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Vitamin and trace mineral levels in swine

Greiner L, Elefson S, Radke S, et al

Ceftiofur treatment can prevent death
from *S equi* subspecies *zooeidemicus*

Hau SJ, Buckley A, Brockmeier SL

Acute MHP infection in a naive
breed-to-wean herd

Gillespie T, Gomez Duran O

Environmental monitoring of PEDV

Stewart SC, Jones Ck, Gebhardt JT, et al

Maximizing availability of research

*Sargeant JM, O'Connor AM,
O'Sullivan TL, et al*

The Journal of the American Association of Swine Veterinarians





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JSHAP SPOTLIGHT

Dr John Harding

University of Saskatchewan

Dr John Harding earned a DVM ('88) from the University of Guelph and an MSc ('97) from the University of Minnesota. Dr Harding is a professor of swine production medicine, where he studies infectious swine diseases. Currently, his focus is on porcine reproductive and respiratory syndrome pathogenesis, swine dysentery, and disease resilience. Dr Harding also teaches all 4 years of the DVM curriculum at the University of Saskatchewan. He encourages JSHAP contributing authors to focus on the details of their work and JSHAP reviewers to think critically as they evaluate manuscripts.

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Built on a solid foundation

The AASV Foundation's mission is to empower swine veterinarians to achieve a higher level of personal and professional effectiveness by:

- enhancing the image of the swine veterinary profession,
- supporting the development and scholarship of students and veterinarians interested in the swine industry,
- addressing long-range issues of the profession,
- supporting faculty and promoting excellence in the teaching of swine health and production, and
- funding research with direct application to the profession.

This year, the Foundation's annual funding of applicable research resulted in the support of 4 projects investigating porcine reproductive and respiratory syndrome, *Escherichia coli*, and influenza with total funding of \$100,000.

Scholarship opportunities for both veterinarians and student members are another area of significant funding by the Foundation. The AASV Foundation Hogg Scholarship was established through an endowment in 2008. This \$10,000 scholarship is awarded annually to AASV members who have been accepted into



a qualified graduate program to further their education after years as a swine practitioner. To date, 17 AASV members have received the Hogg Scholarship. The Foundation also offers a scholarship program for members seeking board certification from the American College of Animal Welfare awarding up to \$30,000 per recipient. The applicant must have either a DVM or VMD with at least 5 years of continuous membership in the AASV. The Dr Conrad and Judy Schmidt Family Student Debt Relief Scholarships are awarded annually to 3 young swine veterinarians to offset a portion of their student loan debt. The intent is to relieve some of the burden associated with the significant financial cost of completing a veterinary medical education. One scholarship is funded through the Conrad Schmidt and Family Endowment and 2 by the AASV Foundation.

The support of AASV student members through the Foundation and significant direct sponsorships provides many opportunities. The AASV Foundation-Merck Veterinary Student Scholarship Program seeks to identify and assist future swine veterinarians with their educational expenses. Merck Animal Health provides \$50,000 to enable the AASV Foundation to award \$5000 scholarships to each of 10 veterinary students annually. In 2022, Zoetis provided a grant for a total of \$20,000 to award a \$5000 scholarship to the student whose paper, oral presentation, and supporting information was judged best overall during the student session at the Annual Meeting, a \$750 award to the student presenter of each paper selected for oral presentation, and combined with direct support from AASV, provided each student poster presenter at the meeting with a \$250 award. Elanco Animal Health provided \$20,000 in additional funding enabling the AASV Foundation to award scholarships ranging from \$500 to \$2500 for 2nd through 15th place for the Student Seminar. The presenters of the top 15 poster abstracts compete for scholarship awards ranging from \$200 to \$500 in the Veterinary Student Poster Competition sponsored by United Animal Health. The David A. Schoneweis Scholarship is

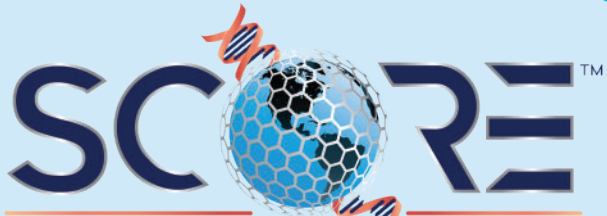
awarded to a student or students from Kansas State University or Oklahoma State University who participate in the student oral or poster presentations at the Annual Meeting. The Foundation also provides grants of \$200 to \$500 to veterinary students who complete an externship of at least 2 weeks in a swine practice or a mixed practice with a considerable swine component. Newport Laboratories contributes \$75 per Annual Meeting student attendee (up to 135 students) to help offset the \$200 travel stipend provided by the Foundation.

The ability of the Foundation to meet its mission is funded by a combination of both unrestricted and restricted assets derived from donations and fundraising activities. The primary fundraising sources are the auction at the Annual Meeting and Foundation golf outing. Multiple giving programs are in place to facilitate donations to the Foundation. The Leman Fellow, Heritage Fellow, and Legacy Fund programs all provide an endowment that invests the initial principal and only the interest, dividends, and capital appreciation are used to fund Foundation programs. Memorial contributions and direct donations are also available methods to support the foundation.

Thank you to all the organizations that directly sponsor Foundation programs, especially those that benefit AASV student members. These make a significant impact on the students and their education. Thank you to all who donate items to the annual auction, and to those who support it. Thank you to the many members who have made a commitment to support the Foundation through one of the endowment programs. Finally, thank you for considering future support to continue to build upon a strong foundation, and providing more opportunities to support AASV members.

Mike Senn, DVM, MS
AASV President





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Prop 12

As I am sure you are aware, Proposition 12 (Prop 12) was a California ballot initiative passed by voters in 2018 affecting egg-laying hens, veal calves, and breeding pigs. Basically, the regulation changes the state's definition of what constitutes confining covered animals in a "cruel manner." For breeding pigs, that means gestation housing with less than 25 ft²/animal, in effect labeling stall gestation as "cruel" and, thus, illegal. As a result of this legislation, only pork produced from pigs housed according to these criteria can be sold in California, regardless of where the farm is located. The breeding pig requirements of Prop 12 were scheduled to go into effect on January 1, 2022.

The AASV's longstanding position on sow housing does not favor one housing design over any other, but rather concentrates on emphasizing animal husbandry, access to food, water, and minimizing environmental extremes, while promoting monitoring and treatment of injuries and disease. In other words, when properly designed, maintained, and managed, a variety of housing systems can adequately provide for the animal's well-being. Proposition 12 would force farmers who want to sell their pork in California to adopt a single set of standards for housing breeding pigs. This

change in housing style may require significant modifications in building design as well as reductions in sow herd size. Additionally, employees will have to be retrained to adapt sow management regimens to minimize behavioral challenges associated with group-housed pigs.

Group housing of sows can certainly be done successfully. Several swine farms around the country have been modified or newly constructed to comply with the Prop 12 guidelines upon assurance of a premium price for pigs raised in adherence with those requirements. Farmers being forced to house their sows in a particular way by people who have little to no knowledge of swine husbandry goes against the position of the AASV and may not be in the best interest of the animals or the farmers. There are concerns regarding safeguarding embryos during early implantation as well as minimizing stress on the sows and injuries resulting from aggressive behavior while establishing a social order in pen gestation systems.

Since the passage of Prop 12, the National Pork Producers Council has been involved in legal challenges to try to get the proposed regulation overturned. Those legal challenges have finally wound up before the Supreme Court of the United States (SCOTUS) which will hear the case on October 11. The animal activist groups wasted no time in filing briefs with the court expressing unfounded and exaggerated concerns about animal welfare and public health with current sow housing systems.

To attempt to counter the erroneous and inaccurate statements contained in these briefs, AASV was asked to submit an amicus brief to the SCOTUS. The AASV Board of Directors considered the request and agreed to work with lawyers to prepare the brief. A copy of the brief¹ along with all the other briefs, and pertinent documents associated with the case can be accessed at [supremecourt.gov](https://www.supremecourt.gov). The document was prepared by the legal team using resources and information provided by AASV. The AASV staff, leadership, and Board of Directors reviewed multiple drafts and approved the final version.

We hope this provides the justices with a more balanced assessment of the current status of sow housing and potential considerations of mass migration to a government-imposed alternative housing design.

While veterinarians and farmers are more concerned about what is in the best interest of the animals in our care, this case focuses more on the economic impacts of one state's regulations on a national industry. The filing asks the justices to consider whether Prop 12 violates the dormant commerce clause. The dormant commerce clause ultimately means that because the US Congress has been given power over interstate commerce, states cannot discriminate against interstate commerce nor can they unduly burden interstate commerce, even in the absence of federal legislation regulating the activity (at least that is what it says on Google).

It is anyone's guess how the SCOTUS will rule, but the outcome could have significant impact on the availability and price of pork in California, and possibly nationally. If Prop 12 is upheld and becomes law in California, I am not sure what impact that will have on the overall swine industry. I hope whatever percentage of production that decides to convert to comply with the regulation will do so with consideration for the animals' well-being first and foremost. Farmers should work with their veterinarians to ensure employees are properly trained and the impact on the animals is minimized.

Harry Snelson, DVM
Executive Director

Reference

*1. *National Pork Producers Council et al v. Karen Ross et al*. Brief amicus curiae of American Association of Swine Veterinarians. Accessed July 25, 2022. https://www.supremecourt.gov/DocketPDF/21/21-468/228285/20220617124311471_21-468%20Amicus%20BOM.pdf

* Non-refereed reference.



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Let me introduce myself

My name is Rhea Schirm and I am the new JSHAP publications manager. You may recognize my name as I previously worked for National Pork Board for 10 years. I had the amazing opportunity to work with farmers, academicians, and veterinarians alike. I have recently started my own consulting business and I am so excited for the opportunity to work in the pork industry again.

My previous role as a business coordinator with the National Pork Board was focused extensively on their research process, which included working with the committees and task forces that determined which research proposals to fund. I was involved with the entire process including receiving research proposals, sending reminders to investigators for interim and final reports, and initiating payment for completed work. It provided a great opportunity to learn many different areas of research including swine health, animal welfare, and human nutrition to name a few. With

my BA in anthropology, my knowledge of different cultures paired with my love for travel and new experiences really helped me transition into the workforce and be able to use my knowledge to help in every aspect of life.

On a personal note, my husband and I have 2 children, our son who lives at home and our adult daughter who lives nearby. We keep very busy with sports activities and really enjoy boating and fishing when we have the time. We got our first dog in December, a goldendoodle puppy that has been keeping us very busy with training both us and her! My son and I also truly love reading and try to visit the library to get a good book in as much as possible. We are currently reading *James and the Giant Peach* together.

I want to personally thank Karen Richardson, the previous JSHAP publications manager, who for the past 20 years has worked to make JSHAP a high-quality publication. She has done this with

"I am truly looking forward to helping authors and reviewers with their submissions to the journal and making the process as seamless as possible."

grace, ease, and patience. To help with a smooth transition, Karen has been training me to understand the publication process of the journal.

I am truly looking forward to helping authors and reviewers with their submissions to the journal and making the process as seamless as possible. I am very excited for this opportunity to learn and grow in this role.

Rhea Schirm
Publications Manager



A survey of vitamin and trace mineral ranges for diagnostic lab reporting from conventionally raised swine

Laura Greiner, PhD; Sarah Elefson, MS; Scott Radke, DVM; Chloe Hagen, BS; Dalton Humphrey, MS; Spenser Becker, MS

Summary

Objective: The purpose of this study was to survey the vitamin and mineral levels in various pig tissues at different phases of the life cycle.

Materials and methods: Forty-eight healthy pigs of different stages of production were used for sampling of different tissues. Seven sows and a minimum of 10 animals from each phase of production (suckling, nursery, and finishing) were selected for sampling. A blood sample was collected via sterile venipuncture for serum vitamin and mineral analysis.

After euthanasia, the diaphragm and liver were collected. Samples were submitted to the Iowa State University Veterinary Diagnostic Laboratory for analysis. Data were analyzed using SAS (version 9.4; SAS Institute Inc) and presented as minimum and maximum concentrations with standard error. The experimental unit was the animal.

Results: Levels of vitamin A, vitamin E, copper, zinc, selenium, iron, and manganese were higher in liver tissues than in serum and diaphragm tissues. Diaphragm muscle had similar levels of

phosphorus as the liver tissue. Serum had similar levels of calcium as the liver tissue.

Implications: These data provide a sampling of vitamin and mineral levels present in tissues and serum of commercial pigs and suggests that vitamin and mineral levels differ between sampling sites.

Keywords: swine, vitamin, mineral, tissue

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Resumen - Una encuesta de los rangos de vitaminas y minerales traza para los reportes de laboratorio de diagnóstico de cerdos criados convencionalmente

Objetivo: El propósito de este estudio evaluar fue estudiar los niveles de vitaminas y minerales en varios tejidos de cerdos en diferentes fases del ciclo de vida.

Materiales y métodos: Para el muestreo en diferentes tejidos se utilizaron 48 cerdos sanos de diferentes etapas de producción. Para el muestreo se seleccionaron siete cerdas y un mínimo de 10 animales de cada fase de producción (lechones lactantes, destete, y finalización). Se tomó una muestra de sangre mediante venopunción estéril para el análisis de vitaminas y minerales en suero. Después de la eutanasia, se recolectó el diafragma y el hígado. Para su análisis las muestras se enviaron al Laboratorio de Diagnóstico Veterinario de la Universidad Estatal de Iowa. Los datos se analizaron utilizando el SAS (versión 9.4; SAS Institute Inc) y los resultados

se presentaron como concentraciones mínimas y máximas y el error estándar de la media. La unidad experimental fue el animal.

Resultados: Al compararlos, los niveles de vitamina A, vitamina E, cobre, zinc, selenio, hierro, y manganeso fueron más altos en los tejidos del hígado, en el suero y los tejidos del diafragma. El músculo del diafragma tenía niveles de fósforo similares a los del tejido hepático. El suero tenía niveles de calcio similares a los del tejido hepático.

Implicaciones: Estos datos proveen una muestra de los niveles de vitaminas y minerales presentes en tejidos y suero de cerdos comerciales e indican que los niveles de vitaminas y minerales difieren entre los sitios de muestreo.

Résumé - Une enquête sur les intervalles de vitamines et d'oligo-éléments pour les rapports de laboratoire de diagnostic des porcs élevés de manière conventionnelle

Objectif: Le but de cette étude était d'étudier les taux de vitamines et de minéraux dans divers tissus de porc à différentes phases du cycle de vie.

Matériels et méthodes: Quarante-huit porcs sains de différents stades de production ont été utilisés pour l'échantillonnage de différents tissus. Sept truies et un minimum de 10 animaux de chaque phase de production (allaitement, pouponnière, et finition) ont été sélectionnés pour l'échantillonnage. Un échantillon de sang a été prélevé par ponction veineuse stérile pour l'analyse des vitamines et minéraux sériques. Après l'euthanasie, le diaphragme et le foie ont été prélevés. Les échantillons ont été soumis au laboratoire de diagnostic vétérinaire de l'Iowa State University

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pour analyse. Les données ont été analysées à l'aide de SAS (version 9.4 ; SAS Institute Inc.) et présentées sous forme de concentrations minimales et maximales avec écart-type de la moyenne. L'unité expérimentale était l'animal.

Résultats: Les taux de vitamine A, de vitamine E, de cuivre, de zinc, de sélénium, de fer, et de manganèse étaient plus élevés dans les tissus hépatiques que dans le sérum et le tissu diaphragmatique. Le muscle diaphragme avait des taux de phosphore similaires à ceux du tissu hépatique. Le sérum avait des concentrations de calcium similaires à celles du tissu hépatique.

Implications: Ces données fournissent un échantillonnage des concentrations de vitamines et de minéraux présents dans les tissus et le sérum des porcs commerciaux et suggèrent que les taux de vitamines et de minéraux diffèrent entre les sites d'échantillonnage.

Over the years, nutritionists have continued to evaluate the vitamin and mineral requirements of swine. Recently, it was documented that US swine nutritionists feed a margin of safety above the 2012 NRC recommendations to offset any potential vitamin degradation or manufacturing challenges.^{1,2} Little information has been compiled over the last 15 years to document current vitamin and mineral concentrations present in healthy swine of modern genetics. A widely used publication for mineral and vitamin reference values was published in 1994.^{3,4} Modern hog production has changed greatly in the last 20 years particularly in reference to intensively raised, indoor swine as well as genetics and growth rate. In addition, vitamin D levels of hogs raised indoors have noticeably different levels compared to outdoor raised hogs.⁵

Therefore, sampling healthy swine being raised indoors would be important to establish reference values for vitamins and minerals to assist diagnostic laboratories, veterinarians, and nutritionists in discerning potential nutritional differences when assessing modern day pigs. However, the process of creating new reference values is costly. The objective of this study was to survey the vitamin and mineral levels in various tissues from healthy swine of modern genetics in different production phases to assess if new reference values need to be generated.

Animal care and use

The study was conducted on 6 different farms located across the United States. All animal care practices were conducted by following the routine farm management procedures and Pork Quality Assurance guidelines.⁶ Additionally, the trial was approved by the Iowa State University Animal Care Committee (IACUC #19-340).

Materials and methods

Samples

The 6 farms used in this study were selected based on voluntary participation from written communication with companies identified within the top 25 largest production systems and with individual producers based on timeframe available for study personal to collect the samples. Selected farms verified that the animals were fed vitamins and minerals at levels that met or exceeded the 2012 NRC recommendations.² The farms had to verify that the pigs used for sample collection were free of acute illness. Animals selected for sample collection were identified as animals with a physical abnormality (eg, hernia or prolapse) that would prevent the animal from completing the production life cycle, were scheduled for euthanasia (eg, growth study sampling), or were being harvested. The number of animals selected from each farm varied due to the number of animals available on the day that sampling personnel were present on the farm. Seven sows and a minimum of 10 animals from each phase of production (suckling, nursery, and finishing) were selected for sampling. The suckling phase was defined as day 1 through 21 of age. The nursery and finisher phases were defined as day 22 to 64 of age and 65 to 165 days of age, respectively. Euthanasia was conducted using methods approved for swine by the American Veterinary Medical Association.⁷ Injectable euthanasia agents were not used in this study. After euthanasia, the diaphragm and liver were collected and placed into a sterile bag and a blood sample was collected using sterile methods. Samples were placed on ice and transported to the Iowa State University Veterinary College and submitted to the Iowa State University Veterinary Diagnostic Laboratory (ISUVDL) to be held in a -20°C freezer until analysis.

Sample analysis

Samples were analyzed for vitamin and mineral concentrations using procedures outlined by ISUVDL (Vitamin A and E in serum – ISUVDL 9.833; Vitamin A in tissue – ISUVDL 9.2429; Vitamin E in tissue – ISUVDL 9.2430; Trace mineral in tissue – ISUVDL 9.2420). Serum and tissue samples were stored at -80°C. Vitamin A and E analyses of both serum and tissues were conducted following the established standard operating procedure (SOP) using internally validated methods. A 0.5 mL aliquot of serum was placed in a 15 mL screw-top tube. Two milliliters of 95% ethanol and 4 mL of 95/5 hexane/chloroform were added. Samples were gently shaken to mix and then centrifuged for 5 minutes at 2000 rpm. Following centrifugation, 2 mL of the hexane/chloroform was transferred to a 7 mL glass vial encased in foil.

One gram of fresh liver for each vitamin A and E analysis was weighed into 50 mL polypropylene tubes and 0.2 g of celite was added. For vitamin A, 5 mL of 0.01% butylated hydroxy toluene in 95% ethanol was added, followed by 1 mL of 50% sodium hydroxide. Samples were placed in an oven at 60°C for 30 minutes, and then chilled for 10 minutes at -20°C. Samples were vortexed at 2000 rpm for 10 minutes, and then centrifuged for 5 minutes at 2000 rpm. Following centrifugation, 1 mL of the hexane/chloroform was transferred to a 7 mL glass vial encased in foil. For vitamin E, 5 mL of 0.01% butylated hydroxytoluene in 95% ethanol was added, followed by 10 mL of 95/5 hexane/chloroform. The sample was vortexed at 2000 rpm for 10 minutes and then centrifuged for 5 minutes at 2000 rpm. Following centrifugation, 5 mL of the hexane/chloroform was transferred to a 7 mL glass vial encased in foil.

Serum and tissue extracts were dried using a nitrogen stream. Serum extracts were dissolved in 250 µL high-performance liquid chromatography (HPLC)-grade methanol while tissue extracts for vitamins A and E were dissolved in 1 mL of 0.09% hydrochloric acid in methanol and 500 µL HPLC-grade methanol, respectively. Following the extraction process, both serum and tissue extracts were analyzed using ultra HPLC. Serum vitamin D was analyzed by liquid chromatography tandem mass spectrometry (LC/MS/MS) through Heartland Assays. Samples were processed and analyzed for mineral content following the established SOP on a wet weight basis.

A National Institute of Standards and Technology liver standard was included in the run. An in-house laboratory control liver was also used to ensure quality control and to verify instrument accuracy. Serum samples were analyzed for calcium, copper, iron, magnesium, manganese, molybdenum, phosphorus, potassium, selenium, and zinc using inductively coupled plasma mass spectrometry (ICP-MS; Analytik Jena Inc) in CRI mode with hydrogen as the skimmer gas. Analysis of tissues was performed by the same instrument but also included cadmium, cobalt, chromium, and sodium per laboratory method. Standards for elemental analyses were obtained from Inorganic Ventures while 15 mL centrifuge tubes, 50 mL digestion vessels, trace mineral grade nitric acid, and hydrochloric acid were obtained from Fisher Scientific. Serum samples were diluted in 1% nitric acid. Serum samples were transferred to 15 mL tubes in 0.25 mL portions and 4.75 mL of 1% nitric acid was added and then analyzed by ICP-MS. Tissue samples were digested using a microwave digester by placing 0.5 g samples into 50 mL digestion tubes and adding 10 mL of 70% nitric acid. After digestion, all samples were diluted to 25 mL using 1% nitric acid with 0.5% hydrochloric acid. An additional 1:10 dilution using 1% nitric acid was made and then analyzed by ICP-MS. For quality control, bismuth, scandium, indium, lithium, yttrium, and terbium were used as internal standards for the ICP-MS.

Data analysis

Data were analyzed using SAS (version 9.4; SAS Institute Inc) and were presented as minimum and maximum concentrations with standard error. If the element of analysis was below the detectable limit, the lower limit threshold was divided by 2 to provide a value.⁸ The experimental unit was the animal. Tables were generated to demonstrate the different concentrations of each vitamin and mineral by sample type along with phase of growth.

Results

Vitamins and minerals are stored in different locations of the body and dictates which locations are more ideal for analysis (Table 1). Liver tissue levels of vitamin A, vitamin E, copper, zinc, selenium, and iron were higher than those in serum and diaphragm tissue (Table 2). Vitamin A and E levels were not detectable in the diaphragm tissue at any phase of

Table 1: Preferred sampling sites for common vitamins and minerals tested in swine*

Nutrient	Preferred biological sample
Vitamin A	Liver
Vitamin E	Serum
Vitamin D3	Serum
Calcium	Serum
Cobalt	Liver
Copper	Liver
Iron	Liver
Magnesium	Serum
Manganese	Liver
Molybdenum	Liver
Phosphorus	Serum
Potassium	Serum
Selenium	Liver/Serum/Blood
Sodium	Serum
Zinc	Liver

* Preferred sample sites such as serum may not reflect true nutrient status. Samples should be collected from locations of vitamin and mineral storage to best assess status.

production (Tables 2, 3, and 4). Most mineral concentrations tended to be higher in tissues (diaphragm and liver) compared to serum. Serum had similar levels of calcium as the liver tissue (Table 4). Median data were provided for each sampling location in Tables 5, 6, and 7. Data from previously published references were compiled for further evaluation of current findings (Table 8).

Discussion

Vitamin and mineral concentrations do differ across production phases and sample types. Some of this variation can be associated with dietary ingredients or immune status, which can influence antioxidant status. In addition, vitamin and mineral analysis conducted in tissues or serum which do not adequately reflect common stores can result in misinterpretation of results. Understanding where vitamins and minerals are stored within the body is important when determining the appropriate sample to assess for concentration status. Iron, copper, manganese, selenium, zinc, and vitamins A, D, and E are stored in the liver. Although predominately stored in adipose tissue, vitamin E is stored in the liver in a limited capacity. Lastly,

minerals such as magnesium, phosphorus, and calcium are typically found in the bone. These macrominerals are tightly regulated within the body as evidenced by the maintenance of serum concentrations.

Samples derived from the liver had higher concentrations of certain vitamins and minerals compared to other samples. For example, most of the body's vitamin A is stored in the liver as retinyl esters and therefore, the liver would be the primary sample site when testing for a vitamin A deficiency.⁹ When sampling, personnel must not only understand the correct sample type to collect, but also the health status of the animal and the manner and condition in which samples are collected to allow for adequate interpretation. For example, minerals such as iron and zinc may be sequestered in the liver during inflammatory or infectious processes resulting in elevated concentrations. Conversely in serum samples, the degree of hemolysis may result in elevated concentrations of iron and potassium but decreased vitamin E concentrations resulting from degradation. Furthermore, some vitamin and mineral concentration ranges are different from the values presented in Puls.^{3,4} Serum

Table 2: Vitamin and mineral concentrations in the liver of suckling, nursery, and finisher pigs and lactating sows

Nutrient, ppm*	Phase of production											
	Suckling piglet†			Nursery†			Finisher†			Lactating sow†		
	Mean	Range	SE	Mean	Range	SE	Mean	Range	SE	Mean	Range	SE
Vitamin A [§]	29	18-63	3	13	0.5-25.0	2	71	47-90	4	262	80-530	56
Vitamin E	8.5	3.3-17.1	1.0	4.2	0.9-8.0	0.6	5.9	3.4-9.7	0.5	9.5	6.1-12.5	0.9
Cadmium [§]	0.004	0.001-0.030	0.002	0.010	0.002-0.021	0.002	0.027	0.014-0.062	0.004	0.026	0.012-0.041	0.004
Calcium	98	59-145	7	96	63-128	5	100	67-118	5	89	60-121	8
Chromium	10.97	0.09-181.00	10.63	0.17	0.06-0.53	0.04	0.11	0.04-0.16	0.01	0.08	0.03-0.18	0.02
Cobalts	0.013	0.001-0.150	0.009	0.009	0.002-0.017	0.001	0.018	0.013-0.022	0.001	0.016	0.008-0.025	0.002
Copper	44	16-104	6	12	7-21	1	10	4-16	1	158	11-435	59
Iron	1091	134-3458	242	114	74-195	10	263	115-474	34	226	143-352	27
Magnesium	195	174-227	4	221	191-267	6	194	158-233	9	154	121-189	10
Manganese	2.2	1.2-3.4	0.2	3.3	2.4-4.2	0.1	3.3	2.2-4.9	0.3	1.8	1.3-2.3	0.1
Molybdenum	0.47	0.29-0.65	0.03	0.66	0.14-1.10	0.08	1.43	0.97-1.69	0.07	1.28	0.97-1.47	0.07
Phosphorus	2907	2546-3456	62	3729	3083-4319	120	3468	2742-4490	167	2485	1678-3519	244
Potassium	2745	868-3487	142	3647	3182-4176	80	2782	1481-3386	166	2548	1695-3434	217
Selenium	0.55	0.45-0.80	0.03	0.72	0.56-0.87	0.02	0.98	0.75-1.19	0.04	1.01	0.67-1.72	0.16
Sodium	1425	128-2187	127	967	798-1227	35	1275	751-1864	92	1314	821-1695	130
Zinc	70	27-120	7	163	42-562	53	131	51-313	25	62	38-91	6

* Values presented as per unit of wet tissue weight.

† Suckling piglets were 1-21 days of age (n = 17); Nursery pigs were 22-64 days of age (n = 13); Finisher pigs were 65-165 days of age (n = 11); and Lactating sows (n = 7).

‡ Represented as retinol.

§ When the element of analysis was below the detectable limit, the lower limit threshold was divided by 2 to provide a value.⁸

Table 3: Vitamin and mineral concentrations in the diaphragm of suckling, nursery, and finisher pigs and lactating sows

Nutrient, ppm*	Suckling piglet†						Phase of production					
	Suckling piglet†			Nursery†			Finisher†			Lactating sow†		
	Mean	Range	SE	Mean	Range	SE	Mean	Range	SE	Mean	Range	SE
Vitamin A ‡	NA	NA	NA	§	§	§	§	§	§	§	§	§
Vitamin E	NA	NA	NA	¶	¶	¶	¶	¶	¶	¶	¶	¶
Cadmium**	0.005	0.001-0.012	0.001	0.002	0.001-0.005	0.0004	0.002	0.001-0.006	0.0005	0.005	0.001-0.019	0.0025
Calcium	132.8	76.000-229.171	10.081	103	75-118	4	90	57-146	7	137	78-308	30
Chromium	0.126	0.058-0.365	0.020	0.110	0.067-0.164	0.010	0.115	0.041-0.201	0.012	0.106	0.034-0.189	0.019
Cobalt**	0.001	0.001-0.005	0.0003	0.001	0.001-0.003	0.0002	0.002	0.001-0.004	0.0003	0.003	0.000-0.013	0.0017
Copper**	2.01	1.10-5.01	0.231	2.3	0.5-4.0	0.4	2.0	0.5-4.0	0.3	7.30	0.00-43.12	5.980
Iron	56.1	29.0-139.3	8.113	25	17-31	1	29	18-61	4	43.2	7.0-100.2	10.83
Magnesium	190	156-223	4	168	10-249	27	287	183-996	71	738	153-1539	215
Manganese	0.354	0.142-0.627	0.036	0.2	0.1-0.3	0.0	0.2	0.1-0.3	0.0	0.191	0.100-0.340	0.037
Molybdenum**	0.066	0.018-0.570	0.032	0.03	0.02-0.06	0.00	0.02	0.01-0.04	0.00	0.075	0.020-0.272	0.034
Phosphorus	1737	1362-2005	34	2033	1647-2581	88	1989	1665-2418	75	1536	1427-1825	54
Potassium	2816	2415-3388	69	3090	2699-3766	117	3371	2701-3941	117	2986	2567-3617	139
Selenium	0.195	0.135-0.300	0.010	0.31	0.23-0.43	0.02	0.92	0.26-5.00	0.41	0.32	0.28-0.44	0.02
Sodium	1094.3	838.9-1373.3	36.679	1166	1016-1546	47	818	651-996	33	1238	862-1539	93
Zinc	21	14.000-26.000	1	23	18-30	1	30	20-35	1	37	28-42	2

* Values presented per unit of wet tissue weight.

† Suckling piglets were 1-21 days of age (n = 17); Nursery pigs were 22-64 days of age (n = 13); Finisher pigs were 65-165 days of age (n = 11); Lactating sows (n = 7).

‡ Represented as retinol.

§ Vitamin A analysis was below the detectable level of < 1 ppm.

¶ Vitamin E analysis was below the detectable level of < 0.5 ppm.

** When the element of analysis was below the detectable limit, the lower limit threshold was divided by 2 to provide a value.⁸

NA = not measured in suckling pigs.

Table 4: Vitamin and mineral concentrations in the serum of suckling, nursery, and finisher pigs and lactating sows

Nutrient	Phase of Production											
	Suckling piglet*			Nursery*			Finisher*			Lactating sow*		
	Mean	Range	SE	Mean	Range	SE	Mean	Range	SE	Mean	Range	SE
Vitamin A, ppm ^{†‡}	0.12	0.02-0.280	0.02	0.26	0.01-0.39	0.03	0.16	0.10-0.21	0.01	0.13	0.03-0.32	0.04
Vitamin E, ppm [†]	3.8	1.100-10.100	0.6	1.07	0.05-3.20	0.27	1.8	1.1-3.3	0.2	2.4	0.9-4.4	0.5
Vitamin D2, ng/mL [‡]	0.75	0.750-0.750	0.00	0.75	0.750-0.750	0.00	0.75	0.750-0.750	0.00	0.750	0.750-0.750	0.00
Vitamin D3, ng/mL [§]	3.95	0.75-8.60	0.57	16.75	9.20-27.50	1.43	42.74	18.40-115.80	9.35	35.73	9.50-53.00	5.46
Calcium, ppm	106.5	75.1-134.7	3.0	87.1	50.1-120.4	6.5	93.9	83.5-100.9	1.7	97.9	75.9-133.4	6.9
Copper, ppm	1.9	1.000-3.1	0.1	1.3	1.0-1.9	0.1	2.0	1.3-2.4	0.1	1.8	1.4-2.2	0.1
Iron, ppm	39.5	0.4-604.7	35.3	9.7	1.2-59.5	4.8	1.5	0.8-2.2	0.1	4.2	0.8-14.6	1.9
Magnesium, ppm	45.6	4.0-180.0	11.0	19.9	13.7-24.9	1.1	18.9	14.8-26.7	1.1	33.0	17.2-56.9	6.2
Manganese, ppm [†]	0.047	0.003-0.180	0.015	0.007	0.002-0.037	0.003	0.002	0.001-0.004	0.0003	0.014	0.001-0.034	0.006
Molybdenum, ppm [†]	0.003	0.001-0.010	0.001	0.012	0.006-0.015	0.001	0.004	0.002-0.007	0.0004	0.010	0.004-0.015	0.001
Phosphorus, ppm [†]	84.4	46.5-187.4	7.8	49.3	33.0-66.0	2.4	79.6	2.5-444.4	36.7	91.2	35.0-179.1	23.1
Potassium, ppm	583.5	249.8-1124.3	66.5	362.8	248.0-733.3	39.1	255.8	218.6-313.7	9.8	521.7	176.8-1033.7	138.5
Selenium, ppm	0.123	0.088-0.160	0.005	0.124	0.084-0.190	0.010	0.241	0.200-0.278	0.009	0.255	0.133-0.355	0.032
Zinc, ppm	1.5	0.3-10.4	0.6	0.8	0.5-1.2	0.1	0.9	0.5-2.0	0.1	1.8	0.6-4.4	0.6

* Suckling piglets were 1-21 days of age (n = 17); Nursery pigs were 22-64 days of age (n = 13); Finisher pigs were 65-165 days of age (n = 11); Lactating sows (n = 7).

† Represented as retinol.

‡ When the element of analysis was below the detectable limit, the lower limit threshold was divided by 2 to provide a value.⁸

§ Represented as 25(OH)D3.

Table 5: Median vitamin and mineral concentrations in the liver of suckling, nursery, and finisher pigs and lactating sows

Nutrient, ppm [†]	Suckling piglet*	Nursery*	Finisher*	Lactating sow*
Vitamin A [‡]	25	14	72	250
Vitamin E	7.3	4.6	5.7	10.2
Cadmium [§]	0.003	0.012	0.021	0.023
Calcium	91	96	105	95
Chromium	0.235	0.122	0.104	0.062
Cobalt [§]	0.001	0.009	0.019	0.014
Copper	38	11	10	108
Iron	577	113	241	192
Magnesium	197	224	188	159
Manganese	2.3	3.3	2.9	1.8
Molybdenum	0.46	0.64	1.53	1.33
Phosphorus	2811	3702	3287	2592
Potassium	2770	3590	2720	2688
Selenium	0.52	0.74	0.99	0.72
Sodium	1585	941	1187	1415
Zinc	66	79	97	62

* Suckling piglets were 1-21 days of age (n = 17); Nursery pigs were 22-64 days of age (n = 13); Finisher pigs were 65-165 days of age (n = 11); and Lactating sows (n = 7).

† Values presented as per unit of wet tissue weight.

‡ Represented as retinol.

§ When the element of analysis was below the detectable limit, the lower limit threshold was divided by 2 to provide a value.⁸

vitamin A and selenium levels from the current study are lower than previously published values. Previously reported vitamin A ranges were 0.4 to 0.5 ppm in suckling and nursery pigs and 0.25 to 0.40 ppm in sows compared to the current ranges of 0.01 to 0.39 ppm and 0.03 to 0.32 ppm, respectively.⁴ Serum selenium was reported to be 0.14 to 0.30 ppm with no specific age, while the current study documented serum selenium levels to be 0.080 to 0.194 ppm for the suckling/nursery pig and 0.133 to 0.355 ppm for the sow.³ In addition, vitamin D3 concentrations in the current study were lower in the suckling and nursery pigs compared to the published values of 8 to 23 ng/mL and 25 to 30 ng/mL, respectively. Furthermore, more recent work conducted by Flohr et al¹⁰ reported serum vitamin D3 levels in suckling age pigs were between 0.0 and 5.7 ng/mL depending upon maternal dietary consumption and nursery pig serum levels were 22.7 to 30.8 ng/mL. However, the levels in this study were slightly lower than those documented by Flohr et al.¹⁰ Other vitamins and minerals were slightly higher than the referenced values, such as calcium

and zinc in the liver. Elevated zinc levels may be associated with feeding higher levels of zinc in the nursery to aid in controlling pathogenic organisms.

This study demonstrates that while some vitamin and mineral concentrations in modern commercial swine are not different than previously published ranges, concentrations in other samples are either higher or lower than previously published work. In addition, previously published reference values did not completely identify the different phases of production. This study demonstrates the need for additional studies focused on the analysis of multiple biological samples from healthy pigs to best determine the appropriate vitamin and mineral ranges for the modern pig.

Implications

Under the conditions of this study:

- Select sample tissue type based on vitamin or mineral of interest.
- Vitamin and mineral levels vary based on age of the animal.

- Further sampling of both healthy and acutely ill animals is needed.

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Conflict of interest

None reported

Disclaimer

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Table 6: Median vitamin and mineral concentrations in the diaphragm of suckling, nursery, and finisher pigs and lactating sows

Nutrient, ppm [†]	Suckling piglet*	Nursery*	Finisher*	Lactating sow*
Vitamin A [‡]	NA	§	§	§
Vitamin E	NA	¶	¶	¶
Cadmium**	0.003	0.001	0.001	0.002
Calcium	125.3	105	82	119
Chromium	0.087	0.104	0.107	0.111
Cobalt**	0.001	0.001	0.001	0.001
Copper**	1.85	2.5	2.0	1.00
Iron	45.3	27	25	38.0
Magnesium	187.4	195	218	862
Manganese	0.342	0.2	0.2	0.200
Molybdenum**	0.027	0.03	0.03	0.030
Phosphorus	1725	1935	1905	1468
Potassium	2786	2995	3300	2910
Selenium	0.189	0.30	0.51	0.30
Sodium	1121	1139	850	1272
Zinc	21	23	32	39

* Suckling piglets were 1-21 days of age (n = 17); Nursery pigs were 22-64 days of age (n = 13); Finisher pigs were 65-165 days of age (n = 11); Lactating sows (n = 7).

† Values presented per unit of wet tissue weight.

‡ Represented as retinol.

§ Vitamin A analysis was below the detectable level of < 1 ppm.

¶ Vitamin E analysis was below the detectable level of < 0.5 ppm.

** When the element of analysis was below the detectable limit, the lower limit threshold was divided by 2 to provide a value.⁸

NA = not measured in suckling pigs.

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* Non-refereed references.

Table 7: Median vitamin and mineral concentrations in the serum of suckling, nursery, and finisher pigs and lactating sows

Nutrient, unit[†]	Suckling piglet*	Nursery*	Finisher*	Lactating sow*
Vitamin A, ppm ^{‡§}	0.12	0.30	0.17	0.08
Vitamin E, ppm§	2.8	0.70	1.6	2.3
Vitamin D2, ng/mL [§]	0.75	0.75	0.75	0.750
Vitamin D3, ng/mL ^{§¶}	3.1	18.3	31.3	35.5
Calcium, ppm	106.0	82.7	94.8	94.7
Copper, ppm	1.8	1.1	2.0	1.9
Iron, ppm	2.9	2.0	1.4	1.4
Magnesium, ppm	32.1	20.1	18.3	32.9
Manganese, ppm [§]	0.015	0.003	0.002	0.003
Molybdenum, ppm [§]	0.002	0.012	0.004	0.011
Phosphorus, ppm [§]	85.3	50.3	46.3	63.1
Potassium, ppm	479.1	331.3	248.0	402.5
Selenium, ppm	0.123	0.109	0.235	0.273
Zinc, ppm	0.9	0.7	0.7	0.7

* Suckling piglets were 1-21 days of age (n = 17); Nursery pigs were 22-64 days of age (n = 13); Finisher pigs were 65-165 days of age (n = 11); and Lactating sows (n = 7).

† Values presented per unit of wet tissue weight.

‡ Represented as retinol.

§ When the element of analysis was below the detectable limit, the lower limit threshold was divided by 2 to provide a value.⁸

¶ Represented as 25(OH)D3.

Table 8: Previously published reference values for vitamins and minerals in the serum of swine*

Nutrient, ppm	No specified age	Fetus	Weanling/ Nursery	Growing	Adult	Lactating sow
Vitamin A	.	0.100-0.200	0.400-0.500	0.400-0.500	0.400-0.500	0.250-0.400
	.	.	0.080-0.268 [†]	.	.	0.128-0.393 [†]
Vitamin E	.	.	1.000-5.200	0.800-2.100	0.900-2.000	1.200-3.000
Vitamin D ₃	.	.	0.005-0.023	.	.	0.050-0.095
	.	.	0.004-0.016 [†]	.	.	0.025-0.111 [†]
Calcium	90-130	.	.	.	.	.
Copper	1.3-3.0	.	.	.	.	.
Iron	1.0-1.5	.	.	.	.	.
Magnesium	18-39	.	.	.	.	.
Manganese	0.04	.	.	.	.	.
Molybdenum	.	.	.	.	.	.
Phosphorus	60-107	.	.	.	.	.
Potassium	136.84-207.22	.	.	.	.	.
Selenium	0.14-0.30	.	.	.	.	.
Sodium	3218.57-3448.47	.	.	.	.	.
Zinc	0.7-1.5	.	.	.	.	.

* Vitamin and mineral reference values from Puls.^{3,4}[†] Reference values from Flohr¹⁰ were converted from ng/mL to ppm.

Rapid application of long-acting ceftiofur can prevent death losses associated with *Streptococcus equi* subspecies *zooepidemicus* in pigs

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Summary

Objective: Introduction of *Streptococcus equi* subspecies *zooepidemicus* strains into naive populations results in field mortality rates of 30% to 50% over 5 to 10 days. Because of the rapid disease progression, our goal was to determine whether antibiotic intervention could control *S zooepidemicus* disease in a group of animals following development of clinical signs.

Materials and methods: Thirty-two pigs were challenged with *S equi* subsp *zooepidemicus*. Following the development of clinical signs, 16 were treated with long-acting, injectable ceftiofur. Seven unchallenged pigs served as controls.

Clinical signs were monitored following challenge and survival was compared between groups. Antibody titers were measured on day 0 and day 30 post challenge. On day 30 post challenge, 3 contact pigs were commingled with 2 treated animals to evaluate *S equi* subsp *zooepidemicus* transmission.

Results: Ceftiofur treatment eliminated clinical signs in 15 of 16 animals. However, multiple treatments were required to control disease in treated animals (2-3 doses providing 12-18 days of coverage). Antibody titers to *S equi* subsp *zooepidemicus* increased in challenged animals treated with ceftiofur, indicating sufficient exposure for immune stimulation.

No contact pigs developed clinical signs of *S equi* subsp *zooepidemicus* following exposure.

Implication: Rapid application of injectable antibiotics is a viable method to reduce losses due to the introduction of *S equi* subsp *zooepidemicus* into a naive group of pigs and may help prevent transmission to contact animals following recovery.

Keywords: swine, *Streptococcus equi* subspecies *zooepidemicus*, septicemia, antibiotic

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Resumen - La aplicación rápida de ceftiofur de acción prolongada puede prevenir pérdidas por muertes asociadas con *Streptococcus equi* subespecie *zooepidemicus* en cerdos

Objetivo: La introducción de cepas de *Streptococcus equi* subespecie *zooepidemicus* en poblaciones libres da como resultado tasas de mortalidad en el campo del 30% al 50% durante 5 a 10 días. Debido a la rápida evolución de la enfermedad, nuestro objetivo fue determinar si la intervención con antibióticos podría controlar la enfermedad por *S zooepidemicus* en un grupo de animales después del desarrollo de signos clínicos.

Materiales y métodos: Treinta y dos cerdos fueron desafiados con *S equi* subsp *zooepidemicus*. Tras el desarrollo de

signos clínicos, 16 fueron tratados con ceftiofur inyectable de acción prolongada. Siete cerdos no desafiados sirvieron como controles. Los signos clínicos se monitorearon después de la exposición y se comparó la supervivencia entre los grupos. Los títulos de anticuerpos se midieron el día 0 y el día 30 después de la exposición. El día 30 después de la exposición, se mezclaron 3 cerdos contacto con 2 animales tratados para evaluar la transmisión de *S equi* subsp *zooepidemicus*.

Resultados: El tratamiento con ceftiofur eliminó los signos clínicos en 15 de 16 animales. Sin embargo, se requirieron múltiples tratamientos para controlar la enfermedad en los animales tratados (2-3 dosis que proporcionaron 12-18 días de cobertura). Los títulos de

anticuerpos contra *S equi* subsp *zooepidemicus* aumentaron en animales desafiados tratados con ceftiofur, lo que indica una exposición suficiente para la estimulación inmunológica. Los cerdos sin contacto desarrollaron signos clínicos de *S equi* subsp *zooepidemicus* después de la exposición.

Implicación: La aplicación rápida de antibióticos inyectables es un método viable para reducir las pérdidas debidas a la introducción de *S equi* subsp *zooepidemicus* en un grupo de cerdos sin tratamiento previo y puede ayudar a prevenir la transmisión a animales contacto después de la recuperación.

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Résumé - L'administration rapide de ceftiofur à action prolongée peut prévenir les mortalités associées à *Streptococcus equi* ssp *zooepidemicus* chez les porcs

Objectif: L'introduction de souches de *Streptococcus equi* ssp *zooepidemicus* dans des populations naïves entraîne des taux de mortalité sur le terrain de 30% à 50% sur 5 à 10 jours. En raison de la progression rapide de la maladie, notre objectif était de déterminer si l'administration d'antibiotique pouvait limiter la maladie à *S equi* ssp *zooepidemicus* dans un groupe d'animaux après le développement de signes cliniques.

Matériels et méthodes: Trente-deux porcs ont été infectés avec *S equi* ssp *zooepidemicus*. À la suite de l'apparition

de signes cliniques, 16 ont été traités avec du ceftiofur injectable à action prolongée. Sept porcs non infectés ont servi de témoins. Les signes cliniques ont été surveillés après provocation et la survie a été comparée entre les groupes. Les titres d'anticorps ont été mesurés au jour 0 et au jour 30 après la provocation. Au jour 30 après l'infection, trois porcs contact ont été mélangés avec deux animaux traités pour évaluer la transmission de *S equi* ssp *zooepidemicus*.

Résultats: Le traitement au ceftiofur a éliminé les signes cliniques chez 15 des 16 animaux. Cependant, plusieurs traitements ont été nécessaires pour maîtriser la maladie chez les animaux traités (2 à 3 doses fournissant 12 à 18 jours de

couverture). Les titres d'anticorps contre *S equi* ssp *zooepidemicus* ont augmenté chez les animaux provoqués traités avec du ceftiofur, indiquant une exposition suffisante pour une stimulation immunitaire. Aucun porc contact n'a développé de signes cliniques d'infection à *S equi* ssp *zooepidemicus* à la suite de l'exposition.

Implication: L'administration rapide d'antibiotiques injectables est une méthode viable pour réduire les pertes dues à l'introduction de *S equi* ssp *zooepidemicus* dans un groupe de porcs naïfs et peut aider à prévenir la transmission aux animaux contact après la guérison.

Streptococcus equi subspecies *zooepidemicus* is a zoonotic pathogen that causes infections in a variety of mammalian species, including pigs.¹⁻⁴ Historically, *S equi* subsp *zooepidemicus* infection has been sporadic in swine in the United States; however, in 2019, multiple introductions of a novel *S equi* subsp *zooepidemicus* strain occurred in the United States and resulted in mortality reaching 30% to 50% in affected groups of animals.^{3,4} Diseased animals had clinical signs including fever, severe lethargy, and reluctance to rise.^{3,4} Similar clinical signs were observed during experimental replication of disease, which progressed rapidly leading to 100% mortality 72 hours post infection.⁵

Currently, no *in vivo* studies have assessed the use of antimicrobials as an intervention strategy for *S equi* subsp *zooepidemicus* infection in pigs. Though *S equi* subsp *zooepidemicus* isolates, including the 2019 strains,^{3,4} are largely susceptible to β -lactam antibiotics,^{6,7} the rapid progression of disease could prevent antibiotic treatment from controlling losses associated with *S equi* subsp *zooepidemicus* introduction into a swine herd.

In this study, we investigated the use of long-acting ceftiofur crystalline free acid as an intervention strategy to control *S equi* subsp *zooepidemicus* infection in pigs. Our objective was to determine if rapid application of ceftiofur after the development of clinical signs could prevent losses associated with *S equi* subsp *zooepidemicus* infection.

Animal care and use

This animal study was approved by the US Department of Agriculture (USDA) Agricultural Research Service National Animal Disease Center Institutional Animal Care and Use Committee.

Materials and methods

Animal study

Thirty-nine, 10-week-old pigs were divided into three groups. Group 1 animals were challenged with *S equi* subsp *zooepidemicus* (n = 16). Group 2 animals were challenged with *S equi* subsp *zooepidemicus* and treated with a weight-calculated dose of ceftiofur crystalline free acid (Excede; Zoetis) given intramuscularly (n = 16). Group 3 animals were not challenged (n = 7). Animals in groups 1 and 2 were inoculated intranasally and orally with 3 mL of 2×10^8 colony forming units (CFU)/mL (1 mL per nostril and 1 mL orally). Animals in group 2 were treated with ceftiofur after the development of clinical signs on day 1 post challenge and again on day 5 post challenge when fevers started recurring. A third treatment was given only to animals developing a fever following retreatment. Body temperature was monitored twice daily following challenge by temperature chip (Destron Fearing). Following the challenge, animals were monitored every 4 hours excluding an 8-hour overnight period for the development of clinical signs including depression, reluctance to rise, and neurologic signs. Pigs were euthanized and necropsied if clinical signs became severe. At necropsy, the following samples were collected for culture: nasal swab, tonsil swab, serosal

swab, liver swab, splenic swab, joint fluid, cerebrospinal fluid (CSF), bronchoalveolar lavage fluid, and serum. Nasal and tonsil swabs were collected at 7- and 30-days post challenge in surviving animals to assess colonization.

On day 30 post challenge, 2 animals (692 and 697) that had been treated only twice with ceftiofur were commingled with 3 negative control animals from group 3 in a clean animal room to evaluate transmission from recovered animals to naive contacts following treatment. To allow time for development of serologic response, animals were monitored for clinical signs as previously described until day 63 when they were euthanized. At necropsy, samples were collected as previously indicated to screen for *S equi* subsp *zooepidemicus*.

Bacterial isolate and culture conditions

Streptococcus equi subsp *zooepidemicus* 19-031482-K1916623-LUNG1 (SRR10584760, <https://www.ncbi.nlm.nih.gov/sra/SRR10584760>) was isolated from a high mortality event in Tennessee in 2019.^{5,8} *Streptococcus equi* subsp *zooepidemicus* inoculum was grown on trypticase soy agar with 5% sheep blood (Becton Dickinson) at 37°C with 5% CO₂. Overnight *S equi* subsp *zooepidemicus* cultures were harvested in phosphate-buffered saline to an OD₆₀₀ = 0.42, which results in 10⁸ to 10⁹ CFU/mL. The final concentration of *S equi* subsp *zooepidemicus* in the inoculum was quantified by plating serial dilutions. Animal samples were plated on trypticase soy agar with 5% sheep blood and incubated overnight at 37°C with 5% CO₂ to assess

for *S equi* subsp *zooequidemicus*. Suspect colonies were confirmed to be *S equi* subsp *zooequidemicus* by matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) at the National Veterinary Services Laboratories in Ames, Iowa.

Serum antibody assessment

Serum was collected at the time of challenge and on day 30 post challenge from groups 1, 2, and 3. Serum was collected from contact pigs on day 0 (challenge), day 30 (commingling), and day 63 (approximately 4 weeks post commingling). All serum was stored at -80°C until enzyme-linked immunosorbent assays (ELISA) were performed.

For the ELISA, 96-well plates were coated with a 1:10 dilution of heat killed *S equi* subsp *zooequidemicus* ($OD_{600} = 0.6$) in carbonate-bicarbonate buffer. Titer was determined by serially diluting swine serum. Antibody was detected using horseradish peroxidase conjugated

secondary antibody specific to the swine immunoglobulin heavy chain (1:20,000 dilution; SeraCare Life Sciences Inc) and tetramethylbenzidine substrate (Life Technologies). Optical density was measured at 450 nm with correction at 655 nm. Data were modeled with the nonlinear function of the \log_{10} dilution and the log (agonist)-versus-response variable slope four-parameter logistic model in GraphPad Prism (GraphPad Software) with endpoint titer interpolated using two times the average reading for gnotobiotic swine serum.

Statistical analysis

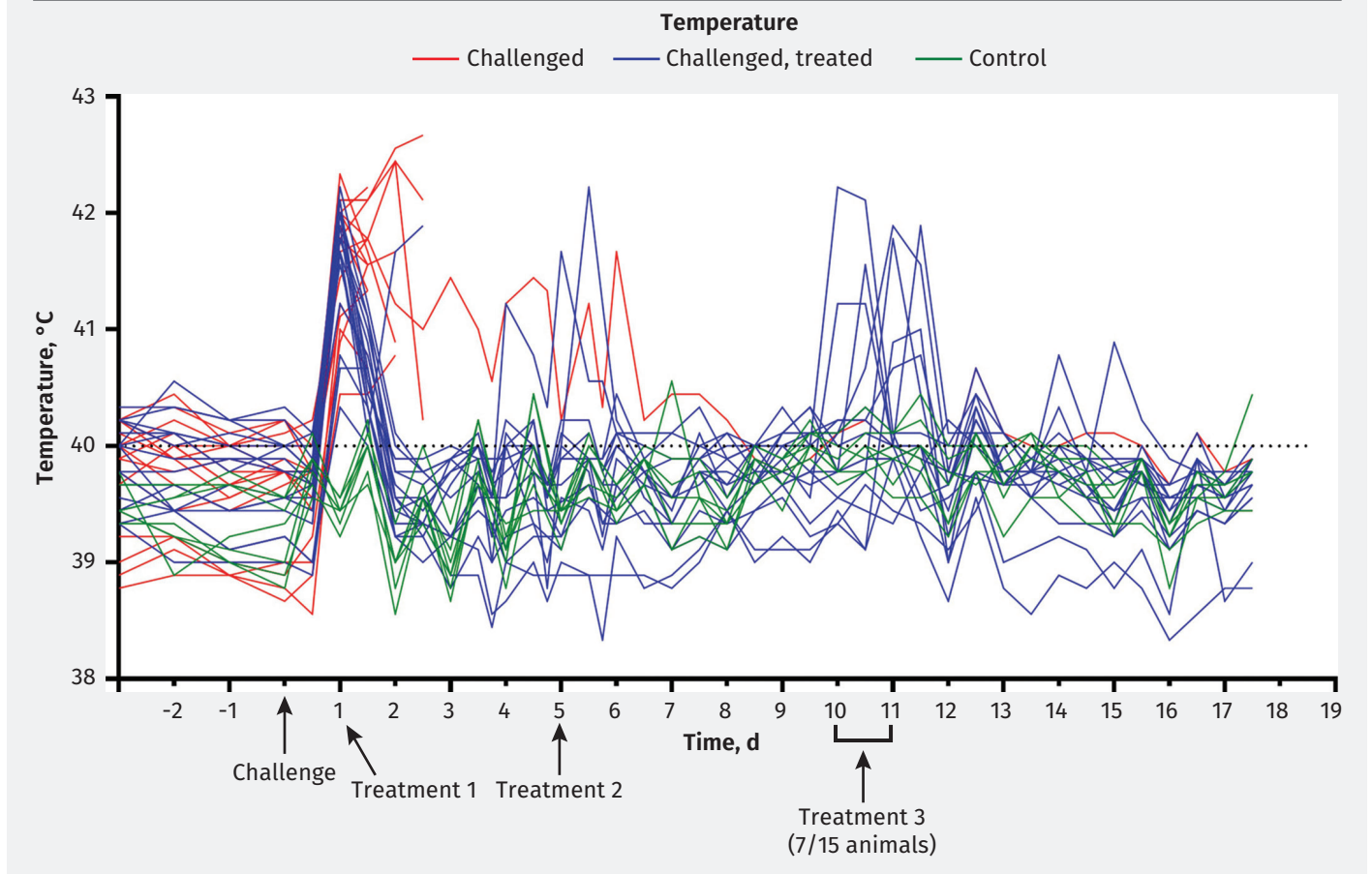
Statistical analysis was completed in GraphPad Prism 8. Survival analysis was performed by the Kaplan and Meier product limit method comparing survival curves using the log-rank test. Antibody titers were converted to \log_{10} values and compared using a two-way analysis of variance. A P value $\leq .05$ was considered statistically significant.

Results

Clinical progression and survival

Challenge of pigs resulted in disease development by 24 hours post challenge (anorexia, fever, and depression) in group 1 and 2 animals. No clinical signs developed in nonchallenged animals (group 3). Following identification of clinical disease, group 2 animals were treated with a weight-calculated dose of ceftiofur. Most pigs (15 of 16) returned to normal behavior and normal body temperature by 24 hours post treatment (Figure 1). One animal (695) in group 2 developed neurologic signs (unable to rise, ataxic) following treatment and was euthanized 72 hours post challenge (Figure 2). *Streptococcus equi* subsp *zooequidemicus* was isolated from the CSF sample but absent from other collected samples. By day 5 post challenge (4 days post treatment), pigs were redeveloping clinical signs. They were

Figure 1: Pig temperature following challenge with *Streptococcus equi* subsp *zooequidemicus*. Body temperature for each animal is plotted individually. Fever is indicated by the dashed line (40°C). All challenged animals developed a fever (> 40°C) following challenge. The challenged, treated pigs received treatment at 24 hours post challenge, which caused their temperatures to drop below 40°C. Temperatures rose again around 5 and 10 days post challenge and a second treatment of all pigs in the group was administered on day 5 post challenge, which brought temperatures back below 40°C. A third treatment was given only to pigs developing clinical signs or a fever (7 of 15 animals).



treated a second time and temperatures and behavior returned to normal. A third treatment was required in 7 of 15 surviving animals in the treatment group as they became febrile at 10- to 11-days post challenge (Figure 1). Following the third treatment, animals did not develop further signs of disease, though temperature fluctuations were common (Figure 1).

In contrast to group 2 animals, group 1 animals rapidly deteriorated without antibiotic intervention and 15 of 16 pigs were euthanized by 72 hours post challenge (Figure 2). *Streptococcus equi* subsp *zooepidemicus* was isolated from multiple systemic sites in all nontreated animals euthanized during the acute phase of infection.

Nasal and tonsil swabs were taken on day 7 and day 30 post challenge to evaluate colonization. On day 7, no *S equi* subsp *zooepidemicus* was isolated from any of the surviving animals in group 2 (n = 15). *Streptococcus equi* subsp *zooepidemicus* was isolated from nasal swabs

from the surviving nontreated animal (group 1, n = 1). By day 30 post challenge, *S equi* subsp *zooepidemicus* was not isolated from any of the surviving animals in group 1 (n = 1) or group 2 (n = 15).

Commingling with naive contact animals

On day 30 post challenge, 3 naive pigs from the nonchallenged controls (group 3) were commingled with 2 treated, challenged animals (group 2) that had only received 2 doses of ceftiofur. None of the commingled pigs showed behavior changes following commingling consistent with *S equi* subsp *zooepidemicus* disease; however, they developed a transient fever (> 40°C; Figure 3), which lasted for 36 to 60 hours. By day 11 post commingling, all temperatures returned to normal and remained normal until the end of the study. At necropsy, nasal and tonsil swabs of contact animals were culture negative.

Assessment of serum antibody titers

All groups had similar titers to *S equi* subsp *zooepidemicus* prior to challenge. At 30 days post challenge, a statistical increase in titer was seen in group 2 (15 of 16) and the surviving nontreated animal in group 1 ($P < .001$; Figure 4). The titer of treated animals was comparable to that of the surviving nontreated animal on day 30 ($P = .47$). No increase in titer was observed in the contact pigs following commingling ($P = .07$).

Discussion

In 2019, introduction of *S equi* subsp *zooepidemicus* into groups of naive swine in North America resulted in severe systemic disease and mortality reaching 30% to 50%.^{3,4} In this study, we evaluated antibiotic intervention to prevent severe death losses associated with *S equi* subsp *zooepidemicus* infection. We used injectable, long-acting ceftiofur, as the North American 2019 *S equi* subsp *zooepidemicus* isolates were found to be susceptible to β -lactam antibiotics.^{3,4}

In nontreated animals, challenge with *S equi* subsp *zooepidemicus* produced clinical signs and mortality consistent with previous research.⁵ All challenged animals rapidly developed clinical disease and 15 of 16 nontreated animals were euthanized within 72 hours post challenge. However, treatment with ceftiofur following identification of clinical disease improved survival (15 of 16 animals survived) and clinical signs completely resolved for 3 days. Though retreatment was necessary, animals did stabilize by 15 days post challenge and no animal required more than 3 ceftiofur treatments (12-18 days of therapeutic plasma levels based on product information). Additionally, when evaluating antibody titers, treated pigs developed titers similar to the surviving nontreated pig by 30 days post challenge. This indicates that immune stimulation was sufficient to develop an adaptive immune response even with antibiotic treatment, and the antibiotic treatment was able to prolong survival until the immune response could develop.

One animal in the treated group developed neurologic signs and was euthanized following the first antibiotic treatment. *Streptococcus equi* subsp *zooepidemicus* was isolated from the animal's CSF, but not from any of the other collected samples. This may be because *S equi* subsp *zooepidemicus* had already

Figure 2: Survival following a challenge with *Streptococcus equi* subspecies *zooepidemicus*. Most animals in the challenged group were euthanized by 72 hours post challenge (15 of 16). In contrast, most animals treated with ceftiofur recovered and only 1 animal was euthanized due to worsening clinical signs.

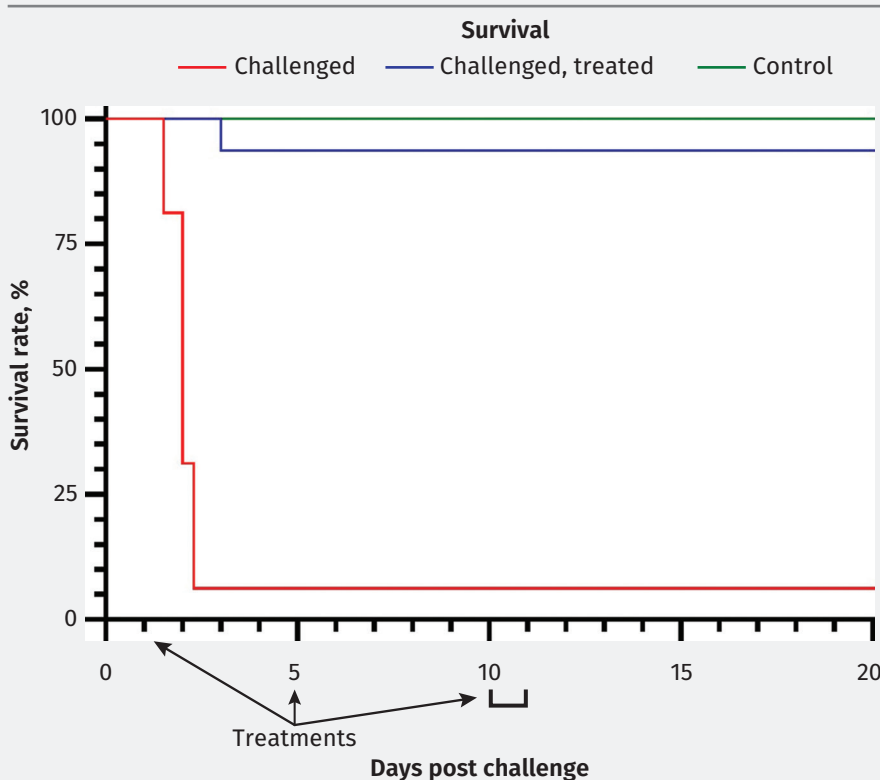
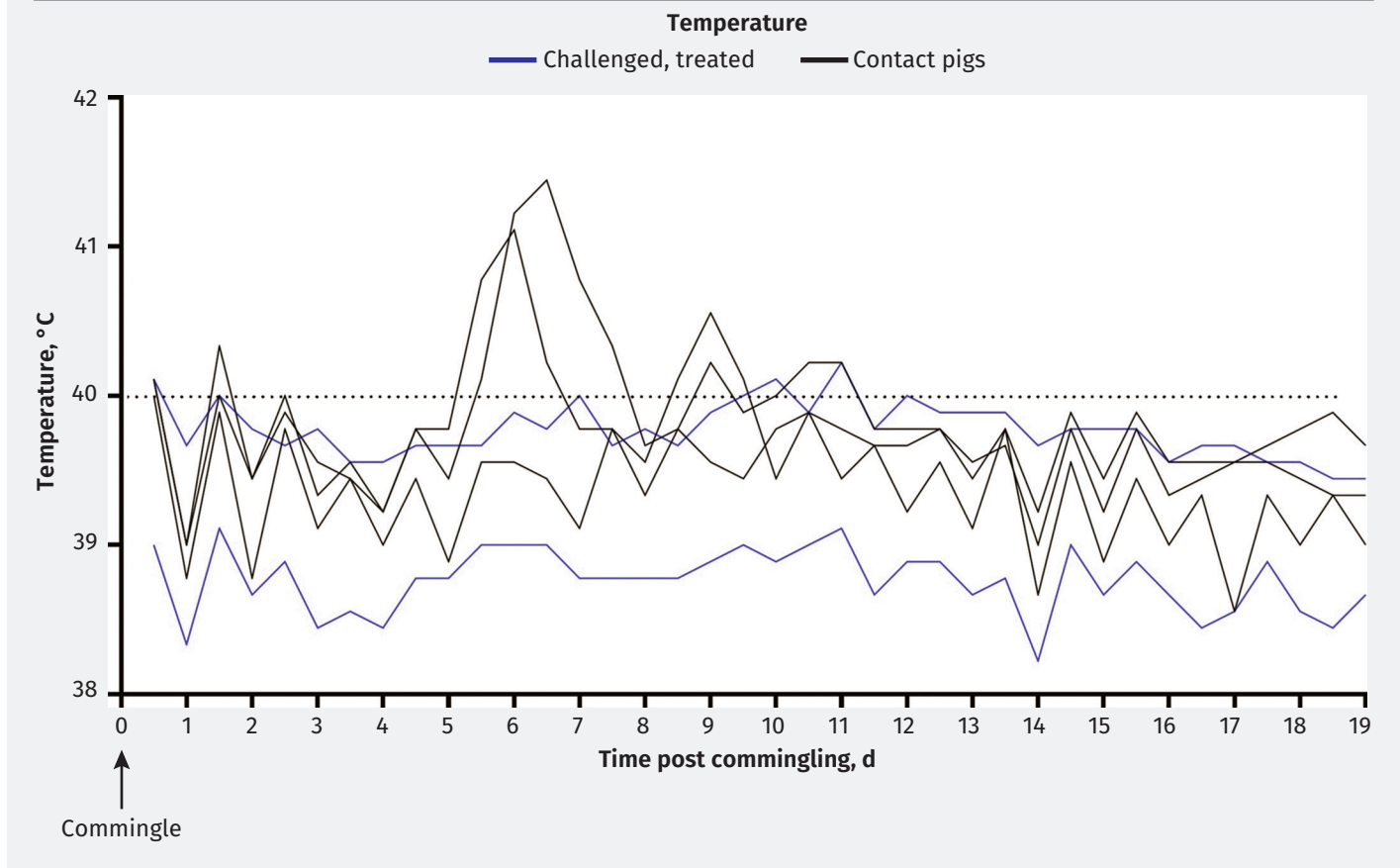


Figure 3: Body temperature following commingling of 2 challenged, treated pigs with 3 contact pigs. Body temperature for each animal is plotted individually. Fever is indicated by the dashed line (40°C). Transient fevers lasting 36-60 hours were noted in all 3 contact animals following commingling. All temperatures returned to normal by day 11 post commingling and remained normal for the rest of the study period.



crossed the blood-brain barrier by the time of treatment, and the treatment was able to clear *S equi* subsp *zooepidemicus* from the systemic sites but not within the central nervous system. This indicates the importance of early detection of disease and rapid initiation of treatment to prevent *S equi* subsp *zooepidemicus* losses.

To assess whether treated pigs could serve as a reservoir for infection in naive pigs introduced following stabilization of *S equi* subsp *zooepidemicus*, we commingled 3 of the nonchallenged controls with 2 pigs that recovered following 2 treatments with ceftiofur. No contact animals developed anorexia or depression; however, all 3 developed a transient fever between day 1 and 11 post commingling that lasted 36 to 60 hours. Peak temperatures were not as high in contact pigs as were seen in primary challenged pigs (average 41.04°C versus 41.75°C, respectively), which could be due to a smaller exposure dose. Additionally, titers were evaluated to detect an exposure event. The absence

of a rise in titers indicates any potential *S equi* subsp *zooepidemicus* exposure in the contact pigs did not stimulate an adaptive immune response. In other work, we have observed commingling of untreated pigs that survived an *S equi* subsp *zooepidemicus* challenge with naive contact pigs led to transmission in 2 of 3 contact animals, with one developing severe disease.⁹ Overall, the data from this study does not support a large exposure risk from previously infected, treated animals. In our experiment, the barn maintained high hygiene and animals were moved into a clean room for the commingling assessment, which minimized the potential for environmental exposure.

Overall, this study indicated that early treatment of *S equi* subsp *zooepidemicus*-infected animals with injectable ceftiofur can reduce clinical signs, reduce mortality, and provide time for the immune system to respond with an adaptive immune response. While we used ceftiofur, there is no reason to expect that treatment with other β -lactam

antibiotics for the same duration would provide different efficacy. It is important to provide treatment rapidly after the detection of clinical signs. It is essential to provide treatment parenterally when clinical signs are present because acutely ill animals are off feed and do not drink, so antibiotics provided in feed or water would be ineffective.

Implications

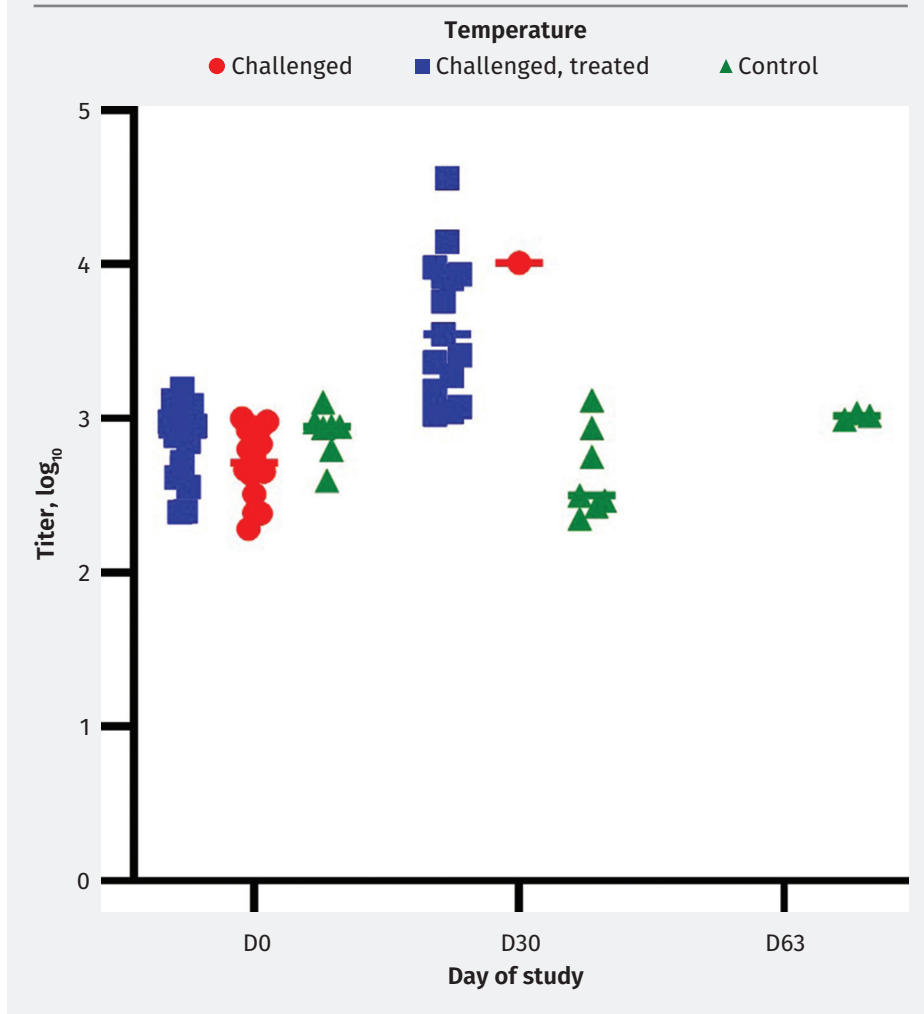
Under the conditions of this study with an *S equi* subsp *zooepidemicus* challenge:

- Long-acting ceftiofur reduced mortality.
- Ceftiofur treatment protected animals without preventing an antibody response.
- Exposure of naive pigs to recovered pigs did not result in disease.

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Figure 4: Antibody titers of pigs challenged with *Streptococcus equi* subsp *zooepidemicus*. Antibody titers were assessed on the day of challenge (D0) and the day of commingling (D30). Titers in the control pigs used as contacts were also measured on day 63 (33 days after commingling). An increased titer was noted in surviving challenged, treated animals (n = 15) and the surviving challenged animal ($P < .001$). The titer of commingled challenged, treated pigs on day 63 was comparable to control pigs on day 0 and day 30 ($P = .74$ and $P = .07$, respectively).



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Conflict of interest

None reported.

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Acute *Mycoplasma hyopneumoniae* infection in a naive breed-to-wean herd

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Summary

Mycoplasma hyopneumoniae (MHP) infection occurs globally and contributes to economic losses. Acute infections occur in immunologically naive populations affecting pigs of all ages and causing clinical signs including fever, coughing, acute respiratory distress, and death. An acute MHP infection was investigated in a naive 4200-sow breed-to-wean herd. An increase in sow mortality (4.16%, 8.33%, and 3.89%) and preweaning mortality (10.45%, 12.38%, and 12.06%) occurred when comparing the naive, acute infection, and post-infection periods, respectively. Further production differences included 166.3, 158.3, and 164.2 kg weaned/sow/year and 29.43, 28.35, and 28.28 pigs weaned/mated female/year in naive, acute infection, and post-infection periods, respectively.

Keywords: swine, naive sows, production loss, *Mycoplasma hyopneumoniae*

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Resumen - Infección aguda por *Mycoplasma hyopneumoniae* en una piara libre desde la cría hasta el destete de los lechones

La infección por *Mycoplasma hyopneumoniae* (MHP) se presenta en todo el mundo y produce pérdidas económicas. La infección aguda ocurre en poblaciones inmunológicamente libres y afecta a cerdos de todas las edades causando signos clínicos que incluyen fiebre, tos, dificultad respiratoria aguda, y muerte. Se investigó una infección aguda por MHP en una piara de 4200 cerdas libres desde el pie de cría hasta los cerdos que iban a ser destetados. Hubo un aumento en la mortalidad de cerdas (4.16%, 8.33%, y 3.89%) y mortalidad de lechones antes del destete (10.45%, 12.38%, y 12.06%) cuando se compararon los períodos antes de la infección, durante la infección aguda, y post infección, respectivamente. Otras diferencias de producción incluyeron 166.3, 158.3, y 164.2 kg destetados/cerda/año y 29.43, 28.35, y 22.8 lechones destetados/hembra inseminada/año en los períodos antes de la infección, durante la infección aguda, y post infección, respectivamente.

Résumé - Infection aiguë à *Mycoplasma hyopneumoniae* dans un troupeau naïf de type saillie-au-sevrage

L'infection à *Mycoplasma hyopneumoniae* (MHP) se produit dans le monde entier et contribue à des pertes économiques. Des infections aiguës surviennent dans des populations immunologiquement naïves affectant des porcs de tous âges et provoquant des signes cliniques tels que fièvre, toux, détresse respiratoire aiguë, et mort. Une infection aiguë à MHP a été étudiée dans un troupeau naïf de 4200 truies de type saillie-au-sevrage. Une augmentation de la mortalité des truies (4.16%, 8.33%, et 3.89%) et de la mortalité avant le sevrage (10.45%, 12.38%, et 12.06%) s'est produite lors de la comparaison des périodes naïve, d'infection aiguë, et post-infection, respectivement. D'autres différences de production comprenaient 166.3, 158.3, et 164.2 kg sevrés/truie/an et 29.43, 28.35, et 28.28 porcs sevrés/femelles accouplées/an dans les périodes naïves, aiguës, et post-infectieuses, respectivement.

M*ycoplasma hyopneumoniae* (MHP) is the primary pathogen of enzootic pneumonia, and a dynamic component of the syndrome labeled porcine respiratory disease complex.¹ The dynamics of MHP infection are becoming better known by practitioners as improved diagnostic methods are used in determining the infectious state of animals.²⁻⁵ An examination of the Infection Chain (Boehringer Ingelheim Vetmedica, Inc) in endemically MHP-infected populations revealed both horizontal and vertical spread of MHP.³ Longitudinal studies within

the downstream flow of MHP-endemic sow herds have shown detection of the same MHP strain in offspring illustrating vertical transmission.⁶ The best way to control MHP within a sow herd is elimination,^{7,8} improving the economic potential of the offspring during the finishing phase.⁷

A common practice of introducing naive replacement gilts or gilts of mixed immune status into an MHP-positive sow herd promotes horizontal transmission and an endemically infected population.¹⁻³ The spread of MHP is insidious,

sporadic, and continuous with a persistent cough, although asymptomatic infection in a breeding herd has also been described.⁴ The duration of an infection in convalescent carriers has been shown to be around 200 days post infection with clearance of MHP infection in less than 254 days.⁵

Mycoplasma hyopneumoniae is commonly introduced directly into a naive population by contact with infected animals.¹ However, airborne detection of MHP near and within sites with active infection demonstrates that transmission

TG: Performance Health, PC, Battle Ground, Indiana.

OGD: Boehringer-Ingelheim Vetmedica GmbH, Ingelheim, Germany.

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does occur by aerosol over short distances.⁹⁻¹¹ Air samples containing infectious MHP have been detected as far as 9.2 km from an infected site.¹² Other routes of pathogen introduction into herds, including contaminated personnel and fomites, have been suspected but not conclusively proven.¹³

Epidemic infections occur when MHP enters an immunologically naive population affecting pigs of all ages. Acutely infected animals present a combination of clinical signs including fever, coughing, acute respiratory distress, and even death.¹ Information on an acute infection in a naive population, especially in pregnant sows, and the impact of MHP infection on performance is limited.¹⁴ This case report documents the clinical characteristics of an acute MHP infection, along with performance parameters in a naive breed-to-wean herd with an on-site gilt development unit (GDU) by comparing the naive, acute infection, and post-infection periods.

Animal care and use

All animals in this study and all procedures were performed in accordance with the swine production and welfare policy of the production system. The farm was Pork Quality Assurance Plus certified and followed the animal care criteria of the National Pork Board's standards.

Case description

Farm history

The acute MPH infection occurred on a 4200-head breed-to-wean farm (unit 1) with an on-site GDU in the Eastern Hog Belt of the United States. The closest swine unit was a 1900-sow sister site (unit 2), which was part of the same production system and located 2.9 km to the southwest. The unit 1 site was remodeled from a 600-head single-site unit in 2008 after a complete herd repopulation allowing the site to be empty for several months over winter. The site was repopulated with MHP- and porcine reproductive and respiratory syndrome virus (PRRSV)-naive animals in early 2009. The sources of the replacement animals were monitored monthly by means of 15 (MHP) and 30 (PRRSV) serum samples for serology by enzyme-linked immunosorbent assay (ELISA; IDEXX PRRS X3 Ab Test and IDEXX M hyo Ab Test) and polymerase chain reaction (PCR; Thermo Fisher Scientific VetMAX NA and EU PRRSV

1.0 kit). The same monitoring program was implemented after placement into the remodeled facility and continued until the acute MPH infection occurred. An on-site GDU in a nonattached building consisting of 2 nursery rooms and 5 finisher rooms was permitted for a closed-herd approach for replacement animal production after repopulation. The first repopulated sows farrowed in June 2009. Monthly clinical observations included, but were not limited to, coughing, fever, off-feed events, mortality, and production performance parameters in addition to the serologic monitoring. If an unusual clinical event occurred, then additional diagnostic tests were performed. This clinical monitoring program continued after the repopulation until the acute MPH infection occurred.

Diagnostic investigation of the MHP infection

In 2016, 2 MHP-positive (sample to positive [S/P] ratio of 0.877 and 0.441 with a positive cutoff ≥ 0.4) and 2 MHP-suspect (S/P ratio of 0.324 and 0.347) samples were detected using an ELISA from 15 samples collected during routine serologic sampling of sows in gestation on week 51 (Table 1). Thirty samples were collected for PRRSV detection, and all samples were negative by ELISA. The results of the confirmatory test (Oxoid Mycoplasma hyopneumoniae DAKO ELISA kit) on the 4 MHP-positive and -suspect samples were negative (Table 1). Since no clinical signs were present, no further diagnostic work was performed.

Routine profiling of 30 animals (approximately 5 months of age) located in the on-site GDU was performed during week 3, 2017, and all results were MHP negative. After receiving these diagnostic results, the first clinical sign observed was coughing by sows in the farrowing room. An aggressive diagnostic investigation was launched early in week 4, 2017. Thirty laryngeal swabs, 10 nasal swabs, and 30 blood samples from parity 0 to parity 8 sows were taken throughout the site including in the farrowing and gestation barns. The selection of animals was random, although some coughing sows and nearby non-coughing sows were sampled. The investigation included real-time PCR detection tests for influenza A virus (IAV), PRRSV, and MHP. The results for IAV and PRRSV were negative. The results confirmed that clinical symptoms were due to an acute MHP infection (Table 2).

A second sampling was performed early in week 5, 2017. Environmental samples, laryngeal swabs from clinical adult animals, and nasal swabs from coughing near-to-wean aged piglets were collected. Three of nine piglet nasal swabs were MHP positive by PCR testing (cycle threshold [Ct] values = 36.83; 34.09; and 35.4). An environmental swab of a cell phone tested MHP suspect by PCR (Ct = 39.0). Other environmental swabs from farrowing crates, office equipment, ultrasound machine, feed cart, and boots of two different employees all tested MHP negative. Laryngeal swabs were collected from 17 adult animals that were showing clinical signs including, but not limited to, coughing, off feed, and fever $> 39.5^{\circ}\text{C}$. The samples were submitted to the University of Minnesota Veterinary Diagnostic Laboratory for MHP detection via PCR and sequencing. Sixteen of the laryngeal swabs were MHP positive (Table 3). The complete P146 adhesion-like gene from MHP was sequenced from 5 of the submitted samples. The acute respiratory infection in the formerly naive herd was confirmed to be caused by MHP.

Clinical symptoms and treatment therapies

During week 3, 2017, sows started coughing in farrowing rooms with nursing piglets that were 12 to 18 days of age. Initially only sows presented with a cough, but by 2 weeks post infection, an occasional piglet near weaning age presented with a dry cough. The starting incidence rate was 6% to 12.5% (2 to 4 adults per 32 farrowing crates) and increased within 3 weeks post infection to approximately 33% (9 to 12 adults per 32 farrowing crates). The incidence rate of sows with a fever paralleled that of coughing sows. Rectal temperatures of clinically affected sows ranged from 39.5°C to 40.5°C and persisted for several days. During the acute outbreak, the number of sows off feed or with reduced feed intake varied from 5% to over 20%. The variation was due to how MHP spread throughout the site and the number of newly infected animals each day. The off-feed events in sows were segregated into 2 groups. One group of sows presented with a high fever and very little, if any, feed consumed for days; the second group had a low fever and was back to normal feed consumption within days. Most off-feed sows had a feed intake reduction of 50% or more within a day of presenting with a fever. Sows of all parities were equally

Table 1: Serologic sampling results for *Mycoplasma hyopneumoniae* during week 51, 2016

Animal ID	S/P (Result)*	OD, % (Result)†
6272	0.877 (Pos)	82.621 (Neg)
3682	0.441 (Pos)	82.292 (Neg)
7229	0.149 (Neg)	NT
6337	0.123 (Neg)	NT
4627	0.159 (Neg)	NT
3658	0.149 (Neg)	NT
6361	0.073 (Neg)	NT
7173	0.008 (Neg)	NT
7334	0.324 (Sus)	83.361 (Neg)
8004	0.178 (Neg)	NT
5245	0.031 (Neg)	NT
3777	0.102 (Neg)	NT
7318	0.128 (Neg)	NT
4441	0.347 (Sus)	91.283 (Neg)
6403	0.055 (Neg)	NT

* Samples tested using IDEXX M hyo Ab Test. An S/P ratio ≥ 0.4 was considered positive and an S/P ratio between ≥ 0.3 and < 0.4 was considered suspect.

† Samples tested using Oxoid ELISA MHP. Samples with an OD $\geq 65\%$ was considered negative.

S/P = sample to positive ratio; OD = optical density; NT = not tested.

affected. Medical intervention therapies consisting of an antibiotic, steroid (Preddef 2x; Zoetis), and flunixin meglumine (Banamine-S; Merck Animal Health Intervet) resulted in clinical improvements in off-feed and febrile animals. The health effects from MHP were most severe in the 10-week period post infection, although the clinical signs in the farrowing rooms continued for 16 weeks post infection. The number of sows expressing severe clinical signs (high fever and long-duration anorexia) during the infection period created the need to mass medicate 6 farrowing rooms with tetracycline (Pennchlor 64; Pharmgate Animal Health) via the water for control of *Pasteurella multocida* and other susceptible bacteria. The severely affected sows also presented with either agalactia or hypogalactia in addition to reduced feed intake. The mass therapy approach in farrowing rooms allowed farm workers to focus on supplemental piglet feeding and care to save as many piglets as possible. Individual sow treatments were the primary therapy used and consisted of injectable lincomycin at 1 mL/27 kg body weight once a day (Lincomix

injectable; Zoetis). The severely affected individuals were injected with enrofloxacin at 3.4 mL/45 kg of body weight one time (Baytril; Bayer HealthCare, LLC, Animal Health Division) or tulathromycin at 1 mL/41 kg of body weight one time (Draxxin; Zoetis). Despite the therapies implemented, sow mortality increased during the infection period compared to the naive period. The increase in sow mortality was directly due to the MHP infection, eg, pneumonia, or indirectly from perforated gastric ulcers in off-feed sows as determined by field necropsies and gross appearance.

Piglet mortality was primarily affected by agalactia or hypogalactia in the dam. In severe cases, entire nurse litters were created increasing cross-fostering management dramatically post infection. Cross fostering piglets included an evaluation of the piglet's birth weight. If the birth weight was low (< 1.6 kg), cross fostering was delayed as long as possible (2-3 days). Commercial milk replacer was used to supplement piglets where needed. In some dire situations, piglets were humanely euthanized due

to their condition or because nurse sows were not available. Prewaning mortality improved as the number of sick sows decreased.

Farm goals and activities to maximize MHP immunity

After confirmation of an acute MHP infection, the first goal for this production site was to minimize production losses. A second goal was to establish that 90% or more of the replacement and adult animals were exposed to MHP before a herd elimination process could begin, which is commonly called Day 0. The decision to use natural exposure to infect the entire gilt and adult populations meant that all animals were tested, with some being tested more than once to determine if the goal to have over 90% positive/exposed animals was achieved. A complete timeline of events from when clinical signs were first documented until the end of the elimination program is shown in Table 4. Because the farm produced its own replacement animals, the farm's animal movements were altered to achieve "closure" by not retaining any replacement females until after MHP elimination. When a site is closed, replacement animals no longer enter into the site for breeding purposes allowing for exposure to occur in the remaining animals within the site and avoiding continuous introduction of animals with a different immune status. The elimination program activities started once $\geq 90\%$ exposure level was achieved in all replacement females in the GDU and adult animals in the sow unit using both serology and PCR on laryngeal swabs. To achieve the desired exposure level, natural exposure occurred by placing coughing animals next to asymptomatic animals. The same exposure procedure was implemented in the on-site GDU by housing MHP-positive (by PCR) and coughing animals in rooms containing asymptomatic or negative gilts. Eventually, the two youngest nursery rooms in the GDU were moved to an off-site finisher location because the 90% exposure goal could not be reached in a short enough time compared to the rest of the animals. All populations within the site were repeatedly tested using laryngeal swabs for PCR and serum for ELISA to establish the goal of $\geq 90\%$ exposure rate. The exposure program required minimal antibiotic treatments except for severely affected animals. Following herd closure and confirmation of broad MHP exposure in all age populations at

Table 2: Diagnostic results for *Mycoplasma hyopneumoniae* during week 4, 2017 using laryngeal swabs (real-time PCR) and serum (ELISA)

Animal ID (parity)	Serum		Laryngeal swab (pooled)	
	Result	S/P	Result	Ct40 level
9632 (0)	Negative	0.06		
9662 (0)	Positive	0.49	Positive	34.37
7067 (3)	Negative	0.08		
4464 (5)	Positive	0.77		
6940 (3)	Suspect	0.36	Positive	29.55
5353 (5)	Positive	0.66		
6303 (4)	Positive	0.78		
4202 (5)	Positive	0.93	Positive	33.92
8082 (2)	Positive	0.67		
5239 (5)	Positive	1.71		
6191 (4)	Positive	2.69	Positive	30.00
5410 (5)	Positive	0.94		
7948 (2)	Positive	1.96		
4296 (6)	Positive	1.86	Positive	35.29
7835 (2)	Positive	0.50		
6654 (3)	Positive	0.47		
6298 (4)	Positive	0.81	Positive	28.94
2598 (8)	Positive	1.33		
7153 (3)	Positive	1.03		
4410 (6)	Positive	0.42	Positive	35.86
5411 (5)	Positive	1.29		
4373 (6)	Positive	0.87		
5981 (4)	Positive	1.85	Positive	36.04
4313 (6)	Positive	1.53		
8806 (1)	Positive	1.47		
5261 (5)	Positive	2.42	Positive	29.65
7885 (2)	Positive	2.00		
8062 (2)	Positive	1.51		
6299 (4)	Negative	0.01	Positive	36.92
3467 (2)	Negative	0.05		

PCR = polymerase chain reaction; ELISA = enzyme-linked immunosorbent assay; S/P = sample to positive ratio; Ct = cycle threshold.

Table 3: Diagnostic results for *Mycoplasma hyopneumoniae* during week 5, 2017

Sample ID/Location	Results	Ct40 level
Laryngeal swab*		
4448	Positive	35.03
7683	Positive	28.52
8909	Positive	31.48
6438	Positive	36.24
7174	Positive	28.41
6201	Positive	32.13
6062	Positive	27.84
7253	Positive	28.26
7989	Positive	29.94
5537	Suspect	37.4
7915	Positive	26.18
8327	Positive	35.95
6236	Positive	28.46
8506	Positive	27.03
8883	Positive	23.18
8856	Positive	28.48
6360	Positive	26.53
Nasal swab[†]		
1	Negative	-
2	Positive	36.83
3	Negative	-
4	Negative	-
5	Suspect	37.7
6	Negative	-
7	Positive	34.09
8	Negative	-
9	Positive	35.4

this site, the herd was mass vaccinated with a commercial MHP vaccine (Respi-Sure; Zoetis) three times (18, 22, and 30 weeks following confirmation of acute infection). The multiple vaccination approach might be considered excessive; however, this program was used to maximize immunization in the entire population to promote reduction of MHP transmission. Successful MHP elimination was documented by testing sentinel animals post entry (starting week 12, 2018) using both laryngeal swabs and serum tests (Table 4).

Post-infection impact on sow and suckling piglet productivity

Sow performance records were entered into Minitab statistical process control (SPC) charts (Minitab V19.0; Minitab, Inc) for a period of 23 weeks when the farm was MHP naive (week 31, 2016 - week 2, 2017), for 13 weeks during the acute infection (week 3-15, 2017), and for another 13 weeks post infection (week 16-28, 2017).¹⁵ The 13 weeks post infection was chosen as a period for monitoring the MHP health program for a potential relapse. Mean values of these production parameters during naive, acute infection, and post infection phases were analyzed using the before-after control charts of Minitab. A marked increase of the annual sow death rate (4.16% naive, 8.33% acute infection, and 3.89% post infection; Figure 1) and pre-weaning mortality (10.45% naive, 12.38% acute infection, and 12.06% post infection; Figure 2) from the naive to acute infection period was documented in SPC charts. A difference in kg weaned per sow per year (166.3 naive, 158.3 acute infection, and 164.2 post infection; Figure 3) and pigs weaned per mated female per year (29.43 naive, 28.35 acute infection, and 28.28 post infection; Figure 4) are also illustrated in SPC charts. Both production parameters are arguably important to the economics of a sow herd and can be compounded by the quality of weaned piglets.

Determination of route of introduction of MHP infection

During the outbreak, an in-depth investigation of possible risks for MHP introduction was conducted. Since repopulation in 2009, the farm's written biosecurity policies were reviewed quarterly with key personnel. Unit 2, located 2.9 km southwest of unit 1, had clinical signs suggestive of MHP in late week 46 with diagnostic confirmation of MHP

Table 3: Continued

Sample ID/Location	Results	Ct40 level
Environmental swab[‡]		
Ultrasound machine	Negative	-
Office	Negative	-
Side	Negative	-
Side	Negative	-
Side	Negative	-
Back gate of farrowing stall	Negative	-
Front gate of farrowing stall	Negative	-
Back gate of farrowing stall	Negative	-
Ultrasound machine	Negative	-
Boots #1	Negative	-
Boots #2	Negative	-
Cell phone	Suspect	39.00
Sort board	Negative	-

* Laryngeal swabs were collected from 17 adult animals showing clinical signs and tested using real-time PCR.

† Nasal swabs were collected from coughing near-to-wean aged piglets.

‡ Environmental swabs were tested using real-time PCR.

Ct = cycle threshold; PCR = polymerase chain reaction.

infection in week 47, 2016 after several years of MHP-naive status. Weather conditions starting week 51, 2016 are illustrated in the supplementary materials (Table S1).

A detailed review of unit 1 biosecurity procedures was conducted and did not find breaches in the protocol. The unit 2 MHP infection confirmed in the weeks preceding this outbreak together with weather conditions conducive to area spread are suspected to be responsible for this outbreak.

Discussion

Reports that describe clinical signs of acute MHP infection in MHP-naive breeding herds are limited in the literature despite 46% of veterinarians reporting experience with outbreaks in sow farms.¹⁴ When MHP is introduced into a naive sow herd, the infection affects all ages of pigs.¹ The production impact of MHP in breeding herds, even in endemically infected herds, is poorly understood, although it is reported to cause increased preweaning mortality and abortions in rare occasions.¹⁴ For this reason, it is important to understand the impact of MHP infection in naive herds.

For this case, production losses were caused by increased sow mortality of all parities. Other economic effects were a reduced number of piglets weaned and reduced weaning weights. Examination of the production records using SPC charting did not detect marked variances but did show trends in other production parameters like farrowing, repeat breeding, stillbirths, and mummy rates. While the production records during the acute infection period did not show a significant increase in the number of abortions, the farm manager stated that abortions associated with the outbreak did occur. A small proportion of swine practitioners have reported abortions as a possible outcome of MHP infections in breeding herds.¹⁴

The main clinical sign observed in this acute MHP infection was coughing, with some individual sows having severe coughing, similar to previous reports.¹³ In addition, this outbreak was characterized by febrile sows ($\geq 39.5^{\circ}\text{C}$), partially or completely off-feed sows, and an increase in mortality despite implementing an aggressive treatment program. Results corroborate findings of a survey of 493 practitioners that reported fever as a typical clinical sign in MHP-infected

sows.¹⁴ In the farrowing house, the main problem was sow hypogalactia that resulted in numerous problems for the nursing offspring. Weak piglets at birth were not a major concern. During the infection period, a few litters had smaller than usual piglet birth weights but were not considered weak. In the litters exhibiting weak normal size piglets, the dam was clinically ill presenting with fever and partially or completely off-feed.

Efforts to eliminate MHP in North American herds have increased in recent years with most attempts being successful.^{7,8} Natural exposure was used to spread the MHP organism throughout the site after confirmation of the positive diagnostic results. It took 14 weeks from confirmation for MHP to spread throughout the sow site to achieve the goal of 90% or more sows testing positive by laryngeal swabs, serum, or both, which was determined to be critical for successful elimination.^{7,8} An additional 6 weeks were needed to confirm the same exposure rate in the replacement gilts housed in the GDU. The two youngest nursery rooms in the GDU were moved off-site to allow for the elimination program to start since these groups were not achieving a $\geq 90\%$ level of exposure. Alternate exposure methods, ie, using herd specific lung homogenate given intratracheally or by fumigation, were considered to shorten the time required to reach a 90% exposure rate.¹⁶ The management decision to use natural exposure instead of lung homogenate was primarily based on concerns it would result in severe clinical disease in far more animals and minimize the risk of entry of another major infection.

The question remains on how MHP entered unit 1. The biocontainment practices were of a high standard and no obvious breaches were detected during the biosecurity audit. In addition, farm staff were not allowed to move between units reducing the likelihood of people being carriers of MHP.^{13,17} Other authors have agreed that the source of an MHP infection can be hard to determine.^{12,16,17} The short time between the acute infection in unit 2 and the subsequent infection in unit 1 supports the hypothesis of possible aerosol transmission. This hypothesis is further supported by the finding of genetically identical MHP strains in both production sites.⁶ Favourable weather conditions (cold, low wind speed, and high humidity) gives additional support to probable aerosol transmission from

Table 4: *Mycoplasma hyopneumoniae* (MHP) elimination timeline on a 4200-head breed-to-wean farm (2017-2018)

Calendar week	Project week	Description
3	-21	First suspicious serological evidence and coughing in lactating sows.
4	-20	Diagnostic confirmation of MHP in the sow herd.
18	-6	Exposure and confirmation in GDU started.
24	0	Exposure considered complete - start 36 weeks of immunity.
27	0	Exposure confirmed by diagnostics. Lots 10, 11, and 12 in GDU finisher was 100% serologically positive on ELISA. Lots 14 and 15 were not used for replacement but finished off site.
42	18	First whole-herd MHP vaccination of sow herd and GDUs.
46	22	Second whole-herd MHP vaccination of sow herd and GDUs.
49	25	Breed project started breeding gilts 15 wks prior to wk 7, when "sentinel" replacements could enter the sow herd.
52 to 2	30	Third whole-herd MHP vaccination of sow herd and MHP-positive replacements.
3	31	Veterinarian visit to sow farm to collect 60 laryngeal samples (30 in youngest replacements at sow farm and 30 in quarantine).
4 to 8	32-36	Period of additional antimicrobial usage to supplement the elimination of possible remaining MHP organisms.
4 to 7	32	Began Pulmotil (tilmicosin) administration in sow feed in both gestation (363 g/ton) and lactation (21 d at 181g/ton). End Pulmotil feed 8 wk, 2018.
4 to 7	32	Injected piglets with Draxxin (tulathromycin) at 1 and 10 d of age (25mg/mL, 0.25 mL IM at birth and 0.5 mL at 10 d of age). End Draxxin 8 wk, 2018.
4	32	Piglets weaned early, maximum wean age was 18 d.
7	35	Off-site bred replacement females entered the sow herd and were used as sentinels on future samplings.
8	36	Immunity considered complete and shedding stopped.
8	36	First piglets born assumed to be MHP negative.
8	36	Selected potential replacement gilts were weaned from sow herd and entered the on-site GDU.
11	39	Began introduction of the outsourced MHP-negative sentinels into isolation at the sow herd. Entry may be delayed for added confidence. Time in quarantine was > 3 wks.
11	39	Began weaning at normal age.
11	39	Began monitoring phase of project - sentinels and weaned pig flow.
12	40	Normal replacement gilts used as sentinels entered sow herd.

GDU = gilt development unit; IM = intramuscular.

Figure 1: Statistical process control chart of sow mortality by each 13-week health status and calendar week. Sow mortality rate significantly increased during the acute infection period contributing to the cost of disease. UCL = upper control limit; CL = center line; LCL = lower control limit.

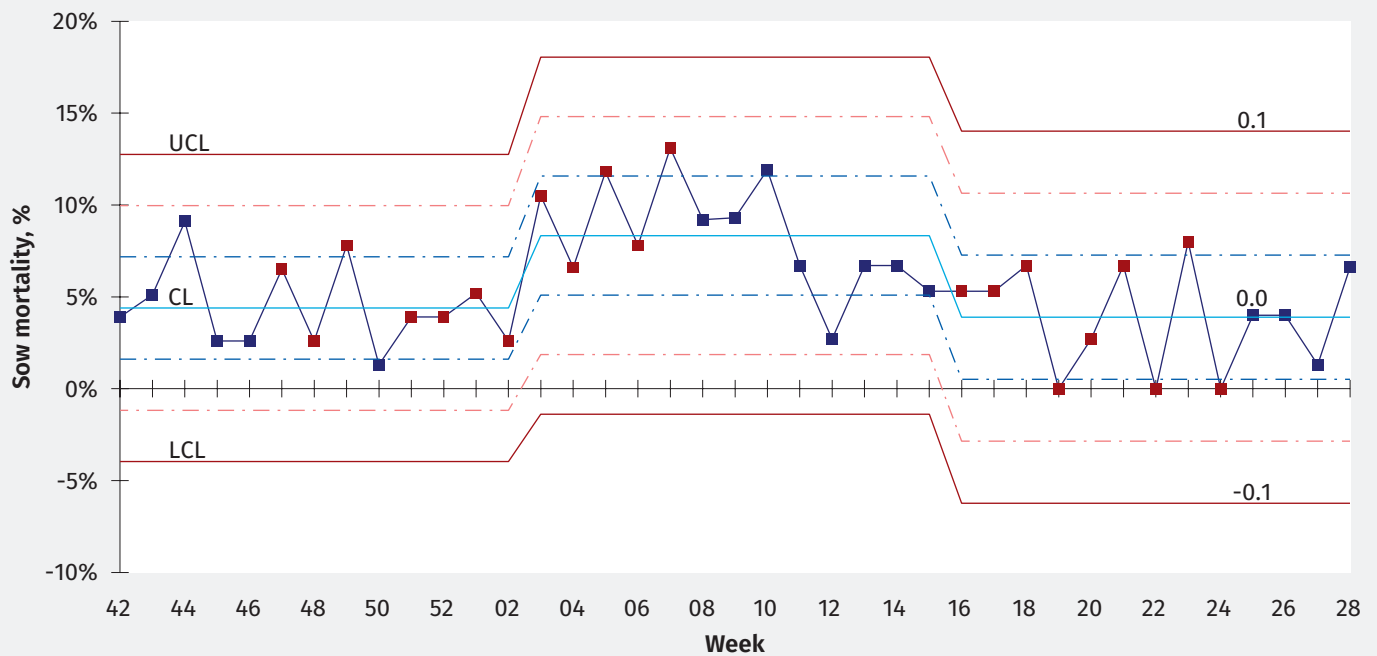
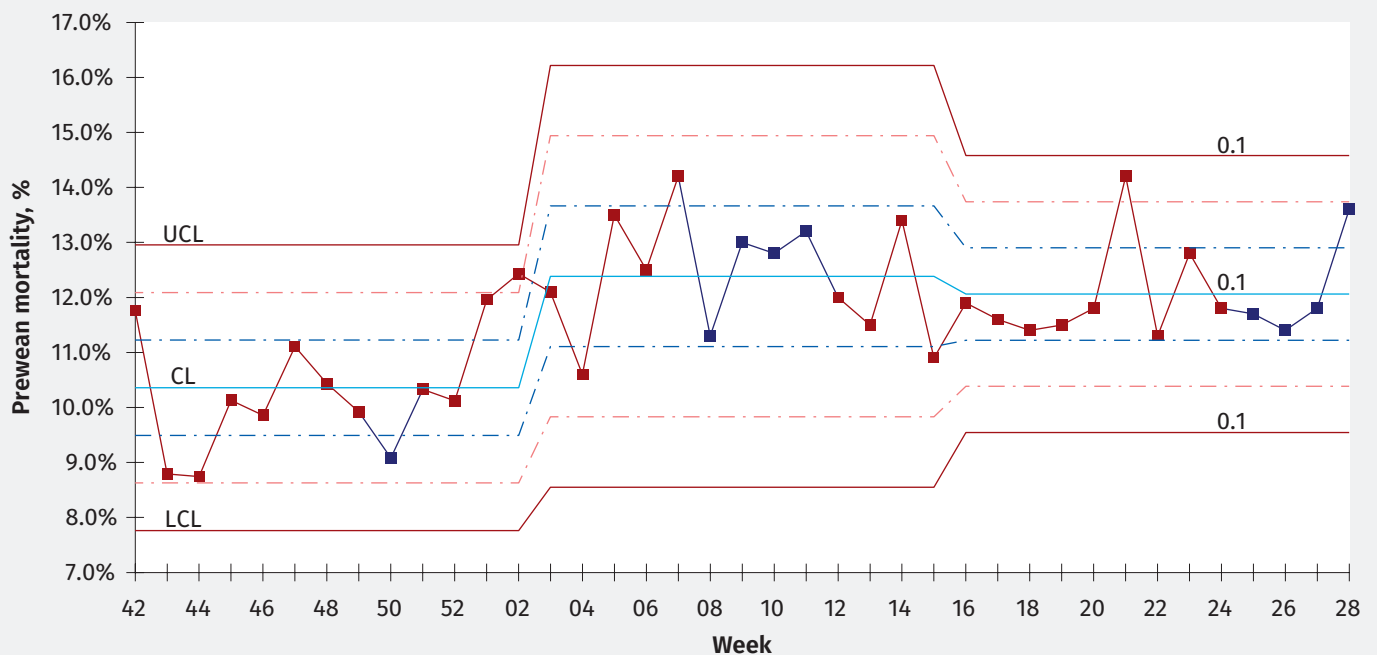


Figure 2: Statistical process control chart of preweaning mortality by each 13-week health status and calendar week. Preweaning mortality rate increased during the acute infection period contributing to reduced number of piglets weaned. UCL = upper control limit; CL = center line; LCL = lower control limit.



unit 2. The hypothesis is supported by previous reports in the literature of aerosol transmission.⁹⁻¹²

Determining if weather conditions are conducive to aerosol transmission is difficult using standard weather reports since the information provided are daily maximum, average, and minimum. During a study of long-range detection of airborne MHP, data indicated that the odds of detecting MHP in a long-distance air sample increased by 46%, 80%, and 200% with each unit increase in mean barometric pressure, minimum temperature, and maximum gust velocity, respectively.¹² The maximum relative humidity during the 4-week period in this case clearly shows most days were near or equal to 100%. Likewise, the average relative humidity during the same time was near or over 90% on several days. Slow wind speed is another factor that could influence aerosol transmission. Data for daily sun hours was not available for analysis.

Even though practitioners have dealt with MHP infections in naive sow herds for years, more case reports need to be documented. In this outbreak, production losses occurred in sow mortality, reduction in the number of piglets weaned, and reduced weaning weights. This case report illustrates clinical responses in adult and neonatal animals,

and timelines that practitioners might consider when discussing acute MHP infection and elimination procedures with their clients.

Implications

Under the conditions of this study:

- Clinical outcomes of MHP infection in naive breeding herds were confirmed.
- Production impacts of MHP in breeding herds are underestimated.
- Reliable methods of rapid MHP exposure are needed.

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Conflict of interest

Gomez Duran is an employee of Boehringer Ingelheim Vetmedica GmbH.

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Figure 3: Statistical process control chart of weight of piglets weaned per sow by each 13-week health status and calendar week. Weaning weight reduction during the acute infection period illustrated the challenges of infection to both sows and piglets in farrowing. UCL = upper control limit; CL = center line; LCL = lower control limit.

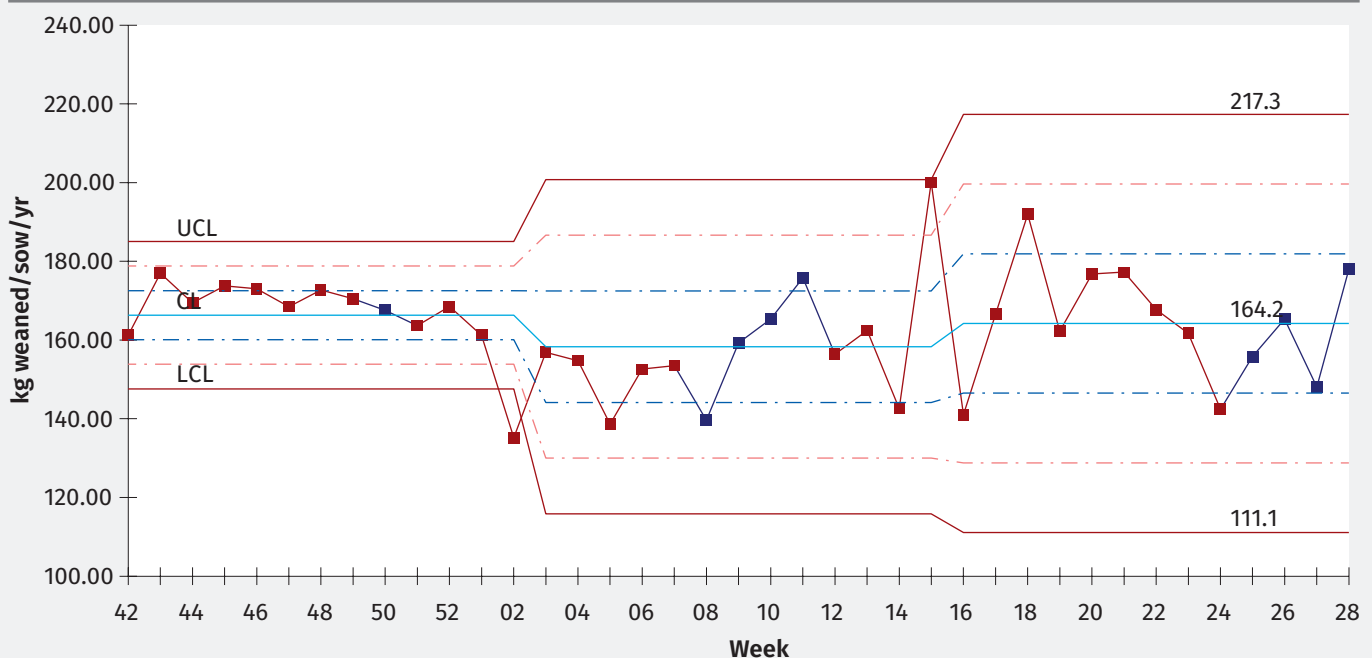
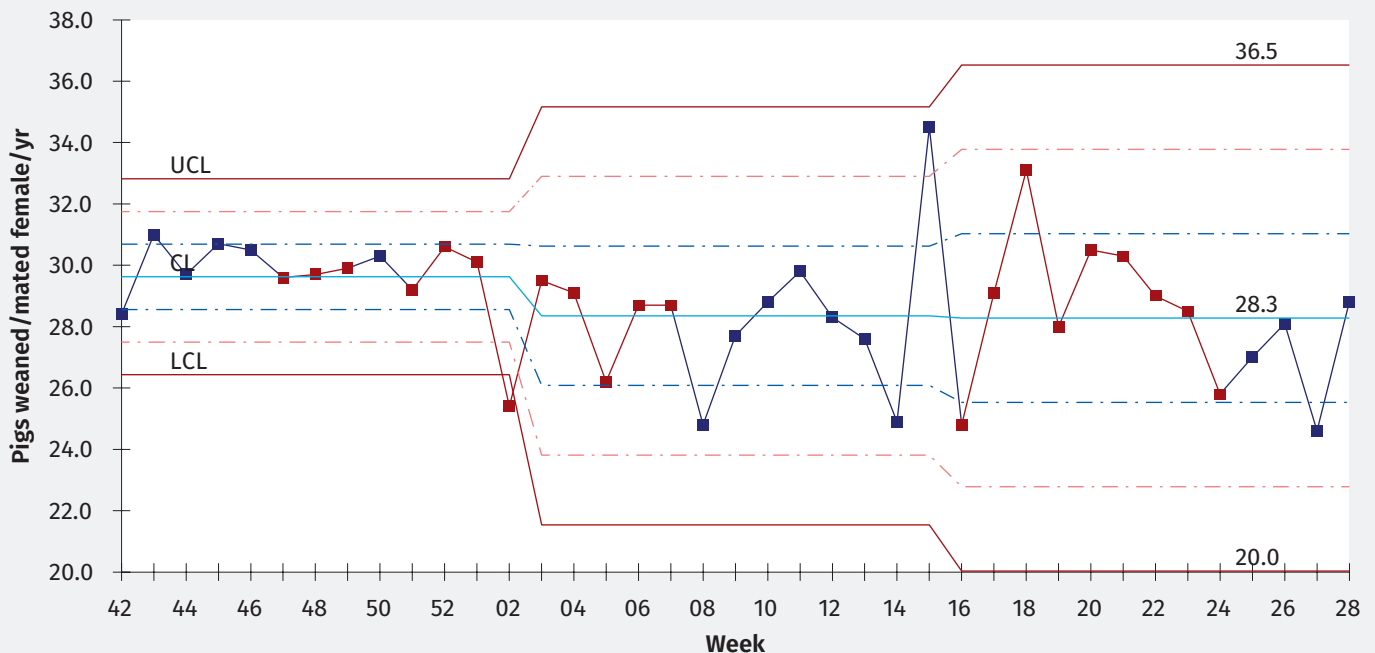


Figure 4: Statistical process control chart of pigs weaned per mated female per year by each 13-week health status and calendar week. UCL = upper control limit; CL = center line; LCL = lower control limit.



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Environmental monitoring of porcine epidemic diarrhea virus within a swine farm during a disease outbreak

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Summary

Environmental swabs were used as a monitoring tool during a porcine epidemic diarrhea virus outbreak at a farrow-to-finish swine facility. Samples were collected over the course of 16 weeks following initial infection, and changes in biosecurity practices were implemented based on results. Separation of on-farm areas into different zones as determined by animal and feed ingredient contact and proximity allowed for a targeted approach to clean-up efforts.

Keywords: swine, environmental monitoring, porcine epidemic diarrhea virus, feed

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Resumen - Monitoreo ambiental del virus de la diarrea epidémica porcina dentro de una granja porcina durante un brote de enfermedad

Se usaron hisopos ambientales como herramienta de monitoreo durante un brote del virus de la diarrea epidémica porcina en una granja porcina de ciclo completo. Las muestras se recolectaron en el transcurso de 16 semanas después de la infección inicial y se implementaron cambios en las prácticas de bioseguridad en función de los resultados. La separación de las áreas de la granja en diferentes zonas según lo que se determinó por el contacto y la proximidad de los ingredientes del alimento y de los animales permitió un enfoque específico para los esfuerzos de limpieza.

Résumé - Surveillance environnementale du virus de la diarrhée épidémique porcine à l'intérieur d'une ferme porcine pendant une éclosion de cas

Des écouvillonnages de l'environnement ont été utilisés comme outil de surveillance pendant une éclosion de cas de diarrhée épidémique porcine dans une installation porcine de type naisseur-finiisseur. Des échantillons ont été prélevés pendant une période de 16 semaines suite à l'infection initiale, et des changements dans les mesures de biosécurité mis en place en fonction des résultats. La séparation d'espaces sur la ferme en zones différentes, telle que déterminée par les contacts et la proximité des animaux et ingrédients alimentaires a permis une approche ciblée des efforts de nettoyage.

Environmental monitoring is commonly used in food and other end-consumer product manufacturing facilities^{1,2} and has gained traction as a method to determine the presence of pathogens that typically indicate fecal presence.³ In addition, some healthcare systems have instituted environmental monitoring for bacteria and viruses to improve hygiene and mitigate biosecurity risks, particularly with bacterial strains known to be resistant to antibiotics.⁴ The use of on-farm environmental monitoring of viral pathogens has increased in popularity with the growing pressure from diseases like porcine epidemic diarrhea virus (PEDV).

Environmental swabs have been shown to be effective when detecting viruses within feed manufacturing environments⁵ and within swine farms. Specifically, environmental sampling has been used to monitor the eradication of PEDV in feed mills⁶ and swine farms.⁷ Feed and feed manufacturing facilities have increased scrutiny because PEDV has been shown to be transmitted through contaminated feed ingredients.⁸⁻¹¹ Therefore, fast and reliable methods to monitor for PEDV, such as environmental sampling, provide an avenue to prevent infections.

Despite documented use within several industries, there is a lack of information regarding the applicability of environmental monitoring within swine facilities. Specifically, there is uncertainty about how the results of environmental sampling can be applied to modify biosecurity practices during an outbreak. Therefore, this case report evaluates the presence of PEDV within a farm currently experiencing a PEDV outbreak. Additionally, this case report evaluates the use of environmental sampling to make real-time biosecurity changes to prevent transmission of the virus to a susceptible animal within the infected herd or to other susceptible herds.

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Case summary

Initial investigation

The opportunity to evaluate the impact of environmental monitoring arose when the Kansas State Swine Teaching and Research Center (KSTRC; Figure 1) experienced an outbreak of PEDV in Spring 2019. The facility includes sow, nursery, and finisher housing separated into different barns for each phase and maintains a 160-head batch-farrow sow herd with additional group housing for nursery, growing, and finishing pigs. On March 8, 2019, a group of weaned pigs with scours was observed. Over the course of the next two days, diarrhea was observed within the gestation barn. Fecal samples submitted to the Kansas State University Veterinary Diagnostic Laboratory (KSU VDL) confirmed the presence of PEDV at the facility.

Pre-outbreak biosecurity procedures included a fenced perimeter buffer zone with limited vehicle and personnel access, off-site quarantine, porcine reproductive and respiratory syndrome testing of new gilts for 8 weeks prior to farm entry, and the requirement that delivered supplies were from pig-free areas of origin. Personnel and visitor entry were restricted with visitor policies posted and a visitor log kept. Employees and visitors were allowed to enter the farm if they had previous pig contact but were required to shower prior to entry if the contact was within the previous 24 hours. Initial

entry requirements included the use of a Danish bench system to establish a clear line between the perimeters. Outside footwear was not permitted to cross the bench and all entrants were required to don provided coveralls and boots once through the shower. Showering upon entry was only required in situations where prior exposure to pigs, livestock facilities, processing plants, or laboratories handling known pathogens or diagnostic samples had occurred. The area prior to crossing the Danish bench was considered dirty and the showers and changing rooms acted as an intermediary between the dirty and transition zone, which was within the main office area (Figure 2). The office area contained 2 different access points to the outside paths leading to different barns; the only requirement for moving between barns was to wash boots and change gloves.

There was typically a greater level of foot traffic in and out of the KSTRC from students and researchers than would be found on a typical swine operation of this size. However, health had historically been good at the facility. Prior to this outbreak, there had been limited environmental monitoring done at the site.

Environmental swabbing

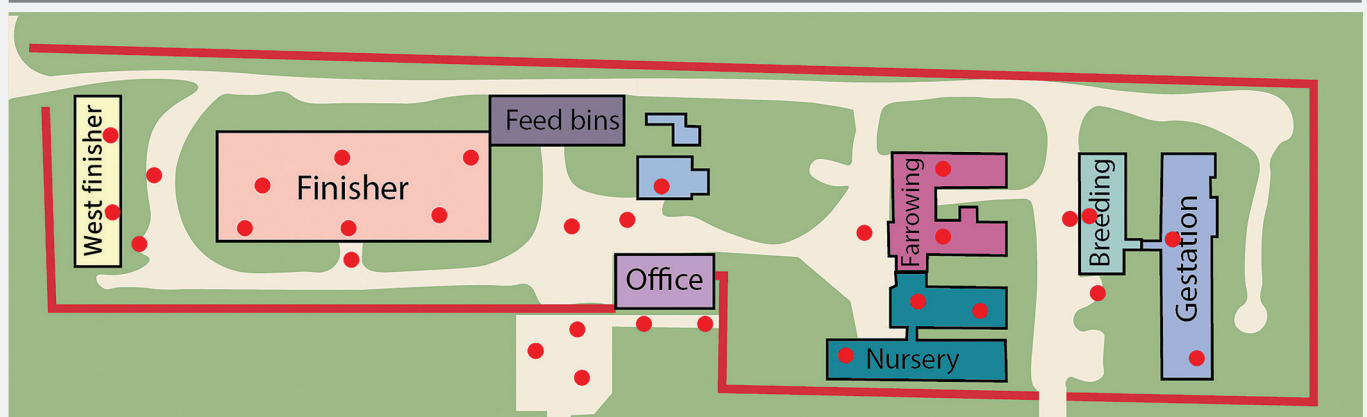
Environmental swabs were collected 2, 4, 6, 8, 12, and 16 weeks after initial PEDV diagnosis. Samples were collected by swabbing a surface area of approximately 20 cm × 20 cm with a 10 cm × 10 cm cotton

gauze square soaked in 5 mL of phosphate-buffered saline with a 7.2 pH as described by Griener.¹² Sampling locations are designated by red circles on Figures 1 and 2, and were collected from a total of 5 zones: 1) on- and off-farm vehicles, including feed delivery trucks, tractors, employee vehicles, and areas outside the farm perimeter (vehicles/outside perimeter); 2) direct pig contact surfaces including pen flooring, pen walls, feeders, and waterers (pig contact); 3) non-pig contact surfaces within one of the barn areas including employee walkways, work areas, feed storage, and in-barn transition zones (non-pig contact inside); 4) non-pig contact surfaces including walkways and work areas outside of the barn (non-pig contact outside); and 5) surfaces in the main office building including laundry areas, change rooms and shower areas, and transition zones upon entering and exiting the building (transition zones; Figure 2). Analysis of PEDV was conducted by KSU VDL using quantitative real-time polymerase chain reaction (PCR) with an upper cycle threshold (Ct) limit of 45.

Environmental swabbing results

A reduction in the number of positive samples over time was observed for multiple zones, particularly within transition areas and areas outside of barns as shown in Table 1. Two weeks following the initial diagnosis, 44% of samples obtained from vehicles/outside perimeter (worker's vehicles, on-site student

Figure 1: Kansas State Swine Teaching and Research Center layout. The red lines indicate the perimeter of the farm and the off-white area indicates walking paths. The red circles indicate the sampling locations for zones 1) on- and off-farm vehicles, including feed delivery trucks, tractors, employee vehicles, and areas outside the farm perimeter (vehicles/outside perimeter); 2) direct pig contact surfaces including pen flooring, pen walls, feeders, and waterers (pig contact); 3) non-pig contact surfaces within one of the barn areas including employee walkways, work areas, feed storage, and in-barn transition zones (non-pig contact inside); and 4) non-pig contact surfaces including walkways and work areas outside of the barn (non-pig contact outside).



housing, and near the entry bench) tested positive for PEDV. At the same timepoint, 81% of the transition zone areas (including the shower/changing area and main office) as well as 66% of samples from non-pig contact areas inside the barns were positive for PEDV.

A reduction in the number of positive samples was observed beginning on week 4 at all locations except pig contact surfaces. There was a 29% reduction in positive results from vehicle samples, a 60% reduction in positive samples seen in transition zones, a 16% reduction in positive samples from non-pig contact areas outside of barns, and a 20% reduction in positive samples from non-pig contact areas within barns. At this timepoint, environmental monitoring of pig-contact areas was initiated, which remained 100% positive until the final collection (16 weeks). These reductions were not consistent throughout the entire data collection period, but upon the final collection at 16 weeks post infection, samples collected from vehicles/outside perimeter, within transition zones, and in non-pig contact areas outside of barns had been consistently negative for the 4 weeks prior.

Implementing biosecurity changes

As environmental swabbing results were reported, biosecurity protocols were modified to prevent the spread of the virus within the facility and to contain it within the farm. Problem areas were noted, especially locations that had multiple positive samples across different timepoints. Specific areas of concern were on-site vehicles, including those that were being used to transport or dispose of waste or carcasses, transition zones in barns and within the main office, and areas within the main office that were part of the clean area in the biosecurity plan.

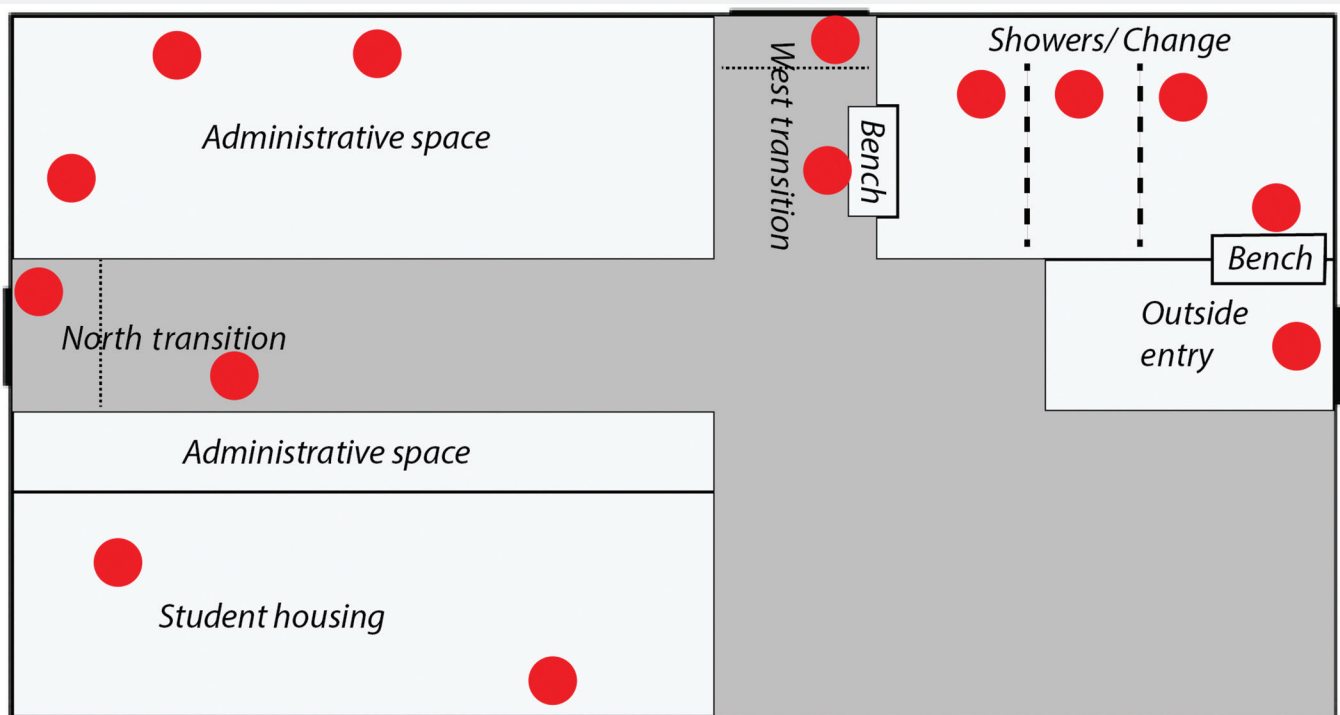
Immediately after receiving the positive PEDV diagnosis, employees were required to use new coveralls when entering a new area or room, and all non-essential entry into the farm was halted. Students and faculty who would typically be visiting the facility for research or class were not allowed onto the farm. Essential employees were assigned to specific areas; either working exclusively in the finishing rooms, farrowing and nursery areas, or the breeding and gestation barns. Since a small amount of virus has

the potential to infect large quantities of feed, there was concern surrounding the feed delivery protocol that was in place when the outbreak first occurred. To mitigate this risk, the driver began bringing the truck to the perimeter barrier and transferring the feed to an intermediary truck that remained within the perimeter. This was done to minimize the risk of transmission from the farm to the feed mill and other off-farm areas.

Following the week 4 testing, the main office and shower/entrance areas were disinfected multiple times per day, and clearly visible transition zones or swing benches were placed in barns where they were not already present. The entrance protocol was modified to require clean gloves and boot covers to be worn from vehicles to the entrance bench, clean scrubs to be worn past the showers, and boots were required to stay in specific barns.

The laundry area was moved from an area adjacent to the showers to a section considered to be dirty at week 6. This was done to minimize contamination of the shower area from the laundry.

Figure 2: Main office layout of the Kansas State Swine Teaching Research Center. The main office is the primary entry point for foot traffic. Benches indicate the location of Danish benches that denote a clean-dirty line. The red circles indicate the sampling locations for transition zone surfaces in the main office building including laundry areas, change rooms and shower areas, and transition zones upon entering and exiting the building.



Discussion

The results of this study were evaluated by separating samples into those that had PEDV RNA detected by PCR and those that did not. This was done due to variation in equipment shapes, sizes, and surface types, which influences the quantity of virus in the samples and therefore, the Ct value. Because directly comparing Ct values between zones is confounded by the surface materials, results are reported as the percentage of positive samples collected from each zone.

All pig-contact surfaces had detectable PEDV RNA through week 12, after which there was a 25% reduction in the number of positive samples observed. However, a positive PCR result indicated the presence or absence of viral RNA and did not indicate whether the sample was from infectious or inactivated, noninfectious RNA. Therefore, these data alone do not indicate the success or failure of the disinfection procedures used.

While the feed mill remained negative for the duration of the outbreak, the virus was found in areas within the farm that were not initially observed to have detectable PEDV RNA, indicating that the initial changes to the biosecurity protocols were not successful in limiting viral spread within the facility. This led to further enhancements to the protocol, including requiring gloves and boot covers to be worn by all entrants from their vehicles to the farm entrance bench,

and instituting a captive boot system in which boots are used in and do not leave that specific barn. The farm was divided into 3 main areas (finishing, farrowing and nursery, and breeding and gestation) and employees working within those zones were prohibited from comingling throughout the day.

Farm entrants donned scrubs after passing through the entrance, put on clean coveralls over their scrubs prior to entering a barn, and then removed the coveralls and left them in a dirty laundry collection area prior to returning to the main office. Dirty laundry was transported in a biosecure manner to the laundry area when necessary. Boot covers were worn while walking between the main office and the barns and were changed prior to entering the main office through either transition zone.

Workers play a huge role in any facility's biosecurity, and employee compliance is essential for a successful biosecurity plan. Demonstrating tangible metrics surrounding the cleanup effort after a disease outbreak can serve as an informational and motivational tool for employees. After each timepoint within the data collection period, results were reported back to employees which allowed for problem areas to be identified and addressed. Sharing data with the employees also aided in developing solutions to recurring issues; for example, the laundry area for the facility

was originally located directly next to the showers. The suggestion of adding a laundry area within the dirty area of the facility at week 6 resulted in the elimination of positive results within the shower area at the next data collection timepoint. While some areas had continued PEDV RNA presence, there was a marked improvement in areas of high concern. Although there are no data to support this, the improvement is likely due to reduced viral shedding or improved employee practices. As the outbreak progressed, some previously negative areas became positive for PEDV RNA, which could be attributed in part to employee complacency. Without environmental data for these timepoints, there is no tangible way to measure or rectify the increase.

While this case shed important light on the use of biosecurity practices to prevent pathogen spread during an outbreak, it is important to note that several limitations exist. A more robust use of environmental monitoring would prove useful with a greater sample size, more refinement in sampling location, and a specific consideration of surface types. The learnings from this have led to the development of the K-State Feed Safety Sampling Resources at www.ksufeed.org, where there are standard operating procedures for how to prepare for sampling of viral pathogens, how to collect environmental samples, and how to

Table 1: Percent PEDV-positive results by PCR in different farm locations across data collection timepoints

Zone, % positive (No. positive/Total No. samples)	Weeks after initial diagnosis					
	2	4	6	8	12	16
Vehicles/outside perimeter*	44 (4/9)	13 (1/8)	0 (0/1)	25 (1/4)	0 (0/2)	0 (0/3)
Transition zones†	81 (13/16)	21 (3/14)	29 (4/14)	44 (4/9)	0 (0/6)	0 (0/7)
Non-pig contact outside‡	66 (4/6)	50 (2/4)	25 (1/4)	NS	0 (0/4)	0 (0/5)
Non-pig contact inside§	100 (12/12)	80 (4/5)	88 (8/9)	75 (3/4)	100 (4/4)	80 (4/5)
Pig contact¶	NS	100 (2/2)	100 (2/2)	100 (4/4)	100 (4/4)	75 (3/4)

* Included on- and off-farm vehicles, feed delivery trucks, tractors, employee vehicles, and areas outside the farm perimeter.

† Included laundry areas, changing rooms, shower areas, and transition zones upon entering or exiting the main office building.

‡ Outside surfaces such as walkways and work areas not in direct contact with pigs.

§ Inside surfaces such as walkways, work areas, feed storage areas, and in-barn transition zones not in direct contact with pigs.

¶ Included pen flooring, pen walls, feeders, and waterers.

PEDV = porcine epidemic diarrhea virus; PCR = polymerase chain reaction; NS = not sampled.

calculate the necessary number of samples based on the severity of the pathogen of interest and the probability of the pathogen being introduced through feed. While this project would have benefited from these materials being available, it was the project itself that led to their development.

In closing, environmental monitoring was an important tool in managing this disease outbreak. In this circumstance, results from environmental monitoring swabs allowed for the real-time adaptation of biosecurity practices to address the greatest areas of risk. There are several considerations when selecting sampling locations and frequency, but consistent environmental monitoring during an outbreak allows for dynamic decisions to minimize disease spread.

Implications

Under the conditions of this study:

- Environmental monitoring was an important tool in managing this disease outbreak.
- Environmental monitoring identified areas in the farm with poor biosecurity.
- Biosecurity adjustments made resulted in fewer contaminated surfaces.

Acknowledgments

Conflict of interest

None reported.

Disclaimer

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Maximizing value and minimizing waste in swine research: Availability and accessibility of research reports

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Summary

To be useful for decision-making, research results need to be available. This means that full reports (methods and results) for trials need to be published, preferably in a journal. However, there is evidence that only a small proportion of swine trials presented at conferences are subsequently published in journals. This is problematic, as results may differ between a conference presentation and journal publication. Published results also need to be accessible, either through open-access or traditional journals or through other sources that do not violate copyright agreements. Researchers should strive to make full research reports widely available.

Keywords: swine, clinical trials, availability, accessibility, publication bias

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Resumen - Maximizar el valor y minimizar el desperdicio en la investigación porcina: disponibilidad y accesibilidad de los informes de investigación

Para que sean útiles para la toma de decisiones, los resultados de la investigación deben estar disponibles. Esto significa que los informes completos (métodos y resultados) de los ensayos deben publicarse, preferiblemente en una revista. Sin embargo, existe evidencia de que solo una pequeña proporción de los ensayos con cerdos presentados en conferencias se publican posteriormente en revistas. Esto es problemático, ya que los resultados pueden diferir entre una presentación en una conferencia y una publicación en una revista. Los resultados publicados también deben ser accesibles, ya sea a través de revistas tradicionales o de acceso abierto a través de otras fuentes que no violen los acuerdos de derechos de autor. Los investigadores deben esforzarse para que los informes de investigación completos estén ampliamente disponibles.

Résumé - Maximisation de la valeur et diminution des pertes en recherche porcine: disponibilité et accessibilité des rapports de recherche

Afin d'être utile lors de décisions à prendre, les résultats de recherche se doivent d'être disponibles. Ceci signifie que des rapports complets (méthodes et résultats) pour des essais se doivent d'être publiés, de préférence dans une revue. Toutefois, il y a des évidences que seulement un petit pourcentage des essais chez les porcs présentés lors de conférences sont par la suite publiés dans une revue. Ceci est problématique car les résultats peuvent varier entre une présentation lors d'une conférence et la publication de la revue. Les résultats publiés doivent également être accessibles, soit via les revues en libre accès ou traditionnelles ou d'autres sources qui ne compromettent pas les droits d'auteur. Les chercheurs devraient essayer de rendre les rapports de recherche complets largement disponibles.

Research is the cornerstone of evidence-based decision-making. Clinical trials are an essential part of the research process; trials provide the highest evidentiary value of primary research studies for addressing intervention questions where it is feasible and ethical to allocate animals to intervention groups.¹ However, information

is only valuable if it is available. There is empirical evidence in human health-care that inaccessible research is impacting its value and leading to research wastage.² As an example, only half of the human health studies funded in the European Union between 1998 and 2006 resulted in identifiable research reports.³ Is availability a concern for

swine veterinarians and researchers? If so, what can we do to improve research availability, and therefore increase the value of swine trial research? This article will explore two aspects of this issue: publication of results and access to research reports. Although we will focus on clinical trials, this discussion has applicability to other study designs.

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Publication of trial results

The utility of research results to end users, including veterinarians, producers, and other researchers, requires the methods and results of the research to be available. A 2011 survey of 2137 veterinarians found that journals were the most common source of information for both clinicians (65.8%) and nonclinicians (75.6%).⁴ Several studies have evaluated the proportion of livestock research presented at conferences that is subsequently published as a journal article with publication rates ranging from 7.1% to 45.0%.⁵⁻⁷ Specific to swine research, Brace et al⁵ reported that only 5.6% (5 of 89) swine vaccine trials presented at the American Association of Swine Veterinarians (AASV) Annual Meeting between 1988 and 2003 were subsequently published as journal articles.

Presentation of research at conferences is important, as this provides a means of early dissemination of results, and as a forum to obtain input on findings and generate awareness. However, failure to subsequently publish full research results is problematic; in many instances, conference proceedings are restricted in length such that key details required to critically appraise the methodological rigor of the study are not provided. The results presented at conferences may represent preliminary, rather than final, results.

There is also empirical evidence that results may differ between conference proceedings and the subsequent journal article. This includes a tendency for trials with beneficial treatment effects to be published more often and more quickly than studies not showing beneficial treatment effects.⁸ In an evaluation of food safety trials in livestock species, trials with at least one positive outcome (ie, intervention benefit) were more likely to be published.⁶ Specific to swine, Brace et al⁵ found that 64% (57 of 89) of swine vaccine trials in conference proceedings reported that the vaccine was efficacious, compared to 80% (4 of 5) of trials reported in journal articles. Due to the low publication level, it was not possible to conclude that these percentages differ.

There is also evidence that, for the same study, details of the study differ between what is reported in a conference proceeding and what is reported in the subsequent journal article. Although there is no empirical evidence specific to swine, several studies in the broader

veterinary literature have compared the methods and results of studies as reported in a conference proceeding to the journal article for the same study. In an evaluation of over 700 studies originally presented at the American College of Veterinary Surgeons Annual Meeting, and subsequently published as journal articles, the study outcome measures changed for 10% of the studies, including omission and addition of outcome measures.⁹ The study design changed between the conference abstract and the journal article for 6% of studies, most frequently because of the addition or omission of a control or experimental group. In some cases, the study results changed because of sample size. However, the study results also changed for 12% of studies when there was no change in sample size, intervention, outcome, or study design between the conference abstract and the journal article.⁹ In a study of 59 preharvest food safety trials which were subsequently published as journal articles, of the 231 outcome measures reported in both the proceedings and the article, different results were reported for 77 (33.3%), with 32 outcomes having a different direction of effect reported in the journal article.¹⁰ The overall conclusion on the efficacy of the intervention changed between the conference abstract and the journal publication for 10.7% of the trials. In a comparison of 384 studies reported at veterinary anesthesia conferences and subsequently published as journal articles, the overall conclusion as to whether the primary outcome was significant changed in 29 (7.6%) studies.¹¹

There are several reasons why a study presented at a conference would not be subsequently published as a journal article. Not all manuscripts that are submitted to a peer-review journal are accepted; veterinary journals have a mean of 47% acceptance for articles submitted, with a mean of only 3% acceptance without the need for revisions.¹² Thus, submission is not a guarantee of publication and authors need to be willing to commit time and effort to advance a manuscript to publication even after a manuscript has been submitted.

The most common reason for rejection of manuscripts submitted to human medical journals was problems with the study design, with the methods section containing the most flaws.¹³ Thus, it seems probable that at least some studies presented at conferences may lack the scientific rigor necessary for

publication. Most scientific journals have a peer-review process in place to evaluate the methodological rigor of articles that are submitted. In this process, two or more individuals with expertise in the area evaluate the manuscript and provide comments, which the author can then use to modify the manuscript prior to acceptance by the journal. In some instances, peer reviewers may recommend that the manuscript be rejected due to major flaws. However, conference abstracts are not evaluated with the same rigor. Abstracts submitted for conferences may be evaluated based on fit with the conference themes as well as quality, and there is not a forum for back and forth between reviewers and authors for clarifications or modifications. Also, conference abstracts often have word count limits which preclude the comprehensive reporting of study methods that would be necessary for an evaluation of study validity.

Nonetheless, the main reason for studies not being published is that authors do not submit their research for publication.^{14,15} The most common reason for not submitting their research is lack of time.^{14,15} In a review of 6 studies on nonpublication, fear of rejection was a more common reason for nonpublication than journal rejection.¹⁴ Authors may also be hesitant to submit the results of trials where the results were not statistically significant.^{14,15} Not submitting study results for publication is problematic because it may lead to unnecessary duplication of efforts, waste limited resources, and potentially result in a loss of trust in the integrity of research conducted. Additionally, there are ethical concerns related to not publishing trial results. Sir Iain Chalmers, a champion of research quality who is one of the founders of the Cochrane Collaboration and a coordinator of the James Lind Initiative, has stated that not publishing research is scientific misconduct.¹⁶ In clinical trials, animals are allocated to treatment groups by the investigator. This means that some animals may receive an inferior treatment. This is justified on the assumption that the findings increase our knowledge; an assumption that is not met if the full results of a trial are not publicly available. In two recent systematic reviews evaluating the efficacy of preventive antibiotics to reduce respiratory disease in swine¹⁷ and vaccines targeted to bacterial respiratory pathogens,¹⁸ there were 105 (of 182) trials reported only in conference proceedings.

An issue related to publication of swine trials, and potentially other livestock and poultry industries, is the issue of private research. Although not explicitly documented, considerable research is undertaken by pharmaceutical companies on private farms or within large production systems, where the results deliberately are not published for proprietary reasons or because the results are intended to provide a competitive advantage to those conducting the research. This is a concept that does not really have an equivalent in human medicine, where clinical trials generally are conducted for the public good. In swine, the argument that publication is for the public good may hold true for research involving zoonotic diseases but is less obvious for research on production-limiting diseases and productivity. The argument also has been made that research funded with public monies should be published regardless of results, but again, this is not the case for in-house research. So, the dilemma is whether research results should be made available for the good of the industry or whether it is justified to not publish for competitive advantage. The answer is not in the scope of this article but may be an issue that swine veterinarians and the research community should consider.

Thus, some key messages are apparent related to publication of research. First, the empirical evidence illustrates that a substantive proportion of trials conducted in swine populations are not subsequently published in journals, and that there may be differences between trial results in conference proceedings compared to subsequent journal publications. This highlights the importance of submitting research results for publication. The evidence also provides important caveats for using trial results presented in conference proceedings. Publication is time consuming for researchers; however, without public dissemination of final results and a full presentation of the methodology, it is not possible to build a scientifically defensible body of knowledge to make evidence-based clinical decisions.

Access to research reports

Access to research reports is pertinent to two groups: researchers need to ensure that their work is accessible to those who need the information for clinical decision-making, and readers of research need to know how to access the results to make evidence-based decisions. There

are several aspects of access, including knowing how to effectively search for publications, language of publication, and whether the research report (conference proceeding, industry report, or journal article) is freely available online or available via a charge or subscription.

Large volumes of articles are published every year, and it can be a challenge to find all the literature on a specific subject. There are tools available to help with searching the literature, including online databases which catalogue citations of research reports from journals (and other sources to some extent). However, not all articles are available through each database, and not all databases are freely available online. Therefore, searching for the literature can be complex. Grindlay et al¹⁹ evaluated the journal coverage of databases in veterinary literature and found that CAB abstracts (<http://www.cabdirect.org>) provide the highest coverage. Once databases have been identified, searches consist of identifying key words or phrases related to the topic of interest and combining those words in a search string using “AND”, “OR”, or “NOT” operators. Guidelines for searching the veterinary literature are available^{20,21} and certainly can be applied by academic researchers and those with access to a wide range of journals. However, searching and finding publications can be challenging for those without extensive journal access. It has been reported that approximately half of North American swine veterinarians interested in infectious disease research have access to 2 or fewer journals.²²

Some research may not be available to end users because of the language in which the report was written; this may be because English-speaking individuals cannot read non-English publications or because non-English-speaking individuals cannot read English publications. However, English is recognized as the *lingua franca* of scientific publications. This is the case even for non-English speaking scientists; based on the results presented in 4 recent systematic reviews of trials addressing swine health topics, a substantial proportion of the trials were conducted in non-English speaking countries but published in English (7 of 20 trials in a review of preventive antibiotics for respiratory disease¹⁷; 27 of 142 trials in a review of bacterial vaccines to prevent respiratory disease¹⁸; 16 of 34 trials in a review of antibiotics to treat respiratory disease²³; and 23 of 44 trials in a review

on vaccines to prevent *Salmonella*²⁴). However, language of publication still may be a barrier. Based on the reasons for full text exclusions from 4 systematic reviews, the number of trials excluded because of the language of publication was 0 of 190 full texts evaluated,¹⁷ 41 of 536 full texts evaluated,¹⁸ 8 of 90 full texts examined,²³ and 54 of 126 full texts examined.²⁴

Another issue is whether research reports can be found. Notwithstanding the caveats for using conference proceedings for decision-making, they still may provide useful information on what is being researched. To explore the availability of conference proceedings, we used 2 recent systematic reviews which evaluated the efficacy of preventive antibiotics to reduce respiratory disease in swine¹⁷ and vaccines targeted to bacterial respiratory pathogens.¹⁸ Of the 182 articles included in those reviews, 105 were published in conference proceedings. As the eligibility criteria for these reviews would preferentially include a journal article over a conference proceeding, it is assumed that these represent studies reported only at a conference venue. There were 7 organizations represented: AASV Annual Meeting, Asian Pig Veterinary Society Congress, International Pig Veterinary Society Congress, International Society for Veterinary Epidemiology and Economics, International Symposium on Emerging and Re-emerging Pig Diseases, European Symposium of Porcine Health Management, and World Association of Veterinary Laboratory Diagnosticians and OIE Seminar on Biotechnology. Of these 7 organizations, it was only possible to access the conference proceedings for 4 organizations, with 2 unavailable online and 1 being password protected and available to members only. These results represent conference proceedings availability for only 2 topic areas and may not represent the availability of swine conference proceedings in general. Nonetheless, these results illustrate that some, but not all, conference proceedings can be freely accessed via the internet.

Journal articles are an important source of information for veterinarians and researchers,⁴ although not all journals are freely accessible. When an article is published in a journal, it is common for the researcher(s) to transfer their copyright to the publisher, who controls further access. There are several access options: publishers may require a subscription to access the journal or a singular article,

the journal may be open access and thus full-text articles are freely available to all, or the journal may be a hybrid where researchers can pay a fee to have their article made open access.

A study of veterinary research articles published between 2000 and 2014 found that over half (62%) of the articles were freely available.²⁵ Specifically for swine and based on trials included the systematic reviews as described previously,^{17,18} we evaluated the accessibility of these published trials. There were 77 articles published in 35 journals included in the 2 reviews. Of the 35 journals, 16 were fully open access, 9 were hybrid, 4 were available to association members, and 6 were no longer active journals. Open access provides a way for potential users of research to have access to the full study results. However, it is not always without cost; the publication fees, as billed to the article authors, for the open access and hybrid journals identified in the two systematic reviews ranged from \$0 to \$4200 per article, with a median cost of \$1935.

There are other ways researchers can make their work freely available. These tend to include preprints (the researcher's own write-up of results and analysis that has not been peer reviewed, nor had any other "value added" by a publisher) posted on faculty or departmental websites, government websites,²⁵ or profiles on sites such as ImpactStory or ORCID. Institutional or subject-based digital repositories are of growing importance in the research community, especially as government mandated open access policies such as those put forth by the Tri-Agency (Canada) and UKRI (United Kingdom) are introduced and begin to be implemented. These sites, which tend to be maintained by research centers or academic libraries, provide permanent and stable access to various types of research outputs including articles, theses, dissertations, data, diagrams, posters, and other items.²⁶ Outputs are assigned appropriate metadata (researcher name[s], title, abstract, keywords, and copyright or licensing information) as well as a digital object identifier (DOI) or permalink ensuring perpetual access at the same digital location. Institutional repositories (IRs) tend to be set up in hierarchical structures. For instance, the University of Guelph IR ("the Atrium"; <https://atrium.lib.uoguelph.ca/>) has collections within existing faculties (eg, Ontario Veterinary College), and departments (eg, Department of Population Medicine), and then within topic areas

(eg, theses and dissertations, systematic review protocols, and study protocols for research involving animals). Some repositories also house collections for outputs related to conferences, projects, research units, or researchers.

While there are many advantages to using an institutional or subject-based repository, such as they are free to use, often maintained by staff with preservation expertise, equipped with functionality that reveals basic or advanced usage metrics, and facilitate wider impact, they tend not to have the same popularity as tools such as ResearchGate or Academia.edu.^{27,28} These sites are social networking tools for academics, with some of the same problematic approaches to user privacy and data monetization as their nonacademic counterparts.^{29,30} Since much of the perceived value of these sites is discoverability, it has become a focal point for copyright violations, with many researchers uploading the published versions of their research to the site in an infringement of copyright.^{31,32} To avoid such infringement, researchers should be seeking to self-archive an appropriate version of their published research in a repository. Such action is often permitted by journal publishers, so long as particular conditions are met: usually only preprints (the version of the article submitted to the journal prior to being peer-reviewed) and postprints (the version of the article that has been through peer-review, has been accepted for publication, but lacks "value-added" services of the publisher such as formatting) can be archived, though there may be a particular length of time that must pass before the researcher can do so. Digital repositories can easily accommodate these embargoes, putting in place a "dark deposit," whereby the full text is not openly available until a predetermined date.³³ The metadata associated with the work is still public, allowing the record to remain discoverable both through the repository as well as aggregated search tools such as Digital Commons Network (<https://network.bepress.com/>) and Google Scholar.

Another interesting situation related to access to research is for emergency situations, where it is imperative that research results be made available quickly for rapid decision-making, even if the results are not final or there is not time to complete a highly polished manuscript as one would expect for peer-review. An example of this was the recent emergence of porcine epidemic

diarrhea (PED), where funding organizations, such as the National Pork Board, publicly promoted titles of funded projects to increase awareness of pending research helping to identify remaining knowledge gaps and avoid unnecessary duplication of studies (see <https://www.nationalhogfarmer.com/health/pork-board-funds-eight-ped-virus-projects>). Their requirement for updates on the results of research they had funded meant they could make these reports freely available to help producers to quickly use knowledge gained to deal with the crisis. Journals can assist in this situation by being flexible with allowing subsequent publication of full research results, even when early results have been made publicly available.

These examples serve to illustrate not only the magnitude of the accessibility issue in swine research, using clinical trials as an example, but also the serious consequences of not making research available. The onus is largely on researchers to ensure that they complete research using animals and submit full reports of that research to journals. Although paying for open access may not be an option for all researchers, there are increasingly other ways that researchers can ensure that knowledge users can access their findings. Researchers who wish their work to be used for clinical decision-making should take advantage of emerging options for wider accessibility of their research results.

Proposed solutions to increase research availability and accessibility

To provide utility to the swine industry, research must be available and accessible. Researchers employed in academia have received advanced training in research methodologies and are incentivized to publish research. However, this may not be the case for those employed in other types of organizations; publication takes time and may therefore be a low priority. One possible solution to increase publication would be to increase collaborative opportunities between academics and others in the design, conduct, and dissemination of research. There is a role for academia in teaching not only graduate students but student veterinarians on the appropriate conduct of research and critical appraisal. Incentives to publish also may come from

the consumers of research; as evidence-based medicine continues to evolve, veterinarians and practitioners may expect a higher standard for research availability. Funding agencies could assist by linking funding to publication of results or, if publication is not possible, posting of full methods and results of their research on a publicly accessible site. Organizations involved in research should promote open-access publication and researchers should include possible open-access fees into grant applications. While being aware of copyright obligations, researchers should take advantage of new options for publicly disseminating research articles free of charge. Improving availability and access to research will benefit the entire swine industry and help to maximize the value of the research investment.

Implications

- Accessible swine research results may positively impact the swine industry.
- Results must be available to avoid waste and understand intervention efficacy.
- Opportunities exist to enhance research availability and benefit the swine industry.

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Conflict of interest

None reported.

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*Non-refereed references.



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

$$^{\circ}\text{F} = (^{\circ}\text{C} \times 9/5) + 32$$

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times 5/9$$

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

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

1 tonne = 1000 kg
1 ppm = 0.0001% = 1 mg/kg = 1 g/tonne
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National Pork Board elects new 2022-2023 officers

Indiana pork producer Heather Hill was elected to serve as president of the National Pork Board (NPB) for the 2022-2023 term. The NPB's 15-producer directors represent the 60,000 US pig farmers who pay into the Pork Checkoff - a program funding research, promotion, and education efforts for the benefit of the whole industry.

"Real Pork is about real farmers leading efforts to ensure the public understands our product is real nutritious and real sustainable," explains Hill, who co-owns a 600-sow farrow-to-finish operation in Indiana with her husband and his parents. Hill's family also grows corn, soybeans, and wheat. "Along with my fellow volunteer leaders on the Board of Directors, we will deliver real results to help protect producer freedom to operate and promote continuity of business should a foreign animal disease, like African swine fever, challenge the US herd."

The board allocates Checkoff funds to address producer priorities, outlined in the producer-led annual planning process, to build trust and add value for US pork and pork products.

In addition to Hill, other members of the 2022-2023 officer team include, Vice President Bob Ruth, from Harrisburg, Pennsylvania. "I just believe we have a lot of great momentum in the organization right now and so much potential for



the future," says Ruth. "The best of our work as board is just beginning and I am excited to have the opportunity to be a part of it."

Al Wulfekuhle from Quasqueton, Iowa, will serve as treasurer. "I really like the direction this board is headed in. We have a good group of talented, passionate people who want to make a difference," Wulfekuhle explains. "I am looking forward to being in leadership and working more closely with staff to use Pork Checkoff dollars for the maximum effect for the industry."

And, Gene Noem from Ames, Iowa, will serve as past president in an ex-officio status. "Give back to the industry; we need to be relevant now, but with the long view in mind," advises Noem. "I have come to realize it is not just an honor, it is also the enormity of the responsibility we have to make sure funding is spent in a way that the majority of investors would say 'that was a good move.'"

For more information, go to porkcheckoff.org.





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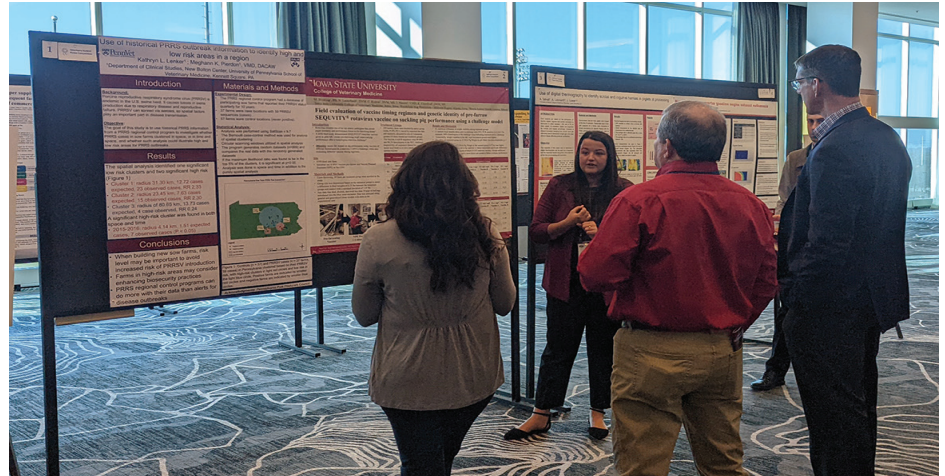
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AASV student abstracts due September 14

The American Association of Swine Veterinarians announces an opportunity for veterinary students to make a scientific presentation at the AASV Annual Meeting in Aurora (Denver), Colorado on Sunday, March 5, 2023. Interested students are invited to submit a one-page abstract of a research paper, clinical case study, or literature review for consideration. The submitting student must be a current (2022-2023) student member of the AASV at the time of submission and must not have graduated from veterinary school prior to March 5, 2023. Submissions are limited to 1 abstract per student.

Abstracts and supporting information must be submitted online at cmt3.research.microsoft.com/AASV2023. Submissions must be completed before **11:59 PM Central Daylight Time on Wednesday, September 14, 2022** (firm deadline). Late submissions will not be considered. Students will receive an email confirmation of their submission. If they do not receive the confirmation email, they must contact Dr Andrew Bowman (bowman.214@osu.edu) by Friday, September 16, 2022 with supporting evidence that the submission was made in time; otherwise the abstract will not be considered for judging.

The abstracts will be reviewed by an unbiased, professional panel consisting of private practitioners, academicians, and industry veterinarians. Fifteen abstracts will be selected for oral presentation in the Student Seminar at the AASV Annual Meeting. Students will be notified of the review results by October 15, 2022, and those selected to participate will be expected to provide the complete paper or abstract, reformatted for publication in the conference proceedings, by November 15, 2022.



Student Seminar

The **Zoetis Foundation** has provided a grant for a total of \$20,000 for awards and the top student presenter scholarship. The grant will go towards a \$750 award for the student presenter of each paper selected for oral presentation when they present at the meeting. These students also compete for one of several scholarships awarded through the AASV Foundation. The oral presentations will be judged to determine the amount of the scholarship awarded. As part of the Zoetis Foundation grant, the AASV Foundation will award a \$5000 scholarship for the student whose paper, oral presentation, and supporting information are judged best overall.

Elanco Animal Health provides \$20,000 in additional funding, enabling the AASV Foundation to award scholarships of \$2500 each for 2nd through 5th place, \$1500 each for 6th through 10th place, and \$500 each for 11th through 15th place.

Student Poster Session

Abstracts that are not selected for oral presentation in the Student Seminar will be considered for presentation in a poster session at the Annual Meeting. The **Zoetis Foundation** grant, combined with direct support from AASV, will provide each student poster presenter

at the meeting with a \$250 award. Students selected to make a poster presentation will be expected to supply a brief paper, formatted for publication in the conference proceedings, by November 15. The guidelines for preparing posters for the display are available at aasv.org/annmtg/2023/posters.php.

Veterinary Student Poster Competition

The presenters of the top fifteen poster abstracts compete for scholarship awards ranging from \$200 to \$500 in the Veterinary Student Poster Competition, sponsored by **United Animal Health**. See aasv.org/annmtg/2023/postercomp for poster judging details.

In all cases, the student presenter is required to attend the meeting in person to make the presentation. Recorded/virtual presentations will not be accepted unless the meeting converts to an entirely virtual event.

Complete information for preparing and submitting abstracts is available at aasv.org/annmtg/2023/studentseminar. The rules for submission should be followed carefully. For more information, contact the AASV office by phone, 515-465-5255, or email, aasv@aasv.org.

AASV news continued on page 325



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Call for submissions - Industrial Partners

The American Association of Swine Veterinarians is making plans for the 2023 AASV Annual Meeting, to be held March 4-7, 2023 in Aurora (Denver), Colorado.

The AASV invites submissions for the Industrial Partners oral and poster sessions at the 54th AASV Annual Meeting. This is an opportunity for commercial companies to make brief presentations of a technical, educational nature to members of the AASV.

The oral sessions consist of a series of 15-minute presentations scheduled from 1:00 to 5:00 PM on Sunday, March 5. A poster session takes place the same day. Poster authors will be required to be stationed with their poster from noon until 1:00 PM, and the posters will remain on display throughout the afternoon and the following day for viewing.

SUBMISSION PREREQUISITE: All companies submitting topics for presentation during the Industrial Partners sessions must register to participate in the AASV Technical Tables Exhibit before September 30.

SUBMISSION LIMIT: Restricted program space necessitates a limit on the number of presentations per company. Companies that are a member of the *Journal of Swine Health and Production* Industry Support Council **and** sponsor the AASV e-Letter may submit 3 topics for oral presentation. Companies that are **either** a member of the JSHAP Industry Support Council **or** sponsor the AASV e-Letter may submit up to 2 topics. All other companies may submit 1 topic for oral presentation. In addition, every company may submit 1 topic for poster presentation, but the topic must not duplicate the oral presentation. All topics must represent information not previously presented at the AASV Annual Meeting or published in the meeting proceedings.

SUBMISSION REQUIREMENTS:

To participate, send the following information to aasv@aasv.org by **September 30, 2022:**

- 1) Company name
- 2) Presentation title
- 3) Brief description of the presentation content

4) Presenter name (one only) and contact details (mailing address, telephone number, and email address)

5) Whether the submission is intended for oral or poster presentation

Receipt of submissions will be confirmed by email. Presenters will be notified of their acceptance by October 15 and must submit a paper by November 15 for publication in the meeting proceedings. Failure to submit the paper in a timely manner will jeopardize the company's future participation in these sessions.

The presenting author is required to register for and attend the meeting in person to make the presentation. Recorded/virtual presentations will not be accepted unless the meeting converts to an entirely virtual event.

Presenters may register for the meeting either as a Tech Table representative, or as an individual registrant (nonmember oral and poster presenters are eligible to register at the AASV regular member rate). The AASV does not provide a speaking stipend or travel reimbursement to Industrial Partners presenters.

Who you gonna nominate? (for an AASV award)

Do you know an AASV member whose dedication to the association and the swine industry is worthy of recognition? A practitioner who goes above and beyond in providing service to clients? A young swine vet who is already leading the way? An academic whose teaching and research is making a difference? Now is the time to speak up! The AASV Awards Committee requests nominations for six awards to be presented at the 54th AASV Annual Meeting.

See aasv.org/aasv/awards for a list of previous recipients of the following awards and submit your nomination(s) now for 2023.

Howard Dunne Memorial Award – Given annually to an AASV member who has made a significant contribution and rendered outstanding service to the AASV and the swine industry.

Meritorious Service Award – Given annually to an individual who has consistently given time and effort to the association in the area of service to AASV members, officers, and staff.

Swine Practitioner of the Year – Given annually to the swine practitioner (AASV member) who has demonstrated an unusual degree of proficiency in the delivery of veterinary service to his or her clients.

Technical Services/Allied Industry Veterinarian of the Year – Given annually to the technical services or allied industry veterinarian who has demonstrated an unusual degree of proficiency and effectiveness in the delivery of veterinary service to his or her company and its clients as well as given tirelessly in service to the AASV and the swine industry.

Outstanding Swine Academic of the Year – Given annually 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.

Young Swine Veterinarian of the Year – Given annually to a swine veterinarian who is an AASV member, 5 years or less post graduation, who has demonstrated the ideals of exemplary service and proficiency early in their career.

Nominations are due December 15.

The nomination letter should specify the award and cite the qualifications of the candidate for the award. Submit to AASV by mail, 830 26th Street, Perry, Iowa 50220, or by email, aasv@aasv.org.



AASV publishes Animal Depopulation Resiliency Debriefing Tool

The American Association of Swine Veterinarians received funding from the US Department of Agriculture Animal and Plant Health Inspection Service through their National Animal Disease Preparedness and Response Program in 2021 to develop resources to build and improve capabilities and capacities for responding to emergency events that require animal depopulation. Those resources are available at aasv.org/Resources/welfare/.

Animal depopulation is associated with distressing psychological impacts on people. These impacts can affect all stakeholders including veterinarians, producers, public health officials, and others who make decisions about and carry out depopulation. As part of this project, AASV collaborated with Dr Elizabeth Strand, clinical associate professor and director of Veterinary Social

Work at University of Tennessee Colleges of Veterinary Medicine and Social Work, to develop an Animal Depopulation Resiliency Debrief Tool (ADRDT). Questions used in the ADRDT have been developed as a debrief in a veterinary clinical setting over the last 20 years through the University of Tennessee Veterinary Social Work Program, and the ADRDT has been adapted specifically for animal depopulation.

The goals of using the ADRDT are to:

- reduce psychological distress that may result from depopulation,
- promote social support and coping among those engaged in the process, and
- identify individuals who may need further mental health support and refer them for the appropriate level of care.

The five-item resiliency debrief tool can be used by veterinarians and other animal-related professionals who are preparing for, participating in, and recovering from depopulation. This tool is not species specific and can be used in any animal depopulation event by an individual or with a team.

The ADRDT is available in two formats: 1) a long form with background on how to use the tool and rationale for each of the 5 questions, available at aasv.org/Resources/welfare/depopulation_debrief.pdf and 2) an abbreviated worksheet version available at aasv.org/Resources/welfare/depopulation_debriefwksht.pdf. Both are available on the AASV veterinarian wellbeing and animal welfare webpages.



54th AASV Annual Meeting

March 4-7, 2023

Aurora, Colorado

Be There!

**Gaylord Rockies Resort
& Convention Center**

aasv.org/annmtg/lodging.php

Latest information: aasv.org/annmtg





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www.aphis.usda.gov/ProtectOurPigs



Benjamin achieves board certification in animal welfare

Dr Madonna Benjamin recently achieved board certification in the American College of Animal Welfare (ACAW). Dr Benjamin was one of the first recipients of the ACAW Scholarship Program funded by the AASV Foundation. The scholarship was established in 2018 to encourage swine veterinarians to undertake the challenge of board certification in animal welfare.

Dr Benjamin is Associate Professor, Swine Extension Veterinarian in the Department of Large Animal Clinical Sciences at Michigan State University (MSU), where her clinical activities include serving as a swine health extension veterinarian with the MSU Extension team. In her research and extension role, she contributes to swine welfare through training first responders on identification of compromised livestock resulting from accidents during transport, low-stress handling, digital imaging for body composition and locomotion scores, and using simulator pigs for training on effective, safe, and humane methods of swine euthanasia. Dr Benjamin's research interests include human-animal interaction, the use of systematic observation techniques to identify compromised animals within a population, and factor determinants of timely euthanasia.

Dr Benjamin received her DVM from the University of Guelph ('95) and a master's degree in applied ethology from MSU ('98). She was employed by Elanco Animal Health in research and technical support, with early research that included cause and effect of nonambulatory pigs during transport. Dr Benjamin established Veterinary Science Consulting Inc in Alberta, Canada, a swine practice with an "overarching goal to improve the well-being and prosperity of both livestock (pigs) and producers," before returning to join the faculty at MSU.

Please join us in congratulating Dr Benjamin on her accomplishment.

The AASV Foundation Board of Directors continues to accept applications from AASV members seeking ACAW board certification. Applicants must have a DVM or VMD degree and at least 5 years of continuous membership in the AASV.

To apply, the applicant must submit a curriculum vitae, an ACAW-approved program plan, and 3 letters of reference (one of which must come from the applicant's mentor). There is no submission due date, but there is a limit to the amount of funding available each year. A selection committee reviews applications as they are received.



The scholarship will provide annual reimbursements for actual expenses related to the ACAW program, including travel, course fees, and textbooks, with a maximum reimbursement amount of \$20,000. Reimbursement will not cover lost income. An incentive payment of \$10,000 will be issued upon successful and timely completion of the ACAW board certification.

For more information about the ACAW Scholarship program, or to apply, see aasv.org/foundation/ACAW_Scholarship.php.

Students: Swine externships, grant funds available

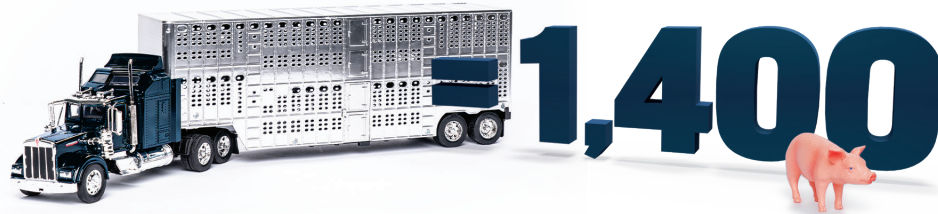
Veterinary students, would you like to obtain experience in swine practice? The AASV Foundation can help! Students who complete an externship of at least 2 weeks in a qualifying practice can receive up to \$500 in expense reimbursement. Access complete details and the application at aasv.org/students/externgrant.

To help locate the perfect opportunity, check out the roster of practices and companies willing to mentor students at aasv.org/internships/index.php.

AASV members, does your veterinary practice host students? Please contact AASV's Alternate Student Delegate Hunter Everett (studentdelegate@aasv.org)

to have your internship and externship opportunities included in AASV's online listing. Make sure students who visit your practice are aware of the opportunity to join AASV and apply for the grant!





200 mg = 1,109 

2 x 200 mg = 427 

x (-\$2.77) = ? 

Optimal*



≥ 110 g/L

Deficient*



<90 g/L

Q:

A truck holds an average of 1,400 baby pigs. If given a single 200 mg dose of iron 1,109 baby pigs will be subject to iron deficiency anemia. If given a second 200 mg dose, only 427 baby pigs will be subject to iron deficiency anemia, which is an increase of 682 optimal-iron baby pigs. If baby pigs subject to iron deficiency anemia bring \$2.77 less at market per head,^{1,2,3} how much money is a pork producer leaving on the table with every truckload if they don't use a second dose of Uniferon®?

A: \$1,889

Change the math by adding a second dose of Uniferon®.

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.

2: Fredericks L et al. Evaluation of the impact of iron dosage on post-weaning weight gain, and mortality. AASV. 2018;315.

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)

Student membership: A real bang for a buck

The AASV has long been praised for its support of students. In fact, part of AASV's mission is to mentor students, encouraging life-long careers as swine veterinarians. Many members have reaped the benefits during their time as students, and others were integral in developing the programs that have ensured student support, success, and commitment to the swine industry upon graduation.

Today, \$15 does not seem to go very far. Unless you consider the \$15 veterinary students spend to become student members of the AASV. It may be the best bang for \$15 a student can spend.

Communications and connections

Student members receive a subscription to the *Journal of Swine Health and Production*. For some, this may be their very first issue. They receive the weekly AASV e-Letter, which provides current news of interest to swine veterinarians, including current research abstracts,



industry news, position announcements, and AASV information. Students are also able to view and participate in swine case discussions on the AASV-L email list.

The AASV membership directory is available to all members, including students, and contains the most current contact information for AASV members. It can be helpful in making connections to establish mentorship relationships, arrange swine preceptorships, or secure job opportunities.

Educational resources

Student members can use the online Swine Information Library to search swine conference proceedings and JSHAP - more than 16,000 fully searchable papers on every swine topic imaginable. Also included in the Swine Information Library is the online version of the fifth edition of the *Swine Disease Manual*, published in 2020.

Students can review facilities, pathologies, disease presentations, and more in the AASV photo library and listen to discussions in the podcast library. They can view past webinars, AASV Annual Meeting sessions, and the AASV Early Career Conference in the AASV video library.

Day-1 Competencies for Swine-interested Veterinary Graduates, a checklist prepared with funding assistance from the AASV Foundation, describes the basic, intermediate, and advanced knowledge and skills expected of a graduate veterinarian entering swine practice.

Financial support

The AASV Foundation-Merck Veterinary Student Scholarship program seeks to identify and assist future swine veterinarians with their educational expenses. Second- and third-year students enrolled in AVMA-accredited or -recognized colleges of veterinary medicine in the United States, Canada, Mexico, South America, and the Caribbean Islands are eligible to apply for one of the \$5000 scholarships.

The AASV Foundation provides grants of up to \$500 to veterinary students who complete a two-week or longer externship in an AASV-member swine practice.

More scholarship opportunities are available in conjunction with the AASV Annual Meeting.

AASV Annual Meeting

The AASV encourages veterinary students to attend the AASV Annual Meeting and offers a variety of activities for students to learn about swine medicine, network with each other, connect with swine faculty, and meet veterinarians and potential mentors.

In addition to free registration, student members who preregister for the conference qualify for a \$300 travel stipend provided by the AASV Foundation and Newport Laboratories. Registration includes access to all educational sessions and activities, including the preconference seminars. The Student Engagement Committee promotes 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, a swine student trivia event, and a student reception.

The AASV Foundation provides opportunities for scholarship awards via participation in the Student Seminar at the AASV Annual Meeting. The Zoetis Foundation provides a \$750 award to each of the 15 students whose papers are selected for oral presentation at the meeting. Students who participate in the Student Seminar compete for the \$5000 veterinary student scholarship funded by the Zoetis Foundation and a total of \$20,000 in additional Elanco-sponsored scholarships ranging from \$500 to \$2500. Papers not selected for oral presentation are considered for poster presentation (poster participants receive a \$250 award from the Zoetis Foundation and AASV), and 15 poster presenters compete for

Advocacy in Action continued on page 333

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(gonadotropin releasing factor analog-diphtheria toxoid conjugate) 0.2 mg/mL



CLOSE THE GILT GAP

By suppressing estrus, your market gilts perform more like barrows

It's a fact of life that gilts don't perform as profitably as barrows, creating a costly production gap for the pork industry. But now there's a **NEW** way to help close that gap with IMPROVEST[®].

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BuiltForTheGilt.com

IMPORTANT SAFETY INFORMATION

Pregnant women should not administer IMPROVEST. Women of childbearing age should exercise extreme caution when administering this product. Exercise special care to prevent accidental self-injection because of negative effects on reproductive physiology in both men and women. However, there is no risk associated with consuming pork from animals administered this product. Do not use IMPROVEST in male pigs or gilts intended for breeding, or in barrows, cull boars or sows. See Brief Summary of Prescribing Information on page XX.

¹Nautrup, BP, et al., Res Vet Sci, 2020
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Brief Summary of full Prescribing Information.



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

DESCRIPTION: IMPROVEST (gonadotropin releasing factor analog-diphtheria toxoid conjugate) is a sterile solution for subcutaneous injection. Each mL contains 0.2 mg gonadotropin releasing factor analog-diphtheria toxoid conjugate, 150 mg of diethylaminoethyl-dextran hydrochloride, 1 mg chlorocresol, sodium hydroxide as needed to adjust pH and water for injection.

INDICATIONS FOR USE: For the temporary immunological castration (suppression of testicular function) and reduction of boar taint in intact male pigs intended for slaughter.

For the temporary suppression of estrus in gilts intended for slaughter.

DOSAGE AND ADMINISTRATION: IMPROVEST should be administered via subcutaneous injection into the post auricular region of the neck. A safety injector should be used, preferably one which has a dual safety system providing both a needle guard and a mechanism to prevent accidental operation of the trigger. The bottle is to be punctured by a vaccinators spike. Use bottle within 28 days of first puncture and puncture a maximum of twice. Each intact male pig or gilt should receive two 2-mL doses of IMPROVEST. The first dose should be administered no earlier than 9 weeks of age. The second dose should be administered at least 4 weeks after the first dose. For reduction of boar taint, intact male pigs should be slaughtered no earlier than 3 weeks and no later than 10 weeks after the second dose. In case of misdosing, the animal should be re-dosed immediately.

CONTRAINDICATIONS: Do not use IMPROVEST in intact male pigs or gilts intended for breeding because of the disruption of reproductive function. Not approved for use in barrows, cull boars, or sows.

WARNINGS AND PRECAUTIONS:

WITHDRAWAL PERIODS:
No withdrawal period is required when used according to labeling.

Not for Human Use. Keep Out of Reach of Children.

USER SAFETY WARNINGS:

Warning for person administering IMPROVEST: Accidental self-injection could affect reproductive physiology of both men and women and may adversely affect pregnancy and fertility. **Pregnant women should not administer this product. Women of childbearing age should exercise extreme caution when handling this product.** Special care should be taken to avoid accidental self-injection and needle stick injury when administering the product. Protective clothing including, but not limited to, safety glasses and gloves should be worn. Use a safety injector, preferably one which has a dual safety system providing both a needle guard and a mechanism to prevent accidental operation of the trigger. In case of eye contact, rinse immediately with copious amounts of water. In case of skin contact, wash immediately with soap and water. The product should be stored safely out of the reach of children. As a reminder, it is the prescribing veterinarian's responsibility to inform drug administrators of the user safety warnings associated with IMPROVEST.

Advice to the user in the event of accidental self-injection: In the event of accidental self-injection, wash the injury thoroughly with clean running water. Seek prompt medical attention and take the package leaflet with you. Do not administer the product, and/or any other product with a similar action, in the future.

Advice to the physician: Accidental self-injection could affect reproductive physiology of both men and women and may adversely affect pregnancy and fertility. If self-injection with IMPROVEST is suspected, reproductive physiology should be monitored by assay of testosterone or estrogen levels (as appropriate).

The risk of a physiological effect is greater after a second or subsequent accidental injection than after a first injection. The patient should be advised not to administer IMPROVEST, and/or any other product with a similar action, in the future.

To report suspected adverse events, for technical assistance, or to obtain a copy of the safety data sheet (SDS), contact Zoetis 1-888-963-8471.

For additional information about adverse drug experience reporting for animal drugs, contact the FDA at 1-888-FDA-VETS or online at www.fda.gov/reportanimalae.

ANIMAL SAFETY WARNINGS AND PRECAUTIONS: Subcutaneous injection in intact male pigs and gilts can cause a transient local injection site reaction that may result in trim loss at slaughter.

ADVERSE REACTIONS:

Preapproval Experience: The field study observations from field effectiveness studies were consistent with the observations made during the target animal safety studies of transient inflammation at the injection sites. IMPROVEST did not cause unusual clinical signs or an unexpected frequency or severity of injection site reactions, apart from the mild anaphylactoid-type reactions immediately following the first injection. Otherwise adverse events, as reported, were not uniquely attributable to IMPROVEST.

Postapproval Experience: (December 2013) The following adverse events are based on voluntary, post approval reporting in male pigs. Not all adverse events are reported to FDA/CVM. It is not always possible to reliably estimate the adverse event frequency or establish a causal relationship to product exposure using these data.

In some cases anaphylactoid / anaphylactic-type reactions have been observed within a few minutes after the first administration of IMPROVEST with duration up to 30 minutes. Clinical signs may include dyspnea, cyanosis, ataxia, emesis or hypersalivation. Most animals recovered. In some cases, death has been reported as an outcome.

STORAGE INFORMATION: Store under refrigeration at 2°-8°C (36°-46°F). Once broached, product may be stored under refrigeration for 28 days. Store bottle in carton until used. Protect from light. Protect from freezing.

HOW SUPPLIED: IMPROVEST is available in a 250 mL bottle.

Approved by FDA under NADA # 141-322



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Kalamazoo, MI 49007

Revised: January 2020
40018847A&P



Students at the 2022 AASV Annual Meeting.

scholarships (\$200 to \$500) in the Student Poster Competition, sponsored by United Animal Health.

Students also have an opportunity to earn \$200 for recording a podcast interview with a speaker at the meeting.

Career and experience resources

The AASV maintains a list of veterinary practices, production companies, and other organizations that host veterinary students for externships and internships ranging in length from 1 week to 3 months.

Veterinary student members considering careers as swine veterinarians might find the AASV Salary Survey particularly useful. It provides insight into the value of professional services provided by swine veterinarians in both public and private practice.

Leadership opportunities

Students are valued and respected members of the AASV. Selected by the Student Engagement Committee, two students sit on the AASV Board of Directors as nonvoting members to provide a student perspective on issues being addressed by the board.

The organization, its leaders, and most importantly, its members, strive to provide exceptional learning opportunities for students. If you have ideas or suggestions to enhance student membership, please consider joining the Student Engagement Committee by contacting the AASV office.

To view the full list of student membership benefits, visit aasv.org/students.

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



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UPCOMING MEETINGS

Gordon Lawson Ileitis Symposium

September 16, 2022 (Fri)
St. Paul River Centre, Minnesota

For more information:
Email: info@ileitis-symposium.com
Web: ileitis-symposium.com

Allen D. Lemman Swine Conference

September 17 - 20, 2022 (Sat-Tue)
Saint Paul, Minnesota

Hosted by the University of Minnesota
College of Veterinary Medicine

For more information:
Web: lemanconference.umn.edu

126th US Animal Health Association Annual Meeting

October 5 - 12, 2022 (Wed-Wed)
Hyatt Regency Minneapolis
Minneapolis, Minnesota

For more information:
Web: usaha.org/meetings

ISU James D. McKean Swine Disease Conference

November 3 - 4, 2022 (Thu-Fri)
Scheman Building
Iowa State University
Ames, Iowa

For registration information:
Registration Services
Iowa State University
Ames, Iowa
Email: registrations@iastate.edu
Web: regcytes.extension.iastate.edu/swinedisease/

For questions about program content:
Dr. Chris Rademacher
Conference Chair
Iowa State University
Email: cjrdvm@iastate.edu

Forum: Autogenous Vaccines in Swine Medicine: Why and How?

December 1, 2022 (Thu)
Hotel le Dauphin
600 Boul St-Joseph
Drummondville, QC J2C 2C1
CANADA

Organized by the Swine and Poultry
Infectious Diseases Research Center
(CRIPA)

For more information:
Cécile Crost
Email: c.crost@umontreal.ca
Web: cripa.umontreal.ca

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

AVMA Leadership Conference

January 5 - 7, 2023 (Thu-Sat)
Chicago, Illinois

Hosted by the American Veterinary
Medical Association

Web: avma.org/events/veterinary-leadership-conference

American Association of Swine Veterinarians 54th Annual Meeting

March 4 - 7, 2023 (Sat-Tue)
Gaylord Rockies Resort &
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: aasv.org/annmtg



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

AASV INDUSTRY SUPPORT COUNCIL

The *Journal of Swine Health and Production* is made possible by the generous support of these Industry Support Council members:



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