience by saying, "The ultimate measure of an organization is not where the members stand in moments of comfort and convenience, but where they stand at times of challenge and controversy."

Dr James Kober, an independent consultant and contract hog finisher, presented the Alex Hogg Memorial Lecture titled "Learning for the future." Reminding attendees that Dr Alex Hogg completed the Executive Veterinary Program in Swine Health at age 75, he demonstrated that it was never too late to learn. Dr Kober encouraged members to reconnect with their mentors throughout their careers, emphasizing that mentorship is a lifelong endeavor.

A panel of dynamic speakers shared their perspectives on diversity, equity, and inclusion in veterinary medicine during the general session. Speakers shared a similar theme of acknowledgment and apology, acceptance of an opportunity to learn, and forward movement with new knowledge.

The Monday afternoon concurrent sessions challenged veterinarians to evaluate PRRSV RFLP 1-4-4 and its management; think critically about sustainability and animal welfare; and consider new tools to address disease prevention, control, and elimination. The Tuesday general session focused on foreign animal disease preparedness and response. A panel of state animal health officials from Indiana, Iowa, and Minnesota answered numerous questions from the audience.

Dr Mike Senn, AASV president-elect and conference program chair welcomes attendees to the 53rd Annual Meeting.

The AASV continued to emphasize member well-being by hosting the AASV Veterinarian Well-being Center. The center offered an American Veterinary Medical Association (AVMA) Wheel of Well-Being, interactive displays, and tips to support a culture of well-being from AASV leaders past and present. The AASV Human Health, Safety, and Well-Being Committee prepared an activity to help attendees get to know and appreciate their AASV colleagues and promote well-being and inclusivity at the annual meeting.

In addition, 15 AASV committees met during the annual meeting to discuss important issues in swine health, public health, animal well-being, and membership services. A new Diversity, Equity, and Inclusion committee, established by the AASV Board of Directors at their April 2021 meeting, focused their discussions on promoting a socially conscious organizational culture that affirms the value of diversity, equity, and inclusion.

The AASV Awards Reception was held Monday night, followed by the AASV Foundation's annual fund-raising

auction. Dr Scanlon Daniels, 2018 AASV president and 2022 AASV Awards Committee chair, introduced the recipients of the Swine Practitioner of the Year Award (Dr Dyneah Classen), the Howard Dunne Memorial Award (Dr Tim Loula), the Meritorious Service Award (Dr Daryl Olsen), the new Outstanding Swine Academic of the Year Award (Dr Montserrat Torremorell), the Technical Services/ Allied Industry Veterinarian of the Year Award (Dr Gregory Cline), and the Young Swine Veterinarian of the Year Award (Dr Lauren Glowzenski).

Swine Practitioner of the Year

Dr Dyneah M. Classen was named the 2022 Swine Practitioner of the Year. The award is given to the swine practitioner who has demonstrated an unusual degree of proficiency and effectiveness in the delivery of veterinary service to clients.

Dr Classen is a partner and veterinarian in Carthage Veterinary Service, Ltd, where she is responsible for overall animal health as the Director of Health for the Carthage System, as well as assigned herds. She joined the practice in 2007 and became a partner in 2010. She earned her DVM (2007) and BS in animal science (2003) from the University of Illinois.

While Dyneah worked at a veterinary clinic as a teenager, she had also grown up around pigs. She recognized her passion for working with pig farmers in rural Illinois and sought out internships and experiences to become a swine veterinarian. One internship brought her to Carthage Veterinary Service, Ltd.

Dr Dyneah Classen, recipient of the AASV Swine Practitioner of the Year Award.

As a member of the AASV dedicated to the future of the veterinary profession, Dr Classen has served as a member of the AASV Pig Welfare Committee and member and chair of the AASV Student Recruitment Committee.

"Her strong work-life balance makes her a good role model for students entering into our swine veterinary profession," expressed a peer.

Asked to share her thoughts about receiving this award, Dr Classen replied, "I am surprised. I didn't even know I was nominated. I'm very grateful and a little emotional. To have your peers honor you with such an award is very humbling."

Dr Classen lives in Hamilton, Illinois, with her husband Nathan and four children Elsa, Freya, Willa, and Noah.

Howard Dunne Memorial Award

Dr Tim Loula received the 2022 Howard Dunne Memorial Award. The award recognizes an AASV member who has made important contributions and provided outstanding service to the association and the swine industry.

A Minnesota native, Loula received a BA from Drake University and BS and DVM from the University of Minnesota. He spent his first 12 years of his veterinary career in a mixed-animal practice with a focus on swine.

Dr Loula became the cofounder and coowner of the Swine Veterinary Center in St. Peter, Minnesota in 1991. He helped build the business into an exclusive swine veterinary practice with 15 veterinary consultants. Dr Loula has devoted his life to the swine industry, leading efforts to improve production and herd health status while maintaining profitability for clients. He has consulted in 34 states and 30 foreign countries.

Dr Loula exemplifies the qualities of a Howard Dune Memorial Award recipient. He shares his extensive knowledge with the industry through presentations at producer and veterinary meetings and published articles. He has continuously provided outstanding service to the AASV as president (1993), district director (two terms), and as a member of multiple committees. His lifetime of service has helped swine operations around the world improve health and production.

Dr Tim Loula, recipient of the Howard Dunne Memorial Award.

Others have also recognized Dr Loula's outstanding service. He earned the AASV Swine Practitioner of the Year award (1990), Allen D. Leman Science in Practice award (2001), Master of the Pork Industry (2009), and Minnesota Pork Distinguished Service award (2021).

Dr Loula's colleagues and mentees describe his greatest impact as what he has passed forward to others, especially through mentorship to young swine veterinarians and production staff. He is always willing to teach, share, and support. He has always emphasized the importance of building relationships and knowing all people and knows when to enlist the help of fellow swine veterinarians to solve a problem.

When asked to comment on what the award means to him, Dr Loula said, "I feel incredibly honored to receive this award and to be in the company of such an impressive list of past recipients. I would like to thank my colleagues in the AASV, especially my partners at Swine Veterinary Center, for your friendship and for being an invaluable source of continual learning for me. I thank all my clients for allowing me to learn at least as much from them as they did from me. And thank you to all my other friends in this industry who helped me in countless ways to do my job and have fun doing it. But above all, I'd like to thank my family – my wife Ruth, my business and life partner for 44 years, our 2 children and their spouses, and our 6 grandchildren. Their love and support have kept me grounded and have been essential to not only my career, but to every part of my life."

Meritorious Service Award

Dr Daryl Olsen was named the 2022 recipient of the Meritorious Service award. The award recognizes individuals who have provided outstanding service to the AASV.

Olsen grew up on a livestock farm in South Dakota. He earned his BS at South Dakota State University and DVM at Iowa State University. Immediately after graduating in 1982, he went to the Audubon Veterinary Clinic, what was then a traditional mixed-animal veterinary clinic. Audubon-Manning Veterinary Clinic (AMVC) has since developed into a diversified veterinary practice and swine production company doing business in 15 states, employing 23 veterinarians, and 750 total employees. Dr Olsen is a partner at AMVC, currently serving as a managing partner for AMVC, LLC.

Dr Olsen played a key role in establishing and currently serves on the board of directors for the Swine Medicine Education Center at Iowa State University. He chairs the Swine Health Information Center's Board of Directors. He is committed to his community, as evidenced by his philanthropic leadership.

As expected of a recipient of the Meritorious Service award, Dr Olsen has given tirelessly to the AASV. He has served on the AASV Foundation Auction Committee, multiple issue-based committees, the Program Planning Committee, and was president in 2007. Dr Olsen's vice-presidential campaign platform was to support the mission of the AASV. He devoted his tenure to ensuring the AASV continued to be a strong organization that united swine veterinarians.

Dr Daryl Olsen, recipient of the AASV Meritorious Service Award.

Dr Olsen's peers admire his ability to always bring out the very best in those around him. He has built a swine veterinary and management business whose greatest accomplishment may be encouraging and allowing the growth and development of his colleagues in the swine veterinary profession.

Grateful for the association, Olsen stated, "Being recognized by your peers is probably the greatest achievement in a professional career. But more importantly, my involvement in AASV has provided me with unbelievable personal and professional satisfaction. AASV is an amazing organization, and I am so proud to be a member."

Daryl and Nancy's family includes two daughters and their families. Erika and her husband, Matt Weber, have two daughters, Lucy and Ruby, and reside in Waukee, Iowa. Dena and her husband, Dan Hoffman, have a son, Mack, and a daughter, Ellie, and reside in Prior Lake, Minnesota.

Outstanding Swine Academic of the Year Award

Dr Montserrat Torremorell was named the 2022 recipient of the Outstanding Swine Academic of the Year award. Newly established and presented for the first time this year, the award is given to an AASV member employed in academia who has demonstrated excellence in teaching, research, and service to the swine veterinary profession. Faculty members, graduate students, and researchers are eligible to receive this award.

Torremorell earned her DVM from the University Autonomous of Barcelona and her PhD from the University of Minnesota. With an extensive background in swine health, research, and production systems, including health improvement strategies, disease eradication, diagnostics, biosecurity programs, and health genomics, she joined the University of Minnesota as the Leman Chair in Swine Health and Productivity in May 2009. She is currently professor and interim chair of the Department of Veterinary Population Medicine.

Torremorell conducts research of economically significant swine diseases focusing on the transmission, control, and elimination of influenza and porcine reproductive and respiratory syndrome

Dr Montserrat Torremorell, recipient of the Outstanding Swine Academic of the Year Award.

(PRRS) infections in pigs. She also researches biosecurity technologies with applicability to prevent and mitigate airborne infections in pigs. She serves as the chair of the planning committee for the Allen D. Leman Swine Conference, has served on the AASV Annual Meeting Program Planning Committee, and volunteers for the AASV PRRS Task Force. She teaches both DVM and graduate students and is passionate about helping producers and veterinarians to apply science to control diseases. Mentees and graduates have become leaders within the swine industry and academia.

Described by her peers as a true servant leader, Dr Torremorell is an exemplar academic broadly involved in teaching, outreach, and research. She not only focuses on sharing her own work, but the work of academic and industry members to advance the shared profession. Her peers recognize her academic contribution to the industry as long and impressive, her enthusiasm relentless, her professionalism unchallenged.

The AASV is not alone in recognizing Dr Torremorell's commitment to academia. She has been awarded the Allen D. Leman Science in Practice award, the Mark of Excellence in Research award, the Outstanding Graduate Student Advising and Teaching award, and the prestigious Zoetis award for Veterinary Research Excellence at the University of Minnesota.

Grateful to her peers, Torremorell stated, "I'm truly honored and humbled by the recognition of this award. I never imagined I would be recognized by my peers in such a distinguished way. It

means more than you know, and I am thankful to everyone who has contributed to my success over the years."

Torremorell dedicates this award to her husband, Kevin, children Alexander and Isabel, and parents, Ramon and Provi.

Technical Services/Allied Industry Veterinarian of the Year

Dr Gregory Cline received the Technical Services/Allied Industry Veterinarian of the Year award. This award recognizes swine industry veterinarians who have demonstrated an unusual degree of proficiency and effectiveness in delivery of veterinary service to their companies and their clients, as well as given tirelessly in service to the AASV and the swine industry.

With a DVM from the University of Missouri, Dr Cline started his career in private practice as a food-animal practitioner, later transitioning to production as a veterinarian for Cargill Pork and Carroll's Foods.

In 2001, Dr Cline joined Boehringer Ingelheim Animal Health and has held multiple roles. Currently, he is the senior key account veterinarian-swine at Boehringer Ingelheim Animal Health. In this role, he offers sales support of key corporate accounts by on-farm diagnostic, therapeutic, and swine management support and ensures compliance with US Department of Agriculture's pharmacovigilance requirements. He establishes and manages product demonstrations and field trials and communicates technical trial results to internal and external stakeholders. He is also involved in the training of customers.

Dr Gregory Cline, recipient of the AASV Technical Services/Allied Industry Veterinarian of the Year award.

Dr Cline's extensive experience in production systems, private practice, and technical service contribute to his ability to support practitioners and truly make them better veterinarians, as stated by peers and clients. Practitioners rely on Dr Cline's humble yet direct approach to problem solving and technical service to guide decisions for strategic product implementation.

Finishing his second term on the AASV Board of Directors representing the states of Missouri, Kentucky, and Arkansas in District 3, Dr Cline has a long history of leadership and service within AASV. He is an active member of the Human Health, Safety, and Well-being Committee.

Upon acceptance of the award, Dr Cline commented, "I can think of no greater honor than to be recognized by one's peers. It certainly is a privilege to work in the swine industry, a privilege I enjoy every day."

Dr Cline lives in Plattsburg, Missouri, with his wife Dana. He has three children and three grandchildren.

Young Swine Veterinarian of the Year

The Young Swine Veterinarian of the Year award was presented to Dr Lauren Glowzenski. The award is given annually to an AASV member five or less years post veterinary graduation who has demonstrated the ideals of exemplary service and proficiency early in their career.

Dr Glowzenski is the Manager of Veterinarian Services at TriOak Foods in Oakville, Iowa, where she is responsible for the overall health and well-being of all TriOak Foods' pigs.

Glowzenski was raised in Atlantic Highlands, New Jersey, where her family established and continues to run Highland Farms, a full-service horse boarding and training facility. Her upbringing around large animals fueled her interests in animal health and helped inspire her pursuit of veterinary medicine.

Glowzenski received a BA from Sarah Lawrence College in 2009. With an indirect path into veterinary medicine, she spent two years as a general science and emotional support educator in inner-city Philadelphia with Teach for America. She simultaneously completed her MSEd (University of Pennsylvania) in 2011.

Dr Lauren Glowzenski, recipient of the AASV Young Swine Veterinarian of the Year Award.

A 2016 VMD graduate from the University of Pennsylvania, Dr Glowzenski discovered her calling in swine medicine through internships and mentorship. She has been employed as a swine production company veterinarian since graduation, holds licenses to practice in 10 states, and has demonstrated exemplary proficiency early in her career.

Dr Glowzenski is dedicated to the swine veterinary profession and to the AASV. She embraced opportunities to become involved as a student through attendance and poster presentations at AASV Annual Meetings. She received the top "AASV's Got Talent" award for her 2018 presentation, "Deep tracheal sampling technique for *Mycoplasma hyopneumoniae* PCR diagnostics: An alternative to laryngeal sampling." Currently, she is a member of the AASV Boar Stud and Pharmaceutical Issues Committees and PRRS Task Force.

Nominated for this award by many mentors, colleagues, and clients, all spoke to Dr Glowzenski's unique ability to think critically. Her creativity in clinical skills has led to significant reduction and elimination of disease in herds she oversees. She readily shares her innovative practices and encourages others to think critically, while always maintaining a positive outlook and a smile, even in the worst of times.

Upon acceptance of the award, Dr Glowzenski commented, "I am honored to be the 2022 recipient of AASV's Young Swine Veterinarian of the Year award and am extremely thankful for this

recognition early in my career. Receiving this accolade from an organization that is composed of my peers and mentors is truly a privilege. I am grateful to be a member of AASV and look forward to our industry's future."

Glowzenski resides in southeast Iowa with her family, including a herd of meat goats, laying hens, dogs, and horses. She enjoys horseback riding in her spare time.

AASV annual business meeting

American Association of Swine Veterinarians President Dr Mary Battrell reported on the association's membership and activities during the annual business meeting on Tuesday, March 1st. The 2022 AASV officers, Drs Mike Senn, president; Bill Hollis, president-elect; Angela Baysinger, vice president; and Mary Battrell, past president, were installed. The board welcomed newly elected district directors Drs Stephen Patterson (District 3) and Maryn Ptaschinski (District 7). Dr Battrell also welcomed Hunter Everett (North Carolina State University, class of 2024) as incoming alternate student delegate to the AASV Board of Directors and thanked outgoing Student Delegate Amanda Anderson (Iowa State University, 2022). Sydney Simmons (North Carolina State University, 2023) assumes the role of student delegate. Honored guests at the business breakfast included Drs Jose Arce (American Veterinary Medical Association president), Sam Miller (American Veterinary Medical Association), Dustin Oedekoven (National Pork Board), Liz Wagstrom (National Pork Producers Council), and Paul Sundberg (Swine Health Information Center).

Student activities held during AASV Annual Meeting

It is part of the mission of the American Association of Swine Veterinarians to "mentor students, encouraging life-long careers as swine veterinarians." To help fulfill this mission, the association encourages veterinary students to attend the AASV annual meeting and offers a variety of activities for student participation during the conference. Once again, the AASV Annual Meeting offered excellent opportunities for students to learn about swine medicine, network with each other, connect with swine faculty, and meet veterinarians and potential mentors.

Annual AASV student membership is $15. Student member registration to the Annual Meeting is free and includes access to all educational sessions and activities, including the preconference seminars on Saturday and Sunday – a real squeal-of-a-deal! As usual, AASV's Student Recruitment Committee promoted several conference activities designed especially for veterinary students, including the Swine Medicine for Students preconference seminar, a vet hunt, a speed networking opportunity for upper-class students, and the Swine Student Trivia event.

Student Trivia

Merck Animal Health hosted and sponsored prizes for a pub-style trivia event. Nearly 70 students from 13 veterinary schools participated, and all teams competed extremely well! Prizes were awarded for the top three teams, with the winning team getting Bluetooth speakers, tumblers, and gloves. The AASV student delegates Sydney Simmons and Hunter Everett coordinated the sign-ups, Dr Megan Inskeep welcomed the students and reviewed the benefits of AASV student membership, and AASV Student Recruitment Committee Chair Dr Chelsea Hamilton and members Drs Corinne Bromfield and Bri Fredrich emceed the event. While only student teams were eligible to participate, anyone attending the Annual Meeting was welcome to observe and cheer on the teams.

Vet Hunt

The Vet Hunt encouraged veterinary students to network with veterinarians. For a chance to win prizes, students introduced themselves to and visited with at least ten veterinarians who voluntarily participated in the Vet Hunt. The prizes were sponsored by Merck Animal Health.

Speed Networking

Speed networking during the Annual Meeting provided a fun way for mentors, potential employers, swine-savvy students, future interns, and potential new employees to interact with each other. Eight upper-class veterinary students met with sixteen veterinarians, spending 3 minutes to visit with each other in speed-dating style.

Students made meaningful connections and appreciated the opportunity to practice their interviewing and networking skills, even if participating veterinarians were not hiring. In addition to helping students become more proficient at discussions with potential employers, veterinarians also used the opportunity to screen potential candidates for jobs or preceptorships.

Podcasts

AASV once again provided an opportunity for students to earn a $200 stipend by conducting a recorded interview of an AASV speaker for podcasting. Six students selected a speaker, prepared questions in advance, and interviewed speakers during the Annual Meeting. The end products will be 5- to 15-minute MP3 audio recordings available to members in the AASV Podcast Library at **aasv.org/podcast/**.

Student Reception

Always a favorite, the Student Reception sponsored by Merck Animal Health drew a large crowd on Sunday evening. Students, veterinarians, researchers, and industry representatives spent the evening interacting with each other in an informal setting. The reception was filled with plenty of snacks, beverages, and magical entertainment.

AASV Foundation announces Student Seminar awards and scholarships

The American Association of Swine Veterinarians Foundation awarded scholarships totaling $25,000 to 15 veterinary students.

Taylor Williams, The Ohio State University, received the $5000 scholarship for top student presentation. Her presentation was titled "Evaluation of water-based foaming as a mass depopulation method for swine." Zoetis provided the financial support for the Top Student Presenter Award.

Additional scholarships totaling $20,000 were funded by Elanco Animal Health.

Four veterinary student presenters received $2500 scholarships: Madison Durflinger, Iowa State University; Hunter Everett, North Carolina State University; Katyann Graham, Iowa State University; and Megan McMahon, University of Minnesota.

Five veterinary student presenters received $1500 scholarships: Don Banks, North Carolina State University; Seth Melson, University of Minnesota; Andrea Sisk, North Carolina State University; Glorianne Vazquez, Iowa State University; and Kaci Way, The Ohio State University.

The student presenters receiving $500 scholarships were: Amanda Archer, Lincoln Memorial University; Shelby Haryslak, University of Pennsylvania; Kyle Nisley, Iowa State University; Donna Presnell, Lincoln Memorial University; and Nathan VanKley, Michigan State University.

Thirty-seven veterinary students from 12 universities submitted abstracts for consideration by student abstract volunteer judges Drs Alex Ramirez, Christa Goodell, Jessica Higgins, Marlin Hoogland, Russ Daly, and Thomas Painter. From those submissions, 15 students were selected to make oral presentations during the annual meeting. Drs Andrew Bowman and Perle Zhitnitskiy chaired the Student Seminar, which was judged by Drs Russ Daly, Alex Ramirez, Jessica Higgins, Marlin Hoogland, Tom Painter, and Christa Goodell. Zoetis, sponsor of the Student Seminar, provided a $750 award to each student selected to participate.

$5000 STUDENT SEMINAR WINNER

Recipient of the $5000 scholarship for Top Student Presenter during AASV's Student Seminar: Taylor Williams, The Ohio State University. Pictured with Taylor is Dr Lucina Galina (right) of Zoetis, sponsor of the Student Seminar and Top Student Presenter Award.

$2500 STUDENT SEMINAR WINNERS

Dr Jessica Risser (left) presented scholarships sponsored by Elanco Animal Health. Recipients of the $2500 AASV Foundation scholarships were (from left): Katyann Graham, Madison Durflinger, Hunter Everett, and Megan McMahon.

$1500 STUDENT SEMINAR WINNERS

Dr Jessica Risser (second from left) presented scholarships sponsored by Elanco Animal Health. Recipients of the $1500 AASV Foundation scholarships were (from left): Seth Melson, Don Banks, Andrea Sisk, Glorianne Vazquez, and Kaci Way.

$500 STUDENT SEMINAR WINNERS

Dr Jessica Risser (left) presented scholarships sponsored by Elanco Animal Health. Recipients of the $500 AASV Foundation scholarships were (from left): Kyle Nisley, Shelby Haryslak, Donna Presnell, and Amanda Archer.
Not pictured: Nathan VanKley.

Student Poster Competition awardees announced

The American Association of Swine Veterinarians (AASV) provided an opportunity for 15 veterinary students to compete for awards in the Veterinary Student Poster Competition. United Animal Health sponsored the competition, offering awards totaling $4000.

Thirty-seven veterinary students from 12 universities submitted abstracts for consideration by student abstract volunteer judges Drs Alex Ramirez, Christa Goodell, Jessica Higgins, Marlin Hoogland, Russ Daly, and Thomas Painter. Based on judging scores, the top 15 abstracts not selected for oral presentation were eligible to compete in the poster competition. A panel of three AASV practitioner volunteers, Drs Todd Price, Jessica Davenport, and Dennis Villani, interviewed the competing students and scored their posters to determine the scholarship awards. Drs Andrew Bowman and Perle Zhitnitskiy chaired the competition.

Joel Spencer, United Animal Health, announced the following awards during the AASV Luncheon on February 28th:

$500 scholarship: Courtney Wangler, University of Illinois – Top student poster titled "Differentiation of H3N2 and H1N2 IAV-S antigenic sites by RT-qPCR."

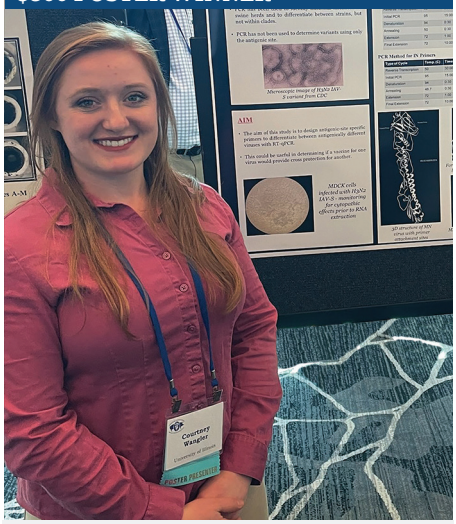
$400 scholarships: Lindsay Miller, University of Minnesota; and Evan Schwarz, University of Illinois.

$300 scholarships: McKenna Brinning, Iowa State University; Megan Kellen, Iowa State University; and Sydney Simmons, North Carolina State University.

$200 scholarships: Alexis Berte, Iowa State University; Isaac Goldner, University of Illinois; Austin Janssen, Iowa State University; Rachel Kanefsky, Tufts University; Kathryn Lenker, University of Pennsylvania; Justin Moeller, The Ohio State University; Katie Parker, Iowa State University; Kaylee Robinson, University of Missouri; and Adam Tatnall, University of Illinois.

In addition to the poster competition awards, each student poster competition participant received a $250 award from Zoetis.

$500 POSTER WINNER



Recipient of the $500 scholarship for Top student poster: Courtney Wangler, University of Illinois.

$300 POSTER WINNERS

Dr Joel Spencer (left) presented scholarships sponsored by United Animal Health. The $300 poster competition winners were: Sydney Simmons, Megan Kellen, and McKenna Brinning.

$400 POSTER WINNERS

Dr Joel Spencer (left) presented scholarships sponsored by United Animal Health. The $400 poster competition winners were Lindsay Miller and Evan Schwarz (not pictured).

$200 POSTER WINNERS

Dr Joel Spencer (left) presented scholarships sponsored by United Animal Health. The $200 poster competition winner were (from left): Katie Parker, Isaac Goldner, Kathryn Lenker, Austin Janssen, Alexis Berte, Justin Moeller, and Rachel Kanefsky. Not pictured: Kaylee Robinson and Adam Tatnall.

Thank You, Sponsors and Exhibitors!

AASV members attending the annual meeting make a substantial investment in the form of registration fees, travel, lodging, meals, and potential loss of income while away from work. However, the cost of attendance would be even greater - or the quality of the meeting experience reduced - if it were not for the financial support provided by corporate sponsors for refreshments, meals, and social activities, as well as for travel stipends, awards, and scholarships for veterinary students. In addition, considerable support was provided by the 90 companies and organizations in the 2022 Technical Tables exhibit.

Please join AASV in expressing your personal appreciation to representatives of the following companies for their generous support of the AASV Annual Meeting:

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- **Elanco Animal Health** (AASV Foundation Veterinary Student Scholarships)
- **Hog Slat** (Refreshment Break Cosponsor)
- **Merck Animal Health** (AASV Awards Reception, Student Reception, Veterinary Student Trivia Event, AASVF-Merck Veterinary Student Scholarships)
- **Newport Laboratories** (Veterinary Student Travel Stipends)
- **Stuart Products** (Praise Breakfast)
- **United Animal Health** (Veterinary Student Poster Awards)
- **Zoetis** (AASV Student Seminar and Student Poster Session, AASV Foundation Top Student Presenter Scholarship)

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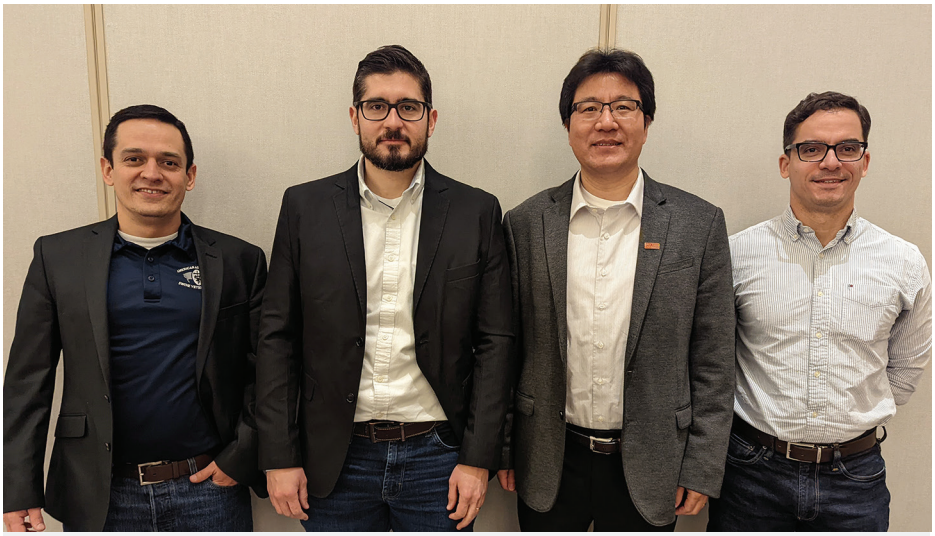
AASV Foundation awards $100,000 for research

As part of its mission to fund research with direct application to the profession, the American Association of Swine Veterinarians Foundation awarded $100,000 in funding for research. Dr Ross Kiehne, chair of the AASV Foundation, announced the selection of four research proposals for funding during the Foundation's luncheon on February 27th held during the AASV Annual Meeting in Indianapolis. The Foundation granted funds to support efforts by principal researchers, all from Iowa State University.



The AASV Foundation granted funds to support research efforts of (from left) Drs Daniel Linhares, Gustavo Silva, Jianqiang Zhang, and Marcelo Almeida, all from Iowa State University.

The Foundation granted $30,000 to Dr Marcelo Almeida and co-investigators to fund the proposal "Comparison of the pathological and clinical effects of an F18 enterotoxigenic *Escherichia coli* containing a *tia* adhesin gene against a contemporary F18 *Escherichia coli* strain." The two objectives of the study are to compare the clinical impact and to assess the efficacy of a commercially available F18 *E coli* competitive exclusion product in controlling postweaning diarrhea caused by an ETEC-F18+/tia+.

Dr Jianqiang Zhang and co-investigators received $30,000 to fund the proposal "Evaluation of the protective efficacy of three PRRSV MLV vaccines against the newly emergent PRRSV 1-4-4-L1C variant strain in weaned pigs." The objective of this study is to evaluate the protective efficacy of three porcine reproductive and respiratory syndrome modified live virus vaccines against the newly emergent PRRSV 1-4-4 L1C variant strain in a weaned-pig model.

Dr Daniel Linhares and co-investigators were awarded $21,736 to fund the project "Assessment of population-based sampling for detection of influenza A virus RNA in breeding herds." The two objectives of this project are to compare the probability of detection of influenza A virus-swine (IAV-S) RNA between individual and population-based samples and to establish the probability of identifying IAV-S positive litters by using different sample sizes.

The Foundation granted $18,264 to Dr Gustavo Silva and co-investigators to partially fund the project, "Comparing herd-level sensitivity to detect PRRSV outbreaks among different surveillance methods." The overarching goal of this study is to assess herd-level sensitivity among different surveillance samples to detect PRRSV outbreaks. A secondary objective is to characterize the impact of PRRSV.

Investigators will share results at various swine meetings and in peer-reviewed publications.

Dr Teddi Wolff chaired the scientific subcommittee responsible for reviewing and scoring the 11 proposals received for consideration, and she joins the Foundation in thanking Drs Monte Fuhrman, Amber Stricker, Todd Wolff, Eva Jablonski, and Brett O'Brien for their participation on this important subcommittee.

An overview of past and current projects funded by the AASV Foundation is available at **aasv.org/foundation/research**. The Foundation will issue its next call for research proposals in fall 2022.

AASV Foundation Legacy, Heritage Fellows recognized

The American Association of Swine Veterinarians Foundation is committed to fund research, scholarships, externships, tuition grants, and other programs and activities that benefit the profession of swine veterinary medicine. The Foundation relies on the generous support of donors to fulfill this commitment.

During the recent AASV Foundation Luncheon held February 27th during the AASV Annual Meeting, AASV Foundation Chair Dr Ross Kiehne announced new Legacy and Heritage fellows.

This year, Dr Rodney "Butch" and Emma Baker were recognized as Legacy Fellows. Drs Angela Baysinger, Kent Schwartz, Michael Senn and Stephanie Gibson-Senn, and Richard Sibbel were recognized as Heritage Fellows.

Leman

Named for the late industry leader and former AASV president Dr Allen D. Leman, this giving program confers the title of Leman Fellow upon those who contribute $1000 or more to the Foundation endowment.

Heritage

The Heritage Fellow program recognizes contributions of $5000 or more. In addition to monetary donations, other giving options such as life insurance policies, estate bequests, and retirement plan assets may be used.

Drs Angela Baysinger, Mike Senn, Richard Sibbel, and Kent Schwartz (not pictured) were recognized as Heritage Fellows during the AASV Foundation Luncheon.

Legacy

A donor, multiple donors, or a veterinary practice may establish and name a Legacy Fund with a gift of $50,000 or more. The fund may be named after the donor or another individual or group. The donor designates which of three Foundation mission categories the fund's proceeds will support: 1) research, 2) education, or 3) long-range issues.

If you are ready to lend your support and help build the endowment to ensure future support of the swine veterinary profession, visit **aasv.org/foundation** or contact the Foundation by phone, 515-465-5255, or email, **aasv@aasv.org**.

Dr Rodney "Butch" Baker received recognition as a Legacy Fellow during the AASV Foundation Luncheon.

AASV Foundation announces recipients of Hogg Scholarship

Drs Neal Benjamin and Jessica Seate were named the 2022 recipients of the American Association of Swine Veterinarians Foundation Hogg Scholarship during the American Association of Swine Veterinarian's 53rd Annual Meeting in Indianapolis on February 27th.

Established in 2008, the scholarship is named for Dr Alex Hogg who was a leader in swine medicine and pursued a master's degree in veterinary pathology after 20 years in a mixed-animal practice. The scholarship is awarded annually to an AASV member who has been accepted into a qualified graduate program to further their education after years as a swine practitioner. Former Hogg Scholarship recipients Drs Meghann Pierdon, Angela Baysinger, Kate Dion, and AASV Foundation Chair Ross Kiehne reviewed the 2022 applications.

Dr Neal Benjamin, recipient of the AASV Foundation Hogg Scholarship.

After receiving his DVM in 2016 from the University of Illinois College of Veterinary Medicine, Dr Benjamin worked exclusively as a swine veterinarian at Carthage Veterinary Services. In June 2021, he became the Director of Health and Production at Valley Pork. With a strong desire to improve individual and herd immunogenetics and overall herd health, he is pursuing a PhD in genetics at the University of Illinois' Program in Ecology, Evolution, and Conservation Biology. With a passion for teaching, he would like to serve as a liaison between veterinarians and geneticists.

Dr Seate earned her DVM from Michigan State University College of Veterinary Medicine in 2011. She has dedicated her career to swine medicine, providing veterinary services to one of the world's leading swine producers as well as technical veterinary service for two world-renowned animal health companies. She is currently the Director of Veterinary Science at Animal Science Products, Inc. Dr Seate has been active in the AASV since veterinary school. She is an active member of the AASV PRRS Task Force and Pork Safety, Early Career, Student Recruitment, and Diversity, Equity, and Inclusion Committees. She has been a member of the Program Planning Committee twice. She plans to use the Hogg Scholarship to help fund her master's degree in veterinary science at the University of Illinois.

Dr Jessica Seate, recipient of the AASV Foundation Hogg Scholarship.

AASV Foundation news continued on page 191

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AASV Foundation news continued from page 189

AASV members receive Dr Conrad and Judy Schmidt Family Student Debt Relief Scholarship

Three $5000 scholarships were awarded to early-career swine practitioners through the Dr Conrad and Judy Schmidt Family Student Debt Relief Endowment. Recipients Drs Brandi Burton, Chris Deegan, and Allison Knox were announced February 27th during the American Association of Swine Veterinarian's 53rd Annual Meeting in Indianapolis.

The purpose of the $5000 scholarship is to help relieve the student debt of recent veterinary graduates engaged in swine practice who still have significant debt burden. Qualified applicants must have been engaged in private practice with at least 50% of their time devoted to swine, providing on-farm service directly to independent pork producers. All three recipients have been continuous members of the AASV since joining as students, and each attended the Annual Meeting 4 times during their veterinary education.

The AASV Member Student Debt Relief Scholarship was awarded to (from left) Drs Allison Knox, Brandi Burton, and Chris Deegan.

Dr Burton, a University of Illinois graduate, has been a veterinarian at Suidae Health and Production since graduation in 2019. She provides veterinary services for independent producers in Iowa, Minnesota, and Nebraska. Dr Burton currently cochairs AASV's Early Career Committee where she had led the development and implementation of new resources for early-career swine veterinarians. She credits AASV's student engagement and support for her participation in the association.

Dr Deegan, a 2018 University of Minnesota graduate, also joined Suidae Health and Production as a veterinarian after graduation. His passion is to help independent producers of all sizes be as successful as possible. Dr Deegan said his activities within AASV as a student drove him to a career in swine medicine. He enjoys participating in the AASV Foundation Auction Committee and supporting students through activities at the Annual Meeting like the Vet Hunt.

Dr Knox is a 2019 graduate of the University of Illinois. She is a partner and veterinarian at the Walcott Veterinary Clinic in Iowa where she provides on-farm services to family-owned farms in Iowa and northwest Illinois. She enjoys connecting with her producers to help implement new herd health protocols, adapt to evolving disease challenges, and prepare for continued success in the industry. Connections made while attending the AASV Annual Meeting as a student helped her secure internships, scholarships, and ultimately her position in her current practice. She appreciates learning new information and sharing knowledge at the AASV Annual Meeting.

The AASV Foundation thanks Drs Ross Kiehne, Lisa Tokach, and Nathan Winkelman for reviewing the applications.

The scholarship was initiated with a generous $110,000 contribution to the Foundation by the Conrad Schmidt and Family Endowment. Dr Schmidt, a charter member of the American Association of Swine Practioners, explained, "Together, Judy and I noticed that many new DVM graduates interested in swine medicine begin their professional life with heavy educational debt obligations. As a long-time AASV member and animal industry supporter, it was our desire to help AASV members who have dedicated their professional skills to swine herd health and production. We hope that this endowment will grow over time to assist in reducing the educational debt load of AASV members as they begin their professional journeys."

Merck Animal Health supports future swine practitioners through partnership with AASVF

Merck Animal Health, known as MSD Animal Health outside the US and Canada, continued its commitment to the swine industry's next generation of veterinarians by partnering with the American Association of Swine Veterinarians Foundation (AASVF) to sponsor the 2022 recipients of the AASVF/Merck Animal Health Veterinary Student Scholarships.

"At Merck Animal Health, we have an unconditional commitment to the veterinary profession, and that means supporting the next generation of veterinary leaders," said Justin Welsh, DVM, Executive Director, Livestock Technical Services, Merck Animal Health. "Through our partnership with AASVF, we are helping to build students' knowledge of swine health and well-being as they prepare for a career in this important field."

Dr Jack Creel (back left) presented the $5000 AASVF-Merck Veterinary Student Scholarships to (row 1 left): Hannah Lathom, Katie Parker, Lindsay Miller, Kaci Way, McKenna Brinning, (row 2 from left) Kyle Nisley, Lucas Buehler, and Justin Moeller. Not pictured: Sam Gerrard, Allyson Witt.

The 2022 recipients of the $5,000 scholarship were announced on February 28, 2022, and include:

- McKenna Brinning, Iowa State University, class of 2024
- Lucas Buehler, The Ohio State University, class of 2023
- Sam Gerrard, Virginia-Maryland Regional CVM, class of 2023
- Hannah Lathom, North Carolina State University, class of 2024
- Lindsay Miller, University of Minnesota, class of 2023
- Justin Moeller, The Ohio State University, class of 2023
- Kyle Nisley, Iowa State University, class of 2023
- Katie Parker, Iowa State University, class of 2024
- Kaci Way, The Ohio State University, class of 2024
- Allyson Witt, Iowa State University, class of 2023

The scholarship program assists the foundation's mission to support the development and scholarship of students and veterinarians interested in the swine industry. Second-and third-year students enrolled in American Veterinary Medical Association-accredited or recognized colleges of veterinary medicine in the US, Canada, Mexico, South America, and the Caribbean islands are eligible for the scholarship. The AASV Foundation thanks Drs Clayton Johnson, Jason Kelly, Ross Kiehne, and Teddi Wolff for judging this year's applications. Learn more at **aasv.org**.

Auction fundraiser nets over $112,000

Even though items were not on display at the meeting, the 2022 AASV Foundation Auction was hugely successful, raising a total of $112,199 to support foundation-funded scholarships, research grants, travel stipends, externship grants, student debt relief, and more. The annual fundraiser was held in conjunction with the AASV Annual Meeting in Indianapolis.

Silent auction items were described on the AASV and ClickBid websites and featured on signs and the auction leaderboard display at the Annual Meeting. The 61 donated items generated $15,149 in winning bids. Donors shipped the items directly to the winning bidders after the auction, saving the Foundation transportation and postage costs.

Auctioneer and AASV member Dr Shamus Brown called the ever-popular live auction, which featured a wide variety of hunting and fishing trips, firearms, sporting events, tools, and more. Dr Brown was assisted in the auction by Wes Johnson, who served as auction clerk, and ring men Drs Bill Hollis, Ross Kiehne, David Reeves, Chase Stahl, Jon Van Blarcom, and John Waddell. The 2022 Auction Committee was led by co-chairs Drs Chase Stahl, John Waddell, and Butch Baker.

One item, the "tailgate palooza," prompted bidding competition between university alumni to secure football tickets and a tailgating experience at the college of their choice. Drs Erin and Jim Lowe won the bidding war with a bid of $3500 to claim the University of Illinois experience offered by the "Praise the Lard" tailgating team of Drs Clayton Johnson and Aaron Lower. Additional bidders stepped up to claim the tickets and tailgates at Kansas State University, Iowa State University, University of Minnesota, and North Carolina State University. All told, the tailgate palooza contributed $15,500 towards the live auction proceeds, which totaled $53,350.

The auction proceeds included an additional $43,700 in generous monetary contributions made by AASV members and sponsors. See **aasv.org/foundation/2022/auctionlist** for the full list of donors and auction items, including the winning bid and bidder for each.

David A. Schoneweis Scholarship awarded to Kansas State University veterinary student

Random (Rahyne) Bolda, a second-year student at Kansas State University's College of Veterinary Medicine, was awarded the David A. Schoneweis Scholarship during the American Association of Swine Veterinarians Annual Meeting held in Indianapolis, Indiana.

The children of the late Dr David Schoneweis established a scholarship in his memory to benefit swine-interested students from Kansas State University (KSU) and Oklahoma State University (OSU). The $1000 scholarship is awarded to a student or students from KSU or OSU who participate in the student oral or poster presentations during the AASV Annual Meeting, based upon a selection rubric prepared with the oversight and approval of the Schoneweis family.

Bolda presented her research, "Identifying pathways of entry of African swine fever virus into sow farms and potential improvement in biosecurity to prevent viral entry," during the AASV Student Poster Session. She was one of 21 students presenting a poster.

Dr Schoneweis was born in Clay Center, Kansas and earned his DVM from Kansas State University in 1956. He served two years in the Army Veterinary Corps before teaching clinical sciences at Oklahoma State University for six years. After two years in private practice in Lawrence, Kansas, he joined the KSU College of Veterinary Medicine faculty in 1966, where he received his master's degree in surgery and medicine in 1971 and taught food animal medicine for 30 years. Dr Schoneweis was a charter member of the American Association of Swine Practitioners (AASP) and served on the association's board of directors in the late 1970s and early 1980s. In 1997, he received the AASP Meritorious Service Award for his lifetime of support for the association and in recognition of his work with students as a professor of food animal medicine at KSU and OSU.

Thankful for the scholarship, Bolda said, "I am both thrilled and honored to have been selected for this scholarship. It is a privilege for my work to be acknowledged and my deepest thanks to the family of Dr David Schoneweis."

Random (Rahyne) Bolda, a Kansas State University veterinary student, was the recipient of the David A. Schoneweis scholarship. Photo courtesy of Dr Roman Pogranichniy.

And the winners are...

Thank you to ALL who made a contribution, donated an item, or placed a bid on items in the auction. Thanks to your generosity, the auction raised $112,199 for the AASV Foundation!

We are pleased to recognize the winning bidders who purchased one or more items at the auction:

Matt Anderson
Paul Armbrecht
Angela Baysinger
Corinne Bromfield
Justin Cagle
Scanlon Daniels
Susan Detmer
Todd Distad
Steve England (Furst McNess)
Tim Fakler
Joe Fent
Larry Graham (Clipper Distributing)
Jeffrey Harker
Peggy Anne Hawkins
Jason Hocker
Bill Hollis
Jeff Husa
Kerry Keffaber
Jason Kelly
Todd Kelly
Andrew Kleis
John Kolb
Mike Kuhn
Merlin Lindemann
Jim Lowe
Rodger Main
Michelle Michalak
Gene Nemechek
Joel Nerem
Elizabeth Noblett
Daryl and Nancy Olsen
Mike Pierdon
Doug Powers
Rebecca Robbins
Sue Schulteis
Mike Senn
Randy Simonson
Paul Skartvedt
Rex Smiley
Summer Stahl
Amber Stricker
Lisa Tokach
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AASV committees plan work for 2022

The AASV's issue- and membership-based committees met virtually during the 2022 winter months and in-person at the AASV Annual Meeting in Indianapolis. The AASV Board of Directors establishes committees to address specific issues associated with swine veterinary medicine and provide recommendations for action to the AASV leadership. The AASV committees are an integral part of the leadership structure within AASV, and they also serve as a great way for members to participate in developing positions for the association, learn about critical issues, network with other members, and develop their own leadership skills.

The following are some highlights from the committee meetings:

- During 2021, the **Porcine Reproductive and Respiratory Syndrome (PRRS) Task Force** analyzed preliminary data from the PRRS elimination survey. The task force plans to develop a white paper for distribution to AASV members. The task force continues to work on their AASV-funded project to develop a PRRS case definition for breeding herds. Task force members seek to better understand why swine herds stay in PRRSV Category 1, and if this contributes to viral diversity and regional spread.
- The **Boar Stud Biosecurity Committee** plans to encourage Federal and State Animal Health Officials to develop standardized shipping requirements for semen. They anticipate holding a preconference seminar during the 2023 AASV Annual Meeting.
- The **Committee on Transboundary and Emerging Diseases** formed a biosecurity subcommittee to support and improve bioexculsion and biocontainment practices based on applicable science and sound experience for North American pig farms, limiting the spread of endemic diseases and a potential future foreign animal disease incursion.
- The **Collegiate Activities Committee** published a commentary, Challenges and Opportunities in Modern Swine Veterinary Education, in the *Journal of the American Veterinary Medical Association* (**https://doi.org/10.2460/javma.21.10.0443**). Data collection is complete for a survey sent to all veterinary colleges in the United States to gather information regarding swine curriculum and resources.
- The **Communications Committee** discussed the nearly completed AASV Heritage Video featuring Dr Max Rodibaugh. The committee plans to add more videos to the series during 2022. The committee discussed accessibility of podcasts and will explore opportunities for member-only podcasts.
- Established by the AASV Board of Directors in April 2021, the **Diversity, Equity, and Inclusion Committee** met in person for the first time in Indianapolis. To achieve its mission, the committee is exploring options to collect demographic information on member applications and support swine-interested students from traditionally underrepresented groups within the AASV.
- Following the success of the AASV Early Career Swine Veterinarian Conference in 2021, the **Early Career Committee** discussed opportunities to expand educational outreach to early career swine veterinarians. The committee continues to record podcasts highlighting topics for early career veterinarians. Any AASV member can download the MP3 audio file from the AASV Podcast Library at **aasv.org/podcast/.**
- The **Human Health, Safety, and Well-being Committee** proposed a preconference seminar highlighting multiple topics in human health for the 2023 Annual Meeting. The committee recommends asking those participating in the next AASV Salary Survey if employee assistance programs are a benefit of their employment.
- The **Influenza Committee** is interested in hosting an AASV webinar describing influenza vaccines, uses, and how vaccine licensing is obtained.
- Discussions of the **Nutrition Committee** centered around providing AASV members with educational resources and learning opportunities in nutrition.
- The **Operation Main Street (OMS) Committee** is planning to host OMS speaker training sessions virtually during 2022. The OMS Committee continues to explore avenues to reach veterinary students beyond those already interested in swine.

Almost all committees need additional members who are swine veterinary practitioners. The committees are a critical part of the AASV leadership, and AASV members, leaders, and staff appreciate the efforts of the volunteer members. If you are interested in learning more about the committee activities, visit the committee web pages on the AASV web site (**aasv.org/members/only/committee**). Contact the committee chair or the AASV office to join a committee.

Advocacy in action is continued on page 197

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*Swine Respiratory Disease

PULMOTIL AC
IMPORTANT SAFETY INFORMATION: Before using this product, it is important to read the entire product insert, including the boxed human warning.

WARNING: Exposure to tilmicosin in humans has been associated with chest pain, increased heart rate, dizziness, headache, and nausea. Death has been reported following ingestion or injection of tilmicosin. Avoid direct skin and eye contact. In case of human exposure, call 1-800-722-0987 and consult a physician immediately.

Wear overalls, impervious gloves and eye protection when mixing and handling the product. Wash hands after handling the product. Wash affected parts if skin contact occurs. If accidental eye contact occurs, immediately rinse thoroughly with water. **CAUTION:** Federal law restricts this drug to use by or on the order of a licensed veterinarian. For use only in swine. Not for injection. Injection of tilmicosin has been shown to be fatal in swine and non-human primates, and may be fatal in horses and goats. Swine intended for human consumption must not be slaughtered within 7 days of treatment. Always treat the fewest number of animals necessary to control a respiratory disease outbreak. Prescriptions shall not be refilled. Concurrent use of Pulmotil AC and another macrolide by any route, or use of another macrolide immediately following this use of Pulmotil AC is not advised. Ensure that pigs have continuous access to medicated water during the treatment period. Monitor pigs for signs of water refusal and dehydration while being treated.

The label contains complete use information, including cautions and warnings. Always read, understand and follow the label and use directions.

Advocacy in action is continued from page 195

- The **Pharmaceutical Issues Committee** continued discussing the need for a database listing withdrawal times for countries outside the United States. The committee heard about plans for the Swine Medicine Education Center to create an antimicrobial stewardship course for students and practitioners.
- The **Pig Welfare Committee** was informed that the updated AASV Recommendations for the Depopulation of Swine are now available at **aasv.org/resources/welfare/**. These recommendations and supplemental resources, including a team resiliency debrief tool, were developed by AASV and funded by the USDA National Animal Disease Preparedness and Response Program to capture the first-hand experiences gained by veterinarians and farmers faced with depopulation.
- The **Pork Safety Committee** plans to submit comments in response to the US Department of Agriculture's Food Safety and Inspection Service proposed performance standards for *Salmonella* in raw pork.
- The **Student Recruitment Committee** recommends AASV continue supporting *The Swine Medicine Talks: An AASV series for Veterinary Students*.

Full reports and work plans from each committee are available at **aasv.org/members/only/committee**.

Abbey Canon, DVM, MPH, DACVPM
Director of Public Health and Communications

Elanco™

AH0470

Pulmotil™ AC

960 ml

tilmicosin phosphate (250 mg/ml tilmicosin)

Aqueous concentrate for oral use in drinking water.
For swine only.
Macrolide Antibiotic.
Do not inject this product. Injection of tilmicosin has been shown to be fatal in swine and non-human primates, and may be fatal in horses and goats.

WARNING

Exposure to tilmicosin in humans has been associated with chest pain, increased heart rate, dizziness, headache, and nausea. Death has been reported following ingestion or injection of tilmicosin.
Avoid ingestion. Avoid direct skin and eye contact. In case of human exposure, call 1-800-722-0987 and consult a physician immediately.
NOTE TO THE PHYSICIAN:
The cardiovascular system is the target of toxicity and should be monitored closely.
The primary cardiac effects are tachycardia and decreased contractility.
Cardiovascular toxicity may be due to calcium channel blockade.
See User Safety Warnings for additional information.

CAUTION: Federal law restricts this drug to use by or on the order of a licensed veterinarian.

Active Drug Ingredient: tilmicosin (as tilmicosin phosphate) 250 mg/ml

Description: Pulmotil is a formulation of the antibiotic tilmicosin. Tilmicosin is produced semi-synthetically and is in the macrolide class of antibiotics. Each milliliter (mL) of Pulmotil aqueous concentrate solution contains 250 mg of tilmicosin.

Indications: For the control of swine respiratory disease associated with *Pasteurella multocida* and *Haemophilus parasuis* in groups of swine in buildings where a respiratory disease outbreak is diagnosed.

For the control of swine respiratory disease associated with *Mycoplasma hyopneumoniae* in the presence of Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) in groups of swine in buildings where a respiratory disease outbreak is diagnosed.

Dosage and Administration: Must be diluted before administration to animals. Include in the drinking water to provide a concentration of 200 mg tilmicosin per liter (200 ppm). One 960 ml bottle is sufficient to medicate 1200 liters (320 gallons) of drinking water for pigs. The medicated water should be administered for (5) five consecutive days.

Use within 24 hours of mixing with water. Do not use rusty containers for medicated water as they may affect product integrity.

When using a water medicating pump with a 1:128 inclusion rate, add 1 bottle (960 ml) of Pulmotil AC per 2.5 gallons of stock solution.

WARNINGS:
USER SAFETY WARNINGS: FOR USE IN ANIMALS ONLY.
NOT FOR HUMAN USE. KEEP OUT OF REACH OF CHILDREN.
SEE BOXED WARNING AND NOTE TO THE PHYSICIAN FOR ADDITIONAL INFORMATION.
Wear overalls, impervious gloves and eye protection when mixing and handling the product. Wash hands after handling the product. Wash affected parts if skin contact occurs. If accidental eye contact occurs, immediately rinse thoroughly with water.
To report suspected adverse events, for technical assistance, or to obtain a Material Safety Data Sheet (MSDS), call 1-800-428-4441.

▶ **RESIDUE WARNING:** Swine intended for human consumption must not be slaughtered within 7 days of the last treatment with this product. ◀

Note to the Physician:
The cardiovascular system is the target of toxicity and should be monitored closely. Cardiovascular toxicity may be due to calcium channel blockade. In dogs, administration of intravenous calcium offset tilmicosin-induced tachycardia and negative inotropy (decreased contractility). Dobutamine partially offset the negative inotropic effects induced by tilmicosin injection in dogs. ß-adrenergic antagonists, such as propranolol, exacerbated the negative inotropy of tilmicosin injection in dogs. Epinephrine potentiated lethality of tilmicosin injection in pigs. This antibiotic persists in tissues for several days.

Precautions:
Do not allow horses or other equines access to water containing tilmicosin. The safety of tilmicosin has not been established in male swine intended for breeding purposes.

Always treat the fewest number of animals necessary to control a respiratory disease outbreak. Prescriptions shall not be refilled. Concurrent use of Pulmotil AC and another macrolide by any route is not advised. Use of another macrolide immediately following this use of Pulmotil AC is not advised.

Adverse Reactions in Animals: Decreased water consumption was observed in healthy pigs administered tilmicosin in target animal safety studies. Ensure that pigs have continuous access to medicated water during the treatment period. Monitor pigs for signs of water refusal and dehydration while being treated. If decreased water consumption occurs, replace the medicated drinking water with fresh non-medicated water and contact your veterinarian.

Clinical Pharmacology: Tilmicosin is a macrolide antibiotic with *in vitro* antibacterial activity primarily against Gram-positive bacteria, although certain Gram-negative bacteria are also susceptible. Macrolides interfere with bacterial protein synthesis by reversibly binding to the 50S subunit of the ribosome. They are typically regarded as being bacteriostatic, but at high concentrations can be bactericidal. When administered orally to pigs via the drinking water, tilmicosin is rapidly absorbed and slowly eliminated from the body. Tilmicosin distributes rapidly to the target tissues. Detectable levels are found in lung tissue as early as 6 hours and peak at about 5 days after the commencement of treatment. The relationship of serum tilmicosin concentration to lung tilmicosin concentration or the concentrations in bronchial secretion has not been determined. In addition, the extent to which total lung concentrations represent free (active) drug has not been defined. Therefore, no conclusions can be made with regard to the clinical relevance of elevated tilmicosin concentrations in the lung. Tilmicosin has been shown to concentrate within alveolar macrophages. It is also found at fairly high concentrations in liver and kidney tissue, as it is excreted both via the bile into the feces and also via the urine.

Effectiveness: The effectiveness of Pulmotil AC for the control of SRD associated with *P. multocida* and *H. parasuis* was confirmed in a natural infection field study across six U.S. sites. A total of 960 commercial-type grower pigs were enrolled and assigned to the tilmicosin-treated group (200 mg tilmicosin/L in drinking water for 5 consecutive days), or a non-medicated control group. Pigs that 1) were found dead and were diagnosed with SRD, or 2) had a depression score and a respiratory score ≥ 2 (on a scale from 0 [normal] to 3 [severe]) and a rectal temperature of ≥ 104.5 °F were considered clinically affected. At each site, treatments were initiated when at least 15% of the pigs were classified as clinically affected. After the 5-day treatment period and a 4-day post-treatment period, pigs were evaluated for treatment success (respiration and depression scores of 1 or 0 and rectal temperature < 104.5 °F), and were euthanized and evaluated for lung lesions. A significantly higher ($p = 0.0118$) success rate (based on back-transformed least squares means) was detected for the tilmicosin-treated group (275/473, 58.64%) compared to the control group (230/475, 47.89%).

The effectiveness of Pulmotil AC for the control of SRD associated with *M. hyopneumoniae* in the presence of PRRSV was confirmed in an induced infection model study. A total of 340 commercial-type pigs were enrolled and challenged with *M. hyopneumoniae* (single infection) or *M. hyopneumoniae* and PRRSV (co-infection). When necropsied sentinel pigs had at least 5% lung lesion involvement, study pigs were treated with Pulmotil AC (200 mg tilmicosin/L in drinking water) or non-medicated water for 5 consecutive days. After the 5-day treatment period and a 4 day post-treatment period, pigs were euthanized and evaluated for lung lesions.

For both the single infection and co-infection groups, the lung lesion percentage was statistically significantly different ($p = 0.005$ and $p = 0.0004$, respectively) in favor of the tilmicosin phosphate-treated group (21.01% and 31.74%, respectively) compared with the control group (28.26% and 43.04%, respectively).

Animal Safety: A pharmacokinetic study was conducted to evaluate Pulmotil AC concentrate solution in pigs. The results were compared to pharmacokinetic data generated with Pulmotil 90 Type A medicated article (NADA 141-064). The data demonstrates that blood and tissue levels of tilmicosin when administered to pigs at 200 mg/L (ppm) in water were consistently lower than when tilmicosin was administered to pigs at 181 g/ton (200 ppm) in feed.

A target animal safety study was conducted to evaluate the tolerance of Pulmotil AC concentrate solution in pigs when administered in drinking water. Twenty pigs were administered medicated water at 0, 200, 400, or 600 mg/L (0, IX, 2X, or 3X the labeled dose) for 5 consecutive days or 200 mg/L for 10 consecutive days. No treatment-related lesions were observed in any animals at necropsy. Water consumption was decreased in all tilmicosin-treated groups compared to the non-medicated group. One pig in the 600 mg/L group was euthanized due to decreased water consumption, neurological signs attributed to severe dehydration, and subsequent refusal to drink non-medicated water. Two pigs in the 400 mg/L group had reduced water intake and displayed mild clinical signs attributed to dehydration. One pig recovered after being offered non-medicated water. The second pig completed the treatment regimen without intervention.

Hydration and water consumption were evaluated during the control of SRD effectiveness field study. Tilmicosin was administered to study pigs in drinking water at 200 mg/l for 5 consecutive days. There was no statistically significant difference in water consumption between tilmicosin-treated pigs and pigs receiving non-medicated water. A subset of study pigs (20 tilmicosin-treated pigs and 20 non-medicated pigs) were evaluated for hydration via a physical examination and analysis of blood samples for hematocrit, total protein, creatinine, and blood urea nitrogen. There were no abnormal physical examination findings or clinically relevant differences in clinical pathology variables between tilmicosin-treated pigs and pigs receiving non-medicated water.

How Supplied: Pulmotil AC is provided in a 960 ml amber-colored plastic bottle sealed with a plastic screw cap.

Storage Conditions:
Store at or below 86° F (30° C). Protect from direct sunlight.

Restricted Drug (California) - Use Only as Directed
NADA # 141-361, Approved by FDA

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Greenfield, IN 46140, USA

UPCOMING MEETINGS

Animal Agriculture Alliance Stakeholders Summit

May 11 - 12, 2022 (Wed-Thu)
Kansas City, Missouri

For more information:
Animal Agriculture Alliance
2101 Wilson Blvd, Suite 810-B
Arlington, VA 22201
Web: **animalagalliance.org/initiatives/stakeholders-summit**

PRRSV Management Workshop

June 7, 2022 (Tue)
Iowa State Fairgrounds
Des Moines, Iowa

For more information:
Dr Chris Rademacher
Iowa State University
Email: **cjrdvm@iastate.edu**

World Pork Expo

June 8 - 10, 2022 (Wed-Fri)
Iowa State Fairgrounds
Des Moines, Iowa

For more information:
National Pork Producers Council
10676 Justin Drive
Urbandale, Iowa 50322
Web: **worldpork.org**

7th International Symposium on Animal Mortality Management

June 13 - 16, 2022 (Mon-Thu)
Raleigh, North Carolina

For more information:
Web: **animalmortmgmt.org**

26th International Pig Veterinary Society Congress

June 21 - 24, 2022 (Tue-Fri)
A hybrid conference
Riocentro Convention and Event Center
Rio de Janeiro, Brazil

For more information:
Rua Guaicuí 26, 10º andar
Coração de Jesus
Belo Horizonte, MG 30380.380
BRAZIL
Tel: +55 31 3360 3663
Email: **ipvs2022@ipvs2022.com**
Web: **ipvs2022.com**

ZeroZincSummit 2022

June 22 - 23, 2022 (Wed-Thu)
Copenhagen, Denmark

For more information:
SEGES Danish Pig Research Centre
Axelborg, Axeltorv 3
1609 Copenhagen V
DENMARK
Web: **tilmeld.dk/zerozincsummit2022**

2022 Annual Therio Conference

July 20 - 23, 2022 (Wed-Sat)
Bellevue, Washington

Hosted by the Society for Theriogenology and the American College of Theriogenologists

For more information:
Web: **theriogenology.org**

Allen D. Leman Swine Conference

September 17 - 20, 2022 (Sat-Tue)
Hosted by the University of Minnesota College of Veterinary Medicine
Saint Paul, Minnesota

For more information:
Web: **lemanconference.umn.edu**

North American PRRS/NC229 International Conference on Swine Viral Diseases

December 2 - 4, 2022 (Fri-Sun)
Chicago, Illinois

For more information:
Web: **go.illinois.edu/NAPRRSSymposium**

American Association of Swine Veterinarians 54th Annual Meeting

March 4 - 7, 2023 (Sat-Tue)
Gaylord Rockies Resort and Convention Center
Aurora, Colorado

For more information:
American Association of Swine Veterinarians
830 26th Street
Perry, Iowa
Tel: 515-465-5255
Email: **aasv@aasv.org**
Web: **www.aasv.org/annmtg**

For additional information on upcoming meetings: aasv.org/meetings

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