Journal of
SWINE HEALTH & PRODUCTION
January and February 2023 • Volume 31, Number 1

The Journal of the American Association of Swine Veterinarians

The *Journal of Swine Health and Production* is published by the American Association of Swine Veterinarians.

The *Journal of Swine Health and Production* is a refereed publication and is a benefit of membership in the American Association of Swine Veterinarians. For inquiries regarding membership or subscriptions, please contact:

AASV
830 26th Street, Perry, IA 50220-2328
Tel: 515-465-5255
Email: aasv@aasv.org

Editorial questions, comments, and inquiries should be addressed to Rhea Schirm, Publications Manager:
Email: jshap@aasv.org.

DISCLAIMER

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may be specific to the research or commercial situation presented in the manuscript. It is the responsibility of the reader to use information responsibly and in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

Journal of Swine Health and Production is indexed in ISI®Focus On: Veterinary Science & Medicine,® and in CAB Abstracts, Euroscience VETLINE on CD-ROM

JOURNAL OF SWINE HEALTH AND PRODUCTION

(ISSN 1537-209X) Volume 31, Number 1; January and February

AASV STAFF

AASV OFFICERS

JSHAP STAFF

EDITORIAL BOARD

TABLE OF CONTENTS

Cover photo is courtesy of Tina Smith.

Download this issue at **www.aasv.org/shap/issues/v31n1/v31n1jshap.pdf**

JSHAP SPOTLIGHT

Dr Jordan Gebhardt

Kansas State University

Dr Jordan Gebhardt earned a BS ('14) from Michigan State University and a DVM ('19) and PhD ('20) from Kansas State University (KSU). Dr Gebhardt is currently an assistant professor at KSU where he conducts swine research and provides leadership and teaching of graduate and veterinary students. He enjoys interacting and collaborating with production systems to conduct applied, practical research in the areas of swine nutrition, feed safety, and swine production medicine. The peer review process can be intimidating, but it is beneficial to improve knowledge both as an author and reviewer. Dr Gebhardt reminds authors that the goal of the process is to improve the manuscript and ensure that the information communicated to the readers is accurate and interpreted in proper context.

ENDOVAC-Porci®
with Immune Plus

MORE Than *Just* a Vaccine

Studies have determined that ENDOVAC-Porci; a core antigen vaccine with an immunostimulant, provides pigs broad-spectrum protection against the enteric & respiratory effects of gram-negative bacterial diseases.

Lawsonia Intracellularis Challenge:
ENDOVAC-Porci vs. Porcilis® Ileitis vs. Controls

- **29.0%** (7.7 lb) higher weight gain over controls
- **No** statistical difference in weight gain compared to Porcilis Ileitis
- **40.9%** better clinical scores than controls
- **8.2%** better clinical scores than Porcilis Ileitis
- **37.6%** better fecal scores to controls
- **18.2%** better fecal scores than Porcilis Ileitis

Clinical & Fecal Scores

Study days 58-70:
Clinical Scores: 0 Normal, 1 Mild, 2 Moderate, 3 Severe
Fecal Scores: 0 Normal, 1 Soft, 2 Loose, 3 Watery

Scoring	Saline	ENDOVAC-Porci®	Porcilis® Ileitis
Clinical	24.7^{a}	14.6^{b}	15.9^{ab}
Fecal	27.4^{a}	17.1^{b}	20.9^{ab}

Treatment means with different superscripts differ from each other ($P < 0.05$)

E. coli and Pasteurella Challenge:
ENDOVAC-Porci vs. Controls

- **11.1%** pre-wean survivability advantage
- **7.9%** (1.05 lbs) higher average weaning weight
- **13.6%** (3.3 lbs) higher final 42-day weight
- **61.9%** less mortality over the entire study
- **75.6%** better clinical scores
- **50.8%** better fecal scores

Clinical & Fecal Scores

Study days 22-35:
Clinical Scores: 0 Normal, 1 Mild, 2 Moderate, 3 Severe
Fecal Scores: 0 Normal, 1 Soft, 2 Loose, 3 Watery

Treatment	Saline	ENDOVAC-Porci®	P-value
Clinical	1.19	0.29	.05
Fecal	1.95	0.96	.05

Effect of treatment ($P < 0.01$)

Making a meeting

As we focus on the mission of the American Association of Swine Veterinarians to increase the knowledge of swine veterinarians; protect and promote the health and well-being of pigs; advocate science-based approaches to veterinary, industry, and public health issues; promote the development and availability of resources that enhance the effectiveness of professional activities; create opportunities that inspire personal and professional growth and interaction; and mentor students, encouraging life-long careers as swine veterinarians, the capstone for each of these objectives is our Annual Meeting. While focused effort on the mission is continuous throughout the year, it is at the Annual Meeting that we all can gather to increase our knowledge, meet as committees, engage student members, and celebrate the successes of all our members.

The Annual Meeting takes significant investment of time, talent, and financial support for it to be successful each year. The process begins years in advance starting with the selection of a location for the meeting by the AASV Board of Directors. At the fall 2022 board meeting, locations for the Annual Meeting have been set through 2027. The size of the Annual Meeting is not large enough to use major convention centers but is too large for some hotels to accommodate. The board decision on future meeting locations is made after evaluating location information from multiple cities acquired by the AASV executive director.

The contract with the hotel requires guaranteed food and beverage and lodging night minimums from AASV for the use of the meeting facilities at the hotel. If the contracted requirements are not met, AASV is responsible for payment of the difference to the hotel. With scheduled breaks, receptions, and meals, typically the food and beverage requirements are met. For the most recent meeting, food and beverage expenses were approximately two-thirds of the meeting costs. You would be amazed how much a gallon of coffee, a served luncheon, or a doughnut costs! Room night requirements are usually met. However, for the 2021 meeting in Indianapolis, AASV failed to meet the room night requirement and was responsible for an additional payment of $24,000 (negotiated down from over $40,000). Our attendance was down slightly, likely the result of continued travel restrictions for some as we returned to an in-person meeting. Attendees choosing to stay at other locations also contributed to missing the minimum contracted nights. As you finalize your plans to attend the 2023 Annual Meeting, I hope that you will make your lodging reservations at the meeting hotel to assist AASV achieving the minimum room night requirement.

"The Annual Meeting takes significant investment of time, talent, and financial support for it to be successful each year."

To all the past and present sponsors of the Annual Meeting and those who participate with a technical table, whose support directly offset expenses for the Annual Meeting, thank you for your support! With the loss of sponsorship for the Monday luncheon for 2023, the AASV Foundation Board of Directors has committed to cosponsor 50% of the cost with AASV in lieu of holding their usual separate Foundation luncheon on Sunday. The announcement of foundation grants and recognitions will take place during the Monday luncheon, along with the usual student scholarship awards. The AASV Budget Committee recommended increases in the 2023 Annual Meeting registration fees, which was approved by the board. These increases reflect the increasing costs to host the meeting including food, beverage, and audio-visual support and loss of sponsorships for the meeting.

Dr Bill Hollis and the program committee have put together another tremendous program for the Annual Meeting using input from the post-meeting survey that will provide high value to all attendees. I am looking forward to the Annual Meeting at the Gaylord Rockies Resort & Convention Center in Aurora (Denver), Colorado. See you there!

Mike Senn, DVM, MS
AASV President

Are you and your clients prepared to respond to a Foreign Animal Disease?

Get ready with the **CERTIFIED SWINE SAMPLE COLLECTOR** training program

1. Contact the State Animal Health Official (SAHO) in the state(s) in which you plan to train or use Certified Swine Sample Collectors (CSSCs) to confirm participation eligibility prior to participating in the program.
2. Review the CSSC Program Standards.
3. Identify individuals who could be trained to collect and submit samples on your behalf.
4. Access CSSC training materials at securepork.org/cssc.
5. Conduct classroom and hands-on training.
6. Submit a list of trained individuals to SAHO(s) in state(s) trainees will be collecting samples.

CSSC

For more information on the training program ←

If you are ready to start training, contact the state animal health officials in the state in which you wish to train individuals ←

For additional information or if your state isn't listed, please contact Pam Zaabel at pzaabel@pork.org.

Bathing, perspective, and meeting

When I sit down to write one of these messages, I challenge myself to try to follow in the footsteps of Dr Burkgren or the other astute editorial authors in JSHAP. They seem to always be able to provide something deep and thought-provoking or at least instructional. They often recount how they read an inspiring book or drew inspiration from a lifetime of experience. I am pretty sure I am not that deep. I am not sure I was ever very good at deciphering the "hidden meaning" or grasping the profound references highlighted in the Cliffs Notes that I credit with my ability to eke out a passing grade in undergraduate English literature. I think I am way too "basic" for that kind of thought. I rely much more on the obvious.

A few weeks ago, I contracted COVID. I ran a high fever for the first two days and just generally felt yucky. At one point, it occurred to me that reclining in a hot bath might make me feel better. Now, let me digress from my story to make a couple of points. First, I am a shower guy. I do not take baths. And second, while I am by no means a "clean freak," I do take the time to clean the house (including the bathroom and the tub) on a reasonably frequent basis. Also, just to further define the scene, I have one of those soaker tub/shower combos with an acrylic surround and built-in shelves to hold shampoo and soap. One end of the tub is angled backwards to facilitate reclining should one be so predisposed. Now that I have set the scene and provided the necessary backstory, I can get back to the story.

As I reclined in the tub, I happened to notice that from that angle I could see the underside of the shelves molded into the tub surround. I was shocked, nay appalled, at the build-up of soap scum and other "dirt" accumulated on the underside of those shelves! I do not think I had ever bothered to actually wipe the underside of the shelves. The tub surround looked perfectly (well, acceptably) clean from my perspective standing in the shower. I realize my recounting this tale may not cast my cleaning abilities in the best possible light but I am willing to sacrifice my self-respect to make the point that what you believe to be reality is determined by your perspective.

If you think about it, altering our perspective is what continuing education is all about. It is the key to why we attend the AASV Annual Meeting every year. It is why the hallway talk is always such an important part of the meeting. We like to talk to other colleagues who are experiencing similar challenges and learn how they address those challenges. It gives us a chance to look at things from someone else's perspective. The same is true for the scientific sessions. Science challenges our perceptions. When we make the effort to seek out a different perspective, what we learn might just change our reality.

"If you think about it, altering our perspective is what continuing education is all about."

Ok, so maybe this was a bit of a stretch to encourage you to attend the 2023 AASV Annual Meeting. I do, however, hope you will make the effort to join us on the mountaintop in Colorado this year. While you likely will not find an old man with a white beard wearing a diaper issuing thought-inspiring proclamations, you will hopefully come across a new perspective that will challenge your reality. Although, on second thought, given our AASV demographic, an old man with a white beard wearing a diaper may not be that unlikely!

Harry Snelson, DVM
Executive Director

Shaping the future of piglet care

Prepare, protect, and support resilience in your piglets. As your partner, we provide local swine expertise and complete, tailor-made solutions to help you achieve your goals. Together, we can create a new future for piglet care.

If not us, who? If not now, when?

WE MAKE IT POSSIBLE

ANIMAL NUTRITION AND HEALTH

- ESSENTIAL PRODUCTS
- PERFORMANCE SOLUTIONS + BIOMIN
- PRECISION SERVICES

www.dsm.com/anh-na

Follow us on:

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

Behind the scenes in 2023

The journal had another year of success, and I am looking forward to the 2023 volume of JSHAP. There is an interesting line-up of manuscripts planned for the early issues and many others undergoing the peer-review process. The journal's success remains possible due to the strong support of reviewers, the editorial board, the industry support council, the staff in the AASV office, the journal staff, and of course the authors. Thank you for all your hard work in 2022.

You will see a slight change in this editorial section of the journal for the upcoming issues. The journal staff wants to share with you what happens behind the scenes. We thought you would find it interesting to have a quick peek into what goes into putting an issue together and how journal staff accomplish this. We have put together a "Behind the Scenes" series for you and I am going to kick off this series and share with you some of the tasks that I do.

My primary role as Executive Editor is to oversee the peer-review process for the journal. What that really means is - a lot of reading. I read the manuscript when it is submitted to the journal. At this point, I decide if it is within the scope of the journal and contains appropriate animal use and conflict of interest statements. If there is a concern in any of these areas, the manuscript is returned to the author for clarification or not accepted for review. The journal has a very broad scope and we aim to publish topics with an applied focus. Deciding if a manuscript is within the scope of the journal is probably the most challenging aspect of my decision making.

Once the manuscript is accepted for review, I recruit the help of an editorial board member to act as a lead reviewer. This is a critical component of the review process. The work of the editorial board members is essential as it brings a wealth of expertise to the review process, the journal, and the body of published scientific literature in general. Then, typically, 2 or 3 additional reviewers are identified for each manuscript and are given time to return their reviews. Once the reviews have returned, the lead reviewer takes all of them into consideration and makes a publication recommendation to me.

Then, it is my turn again. Yes, more reading and compiling all the reviews and the publication recommendation. I re-read and review the manuscript, I read all the external reviews and the publication recommendation, and then

"The journal's success remains possible due to the strong support of reviewers, the editorial board, the industry support council, the staff in the AASV office, the journal staff, and of course the authors."

I make the final decision to conditionally accept the manuscript, request revisions, or reject the manuscript. If revisions are requested, the manuscript is returned to the authors, who are given time to respond. As you can imagine, this back and forth can take some time and often, I have read the manuscript 3 to 4 times by this point. Depending on the revisions received from authors, the manuscript may be conditionally accepted at this time, returned for further revisions, or rejected. I meet many times with Publications Manager Rhea Schirm during this process to discuss the manuscript life cycle. Once the manuscript is conditionally accepted, it is forwarded to Associate Editor Sherrie Webb.

Watch this space for more behind the scenes with journal staff.

I hope you enjoy reading this issue – I know I did!

Terri O'Sullivan, DVM, PhD
Executive Editor

Evaluating natural planned exposure protocols on rotavirus shedding patterns in gilts and the impact on their suckling pigs

Amanda V. Anderson, BS; Frances Shepherd, PhD; Francisco Dominguez, PhD; Jeremy S. Pittman, DVM, MS, DABVP; Douglas Marthaler, PhD; Locke A. Karriker, DVM, MS, DACVPM

Summary

Objective: The objectives of this study were to determine the pattern of rotavirus A (RVA), rotavirus B (RVB), and rotavirus C (RVC) shedding in gilts after natural planned exposure (NPE) administration and assess the effects on piglet weaning weight, preweaning mortality, and RV shedding.

Materials and methods: A total of 70 pregnant gilts were enrolled and allocated into 4 groups. Group 1 was given NPE at 5, 4, and 3 weeks prefarrowing (WPF); Group 2 at 5 and 3 WPF; and Group 3 at 5 WPF only. Group 4 (control group) did not receive any NPE. Samples from 46 gilts and litters (5 piglets/litter) were tested at 12 sample times. Piglets were sampled weekly from 24 hours of age until 6 weeks of age and tested by quantitative reverse transcriptase-polymerase chain reaction for RVA, RVB, and RVC.

Results: There was a significant improvement in weaning weight of piglets born to gilts that received 3 NPE administrations compared to fewer or no NPE administrations. Shedding of RVA and RVB from piglets were well controlled in the farrowing room regardless of treatment group, but RVC was observed as early as 1 week of age. This study was conducted on a single farm, and the results should be carefully interpreted with knowledge of variations in farms and systems.

Implications: Three administrations of NPE to gilts prefarrowing had valuable production and economic benefits for the producer. Circulation patterns of RVA, RVB, and RVC appear to correlate; interventions for one have value against the others.

Keywords: swine, rotavirus, natural planned exposure, feedback, immunity

Received: November 14, 2021
Accepted: July 14, 2022

Resumen - Evaluación de los protocolos de exposición natural planificada en los patrones de excreción de rotavirus en primerizas y el impacto en sus lechones

Objetivo: Los objetivos de este estudio fueron determinar el patrón de excreción del rotavirus A (RVA), rotavirus B (RVB), y el rotavirus C (RVC) en primerizas después de la administración de exposición natural planificada (NPE), y evaluar los efectos sobre el peso al destete de los lechones, mortalidad antes del destete, y la excreción del RV.

Materiales y métodos: Un total de 70 nulíparas gestantes fueron reunidas y distribuidas en 4 grupos. El grupo 1 recibió NPE a las 5, 4, y 3 semanas antes del parto (WPF); Grupo 2 a las 5 y 3 WPF; y Grupo 3 a 5 WPF solamente. El grupo 4 (grupo control) no recibió NPE. Se analizaron muestras de 46 nulíparas y sus camadas (5 lechones/camada) en 12 tiempos de muestreo. Los lechones se muestrearon semanalmente desde las 24 horas hasta las 6 semanas de edad y se analizaron mediante reacción en cadena de la polimerasa con transcriptasa inversa cuantitativa para RVA, RVB, y RVC.

Resultados: Hubo una mejora significativa en el peso al destete de los lechones nacidos de primerizas que recibieron 3 administraciones de NPE en comparación con menos o ninguna administración de NPE. La excreción de RVA y RVB de los lechones estuvo bien controlada en la sala de partos, independientemente del grupo de tratamiento, pero se observó RVC a la semana de edad. Este estudio se realizó en una sola granja por lo que los resultados deben interpretarse cuidadosamente debido a las variaciones en las granjas y los sistemas.

Implicaciones: Tres administraciones de NPE a las primerizas antes del parto tuvieron un beneficio productivo y económico para el productor. Los patrones de circulación del RVA, RVB, y RVC parecen estar correlacionados; las intervenciones para uno tienen valor frente a los otros.

AVA, LAK: Department of Veterinary Diagnostic and Production Animal Medicine, College of Veterinary Medicine, Iowa State University, Ames, Iowa.

FS: Department of Veterinary and Biomedical Sciences, College of Veterinary Medicine, University of Minnesota, St. Paul, Minnesota.

FD, DM: Veterinary Diagnostic Laboratory, College of Veterinary Medicine, Kansas State University, Manhattan, Kansas.

JSP: Smithfield Hog Production - North Region, Waverly, Virginia.

Corresponding authors: Dr Locke Karriker, Department of Veterinary Diagnostics and Production Animal Medicine, Iowa State University, 1600 S 16th St, Ames, IA 50011; Tel: 515-294-2283; Email: **karriker@iastate.edu**; Dr Douglas Marthaler, Veterinary Diagnostic Laboratory, Kansas State University, 1800 Denison Ave, Manhattan, KS 66506; Tel: 785-532-5709; Email: **marth027@umn.edu.edu**.

Anderson AV, Shepherd F, Dominguez F, Pittman JS, Marthaler D, Karriker LA. Evaluating natural planned exposure protocols on rotavirus shedding patterns in gilts and the impact on their suckling pigs. *J Swine Health Prod*. 2023;31(1):10-19. **https://doi.org/10.54846/jshap/1294**.

Résumé - Évaluation des protocoles d'exposition naturelle planifiée sur les modèles d'excrétion de rotavirus chez les cochettes et l'impact sur leurs porcelets à la mamelle

Objectif: Les objectifs de cette étude étaient de déterminer le schéma d'excrétion du rotavirus A (RVA), du rotavirus B (RVB), et du rotavirus C (RVC) chez les cochettes après une exposition naturelle planifiée (NPE) et d'évaluer les effets sur le poids au sevrage des porcelets, la mortalité avant le sevrage, et l'excrétion du RV.

Matériels et méthodes: Au total, 70 cochettes gestantes ont été recrutées et réparties en quatre groupes. Le groupe 1 a subi une NPE à 5, 4, et 3 semaines avant la mise bas (WPF); le groupe 2 à 5 et 3 WPF; et le groupe 3 à 5 WPF uniquement. Le groupe 4 (groupe témoin) n'a subi aucune NPE. Des échantillons de 46 cochettes et portées (5 porcelets/portée) ont été testés à 12 temps d'échantillonnage. Les porcelets ont été échantillonnés chaque semaine à partir de l'âge de 24 heures jusqu'à l'âge de 6 semaines et testés par réaction d'amplification en chaîne quantitative par la polymérase avec la transcriptase inverse pour RVA, RVB, et RVC.

Résultats: Il y a eu une amélioration significative du poids au sevrage des porcelets nés de cochettes ayant subi trois NPE par rapport à moins ou pas d'administrations de NPE. L'excrétion de RVA et de RVB des porcelets était bien maitrisée dans la salle de mise bas quel que soit le groupe de traitement, mais le RVC a été observée dès l'âge d'une semaine. Cette étude a été menée sur une seule ferme et les résultats doivent être interprétés avec prudence en tenant compte des variations dans les fermes et les systèmes.

Implications: Trois NPE des cochettes en pré-maternité ont eu de précieux avantages économiques et de production pour le producteur. Les schémas de circulation des RVA, RVB, et RVC semblent corrélés; les interventions pour l'un sont bénéfiques envers les autres.

Rotaviruses (RVs) are common swine pathogens and significant causes of scours in pigs. Of 10 RV serogroups, rotavirus A (RVA), rotavirus B (RVB), and rotavirus C (RVC) are the main RVs infecting swine, with prevalence of 64%, 47%, and 58%, respectively.[1] Rotaviruses increase preweaning mortality 3% to 20% and decrease weaning weight 0.5 to 1.0 lb (0.23-0.45 kg).[2] The fastidious nature of RVB and RVC defies most control measures,[3] and the inability to grow many RVs in cell culture impedes vaccine and diagnostic assay development.

Limited cross-protection both within and between RVA, RVB, and RVC strains further complicates control of RV disease.[4,5] Neutralizing antibodies are generated to viral protein 4 (VP4) and viral protein 7 (VP7), which determine the P and G genotypes, respectively. They are structural proteins on the outer capsid of the virion.[3] The diversity of swine RVA G and P genotypes (12 and 16, respectively) and RVC VP7 and VP4 genotypes (15 and 17, respectively) further confounds vaccine development and control.[6,7] When vaccine and challenge strains share the same G genotype, protection from clinical disease and viral shedding occurs. Sharing the same P genotype leads to protection from clinical illness but not viral shedding. Without prior exposure and immunity to either VP7 or VP4, pigs will exhibit both viral shedding and clinical disease after challenge.[8]

Since the only commercially available swine RV vaccine in the United States (ProSystems RCE, Merck Animal Health) only contains 2 RVA serotypes, alternative control methods such as natural planned exposure (NPE) have been used to control RV infections by using live RV-infected material to generate immunity to specific RV strains circulating on a farm. The term "natural planned exposure" was chosen to convey that immunization was attempted through exposing animals to a natural material, rather than laboratory prepared vaccine, in a controlled manner. While NPE can elicit maternal immunity and passive lactogenic immunity for piglets, poor quality control could have harmful consequences. The NPE material selected from piglets in farrowing that exhibit clinical diarrhea without confirming the presence of RVs or the lack of other infectious pathogens can promote the spread of other diseases and minimize the benefit of immunization.[9] A consistent supply of NPE material is challenging to maintain when RVs are effectively controlled, leading to a cyclic effect of clinical disease in the herd. When clinical disease and infectious material subsides, the herd returns to vulnerability and maternal immunity declines. Gilts that are introduced during a subsidence period likely lack adequate levels of immunity to protect their piglets. Since the survival and growth of piglets are directly correlated to colostrum intake,[10] the lack of a consistent supply of NPE material can lead to a cycle of RV instability in the herd over time.

Natural planned exposure has been administered in the water, via ice cubes, manually sprayed into the mouths of sows, and added to feed as a gruel by thawing frozen RV infected material into water and feed. None of these methods have been subjected to controlled evaluation. The "master seed method" was developed to improve safety and increase efficacy of RV live virus feedback.[11] This method consists of identifying positive RV samples from the farm of interest, creating a laboratory stock or "master seed" of RV infected material using colostrum-deprived piglets, and saving the material to be used for future NPE preparation. Colostrum-deprived piglets are obtained by manually catching piglets as they are being born, and they are inoculated with the RV material. The piglets are euthanized after 18 to 24 hours and used to create an on-farm NPE stock to be used over the next several months. Diagnostic testing ensures the stock is positive for RVs and negative for relevant pathogens.

The objectives of this study were to determine the pattern of RV shedding in gilts after NPE administration and assess the effects on piglet weaning weight, preweaning mortality, and RV shedding.

Animal care and use

The gilts and pigs used in this study were cared for following Pork Quality Assurance Plus guidelines.

Materials and methods

Study design

This pilot study was conducted on an 1800-head commercial, breed-to-wean farm. In the years preceding this study, the farm had alternating periods of time without enteric challenges and with enteric clinical signs diagnosed as rotavirus. A total of 70 pregnant gilts were enrolled and allocated into 4 groups.

Group 1 was given NPE at 5, 4, and 3 weeks prefarrowing (WPF); Group 2 at 5 and 3 WPF; and Group 3 at 5 WPF only. Group 4 was a control group and did not receive any NPE administrations. Gilts were housed in pens of 5 to 6, with only gilts of their same treatment group in the same pen. Pens were initially enrolled by random selection using the randomize function on Microsoft Excel (Microsoft Corporation). At farrowing, 12 gilts from each group were enrolled for collection of shedding data based on inclusion criteria of a narrow farrowing timeframe and at least 6 liveborn piglets. Post farrowing, 2 litters were excluded due to savaging and agalactia. Forty-six litters (Group 1 = 12, Group 2 = 12, Group 3 = 11, Group4/Control = 11) were evaluated for shedding. Piglets from all contemporary litters to those tested were also included in the production data analysis. This led to a total of 59 litters (Group 1 = 15, Group 2 = 14, Group 3 = 14, Group 4/Control = 16) in the production data analysis.

Five piglets per litter were tagged and enrolled in the trial after birth. No intralitter pig movement was allowed. Pigs were enrolled that appeared healthy and were visually similar in weight to the median pig size in the litter to avoid extreme piglet sizes.

Natural planned exposure

The NPE material was created using the master seed method and stored in an on-farm deep freezer.[11] Due to their higher prevalence and more significant production impact, only RVA and RVC were included in the master seed NPE material. This was verified by monitoring the RVs on the farm prior to conducting the study by quantitative reverse transcriptase-polymerase chain reaction (qRT-PCR). The viral strains used were collected at the farm where the gilts were born. Sequence analysis of VP4 and VP7 were performed on samples from the farm and from the stock to ensure the isolates matched. To prepare the NPE, 40 mL of master seed was added to approximately 14 L of water and mixed thoroughly with enough feed to generate approximately 100 doses of gruel. Each gruel dose was approximately 237 mL (1 cup).

Each gilt received 1 dose of NPE gruel administered 5 hours after daily feeding. Gilts were baited to their feeders using a small amount of dry feed. Once positioned in their feeding headstalls, 1 dose of NPE was measured and placed into each feeder space. Researchers remained at the pens until NPE was completely consumed. Samples of each batch of NPE gruel were reserved and tested.

Sampling

Fecal samples were collected from gilts immediately prior to NPE at 5 WPF and then twice per week until 2 WPF, after which weekly sampling occurred until weaning (-5, -4.5, -4, -3.5, -3, -2.5, -2, -1, 0, 1, 2, and 3 weeks) for a total of 12 fecal samples per gilt. Gilt fecal samples were collected by digital rectal examination and stored in individual 50-mL centrifuge tubes. Fecal swabs (BD BBL CultureSwab) were collected from piglets within 24 hours of birth and weekly until 6 weeks of age (0, 1, 2, 3, 4, 5, and 6 weeks of age) for a total of 7 fecal swabs per piglet. All pigs were weaned and transported from the sow farm to a nursery site between samples 3 and 4. All piglets were comingled at the nursery site, with no separation between treatment groups. To prevent contamination during sampling, gloves were changed between every gilt and litter of piglets.

Diagnostic testing

The NPE gruel, feces, and fecal swabs were tested by qRT-PCR for RVA, RVB, and RVC at Kansas State University Veterinary Diagnostic Laboratory. Isolation of RVA was performed on the NPE gruel to confirm live virus by blind-passaging 3 times on MA104 cells. Isolation of RVB and RVC was not attempted due to their fastidious nature.[3] Gruel (500 µL) was incubated with 20 µL of TPCK-treated trypsin (Thermo Fisher Scientific) for 30 minutes at 37°C. Samples were then placed in 24-well plates containing confluent MA104 cells (ATCC). The plates were incubated for 1 hour at 37°C, washed with phosphate-buffered saline (PBS), and incubated for 5 to 6 days at 37°C in fresh minimum essential media (Sigma Aldrich) with 1% bovine serum albumin (Sigma Aldrich). After 2 freeze-thaw cycles, 2 additional passages on fresh MA104 cells were conducted. Samples with cytopathic effect were sent for qRT-PCR to confirm the growth of RVA. For qRT-PCR testing of gilt fecal samples, approximately 1 g of feces was added to 3 mL of PBS and centrifuged to create a fecal homogenate. Gilt fecal homogenates were pooled by 3 within their treatment group. Gilt pools testing positive by qRT-PCR were tested individually. Piglet fecal swabs were placed in 1 mL of PBS and were pooled by litter (n = 5 piglet fecal samples/pool). Cycle threshold (Ct) values less than 36 were considered positive for RV shedding. High and low viral shedding levels were determined based on a Ct value cut-off published for human RV infections to distinguish symptomatic and asymptomatic infections (Table 1).[12,13]

Production data collection

Piglets were weighed 3 days prior to weaning. Additionally, the preweaning mortality rates for each treatment group were determined using the farm's record-keeping system (PigKnows).

Data analysis

Statistical analysis on piglet weaning weight and preweaning mortality was conducted using PROC MIXED/PROC GLIMMIX (SAS v 9.4, SAS Institute Inc). A linear model was fit to explain the effect of treatment on adjusted weight. Least squares means were provided for each treatment group, and all pairwise comparisons of treatment groups were computed. Tukey's method was used to control for multiple comparisons. Similarly, a general linear model was fit to explain the effect of treatment on mortality. Significance was established *a priori* at $P < .05$. Adjusted weights were calculated by adding or subtracting 0.5 lb (0.23 kg) per pig for each day above or below 21 days of age at weaning, respectively.[14]

Table 1: Levels of rotavirus shedding and corresponding quantitative real time polymerase chain reaction (qRT-PCR) cycle threshold (Ct) values used for data analysis

Viral shedding category	qRT- PCR Ct value range
High	Ct < 26
Low	26 ≥ Ct < 36
None	Ct ≥ 36

To investigate variables associated with low virus shedding in piglets, multiple mixed effects logistic regression models were constructed using the lme4 package in R (R Core Team).[15] The outcomes considered were levels of RVA, RVB, or RVC viral shedding in the farrowing and nursery phases of the study (Tables 2 and 3). For each outcome, only the data points where piglets were shedding the virus of interest were considered. Thus, the model outcome was a trinary variable of either high, low, or no viral shedding based on the Ct value cut-offs (Table 1). Treatment group (4-level categorical variable; group 1, 2, 3, or 4) and shedding of other RV species (3-level categorical variable; high, low, or none) were included as fixed effects. A fixed effect in the farrowing models for the duration of gilt shedding prefarrowing (continuous variable, weeks) was incorporated as a proxy for the strength of lactogenic immunity, assuming longer viral shedding in gilts translates to more exposure and a greater immune response against RVA or RVC. This approach was adapted from porcine epidemic diarrhea virus research approaches.[16] A fixed effect was included in the nursery phase models for the duration of piglet RVA or RVC shedding in the nursery phase (continuous variable, weeks) as a proxy for the generation of active immunity. This was included to analyze whether an increased duration of RV shedding in the farrowing room translated to a more robust active immune response and protection in the nursery phase. Previous research showed that piglets shedding RV after a virulent inoculation are better protected upon challenge.[17] Litter was a random effect. Shedding of RVB was not detected until the nursery phase, so this model was not constructed, leaving 5 mixed effects models tested (Tables 2 and 3).

Results

Production impact

The mean 21-day adjusted piglet weaning weights for groups 1, 2, 3, and 4 (control) were 14.55, 13.42, 13.66, and 13.10 lb (6.60, 6.09, 6.20, and 5.94 kg), respectively. Group 1 (3 NPE administrations) weaning weight was significantly different than group 2 (2 NPE administrations), group 3 (1 NPE administration), and the control group. Tukey-Kramer adjusted two-sided *P* values for differences of least squares means for each treatment relative to the control group were < .001, .013, and < .001, respectively. This ultimately resulted in a mean weaning weight increase of 1.45 lb (0.66 kg) between group 1 and the control. No significant differences in preweaning mortality between treatment groups were identified.

Natural planned exposure

The NPE gruel samples were mixed using material that had previously tested positive by virus isolation for RVA. As determined by qRT-PCR, the NPE material fed to the sows yielded a lower Ct value for RVA than RVC (Table 4). The mean Ct value was 23.66 for RVA and 30.69 for RVC, while RVB was negative.

Gilt viral shedding

The qRT-PCR results for RVB were negative for gilts at every sampling point. Prior to the initial administration of NPE, 2 of 46 gilts were positive for RVA, while all gilts were negative for RVC (Figure 1). Based on qRT-PCR results at 4.5 WPF, the first feedback administration induced RVA shedding in 71.4% (25 of 35) of gilts with mean Ct = 30.11 while RVC was shed in only 20.0% of gilts (7 of 35; mean Ct = 32.96). At 4 WPF, the total number of RVA-shedding gilts decreased (20 of 35 gilts), but peak levels of shedding were observed in gilts that were RVA positive (mean Ct = 27.33). The number of gilts shedding RVC increased (14 of 35 gilts) at this time point, along with the level of shedding (mean Ct = 31.49). At week 3.5 after the second NPE administration for group 1, all 12 gilts in this group were shedding RVA, yet only 1 gilt was shedding RVC.

Group 1 had increased levels of shedding after the first 2 NPE administrations (collection points 4.5 and 3.5 WPF) but not after the final NPE administration (collected at 2.5 WPF). Group 2 exhibited increased shedding after both NPE administrations (4.5 and 2.5 WPF). In group 3, RVA shedding levels reached 63.6% (7 of 11) of gilts shedding after their single NPE administration (4.5 WPF) and slowly decreased over 2 weeks before they were all found to be negative at 2.5 WPF. One week prior to farrowing, only 1 gilt each was shedding RVA and RVC at low levels, both from group 2. At farrowing, RVA shedding was observed in gilts from all the treated groups (7 of 35 gilts). At 1 week post farrowing, a single gilt in each of the treated groups was positive for RVA and all gilts were negative by week 3. No RVC shedding was detected in treated gilts at the time of farrowing or at 1 week post farrowing. However, 4 control group gilts were positive for RVC at 1 week post farrowing. One control gilt was positive for RVC at 2 weeks, and 6 total gilts from groups 1 and 2 also became positive for RVC. By 3 weeks post farrowing, all gilts were negative for RVA and RVC. Overall, shedding of RVA was higher in treatment group gilts, while RVC shedding was higher in control group gilts. No apparent differences in RVA and RVC shedding were discerned between the treatment group gilts.

Piglet viral shedding

At week 1 post farrowing, 4.3% (2 of 46) litters were positive for RVA and 32.6% (15 of 46) were positive for RVC (Figure 2). Shedding of RVA in the farrowing room was rarely diagnosed in all treatment groups, with only 1 litter in group 1 and group 3 shedding RVA starting at week 1. One other litter in group 3 became RVA positive during week 3. Shedding of RVC began in week 1 and the piglet pools from control gilts contained the most positive litters (64%), while 17%, 42%, and 9% of litters were positive in groups 1, 2, and 3, respectively. At this time, 5 of the 11 (45.6%) control litters were shedding high levels (Ct < 26) of RVC, but by weeks 2 and 3, 1 litter (9.1%) and 0 litters (0.0%), respectively, had high levels of RVC shedding. No piglet litters were shedding RVB during the farrowing phase.

At the nursery (week 4), RV infections became much more prevalent regardless of the treatment group. At week 4, all litters were shedding high levels of RVA. High RVA shedding levels subsided to low levels (26 ≥ Ct < 36) in all but 1 litter from the control group at week 5 but returned at week 6 in 25% of litters in group 1, 58% of litters in group 2, and 73% of litters in groups 3 and 4. None of the litters that became RVA positive resolved their shedding during the study. Shedding of RVB first appeared at week 4 in 26 of 46 litters. The highest levels of RVB shedding were observed at week 5, while RVA shedding was subsiding. A reduction in RVB shedding was seen at week 6, but none of the litters stopped shedding the virus. Generally, litters testing positive for RVA or RVC in early farrowing tested positive for the respective RV at later sampling points. Piglet pools that were negative at 1 week of age remained negative until the animals were moved to the nursery.

Table 2: Factors tested for association with lower RVA or RVC shedding by piglets in the farrowing room

	Model outcome*	
Possible factors	**Low piglet RVA shedding**	**Low piglet RVC shedding**
Treatment group	X	X
Piglet RVA shed level, farrowing room		X
Piglet RVC shed level, farrowing room	X	
Duration of sow RVA shedding, prefarrow	X	
Duration of sow RVC shedding, prefarrow		X
Litter ID†	X	X

* X indicates that the possible factor in the first column was tested for significance on the model outcome in the marked column.

† All factors were tested as fixed effects except Litter ID, which was modeled as a random effect.

RVA = rotavirus A; RVC = rotavirus C; ID = identification.

Table 3: Factors tested for association with lower RVA, RVB, or RVC shedding by piglets in the nursery

	Model outcome*		
Possible factors	**Low piglet RVA shedding**	**Low piglet RVB shedding**	**Low piglet RVC shedding**
Treatment group	X	X	X
Piglet RVA shed level-nursery		X	X
Piglet RVB shed level-nursery	X		X
Piglet RVC shed level-nursery	X	X	
Duration of piglet RVA shedding in the farrowing room	X		
Duration of piglet RVC shedding in the farrowing room			X
Litter ID†	X	X	X

* X indicates that the possible factor in the first column was tested for significance on the model outcome in the marked column.

† All factors were tested as fixed effects except Litter ID, which was modeled as a random effect.

RVA = rotavirus A; RVB = rotavirus B; RVC = rotavirus C.

Table 4: RVA and RVC cycle threshold values in natural planned exposure gruel mixture at each administration in weeks prefarrowing

	RVA (NPE Gruel) Ct	RVC (NPE Gruel) Ct
NPE 1 (5 WPF)	24.42	32.55
NPE 2 (4 WPF)	22.46	29.32
NPE 3 (3 WPF)	24.15	30.30
Geometric mean	23.66	30.69

RVA = rotavirus A; RVC = rotavirus C; Ct = cycle threshold; NPE = natural planned exposure; WPF = weeks prefarrowing.

Figure 1: Progression of A) rotavirus A (RVA) and B) rotavirus C (RVC) shedding levels over time in gilts receiving 3 (group 1), 2 (group 2), 1 (group 3), or no (group 4/control) doses of natural planned exposure. Gilts farrowed at week 0. Each horizontal bar represents one gilt and shifts up or down based on cycle threshold (Ct) value (low Ct values toward the top and high to negative Ct values at the bottom). High shedding is depicted as red, while low shedding and no shedding are shown as yellow and green, respectively. Black stars indicate time points that natural planned exposure was administered.

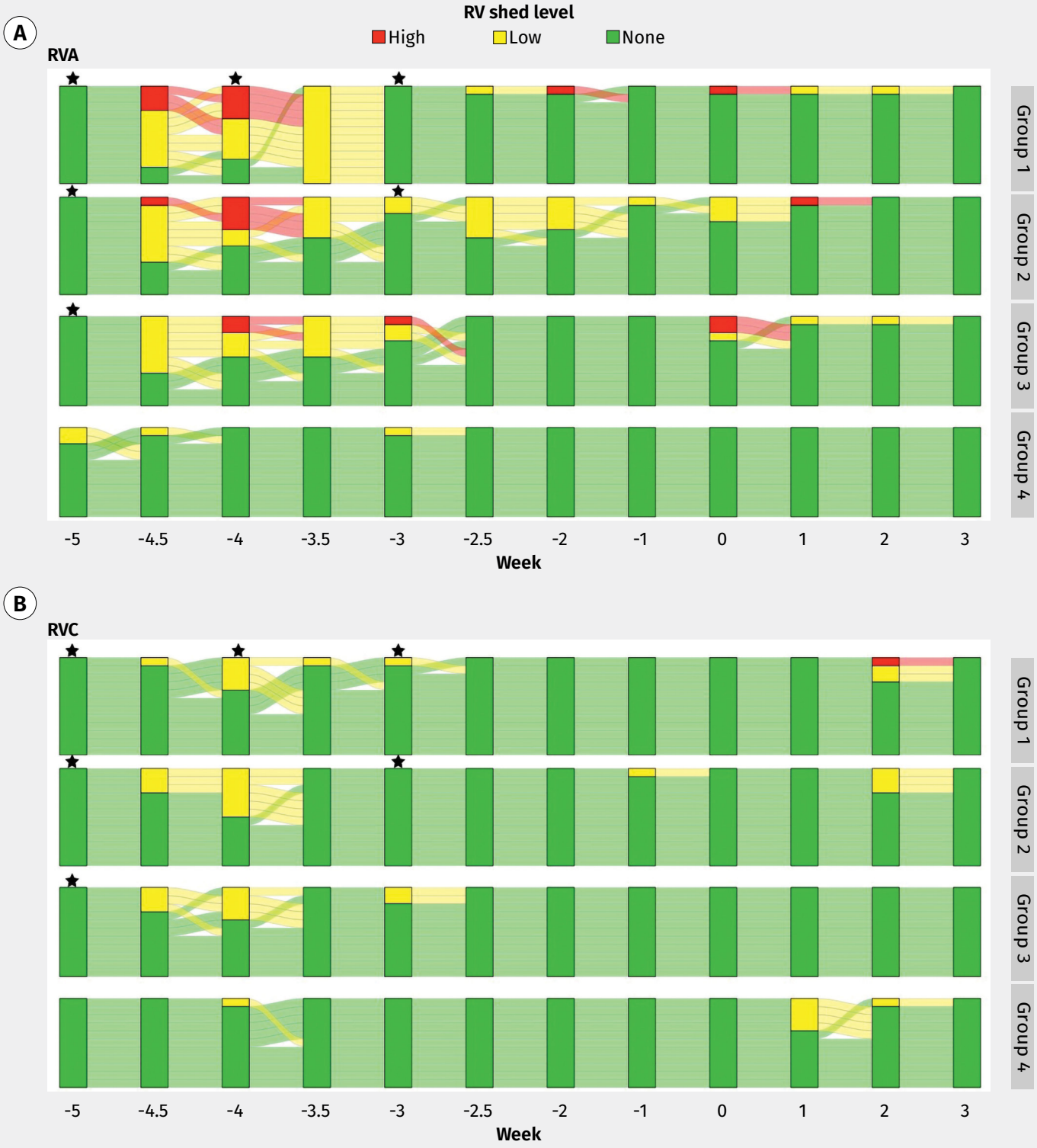


Figure 2: Progression of A) rotavirus A (RVA), B) rotavirus B (RVB), and C) rotavirus C (RVC) shedding levels over time in piglets based on quantitative real time polymerase chain reaction results on fecal samples pooled by litter. Litters were from gilts receiving 3 (group 1), 2 (group 2), 1 (group 3), or no (group 4/control) doses of natural planned exposure. Week 0 is farrowing, and week 4 is the first week in the nursery. Each horizontal bar represents one litter and shifts up or down based on cycle threshold (Ct) value (low Ct values toward the top and high to negative Ct values at the bottom). A gray bar indicates a missing sample. High shedding is depicted as red, while low shedding and no shedding are depicted as yellow and green, respectively.

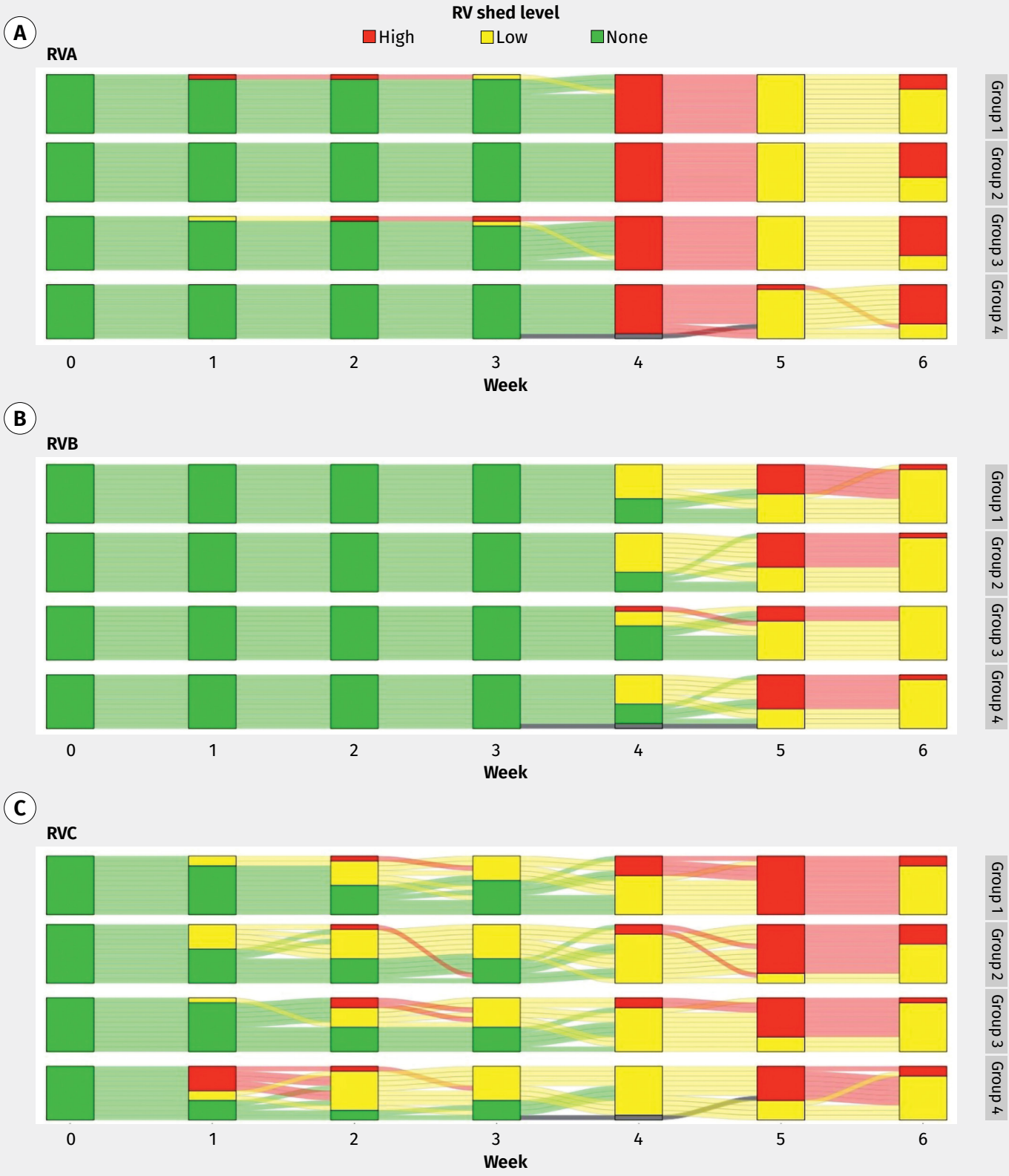


Table 5: Odds ratios and 95% confidence intervals for statistically significant ($P < .05$) fixed effects of fitted models for RVA, RVB, and RVC shedding in each treatment group

The odds of...*	Were...	For...	Compared to...	Odds ratio, 95% CI
Low RVC shedding-farrowing room	86% lower	Group 3 litters (1 dose of NPE)	Group 4 litters (no NPE)	0.14 (0.02, 0.79)
Low RVA shedding-nursery	630% higher	Litters shedding high levels of RVC in the nursery	Litters shedding low levels of RVC in the nursery	7.3 (1.55, 34.37)
Low RVB shedding-nursery	329% higher	Litters shedding high RVA levels in the nursery	Litters shedding low RVA levels in the nursery	4.29 (1.20, 15.32)
	69% lower	Litters shedding high RVC levels in the nursery	Litters shedding low RVC levels in the nursery	0.31 (0.11, 0.90)
Low RVC shedding-nursery	564% higher	Litters shedding high levels of RVA in the nursery	Litters shedding low levels of RVA in the nursery	6.64 (1.27, 34.53)
	75% higher	Each additional week of litter RVC shedding during farrowing	NA	1.75 (1.10, 2.79)

* Litters were from gilts receiving three (group 1), two (group 2), one (group 3), or no (group 4/control) doses of NPE.

RVA = rotavirus A; RVB = rotavirus B; RVC = rotavirus C; NPE = natural planned exposure; NA = not applicable.

Mixed effects logistical modeling

Since all piglet litters became positive for one or more of RVA, RVB, or RVC during the study regardless of NPE exposure group, the researchers were interested in whether lower levels of viral shedding were associated with treatment group and whether lower viral shedding was related to other factors such as the concurrent shedding of other RV species, duration of gilt shedding prior to farrowing (as a potential proxy for lactogenic immunity), or duration of piglet shedding in the farrowing room (as a potential proxy for active immunity). Treatment group was not a significant predictor in any of the models except for RVC shedding in the farrowing room (Table 5). One administration of NPE was correlated to reduced odds of lower viral shedding compared to the control group by 86%. Specifically, it was determined that high RVC shedding was more likely in pigs from groups that received at least one administration of NPE. It was not possible to draw statistically significant conclusions about the effect of NPE administration on the reduction of viral shedding in all other models. The duration of gilt shedding prior to farrowing was not statistically associated with lower shedding in the farrowing room.

In the nursery phase, viral shedding was predominantly associated with the concurrent shedding of other RV species. Shedding of RVA and RVC were inversely related to each other, and higher RVA shedding was associated with increased odds of lower RVC shedding by 564% (Table 5). High RVA shedding was also correlated with increased odds of lower RVB shedding, but the change in odds was 329%. High RVC shedding was associated with increased odds of low RVA by 630% but reduced odds of low RVB shedding by 69%. The odds of lower RVC shedding in the nursery increased by 75% for each additional week that a litter was shedding RVC in the nursery.

Discussion

There was a significant difference in weaning weights of piglets born to gilts that received 3 NPE administrations compared to fewer or no NPE administrations, which is consistent with previous reports on the impact of rotavirus in suckling pigs.[2] This suggests that 3 administrations of homologous NPE improved weight gain under the conditions of this study. This is also consistent with reports of success using NPE programs for other viruses such as transmissible gastroenteritis (TGE). In 1993, a study found that NPE for TGE virus relieved the farrowing house of all clinical signs of the disease and hypothesized that this was due to sows providing a higher level of immunity to their suckling piglets.[18] A recent article specific to RVC showed that lower IgA and IgG titers in milk were related to increased incidence of clinical diarrhea and more viral shedding in piglets.[19]

Shedding of RVA and RVB from piglets was low in the farrowing room regardless of treatment group, but RVC was observed as early as 1 week of age. The RVC prevalence suggests insufficient antibody titers generated in the gilts, which are associated with higher rates of clinical disease in piglets.[19] While RVC shedding was numerically more prevalent in the control group, the analysis did not identify treatment group as significantly associated with a reduction in viral shedding in any of the models. Infections with RVA had low prevalence and treatment did not affect RVA shedding in the farrowing room. The severity of piglet challenge was unknown for RVA. Perhaps NPE benefits may only be realized at higher burdens of environmental RV. Mixed effects logistical modeling highlighted the inverse association between RVA and RVC shedding, where low shedding of one RV was associated with high levels of the other. This contrasts with previous work that has shown RV infections are statistically associated in neonatal piglets.[20] In bovine hosts, Chang and colleagues[21] suggested infection with RVA may enhance RVC infections. Whether the observed peak RVA shedding followed by RVC shedding in

the nursery indicates a similar dynamic relationship between RV species in pigs remains to be fully elucidated.

The piglets born to treated gilts in this study were not fully protected from RV shedding. In fact, the treatment groups were not associated with a reduction of viral shedding, and all piglet litters were positive for RVA, RVB, and RVC by the end of the study. In the case of RVA, where very few infections were seen in the farrowing room, piglets may not have been sufficiently challenged by environmental RVA to induce active immunity. Passive maternal protection certainly hampers the development of active immunity in piglets, even though it is necessary for protecting piglets from preweaning viral infections.[16,17] Various RV vaccine approaches have been studied at length but seldom include the context of passive protection. Studies on porcine RVA modified live vaccines (MLVs) have demonstrated that piglets vaccinated with MLV can be protected entirely from viral shedding,[22] and that active immunity generated after RV vaccination can be heterotypic in nature.[23] Achieving similar heterotypic protection in the context of lactogenic passive immunity remains a challenge. This work nonetheless demonstrates that 3 doses of NPE prior to farrowing can have production and economic benefit to producers.

This study was conducted on a single farm, and the results should be carefully interpreted in other contexts. Additionally, the practicality and legality of this method must be carefully considered based on the location of the farm and regulations that apply. If implemented, the success of an NPE program may vary based on the farm environment, quality controls, and herd immunity. This study was conducted on a gilt-only farm, while most commercial sow farms in the United States have a multiparous organization. The farm was selected to represent the most challenging case scenario since gilts have been shown to have lower levels of IgG in their colostrum than multiparous sows.[24] The use of qRT-PCR testing means that infectivity of virus detected in feces and swabs cannot be determined. The limited knowledge on the optimal infectious dose of RVs in NPE gruel mixtures needs attention. Lastly, increased availability of serological assays may help to understand immune responses and differences in viral shedding.

Implications

Under the conditions of this study:

- Prefarrowing NPE may have production and economic benefits for producers.
- Infection with certain RVs may affect immunity and shedding of other RVs.
- On-farm NPE may be a feasible option for RV control.

Acknowledgments

The authors would like to thank Boehringer Ingelheim for their sponsorship of this project, Smithfield Hog Production for providing the animals and facilities for the trial, and the farm employees for their cooperation.

Conflict of interest

None reported.

Disclaimer

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may be specific to the research or commercial situation presented in the manuscript. It is the responsibility of the reader to use information responsibly and in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

References

1. Marthaler D, Rossow K, Gramer M, Collins J, Goyal S, Tsunemitsu H, Kuga K, Suzuki T, Ciarlet M, Matthijnssens J. Detection of substantial porcine group B rotavirus genetic diversity in the United States, resulting in a modified classification proposal for G genotypes. *Virology*. 2012;433(1):85-96. **https://doi.org/10.1016/j.virol.2012.07.006**

*2. Groth D. Clinical management of rotavirus. In: *Proceedings of the 45th AASV Annual Meeting*. American Association of Swine Veterinarians; 2014:561-562.

3. Estes MK, Greenberg HB. Rotaviruses. In: Knipe DM, Howley PM, eds. *Fields Virology*. 6th ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2013:1347-1401.

4. Hoshino Y, Saif LJ, Sereno MM, Chanock RM, Kapikian AZ. Infection immunity of piglets to either VP3 or VP7 outer capsid protein confers resistance to challenge with a virulent rotavirus bearing the corresponding antigen. *J Virol*. 1988;62(3):744-748. **https://doi.org/10.1128/JVI.62.3.744-748.1988**

5. Shepherd FK, Freeman MJ, Culhane MR, Marthaler DG. Reoviruses (Rotaviruses and Reoviruses). In: Zimmerman JJ, Karriker LA, Ramirez A, Schwartz KJ, Stevenson GW, Zhang J, eds. *Diseases of Swine*. 11th ed. Wiley-Blackwell; 2019:720-721. **https://doi.org/10.1002/9781119350927.ch43**

6. Suzuki T, Hasebe A. A provisional complete genome-based genotyping system for rotavirus species C from terrestrial mammals. *J Gen Virol*. 2017;98(11):2647-2662. **https://doi.org/10.1099/jgv.0.000953**

7. Vlasova AN, Amimo JO, Saif LJ. Porcine rotaviruses: Epidemiology, immune responses and control strategies. *Viruses*. 2017;9(3):48. **https://doi.org/10.3390/v9030048**

8. Franco MA, Angel J, Greenberg HB. Immunity and correlates of protection for rotavirus vaccines. *Vaccine*. 2006;24(15):2718-2731. **https://doi.org/10.1016/j.vaccine.2005.12.048**

*9. Robbins RC, Byers EB. What do we really know about feedback to gestating dams? In: *Proceedings of the 44th AASV Annual Meeting*. American Association of Swine Veterinarians; 2014:533-536.

10. Quesnel H, Farmer C, Devillers N. Colostrum intake: Influence on piglet performance and factors of variation. *Livest Sci*. 2012;146(2):105-114. **https://doi.org/10.1016/j.livsci.2012.03.010**

*11. Pittman JS. Field experiences with interventions for rotavirus control. In: *Proceedings of the ISU Swine Disease Conference for Swine Practitioners*. Iowa State University; 2016:30-36.

12. Phillips G, Lopman B, Tam CC, Iturriza-Gomara M, Brown D, Gray J. Diagnosing rotavirus A associated IID: Using ELISA to identify a cut-off for real time RT-PCR. *J Clin Virol*. 2009;44(3):242-245. **https://doi.org/10.1016/j.jcv.2008.12.001**

13. Bennett A, Bar-Zeev N, Jere KC, Tate JE, Parashar UD, Nakagomi O, Heyderman RS, French N, Iturriza-Gomara M, Cunliffe NA. Determination of a viral load threshold to distinguish symptomatic versus asymptomatic rotavirus infection in a high-disease-burden African population. *J Clin Microbiol*. 2015;53(6):1951-1954. **https://doi.org/10.1128/JCM.00875-15**

14. Ramirez A, Karriker LA. Herd Evaluation. In: Zimmerman JJ, Karriker LA, Ramirez A, Schwartz KJ, Stevenson GW, Zhang J, eds. *Diseases of Swine*. 11th ed. Wiley-Blackwell; 2019:3-16. **https://doi.org/10.1002/9781119350927.ch1**

15. Bates D, Mächler M, Bolker B, Walker S. Fitting linear mixed-effects models using lme4. *J Stat Soft*. 2015;67(1):1-48. **https://doi.org/10.18637/jss.v067.i01**

16. Langel SN, Paim FC, Lager KM, Vlasova AN, Saif LJ. Lactogenic immunity and vaccines for porcine epidemic diarrhea virus (PEDV): Historical and current concepts. *Virus Res*. 2016;226:93-107. **https://doi.org/10.1016/j.virusres.2016.05.016**

17. Hodgins DC, Kang SY, deArriba L, Parreño V, Ward LA, Yuan L, To T, Saif LJ. Effects of maternal antibodies on protection and development of antibody responses to human rotavirus in gnotobiotic pigs. *J Virol*. 1999;73(1):186-197. **https://doi.org/10.1128/JVI.73.1.186-197.1999**

18. Moxley RA, Olson LD, Davis AP. Experience with a planned exposure program for the control of enzootic transmissible gastroenteritis in swine. *J Am Vet Med Assoc*. 1993;202(11):1861-1864.

19. Chepngeno J, Diaz A, Paim FC, Saif LJ, Vlasova AN. Rotavirus C: Prevalence in suckling piglets and development of virus-like particles to assess the influence of maternal immunity on the disease development. *Vet Res*. 2019;50(1):84. **https://doi.org/10.1186/s13567-019-0705-4**

20. Homwong N, Diaz A, Rossow S, Ciarlet M, Marthaler D. Three-level mixed-effects logistic regression analysis reveals complex epidemiology of swine rotaviruses in diagnostic samples from North America. *PLoS One*. 2016;11(5):e0154734. **https://doi.org/10.1371/journal.pone.0154734**

21. Chang KO, Nielsen PR, Ward LA, Saif LJ. Dual infection of gnotobiotic calves with bovine strains of group A and porcine-like group C rotaviruses influences pathogenesis of the group C rotavirus. *J Virol*. 1999;73(11):9284-9293. **https://doi.org/10.1128/JVI.73.11.9284-9293.1999**

22. Welter MW, Welter CJ. Evaluation of killed and modified live porcine rotavirus vaccines in cesarean derived colostrum deprived pigs. *Vet Microbiol*. 1990;22(2-3):179-186. **https://doi.org/10.1016/0378-1135(90)90105-5**

23. Jiang B, Wang Y, Glass RI. Does a monovalent inactivated human rotavirus vaccine induce heterotypic immunity? Evidence from animal studies. *Hum Vaccin Immunother*. 2013;9(8):1634-1637. **https://doi.org/10.4161/hv.24958**

24. Nuntapaitoon M, Suwimonteerabutr J, Am-In N, Tienthai P, Cheusiri P, Kedkovid R, Tummaruk P. Impact of parity and housing conditions on concentration of immunoglobulin G in sow colostrum. *Trop Anim Health Prod*. 2019;51(5):1239-1246. **https://doi.org/10.1007/s11250-019-01816-2**

*Non-refereed references.

ORIGINAL RESEARCH PEER REVIEWED

Water use patterns within each day: Variation between batches of growing pigs in commercial production systems

Stephen B. Little, BVSc; Andrew P. Woodward, BVSc, PhD, DACVCP; Glenn F. Browning, BVSc, PhD; Helen Billman-Jacobe, PhD

Summary

Objective: To measure, describe, and compare the water use patterns within each day for multiple cohorts of weaner, grower, and finisher pigs in farm buildings.

Materials and methods: Prospective, observational cohort studies of the water use patterns within each day were conducted in 5 pig buildings using either a turbine or ultrasonic water flow meter attached to the main water pipe entering each building. Water use data were collected from multiple batches of pigs (second-stage weaners over eleven, 48-day periods and grower-finishers over 4 periods of 21-43 days). Semi-parametric models of pig water use patterns within each day were estimated using the brms software package in R. To estimate the interacting effects of time and pig body weight on water use by pigs, we used tensor product smooths for time and pig body weight.

Results: The water use pattern within each day varied between the cohorts, and the pattern of many cohorts changed as the pigs gained weight. Some patterns were unimodal and others were bimodal, with the main peak in water use occurring early afternoon to late afternoon.

Implications: Water use patterns of pigs within each day varied between and within cohorts. The water use pattern of one cohort cannot be used reliably to predict that of other cohorts, even if they are reared in the same building. Water use pattern data may be valuable for optimizing in-water antimicrobial dosing regimens.

Keywords: swine, drinking water, water flow, semi-parametric models, water medication

Received: December 20, 2021
Accepted: May 25, 2022

Resumen - Patrones de uso de agua en el mismo día: variación entre lotes de cerdos de crecimiento en sistemas de producción comercial

Objetivo: Medir, describir, y comparar los patrones de uso de agua en el mismo día para múltiples cohortes de cerdos destetados, en crecimiento, y finalización en edificios de una granja.

Materiales y métodos: Se realizaron estudios de cohortes observacionales prospectivos de los patrones de uso de agua en el mismo día en 5 granjas porcinas utilizando una turbina o un medidor de flujo de agua ultrasónico conectados a la tubería de agua principal que ingresa a cada edificio. Los datos de uso de agua se recopilaron de múltiples lotes de cerdos (destetados de segunda etapa durante once períodos de 48 días y cerdos de engorde durante 4 períodos de 21 a 43 días). Se estimaron modelos semiparamétricos de patrones de uso de agua por cerdo dentro de cada día utilizando el paquete del programa brms en R. Para estimar los efectos interactivos del tiempo y el peso corporal del cerdo en el uso del agua por parte de los cerdos, utilizamos productos tensoriales suavizados para el tiempo y el peso corporal del cerdo.

Resultados: El patrón de uso de agua dentro de cada día varió entre las cohortes y el patrón de muchos cohortes cambió a medida que los cerdos aumentaban de peso. Algunos patrones fueron unimodales y otros bimodales y el pico principal en el uso de agua se produjo desde la primera hora de la tarde hasta la final tarde.

Implicaciones: Los patrones de uso de agua de los cerdos dentro de cada día variaron entre y dentro de las cohortes. El patrón de uso del agua de una cohorte no se puede usar de manera confiable para predecir el de otros cohortes, incluso si se crían en el mismo edificio. Los datos del patrón de uso del agua pueden ser valiosos para optimizar los regímenes de dosificación de antimicrobianos en el agua.

SBL, GFB, HB-J: Asia Pacific Centre for Animal Health, Melbourne Veterinary School, Department of Veterinary Biosciences, University of Melbourne, Parkville, Victoria, Australia; and National Centre for Antimicrobial Stewardship, Peter Doherty Institute, Grattan St, Carlton, Victoria, Australia.

APW: Melbourne Veterinary School, University of Melbourne, Parkville, Victoria, Australia.

Corresponding author: Dr Stephen B. Little, Asia Pacific Centre for Animal Health, Department of Veterinary Biosciences, Melbourne Veterinary School, Faculty of Veterinary and Agricultural Sciences, University of Melbourne, Parkville, Victoria, 3010, Australia; Email: **stevel@unimelb.edu.au**.

This article was derived from Stephen Little's PhD thesis, University of Melbourne, Parkville, Victoria, Australia.

Supplementary materials available at **https://doi.org/10.54846/jshap/1297suppl**.

Little SB, Woodward AP, Browning GF, Billman-Jocobe H. Water use patterns within each day: Variation between batches of growing pigs in commercial production systems. *J Swine Health Prod*. 2023;31(1):20-28. **https://doi.org/10.54846/jshap/1297**.

Résumé - Modèles d'utilisation de l'eau au cours de chaque journée: variation entre les lots de porcs en croissance dans les systèmes de production commerciale

Objectif: Mesurer, décrire et comparer les patrons d'utilisation de l'eau au cours de chaque journée pour plusieurs cohortes de porcs sevrés, en croissance et en finition dans les bâtiments de la ferme.

Matériels et méthodes: Des études de cohorte prospectives et observationnelles des patrons d'utilisation de l'eau au cours de chaque journée ont été menées dans cinq porcheries à l'aide d'un débitmètre à turbine ou à ultrasons fixé à la conduite d'eau principale entrant dans chaque bâtiment. Les données sur l'utilisation de l'eau ont été recueillies auprès de plusieurs lots de porcs (les porcs sevrés au deuxième stade sur onze périodes de 48 jours et les porcs en croissance-finition sur quatre périodes de 21 à 43 jours). Des modèles semi-paramétriques des patrons d'utilisation de l'eau par les porcs au cours de chaque journée ont été estimés à l'aide du progiciel brms dans R. Pour estimer les effets interactifs du temps et du poids corporel des porcs sur l'utilisation d'eau par les porcs, nous avons utilisé des lissages de produits tensoriels pour le temps et le poids corporel des porcs.

Résultats: Le patron d'utilisation de l'eau au cours de chaque journée variait entre les cohortes, et le patron de nombreuses cohortes changeait à mesure que les porcs prenaient du poids. Certains patrons étaient unimodaux et d'autres étaient bimodaux, le principal pic d'utilisation de l'eau se produisant du début de l'après-midi au la fin de l'après-midi.

Implications: Les patrons d'utilisation de l'eau des porcs au cours de chaque journée variaient entre les cohortes et au sein de celles-ci. Le patron d'utilisation de l'eau d'une cohorte ne peut pas être utilisé de manière fiable pour prédire celui des autres cohortes, même si elles sont élevées dans le même bâtiment. Les données sur les patrons d'utilisation de l'eau peuvent être utiles pour optimiser les schémas posologiques d'antimicrobiens dans l'eau.

Growing pigs use 60% to 65% of the total volume of water consumed by the pig industry.[1] Water is an essential resource on pig farms and approximately 80% of total farm water use is for animal drinking, with the remaining 20% used for animal cooling and facility cleaning.[1] Pigs must maintain a balance between bodily water intake and output. Most (> 75%) of the total daily bodily water intake of a pig is water consumed by drinking.[2] Daily voluntary water use by pigs, ie, water consumed and wasted, is a function of their body weight (BW). This has been measured with various combinations of drinker types, heights, and water flow rates, and averages between 60 and 117 mL/kg BW across studies.[3-5] Water use by pigs is influenced by the time of day. Pigs drink mostly during daylight hours, with their bouts of drinking occurring within 1 to 2 hours of meals.[6-8] The peak period of water use occurs in the afternoon, sometimes with a secondary peak in the morning.[9-17]

Published studies that report the water use patterns of pigs within each day have varied widely in cohort sizes and study duration. Some studies have used water flow meters to describe water use patterns volumetrically, while others have used video recordings to describe water use patterns in terms of the time pigs spend drinking. The statistical methods used to analyze water consumption have not evaluated the dependence of water use by pigs in a given hour on their water use in previous hours (autocorrelation),[18] and changes in water use patterns within each day over successive days as BW increases have not been studied. This study aimed to describe and compare the water use patterns within each day for multiple cohorts of second-stage weaners (many of which were reared in the same building) and of grower and finisher pigs in 2 buildings. The objectives were to 1) assess the extent of variation in the water use pattern within each day across the cohorts, including those reared in the same building; 2) assess the extent to which the water use pattern within each day for each cohort changed as pigs gained weight; and 3) determine whether the water use pattern within each day for a cohort of pigs could be used reliably to predict the patterns of future pig cohorts in the same building or a building of similar design. The water use pattern within each day for a cohort of pigs has implications for in-water administration of antimicrobials and other additives, as it has a substantial impact on water flow rates in each pipe section of the building's water distribution system from hour-to-hour and therefore, on the time course of antimicrobial concentration in water available to pigs at drinkers in each pen. The water use pattern also affects the volume of medicated water consumed by pigs throughout the building hour-to-hour after the antimicrobial first arrives at the drinkers to which they have access.[19]

Animal care and use

An animal use protocol was not necessary for this study as no animals were involved. Water flow data were collected from meters installed in the main water pipe entering each building. Pigs within each building were reared according to routine commercial farm practices in compliance with the standards prescribed by the Australian Pork Industry Quality Assurance Program.

Materials and methods

Data collection

Three studies of pig water use were conducted in commercial production environments on 3 farms located in southeastern Australia. Study 1 was conducted in second-stage weaner buildings A1, A2, and A3 on farm 1. These 3 buildings were identical in their dimensions and configuration (Table 1). Studies 2 and 3 were conducted in grower-finisher buildings B and C on farm 2 and farm 3, respectively. The mean age and approximate BW of each pig cohort upon entry to and exit from a building are provided in Table 1. The BW values were estimates from the generalized pig growth curve used by each farm. Pigs were fed *ad libitum* with a pelleted ration formulated to meet the nutritional requirements of weaner pigs and grower-finisher pigs as specified by the National Research Council (2012).[20] No health challenges were reported by farm staff during the measurement periods. For Study 1, water flow was continuously measured using a turbine water flow meter (Zenner GmbH) installed in the main water pipe entering each building. For Studies 2 and 3, water flow was measured using a clamp-on, doppler-type ultrasonic water flow meter with two transducers (Flexim Fluxus F601;

Table 1: Description of pigs and buildings in studies 1, 2, and 3

	Study 1	Study 2	Study 3
Farm	1	2	3
Building	A1, A2, and A3	B	C
Ventilation & lighting	Controlled	Natural	Natural
Temp, °C	27-18*	Min: 5-13† Max: 18-31†	Min: 3-5† Max: 14-15†
Daylight/d, hrs	18*	10-13†	9.5-11†
Feeders	Wet/dry feeders	Wet/dry feeders	Wet/dry feeders
Floor	Mesh, fully slatted	Concrete, partially slatted	Concrete, partially slatted
Cohorts	11	1	1
Pigs/cohort	2150	2116	2768
Sex	Male and female	Male and female	Male and female
BW at entry, kg‡	8.5	23	29
Entry age, d	35	63	72
BW at exit, kg‡	28	97	70
Exit age, d	82	161	127
Occupancy period, d	48	99	55
Pig flow	All-in, all-out	All-in, all-out	All-in, all-out
Pipe material§	Polyethylene	PVC	PVC
Pipe interior diameter, mm§	40	50	50
Drinker type	Bowl¶	Nipple (in wet/dry feeder)	Nipple¶
Pigs/drinker	15	7	7
Main water source	Underground water	50% underground water and 50% surface water	Town water
Water use measurement periods, d	48	43 (grower phase); 34 (finisher phase)	22 (grower phase); 21 (finisher phase)
Study period	Jul 2020-Mar 2021	Feb-May 2021	Jun-Aug 2021

* Set internal building temperature and lighting program.

† Based on local weather station data.

‡ Estimated bodyweight from the generalized pig growth curve used by each farm.

§ At entry to building where water meter installed.

¶ Drinkers in addition to nipple drinkers within wet/dry feeders.

BW = body weight; PVC = polyvinyl chloride.

Flexim GmbH). Volumetric flow rate data (recorded in increments of 2 minutes using the Zenner water meter and 1 minute using the Flexim Fluxus F601) for each measurement period were exported from each flow meter as a .csv file and summed in Microsoft Excel (Microsoft Corporation) to calculate water use per hour per day over the measurement period. The 1 and 2 minute observations of water flow rate were aggregated into 1 hour periods as described by Madsen and Kristensen.[9]

Estimation of models for cohort water use patterns

Models of pig water use patterns within each day were estimated using the software package brms,[21] which provides an interface to fit Bayesian generalized (non)linear multivariate multilevel models in R,[22] using the probabilistic programming language Stan.[23] The Bayesian inference method was used because it has some advantages over frequentist methods: a hierarchical structure that offered greater flexibility with the ability to readily use datasets of varying sizes and to specify and analyze complex hierarchical models, and a more coherent expression of uncertainty. As it employed a hierarchical generalized additive model (HGAM),[24] brms incorporated the dependence of pig water use in a given hour on their water use in previous hours and identified changes in water use patterns within each day over successive days as pigs gained weight.

Tensor product smooths for time and pig BW were used to estimate the interacting effects of time and pig BW on pig water use.[24] The effective sample sizes were evaluated and increased as necessary and the 'adapt_delta' argument altered to ensure that divergent transitions did not occur. For each model run in brms, for each smooth term, and group and population-level effects, chain convergence was assessed with the Rhat statistic and a value of 1.00 achieved, indicating that the chains had converged to a common distribution.[25] The final version of code used to fit the models in brms in R was:

```
R > Model <- brm(WATERPPIG_
L|cens(CENS)~1+s(TIME,DAY,
bs = 'fs')+t2(TIME,PIGWT), family =
Gamma(link = 'log'), data = (dataset),
cores = 4, iter = 4000, control = list(adapt_
delta = 0.99, max_treedepth = 12))
```

where s(TIME) is the population effect of time of day on water usage, s(TIME,DAY, bs = 'fs') is the day-level variation in the shape of water usage with time of day, and t2(TIME,PIGWT) is the population effect of both time of day and average BW on water usage. In the model, s(TIME) acted as a global smoother, whereas s(TIME,DAY) acted as a random smoother for each day. DAY was specified as a factor. We selected a gamma response probability distribution, as used in modeling human tap water use.[26] A cyclic spline function in R was not used to force alignment of each model's predictions at the end and start of the day.

In post processing, we obtained the following from each model: 1) a single common smooth for all observations by pig BW; 2) a single common smooth for all observations by time of day; 3) smooths specific to pigs on each day within the period reared in the building; and 4) smooths specific to pigs at 3 points in time (expressed as BW) as they gained weight during the measurement period (these BWs equated to the 25th, 50th, and 75th percentiles of the range from entry BW to exit BW based on the farm's generalized pig growth curve). Visualization of the tensor product smooths showing the interacting effects of time of day and BW on water use provided the most insights into the water use pattern within each day for the cohorts studied. As a measure of model fit, the mean posterior distribution of the R^2 value of each model was estimated using bayes_R2 in R.[27]

Results

Second-stage weaners on farm 1

Eleven cohorts of second-stage weaners (35-82 days of age) were studied in buildings A1, A2, and A3. In 9 cohorts, the water use pattern within each day was bimodal (Figure 1 A1-2, A1-3, A2-1, A2-2, A2-3, A2-4, A2-5, A3-1, and A3-3) and the pattern of 2 cohorts were unimodal (Figure 1 A1-1 and A3-2). In building A1, one cohort had a unimodal pattern while the next cohort in the building had a bimodal pattern (Figure 1 A1-1 and A1-2). In the 9 cohorts with a bimodal pattern, the first peak varied from distinct to barely distinguishable and peak water use occurred at approximately 06:00 to 08:00 and 17:00 to 18:00. In the 2 cohorts with a unimodal water use pattern, peak water use occurred at approximately 15:00 to 18:00. The bimodality increased over each cohort's 48-day occupancy period, as pigs gained weight. The afternoon peak shifted 1 to 2 hours earlier in 5 cohorts, 2 to 3 hours later in 3 cohorts, and did not shift in 3 cohorts.

Grower-finishers on farms 2 and 3

In the cohorts of grower-finisher pigs (9-21 weeks of age) in buildings on 2 farms, the water use pattern within each day was unimodal. In the cohort in building B on farm 2, peak water use occurred at approximately 13:00 to 15:00 in both grower and finisher phases (Figure 2 B-1 and B-2). This contrasted with the cohort of grower-finisher pigs in building C on farm 3, in which peak water use occurred at approximately 16:00 to 17:00 in the grower phase and shifted 2 to 3 hours earlier in the finisher phase to approximately 13:00 to 15:00 (Figure 2 C-1 and C-2). Peak water use in the grower-finisher cohorts in buildings B and C spanned shorter periods than those of the afternoon peak in the weaner cohorts on farm 1.

Discussion

The main findings from the study were that 1) the water use pattern within each day of the pig cohorts varied and the pattern of many cohorts changed as the pigs gained weight; 2) some patterns were unimodal and others were bimodal, with the main peak in water use occurring in the early afternoon to late afternoon; and 3) the water use pattern within each day of a pig cohort can therefore not be used reliably to predict the patterns of other cohorts, even if they are reared in the same building.

Our finding that the water use pattern of pigs within each day varied between and within cohorts is consistent with studies of feed consumption patterns within each day.[28] Nearly all the cohorts with a bimodal pattern had an alternans pattern, with a large peak in the afternoon and a smaller peak in the morning that varied in prominence. As with the bimodal feed consumption patterns within each day in cohorts of growing pigs fed *ad libitum*,[29] the alternans, bimodal water use patterns within each day that we identified tended to become more pronounced over successive days as pigs gained weight.

Differences in the water use pattern within each day for pig cohorts across buildings and seasons of the year may be due to differences in factors that influence many behavioral patterns in pigs. These factors include pig genetics and

Figure 1: Smooths showing the interacting effects of time of day and bodyweight (BW) on the water use of pigs within each day over eleven, 48-day water use measurement periods in buildings A1, A2, and A3 on farm 1 between July 2020 and March 2021. Three consecutive cohorts were reared in building A1 (A1-1, A1-2, and A1-3). Five consecutive cohorts were reared in building A2 (A2-1, A2-2, A2-3, A2-4, and A2-5). Three cohort groups were reared in building A3 (A3-1, A3-2, and A3-3). The smooths are specific to pigs at 3 points in time (expressed as BW) as they gained weight during the measurement period. In each smooth, the band edges represent the limits of a 95% credible interval. The random effect of DAY is set to zero. Means of the posterior distributions of the R^2 values for the eleven models were: 0.66-0.87; 2.5th credible limit: 0.6-0.91; 97.5th credible limit: 0.67-0.93.

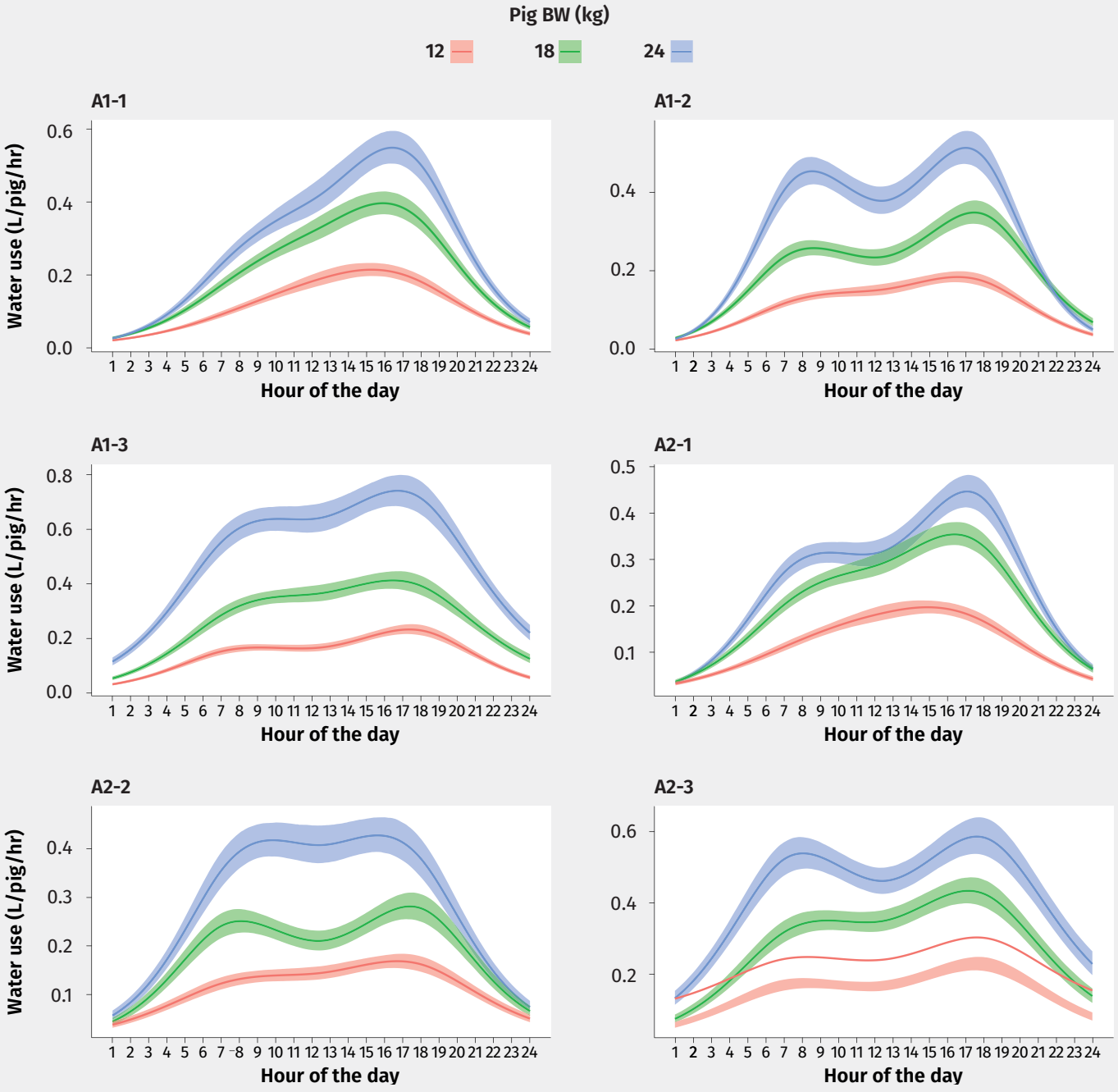


Figure 1: Continued

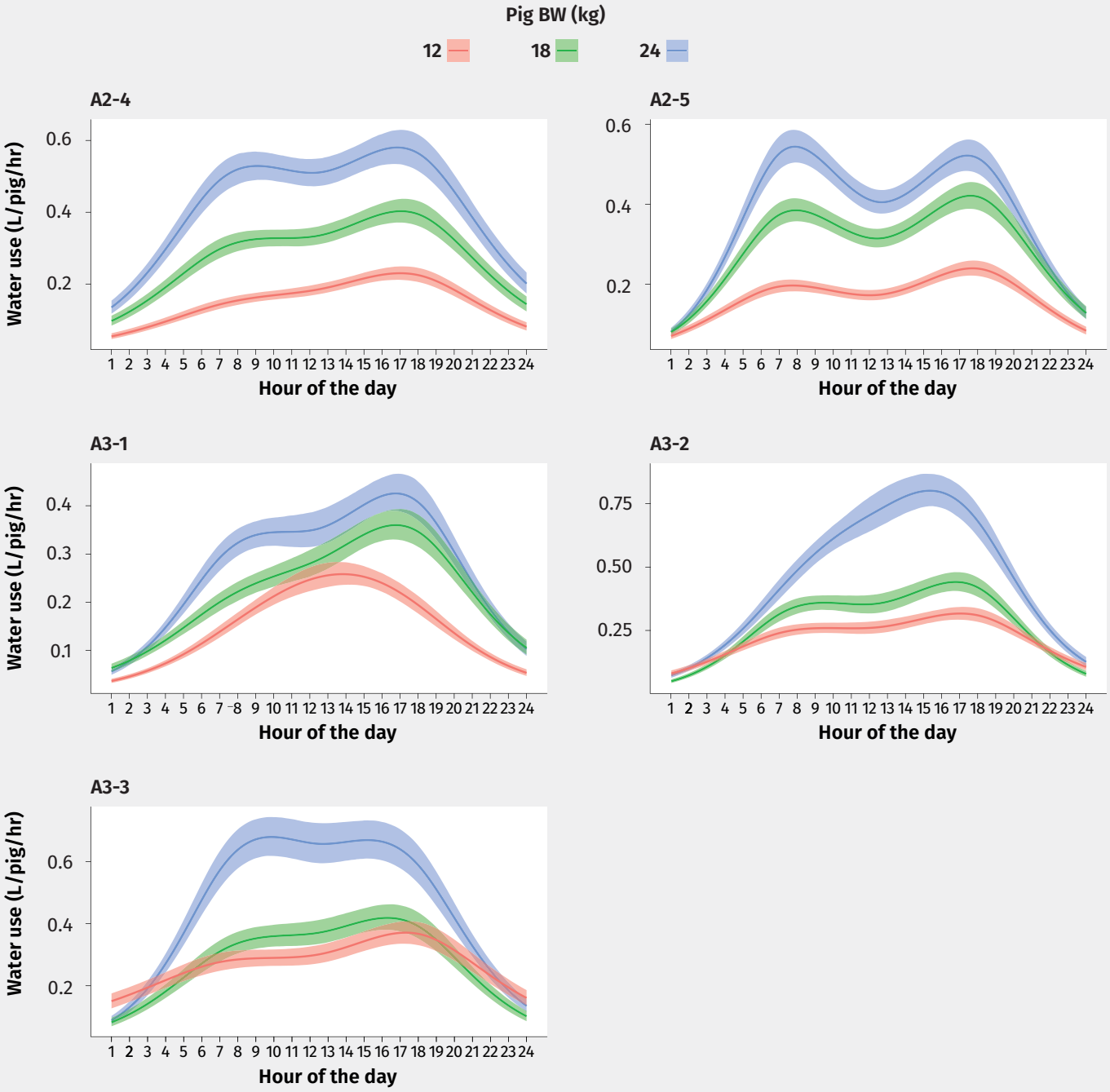
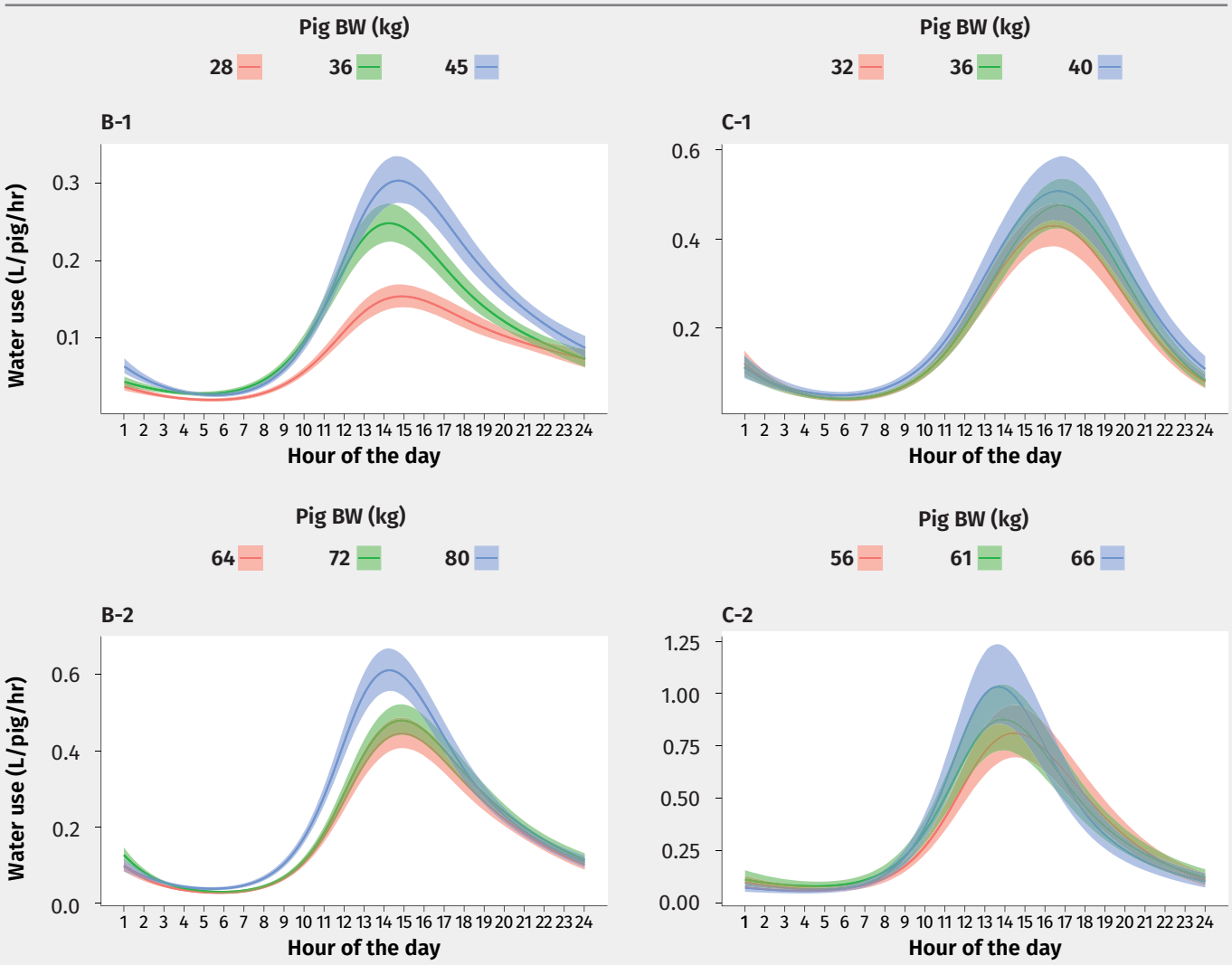


Figure 2: Smooths showing the interacting effects of time of day and bodyweight (BW) on the water use of pigs within each day in 2 cohorts of grower-finisher pigs in buildings on 2 farms in February to May 2021 and June to August 2021, respectively. B-1 and C-1) Smooths for the 2 cohorts in the grower phase. B-2 and C-2) Smooths for the same 2 cohorts in the finisher phase. The smooths are specific to pigs at 3 points in time (expressed as BW) as they gained weight during the measurement period. In each smooth, the band edges indicate the limits of a 95% credible interval. The random effect of DAY is set to zero. Means of the posterior distributions of the R^2 values for the four models were: 0.76-0.85; 2.5th credible limit: 0.74-0.84; 97.5th credible limit: 0.77-0.86.



health status, building type, group size and stocking density, drinker type, number and position of drinkers in each pen, water flow rates from drinkers, water quality, diet, level of competition between animals for water and feed access, type and spatial arrangement of drinkers and feeders within each pen, day length, and climatic conditions.[7,13] Many of these variables were well controlled in the weaner buildings where water use patterns within each day were measured for consecutive pig cohorts reared in the same building or buildings of identical design. While the 2 cohorts of grower-finisher pigs shared the same genetics, they differed in other factors influencing behavioral patterns. Factors not controlled across cohorts were health status and social factors that may affect competition between animals for water.

Installing a system in each farm building that continuously measures the daily water use of each growing pig cohort would be a valuable tool to the consulting veterinarian and herd manager by providing easily interpretable visual representations of water use patterns within each day over the preceding 7 days. It would enable regular checks to confirm that pigs were able to drink to satiety without restriction in the hour of peak water use. This would involve measuring flow rates from drinkers throughout the building to ensure they remain within the recommended range (0.25-0.5 L/min for weaner pigs and 0.5-1 L/min for grower-finisher pigs).[30] It would also be important to confirm the number of pigs per drinker in each pen was not above the recommended maximum. Historical data on pig water use patterns within each day may also be useful in designing a water distribution system for a new building or planning improvements to improve hydraulic performance of a water distribution system in an existing building.

Such a visual display system would also enable veterinarians and herd managers to optimize in-water dosing regimens for administering antimicrobials and other additives. By commencing an antimicrobial dosing event when pig water use is in an ascent phase and approaching a peak, the proportion of the total dose consumed throughout the building in the first 3 hours after the antimicrobial arrives at the drinkers could be maximized. Likewise, between-animal variation in the dose consumed by pigs accessing drinkers at different points along the water distribution system could be minimized. This would likely lead to a more rapid rise in antimicrobial concentration in plasma and at the site of infection in a high proportion of the pigs dosed, and earlier attainment of the pharmacokinetic-pharmacodynamic target that best predicts antimicrobial efficacy.[31,32] This should also help suppress emergent antimicrobial resistance by minimizing the length of time that the plasma antimicrobial concentration lies in the mutant selection window just above the minimum inhibitory concentration.[33,34] Using water use patterns within each day to design dosing regimens would also be valuable when administering other additives for which the degree of efficacy is dose dependant including vaccines, parasiticides, direct-fed microbials, and potential new therapeutic products such as bacteriophages.

The water use of pigs may be measured at a building level using either a turbine flow meter, electromagnetic flow meter, or ultrasonic flow meter attached to the main water pipe entering the building. Factors to consider when determining whether a particular water meter type and model is suitable for use on farm include the water flow range, level of accuracy and repeatability, sensitivity to poor water quality, ease of installation, portability, reliability, longevity, and cost. Characteristics of 3 types of water flow meters are provided in the supplementary materials. The water distribution systems in many conventional pig buildings (such as building B on farm 2) are over-sized relative to their typical peaking factor, ie, maximum daily use rate divided by the mean daily use rate.[35] As a consequence, water flow rates and velocities through main pipe sections in these water distribution systems tend to be very low over many hours each day. Water meters used in such buildings to measure water use patterns within each day must therefore be highly accurate at very low water velocities. For this study we chose to use a higher-end model of ultrasonic water meter that specified a minimum measurable flow velocity (0.01 m/s, with 1% variable error and 0.005 m/s fixed error). Other ultrasonic flow meter features found to be of value were its noninvasive installation (no pipe cutting was necessary), portability, ability to cope with particulate material in pipes, robustness due to absence of any moving parts, protection from rodent damage with stainless steel transducer cables, a protective, hard-shell carry case, ability to report water flow in either direction in a looped pipeline, and ability to reliably and quickly export data from the transmitter unit directly to a personal computer with a USB cable (ie, without relying on Bluetooth or Wi-Fi).

This is the first study of its kind and should be considered a first step in gaining a thorough understanding of the water use patterns of pigs within each day. Further studies are required to better understand the extent to which water use patterns of pig cohorts vary and the factors that influence pig water use patterns within each day, such as internal building temperature and humidity levels and patterns within each day. A limitation of this study was that water use was only measured at the building level and did not quantify the variation in water use at the pen or individual animal level. Furthermore, this study did not distinguish between the two components of pig water use, namely water consumed and water wasted.

Implications

Under the conditions of this study:

- Water use patterns within each day varied between and within cohorts of pigs.
- The water use pattern of one cohort cannot be used to predict those of others.
- Water use pattern data may be useful to optimize in-water antimicrobial dosing.

Acknowledgments

The authors wish to thank Rivalea Australia and SunPork Farms for their assistance with data collection for this study. This research was supported by a National Health and Medical Research Council Centre for Research Excellence grant for the National Centre for Antimicrobial Stewardship (grant No. 1079625). Little was the recipient of a Faculty of Veterinary and Agricultural Sciences Post-Graduate Research Scholarship from The University of Melbourne.

Conflict of interest

None reported.

Disclaimer

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may be specific to the research or commercial situation presented in the manuscript. It is the

responsibility of the reader to use information responsibly and in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

References

*1. Muhlbauer RV, Moody LB, Burns RT, Harmon J, Stalder K. Water consumption and conservation techniques currently available for swine production. In: *Proc of Allen D Leman Swine Conf.* University of Minnesota; 2011:165-196. **https://hdl.handle.net/11299/140901**

2. Brooks PH, Carpenter JL. The water requirement of growing-finishing pigs - theoretical and practical considerations. In: Haresign W, Cole DJA, eds. *Recent Advances in Animal Nutrition*. Butterworths; 1990:115-136. **https://doi.org/10.1016/B978-0-408-04150-8.50013-X**

3. Brooks PH. Water-Forgotten nutrient and novel delivery system. In: Lyons TP, Jacques KA, eds. *Biotechnology in the Feed Industry*. Nottingham Press; 1994:211-234.

4. Harvey RE. Water consumption. *Pig J.* 1994;32:95-98.

5. Li YZ, Chénard L, Lemay SP, Gonyou HW. Water intake and wastage at nipple drinkers by growing-finishing pigs. *J Anim Sci.* 2005;83:1413-1422. **https://doi.org/10.2527/2005.8361413x**

6. Bigelow JA, Houpt TR. Feeding and drinking patterns in young pigs. *Physiol Behav.* 1988;43:99-109. **https://doi.org/10.1016/0031-9384(88)90104-7**

7. Riis TL. *The dynamic relationship between water and feed intake in slaughter pigs.* Thesis. Royal Veterinary and Agricultural University; 2003.

8. Soraci AL, Amanto F, Tapia MO, de la Torre E, Toutain P-L. Exposure variability of fosfomycin administered to pigs in food or water: Impact of social rank. *Res Vet Sci*. 2014;96:153-159. **https://doi.org/10.1016/j.rvsc.2013.12.003**

9. Madsen TN, Kristensen AR. A model for monitoring the condition of young pigs by their drinking behaviour. *Comput Electron Agric*. 2005;48:138-154. **https://doi.org/10.1016/j.compag.2005.02.014**

10. Turner SP, Edwards SA, Bland VC. The influence of drinker allocation and group size on the drinking behaviour, welfare and production of growing pigs. *Anim Sci*. 1999;68:617-624. **https://doi.org/10.1017/S1357729800050645**

11. Turner SP, Sinclair AG, Edwards SA. The interaction of liveweight and the degree of competition on drinking behaviour in growing pigs at different group sizes. *Appl Anim Behav Sci*. 2000;67:321-334. **https://doi.org/10.1016/S0168-1591(00)00084-8**

*12. Brumm MC. Patterns of drinking water use in pork production facilities. *Nebraska Swine Reports*. 2006;221:10-14. **https://digitalcommons.unl.edu/coopext_swine/221**

13. Villagrá A, Althaus RL, Lainez M, Martinez AB, Torres AG. Modelling of daily rhythms of behavioural patterns in growing pigs on two commercial farms. *Biol Rhythm Res.* 2007;38:347-354. **http://doi.org/10.1080/09291010600950131**

14. Rousseliere Y, Hemonic A, Marcon M. Individual monitoring of the drinking behavior of weaned piglets. *Journées de la Recherche Porcine en France*. 2016;48:355-356.

15. Chimainski M, Speroni Ceron M, Kuhn MF, de Costa Mendes Muniz H, Tombesi de Rocha L, Pacheco PS, de Mello Kessler A, de Oliveira V. Water disappearance dynamics in growing-finishing pig production. *Rev Bras Zootec.* 2019;48:e20180258. **https://doi.org/10.1590/rbz4820180258**

16. da Costa Mendes Muniz H, Klein DR, da Silva dos Santos M, Schneider LI, Speroni Ceron M, Rodrigues Bonet de Quadros A, Gewehr CE, de Oliveira V. Water intake and wastage during the growing–finishing period of immunocastrated and surgically castrated pigs. *Anim Prod Sci.* 2021;61:1385-1392. **https://doi.org/10.1071/AN21135**

17. Misra S, Bokkers EAM, Upton J, Quinn AJ, O'Driscoll K. Effect of environmental enrichment and group size on the water use and waste in grower-finisher pigs. *Sci Rep.* 2021;11:16380. **https://doi.org/10.1038/s41598-021-95880-0**

18. Ward MP, Iglesias RM, Brookes VJ. Autoregressive models applied to time-series data in veterinary science. *Front Vet Sci.* 2020;7:604. **https://doi.org/10.3389/fvets.2020.00604**

19. Little S, Woodward A, Browning G, Billman-Jacobe H. Effect of drinking water distribution system design on antimicrobial delivery to pigs. *Animals*. 2021;11:2632. **https://doi.org/10.3390/ani11082362**

20. National Research Council. *Nutrient Requirements of Swine*. 11th ed. National Academies Press; 2012. **https://doi.org/10.17226/13298**

21. Bürkner P-C. brms: An R package for Bayesian multilevel models using Stan. *J Stat Softw*. 2017;80:1-28. **https://doi.org/10.18637/jss.v080.i01**

*22. R Core Team. R: A language and environment for statistical computing [computer program]. Version 1.4.1106. Vienna, Austria: R Foundation for Statistical Computing; 2021. **https://www.r-project.org**

23. Chatzilena A, van Leeuwen E, Ratmann O, Baguelin M, Demiris N. Contemporary statistical inference for infectious disease models using Stan. *Epidemics*. 2019;29:100367. **https://doi.org/10.1016/j.epidem.2019.100367**

24. Pedersen EJ, Miller DL, Simpson GL, Ross N. Hierarchical generalized additive models in ecology: An introduction with mgcv. *PeerJ.* 2019;7:e6876. **https://doi.org/10.7717/peerj.6876**

25. Vehtari A, Gelman A, Simpson D, Carpenter B, Bürkner P-C. Rank-normalization, folding, and localization: An improved R for assessing convergence of MCMC (with discussion). *Bayesian Anal.* 2021;16:667-718. **https://doi.org/10.1214/20-BA1221**

*26. US Environmental Protection Agency. Ingestion of water and other select liquids. In: *Exposure Factors Handbook (Update)*. US EPA Office of Research and Development; 2019.

27. Gelman A, Goodrich B, Gabry J, Vehtari A. R-squared for Bayesian regression models. *Am Stat*. 2019;73:307-309. **https://doi.org/10.1080/00031305.2018.1549100**

28. Bus JD, Boumans IJMM, Webb LE, Bokkers EAM. The potential of feeding patterns to assess generic welfare in growing-finishing pigs. *Appl Anim Behav Sci*. 2021;241:105383. **https://doi.org/10.1016/j.applanim.2021.105383**

29. Boumans I. *Simulating pigs - Understanding their motivations, behaviour, welfare and productivity*. Thesis. Wageningen University & Research; 2017.

*30. Brumm MC. Understanding feeders and drinkers for grow-finish pigs. In: Memorias del X Congreso Nacional de Producción Porcina; 2010:27-37.

31. Little S, Woodward A, Browning G, Billman-Jacobe H. In-water antibiotic dosing practices on pig farms. *Antibiotics*. 2021;10:169. **https://doi.org/10.3390/antibiotics10020169**

32. Little SB, Crabb HK, Woodward AP, Browning GF, Billman-Jacobe H. Review: Water medication of growing pigs: Sources of between-animal variability in systemic exposure to antimicrobials. *Animal*. 2019;13:3031-3040. **https://doi.org/10.1017/S1751731119001903**

*33. Lees P, Pelligand L, Ferran A, Bousquet-Melou A, Toutain P-L. Application of pharmacological principles to dosage design of antimicrobial drugs. *Pharmacology Matters*. 2015;April:22-24.

34. Gianvecchio C, Lozano NA, Henderson C, Kalhori P, Bullivant A, Valencia A, Su L, Bello G, Wong M, Cook E, Fuller L, Neal JB III, Yeh PJ . Variation in mutant prevention concentrations. *Front Microbiol*. 2019;10:42. **https://doi.org/10.3389/fmicb.2019.00042**

35. Little S, Woodward A, Browning G, Billman-Jacobe H. Water distribution systems in pig farm buildings: Critical elements of design and management. *Animals.* 2021;11:3268. **https://doi.org/10.3390/ani11113268**

* Non-refereed references.

Maximizing value and minimizing waste in clinical trials in swine: Selecting outcomes to build an evidence base

Jan M. Sargeant, DVM, PhD, FCAHS; Annette M. O'Connor BVSc, DVSc, FANZCVS; Terri L. O'Sullivan, DVM, PhD; Alejandro Ramirez, DVM, MPH, PhD, DACVPM

Summary

Researchers planning clinical trials should identify the primary trial outcome and adequately power the trial to detect clinically meaningful differences in this outcome. All primary and secondary outcomes and their measurement should be comprehensively described, and their results reported. There is evidence that trials on the same subject use different outcomes or measure the same outcome in different ways, making it difficult to compare intervention effectiveness across clinical trials. Consensus development of core outcome sets could improve consistency in outcome measures used across trials and aid in development of an evidence-based body of literature on intervention effectiveness in swine populations.

Keywords: swine, outcome measures, primary outcome, core outcome sets, research utility

Received: January 7, 2022
Accepted: April 25, 2022

Resumen - Maximizando el valor y minimizando el desperdicio en pruebas clínicas en cerdos: Selección de resultados para construir una base de evidencia

Los investigadores que planifican pruebas clínicas deben identificar el resultado principal de la prueba y potenciar adecuadamente la prueba para detectar diferencias clínicamente significativas en este resultado. Todos los resultados primarios y secundarios y su medición deben describirse exhaustivamente y sus resultados deben ser informados. Existe evidencia de que las pruebas sobre el mismo tema usan diferentes resultados o miden el mismo resultado de diferentes maneras, lo que dificulta comparar la efectividad de la intervención entre las pruebas clínicas. El desarrollo de un consenso de los resultados centrales podría mejorar la consistencia en las medidas del resultado utilizadas en las pruebas, y ayudar al desarrollo de una compilación de literatura basado en evidencia sobre la efectividad de la intervención en poblaciones porcinas.

Résumé - Maximiser la valeur et minimiser le gaspillage dans les essais cliniques chez le porc: Sélectionner les résultats pour constituer une base de données probantes

Les chercheurs qui planifient des essais cliniques doivent identifier le résultat principal de l'essai et alimenter suffisamment l'essai pour détecter des différences cliniquement significatives dans ce résultat. Tous les résultats primaires et secondaires et leur mesure doivent être décrits de manière exhaustive et leurs résultats communiqués. Il existe des preuves que les essais sur le même sujet utilisent des résultats différents ou mesurent le même résultat de différentes manières, ce qui rend difficile la comparaison de l'efficacité des interventions entre les essais cliniques. L'élaboration d'un consensus sur les principaux ensembles de résultats pourrait améliorer la cohérence des mesures de résultats utilisées dans les essais et aider à l'élaboration d'un ensemble de documents fondés sur des données probantes sur l'efficacité des interventions dans les populations porcines.

The recent emphasis on evidence-based decision-making has led to a growth in literature on the design of clinical trials.[1] In this article, we use "clinical trials" as synonymous with "controlled trials" and define clinical trials as an experimental study intended to evaluate products or procedures in swine outside of a laboratory setting (ie, in a realistic-use setting).[2] When random allocation to an intervention group is applied in a clinical trial, the design is referred to as a randomized controlled trial. For clarity, we will use the term "clinical trial" throughout this article.

Clinical trials represent the primary research design with the highest evidentiary value when it is ethical and feasible to allocate animals to treatment groups.[3] Selecting appropriate outcomes is fundamental to clinical trial design because the difference in outcomes between intervention groups is inferred to be the result of the intervention.[4]

The word "outcome" encompasses different constructs. To clarify, we use the following vocabulary to describe the

JMS, TLO: Department of Population Medicine, Ontario Veterinary College, University of Guelph, Guelph, Ontario, Canada.

AMO: Department of Large Animal Clinical Sciences, College of Veterinary Medicine, Michigan State University, East Lansing, Michigan.

AR: University of Arizona College of Veterinary Medicine, Oro Valley, Arizona.

Corresponding author: Dr Jan M. Sargeant, 2536 Stewart Building, Ontario Veterinary College, University of Guelph, 50 Stone Road East, Guelph, Ontario, Canada N1G 2W1; Tel: 519-824-4120 Ext. 54045; Email: **sargeanj@uoguelph.ca**.

Sargeant JM, O'Connor AM, O'Sullivan TL, Ramirez A. Maximizing value and minimizing waste in clinical trials in swine: Selecting outcomes to build an evidence base. *J Swine Health Prod*. 2023;31(1):29-35. **https://doi.org/10.54846/jshap/1300**

various components of an "outcome" with illustrative examples provided in Figure 1. The first level of outcome is the outcome domain; in swine research, relevant outcome domains include health, productivity, and animal welfare. Within an outcome domain there can be one or more conceptual outcomes. For instance, the domain of productivity would include conceptual outcomes such as growth performance or reproductive performance. Next, within a conceptual outcome, one or more operational outcomes may be relevant. Operational outcomes are something that can be measured. For the conceptual outcome of growth performance, operational outcomes may include feed:gain ratio or average daily gain. Finally, there is the outcome measure, which includes case definition, measurement tool, and time-at-risk. A conceptual outcome such as average daily gain could be measured in different ways. For example, the outcome measure for average daily gain may involve weighing a pen at the start and end of production or by calculating weight gains at the end of a production phase for surviving pigs. Decisions about trial outcomes require specification of each component of an outcome. These decisions then need to be conveyed to the reader.

Considerable attention has been paid to potential sources of bias in clinical trials; however, the choice of outcome measures has received less attention.[1] This article will overview considerations when selecting outcomes and outcome measures for use in clinical trials, the importance of identifying the primary outcome, and the need for consistency in selecting outcomes across trials.

Considerations when selecting and reporting clinical trial outcomes

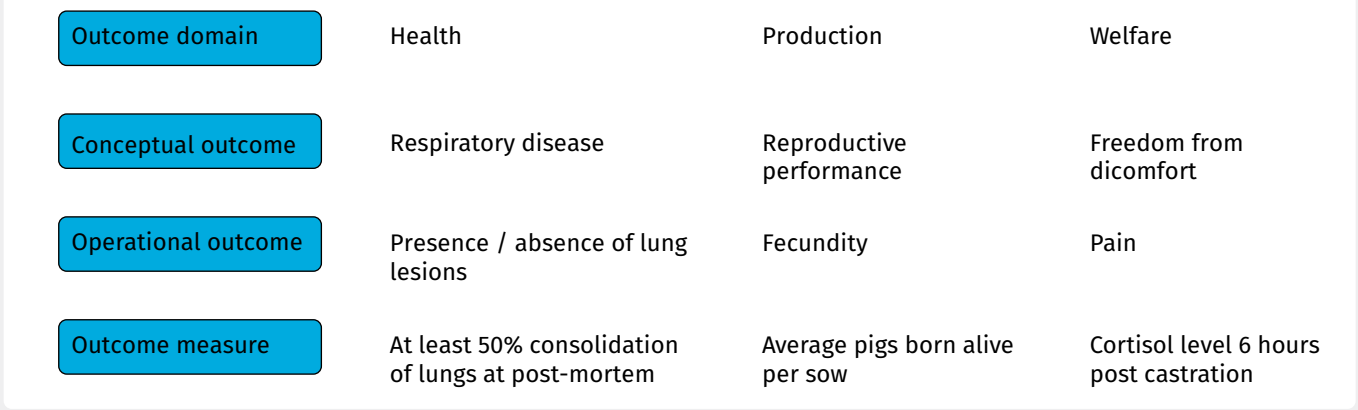
Once the researcher has determined the outcome domain and the conceptual outcome, operational outcomes need to be specified. The operational outcomes that are selected should be an expected benefit or harm of the intervention if that intervention is effective. The researcher must ask what they *expect* the intervention to do that is meaningful to those who might use the intervention.[1]

Relevant operational outcomes will differ as the intervention development research moves from proof-of-concept or safety trials to clinical trials evaluating efficacy in realistic-use settings.[5] Thus, as an example, in the early stages of vaccine development, the ability to produce antibodies to the target protein might be the most relevant operational outcome for a company considering whether to take the next step in product development by investing in a large-scale clinical trial. However, in clinical trials on the efficacy of that vaccine, the primary outcome measure should be of clinical relevance to the end-user of the vaccine. Therefore, in a clinical trial, outcome domains like health, production, and welfare should be operationalized with clinically relevant outcomes such as a mortality, morbidity, growth performance, or animal comfort.

Once an operational outcome is selected, the researcher must determine the associated outcome measure. There are a number of types of outcome measures that can be used. Clinical outcomes are outcomes that reflect how an animal feels, functions, or survives.[5] Examples of clinical outcomes include measures of morbidity (disease occurrence) and mortality and outcome measures related to welfare. Outcomes also may be surrogates for a clinical outcome (eg, rectal temperature as a surrogate for morbidity) or may be biomarkers (biological measurements) used to predict a clinical outcome such as acute phase proteins as a biomarker for risk of morbidity. Composite endpoints represent a combination of correlated variables.[6,7] An example of a composite endpoint in swine could be the incidence of any clinical sign of disease (eg, at least one of diarrhea, lameness, weight loss, or coughing). Although composite endpoints may increase statistical power for rare outcomes, their use is not without issues. Interested readers are directed to other articles if composite outcomes are used.[6,8]

Determining the outcome measure pertains not only to what is measured and how it is measured, but also to the time at which it is measured. For instance, an operational outcome such as average daily gain could be measured over a specific period (eg, the 15 days following intervention administration), over a specific production period (eg, during the nursery phase), or over the entire period from weaning to market. In contrast, some outcome measures may logically only pertain to a single time or specific event; an example would be pigs born alive per litter, which is measured at a single time.

Figure 1: Flow chart of outcomes from domains to measures, with examples for swine research.



As an example of how the process of selecting an outcome might work, consider a researcher planning a trial of an intervention intended to reduce respiratory disease in finishing pigs. The trial could be designed to evaluate health as an outcome domain, occurrence of pneumonia as the conceptual outcome, lung lesions as an operational outcome representing a surrogate measure of pneumonia, and a specific scoring system of lung pathology at slaughter as the outcome measure. The trial could be designed to evaluate production as an outcome domain, growth performance as the conceptual outcome, average daily gain as an operational outcome, and average daily gain for 30 days post intervention as the outcome measure.

It is important to consider whether the selected outcome measure (including what, how, and when it is measured) is sensitive to the nature and degree of change expected from the intervention.[1] For instance, consider an intervention is applied to nursery swine where the outcome is measured as average daily gain at slaughter. It is possible that the intervention was successful at reducing production losses in the short term, but that the outcome at slaughter was not sensitive to the intervention due to compensatory growth. As another example, suppose that a researcher evaluated trembling as a welfare outcome. This outcome could be measured on a dichotomous scale (presence or absence during a defined period) or on a continuous scale (number of episodes of trembling during a defined period). An intervention might reduce the frequency of trembling, but not whether it occurred. Therefore, the researcher will need to decide whether the presence or absence of trembling is sensitive to the intervention or whether the outcome of number of episodes of trembling would be more appropriate.

The number of outcomes to include in a trial also should be considered. It is common for trials to include multiple outcome domains (eg, health and welfare), and a single trial may include multiple conceptual and operational outcomes within each domain. Additionally, an operational outcome may be measured in multiple ways (eg, presence or absence of coughing, respiratory illness requiring treatment, or cough index). In studies on reporting of clinical trials for health and production and for on-farm food safety in livestock, 182 of 200 trials had multiple outcomes.[9,10] In the study on food safety trials, [9] the mean number of outcomes per trial was 8.5 (range: 1-51) and in the study on livestock health and production trials,[10] the mean number of outcomes per trial was 9.5 (range: 1-41).

The outcomes selected should be those necessary for decision-making. Too many outcomes may lead to a lack of focus or difficulties in interpreting trial results, for instance when different outcome measures for the same conceptual outcome have different results or interpretation.[6] Additionally, as the number of outcome measures increases, so too does the probability of a type I error (a false positive finding).[6,11] If the authors are using null hypothesis significance testing with a type I error rate of 5% for each test, when there is no association, we would expect one type I error within each 20 independent tests. To illustrate the potential magnitude of this issue of multiplicity, the probability of *at least one* type I error in a population where the null is true, if testing for each outcome is at $P = .05$ and the outcomes are independent, can be calculated as $(1-[1-0.05]^k)$, where k = the number of outcome measures. Therefore, using the minimum (1), mean (9.5), and maximum (41) number of outcomes from the 100 trials evaluated in the study on reporting of livestock health trials,[10] and assuming an alpha of 0.05 for hypothesis testing, then the probability of at least one false positive result would be 5%, 38.6%, and 87.8%, respectively. Therefore, it is important to restrict the outcomes (and outcome measures) to those that are appropriate to the stage of the intervention development and evaluation and, in the case of clinical trials in the real-world, to those that are necessary for decision-making.

Further, when multiple outcomes are measured, causation should be used in interpreting the value of each additional outcome to the end-user, especially when the outcome measures are within the same operational outcome. For example, a randomly occurring type I error that impacts average daily gain will also randomly impact feed:gain ratio and feed conversion, as they are likely measuring much the same outcome. If two variables are highly correlated, not a lot of additional information is gained by including both. Therefore, evidence of an impact in multiple outcomes should not necessarily be interpreted as building a stronger evidence base. A stronger evidence base would exist if the impact of the intervention is observed in multiple domains, ie, incidence of tail biting (welfare) and average daily gain (production). Therefore, when using multiple outcomes, these should be in different domains as much as feasible.[12]

The outcome measures must be comprehensively described or else the results of the trial cannot be interpreted. In an assessment of reporting in trials in livestock species, the measurement of all outcomes was described in 79% of trials, meaning that information with respect to all outcomes was not provided in approximately one-fifth of trials.[10] Guidance is available for the detail recommended when reporting outcomes, outcome measures, and results of a clinical trial.[13,14] There is a responsibility not only for authors to improve reporting of outcomes, but also for peer reviewers and journal editors to ensure that reporting is comprehensive.

It also is important that the results are reported for all outcome measures that were included in the trial, otherwise there is potential for selective outcome reporting.[15] There is evidence from human trials that outcomes associated with statistically significant results are more likely to be reported than those that are not significant.[16] Because it is uncommon to publish protocols for swine clinical trials, it is not possible to determine the extent to which this is an issue in swine research. However, if outcomes associated with statistically significant results are more likely to be presented in a manuscript (or, conversely, if outcomes associated with nonsignificant findings are excluded), it will lead to an exaggeration of intervention effectiveness and the probability of a type I error cannot be assessed. It may also mean that interventions that are not effective will continue to be researched.

Importance of defining the primary outcome

Regardless the number of outcomes, it is important that a primary outcome is identified. The primary outcome should be the outcome of most relevance to decision-making by the target audience, and is the outcome used to calculate the sample size required to ensure adequate power.[17] There may be situations where more than one outcome is considered of extremely high relevance. For instance, a researcher may be equally interested in a health outcome and a welfare outcome. In this instance, researchers should declare both outcomes as

primary and conduct sample size calculations for both, using the higher calculated sample size in the trial.[14]

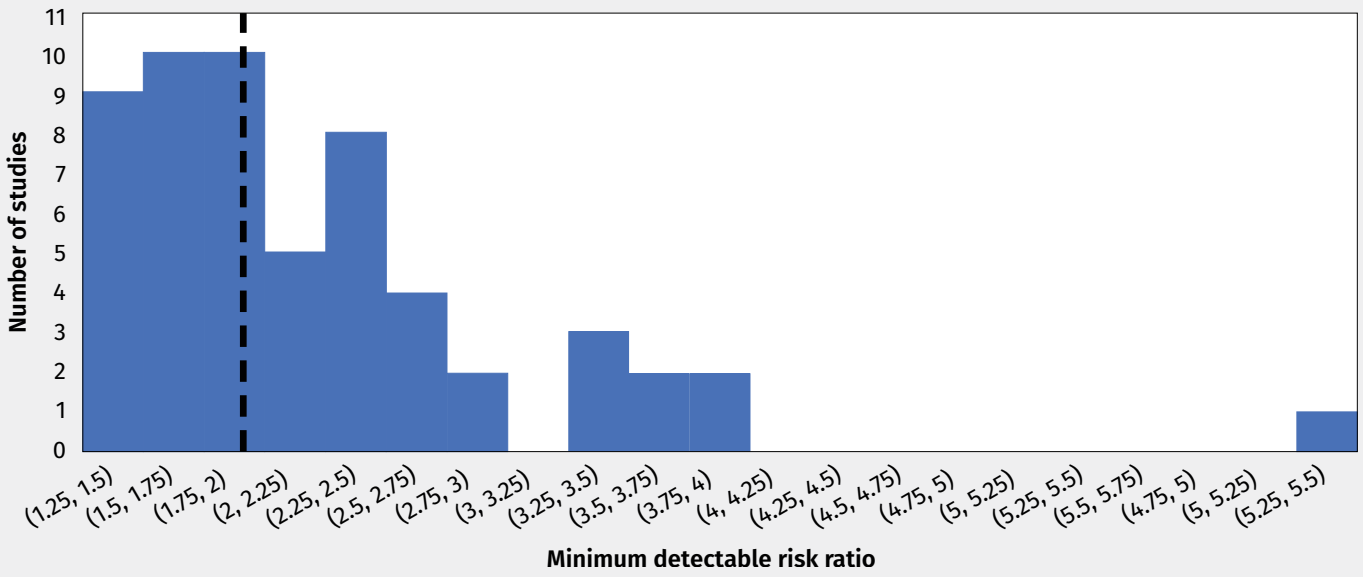
Primary outcomes are not consistently identified in many veterinary trials; for trials published in veterinary journals in 2013, the primary outcome was identified in 19.3% of trials, compared to 98.3% of trials published in human medical journals.[18] In swine trials, this proportion has improved since the publication of the REFLECT reporting guidelines.[13,14] Prior to publication of REFLECT, the primary outcome was identified in 14% of vaccination trials in swine compared to 42% after 2010.[19] Although this improvement is encouraging, these results still suggest that the primary outcome is not identified in over half of the vaccine trials conducted in swine populations.

If there is no sample size calculation, or if there are secondary outcomes that are underpowered, then meaningful differences may not be detected as statistically significant at $P = .05$; the (arbitrary) cutpoint often used in clinical trials. This may result in meaningful differences being presented as "no difference between groups." To illustrate this concept, the minimum detectable risk ratio (RR) was calculated using data on mortality collected from 56 trials included in a systematic review and network meta-analysis on the comparative efficacy of swine bacterial respiratory vaccines.[20] When calculating a sample size for a binary outcome, the researcher needs to define the proportion with the event in the baseline intervention group, the difference in the outcome that is clinically meaningful, and the desired confidence and power. In this example, we used data from completed trials to determine the smallest difference between treatment groups (expressed as a risk ratio) that could have been detected as statistically significant, given the baseline prevalence and the sample size used. The minimum detectable RR was calculated for each trial using the proportion of swine with the mortality outcome in the placebo group, the total sample size, power of 0.8, and confidence of 0.95 using epi.sscompb program in EpiR. The sample size corresponded to the individual animal level, and thus did not account for nonindependence of swine within pens. Figure 2 shows the distribution of minimum detectable RR, with the vertical dashed line representing the median of the minimum detectable RR of 2.0. The median proportion of swine mortality in the baseline intervention group was 0.06 (ie, 6%). A minimum detectable RR of 2.0 means that the proportion of pigs dying in the intervention group would need to be approximately double (or ½ for a preventive outcome) before detecting the RR as statistically significant. This may be a larger difference than what would be clinically meaningful. Therefore, by designating a primary outcome and powering the study to detect clinically meaningful differences in this outcome, the researcher can ensure adequate power. The example illustrates that many current studies can only identify a relatively large difference as statistically significant.

Inconsistency of outcomes across trials

It is necessary to replicate the results across multiple trials to inform evidence-based decision-making because the results of a single trial are based on a sample from the source population and thus are subject to sampling error. Sampling error, also referred to as chance, occurs when the parameter of interest (eg, a mean or a proportion) is different between the source population and the study population. Combining the results of multiple trials, as is performed statistically with meta-analysis, increases precision of the estimate of effect size[15] and increases confidence that the results are not a reflection of sampling error.[21] However, trials evaluating the same intervention often do not use the same outcomes or outcome measures, precluding the ability to build a body of evidence across trials. Outcomes across trials may represent different outcome domains (eg, one trial measuring a welfare outcome and another measuring a production

Figure 2: Distribution of minimum detectable risk ratios for trials included in a systematic review and network meta-analysis on the comparative efficacy of swine bacterial respiratory vaccines.[20] Dotted vertical line represents the median value for the minimum detectable risk ratio.



outcome), may represent the same conceptual outcome but with different operational outcomes (eg, one trial may measure pain using postural changes and another trial may measure pain using activity levels), or may represent the same operational outcome but with a different outcome measure (eg, average daily gain during the first 2 weeks post weaning in one trial and across the entire growing period in another).

To illustrate, we used data from 61 lung lesion outcome measures reported in 58 trials evaluating nonspecific lung lesions at slaughter from a systematic review of the efficacy of bacterial respiratory vaccines (Table 1).[20] Not only were different outcome measures used across the trials, but key features of the measurement of the specific outcomes often were not provided. For example, the outcome "general appearance" often did not include a comprehensive description of the criteria for determining whether the general appearance corresponded to a positive or negative result. This limits the ability to combine results across trials and thereby build a body of evidence. The example provided represents only one type of intervention (vaccination against bacterial pathogens) and one operational outcome (lung lesions). However, the example serves to highlight the inadequate reporting and inconsistency in outcome measures across trials, and the resulting challenges in synthesizing research results.

To reduce inconsistencies in outcomes across trials, individual researchers should be familiar with the literature in their area and select operational outcomes and outcome measures that have been used in previous trials. Ideally, outcome measures should be validated or agreed upon by consensus of experts in the area; otherwise, outcomes with poor reliability or validity might be selected based on use in a previous trial. At the industry level, a possible solution to inconsistency and selective reporting of outcome measures is the creation of core outcome sets for specific topic areas within swine research. Core outcome sets represent an agreed minimum set of outcomes and outcome measures that should be reported in all trials that are conducted on a specific disease or condition.[4,29] Although the core outcomes should be included in all trials, researchers may include other primary or secondary outcomes that are of interest in their specific trial.[4,30] Core outcome sets also may need to be updated as technologies and diagnostic tests are developed and validated. Guidelines are available for developing core outcome sets in the COMET initiative handbook.[4] The COMET initiative was launched in 2010 with a key objective of encouraging the development and updating of core outcome sets.[4] The COMET initiative was developed for human health outcomes, and the relevant outcome domains may differ for swine. Nonetheless, the process for developing core outcome sets would be relevant for swine applications. The process of developing a core outcome set involves a decision as to the topic (eg, a disease, a domain such as welfare, a conceptual outcome such as pain, or a type of intervention and a disease), evaluation of the existing literature on trials to determine what outcome domains, conceptual outcomes, operational outcomes, and outcome measures have previously been used, and a consensus process to determine which of these to include in the core outcome set.[4,31] The creation of core outcome sets should include the

Table 1: Lung lesion outcome measures reported in 58 trials evaluating nonspecific lung lesions at slaughter from a systematic review of the efficacy of bacterial respiratory vaccines[20]

Lung lesion scoring system	Range of scores for scoring system	# trials (dichotomous outcome)	# trials (continuous outcome)
Christensen et al,[22] 1999			1
Madec and Kobisch,[23] 1982	0 - 28	2	
Madec and Kobisch,[23] 1982	0 – 24	1	
Madec and Kobisch,[23] 1982	Not reported	1	1
Goodwin et al,[24] 1969	Not reported	1	
Goodwin and Whittlestone,[25] 1973	0-55	1	10
Goodwin and Whittlestone,[25] 1973	Not reported	1	1
Piffer and Brito,[26] 1991	Not reported	1	
Hannan et al,[27] 1982	0 -55	1	
Morrison et al,[28] 1985	Percentage of pneumonia in different lung lobes	1	1
None reported	0 - 14	2	
None reported	0 – 28	1	1
None reported	0 - 35		1
None reported	Not reported	1	3
General appearance		28	

input of relevant stakeholders.[4,29] For instance, individuals from academia, industry, and other relevant stakeholders might decide to identify a core outcome set for trials evaluating interventions to prevent respiratory disease in swine or a core outcome set for trials related to improving swine welfare. Creating the core outcome sets would involve identifying relevant domains, then relevant conceptual outcome within domains, followed by specific operational outcomes within each conceptual outcome and finally the outcome measure for each conceptual outcome, including case definition, measurement tool, and period at risk. Defining the core outcomes also may involve defining normal or abnormal cut points for outcomes measured on a continuous scale for which a qualitative label is desired. This may be more challenging for welfare or other domains that are more recently included in trials where there has not been a long history of using, validating, and interpreting relevant outcome measures. The selection of core outcomes would need to take into consideration the validity of the outcomes in measuring the construct that they are intended to measure. The cost associated with collecting the outcome data also may be a consideration. The COMET initiative handbook for development of core outcome sets[4] does not provide specific input on the number of outcomes that should be included in a core outcome set; however, the number will need to be a balance between feasibility, probability of type I error, and information required for clinical decision-making.

Core outcome sets increasingly are being developed for use in human trials; as of 2018, there were 410 core outcome sets for a wide range of human trial topic areas including cancer, urology, and child health.[32] Veterinary medicine has been slower to adopt core outcome sets; to date, there is a core outcome set published for trials in feline chronic kidney disease[33] and one for therapeutic trials for canine atopic dermatitis.[34] The development of core outcome sets is an area in which the swine industry could provide leadership. In swine research, core outcome sets could include outcomes from domains such as health, production, and welfare. Stakeholders could include swine producers and veterinarians, industry groups, researchers, and research funders. Although consensus can be challenging, there is precedent in swine research; naming of the disease periweaning failure to thrive syndrome was reached by consensus,[35] as were standardized systems for classifying herd level status for porcine reproductive and respiratory syndrome[36] and for *Mycoplasma hyopneumoniae* in breeding herds.[37] Recently, a consortium of researchers, industry, veterinarians, and regulatory agencies developed a methodology to measure pain associated with surgical castration in piglets.[38]

These prior initiatives suggest that the swine industry could be successful in coming to consensus on core outcome sets. Creating core outcome sets will aid individual researchers in identifying outcomes and outcome measures to use in their trial and will facilitate synthesis of results from multiple trials. This will allow a body of evidence to be developed to determine the effectiveness of specific interventions for a disease or condition, to identify when further trials will not increase our knowledge of the effectiveness of an intervention, and to determine the relative efficacy of multiple intervention options for the same disease or conditions. This will maximize the utility of research trials conducted in swine populations.

Implications

- Primary and secondary outcomes should be defined and clearly reported.
- Primary outcomes determine sample size; many swine trials are underpowered.
- Core outcome sets can improve consistency in outcome measures used across trials.

Acknowledgments

The authors were responsible for developing the ideas presented in this commentary. Partial funding support was obtained from the University of Guelph Research Leadership Chair (Sargeant).

Conflict of interest

None reported.

Disclaimer

Drs O'Sullivan and Ramirez, the journal's executive editor and editorial board member, respectively, were not involved in the editorial review of or decision to publish this article.

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may be specific to the research or commercial situation presented in the manuscript. It is the responsibility of the reader to use information responsibly and in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

References

1. Coster WJ. Making the best match: Selecting outcome measures for clinical trials and outcome studies. *Am J Occup Ther*. 2013;67(2):162-170. **https://doi.org/10.5014/ajot.2013.006015**

2. Dohoo I, Martin W, Stryhn H. *Veterinary Epidemiologic Research*. 2nd ed. VER Inc; 2009.

3. Sargeant JM, Kelton DF, O'Connor AM. Study designs and systematic review of interventions: Building evidence across study designs. *Zoonoses Public Health*. 2014;61(Suppl1):10-17. **https://doi.org/10.1111/zph.12127**

4. Williamson PR, Altman DG, Bagley H, Barnes KL, Blazeby JM, Brookes ST, Clarke M, Gargon E, Gorst S, Harman N, Kirkham JJ, McNair A, Prinsen CAC, Schmitt J, Terwee CB, Young B. The COMET Handbook: Version 1.0. *Trials*. 2017;18(Suppl3):1-50. **https://doi.org/10.1186/s13063-017-1978-4**

*5. US Food and Drug Administration. Biomarkers and surrogate endpoints in clinical studies to support effectiveness of new animal drugs. Guidance for Industry #267. Published October 2021. Accessed November 8, 2021. **https://www.fda.gov/media/138160/download**

6. Vetter TR, Mascha EJ. Defining the primary outcomes and justifying secondary outcomes of a study: Usually, the fewer, the better. *Anesth Analg*. 2017;125(2):678-681. **https://doi.org/10.1213/ANE.0000000000002224**

7. Oyama MA, Ellenberg SS, Shaw PA. Clinical trials in veterinary medicine: A new era brings new challenges. *J Vet Intern Med*. 2017;31(4):970-978. **https://doi.org/10.1111/jvim.14744**

8. Freise KJ, Lin T-L, Fan TM, Recta V, Clark TP. Evidence-based medicine: The design and interpretation of noninferiority clinical trials in veterinary medicine. *J Vet Intern Med*. 2013;27(6):1305-1317. **https://doi.org/10.1111/jvim.12211**

9. Sargeant JM, Saint-Onge J, Valcour J, Thompson A, Elgie R, Snedeker K, Marcynuk P. Quality of reporting in clinical trials of preharvest food safety interventions and associations with treatment effect. *Foodborne Pathog Dis*. 2009;6:989-999. **https://doi.org/10.1089/fpd.2009.0321**

10. Sargeant JM, Elgie R, Valcour J, Saint-Onge J, Thompson A, Marcynuk P, Snedeker K. Methodological quality and completeness of reporting in clinical trials conducted in livestock species. *Prev Vet Med*. 2009;91:107-115. **https://doi.org/10.1016/j.prevetmed.2009.06.002**

11. Tukey JW. Some thoughts on clinical trials, especially problems of multiplicity. *Science*. 1977;198(4318):679-684. **https://doi.org/10.1126/science.333584**

12. Li T, Mayo-Wilson E, Fusco N, Hong H, Dickersin K. Caveat emptor: The combined effects of multiplicity and selective reporting. *Trials*. 2018;19:497. **https://doi.org/10.1186/s13063-018-2888-9**

13. O'Connor AM, Sargeant JM, Gardner I, Dickson J, Torrence M, Dewey CE, Dohoo I, Evans R, Gray J, Greiner M, Keefe G, Lefebvre S, Morley P, Ramirez A, Sischo W, Smith D, Snedeker K, Sofos J, Ward M, Wills R. The REFLECT statement: Methods and processes of creating reporting guidelines for randomized controlled trials for livestock and food safety. *J Swine Health Prod*. 2010;18:18-26.

14. Sargeant JM, O'Connor AM, Gardner IA, Dickson JS, Torrence ME, Dohoo IR, Lefebvre SL, Morley PS, Ramirez A, Snedeker K. The REFLECT statement: Reporting guidelines for randomized controlled trials in livestock and food safety: explanation and elaboration. *J Food Prot*. 2010;73(3):579-603. **https://doi.org/10.4315/0362-028x-73.3.579**

15. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, eds. *Cochrane Handbook for Systematic Reviews of Interventions*. Version 6.2. Updated February 2021. Cochrane; 2021.

16. Dwan K, Gamble C, Williamson PR, Kirkham JJ, Reporting Bias Group. Systematic review of the empirical evidence of study publication bias and outcome reporting bias - an updated review. *PLoS One*. 2013;8(7):e66844. **https://doi.org/10.1371/journal.pone.0066844**

17. Moher D, Hopewell S, Schulz KF, Montori V, Gøtzsche PC, Devereaux PJ, Elbourne D, Egger M, Altman DG, CONSORT. CONSORT 2010 explanation and elaboration: Updated guidelines for reporting parallel group randomised trials. *Int J Surg*. 2012;10(1):28-55. **https://doi.org/10.1016/j.ijsu.2011.10.001**

18. Di Girolamo N, Meursinge Reynders R. Deficiencies of effectiveness of intervention studies in veterinary medicine: A cross-sectional survey of ten leading veterinary and medical journals. *PeerJ*. 2016;4:e1649. **https://doi.org/10.7717/peerj.1649**

19. Moura CAA, Totton SC, Sargeant JM, O'Sullivan TL, Linhares DCL, O'Connor AM. Evidence of improved reporting of swine vaccination trials in the post-REFLECT statement publication period. *J Swine Health Prod*. 2019;27(5):265-277.

20. Sargeant JM, Deb B, Bergevin MD, Churchill K, Dawkins K, Dunn J, Hu D, Moody C, O'Connor AM, O'Sullivan TL, Reist M, Wang C, Wilhelm B, Winder CB. Efficacy of bacterial vaccines to prevent respiratory disease in swine: A systematic review and network meta-analysis. *Anim Health Res Rev*. 2019;20(2):274-290. **https://doi.org/10.1017/S1466252319000173**

21. Valentine JC, Biglan A, Boruch RF, Castro FG, Collins LM, Flay BR, Kellam S, Mościcki EK, Schinke SP. Replication in prevention science. *Prev Sci*. 2011;12:103-117. **https://doi.org/10.1007/s11121-011-0217-6**

22. Christensen G, Sorensen V, Mousing J. Diseases of the Respiratory System. In: Straw BE, D`Allaire S, Mengelind WL, Taylor DJ, eds. *Diseases of Swine*. 8th ed. Iowa State University Press; 1999:913-940.

23. Madec F, Kobisch M. Bilan lesionnel des poumons de porcs charcutiers a l'abattoir [Lesion assessment of the lungs of slaughterhouse pigs]. *Journées de la Recherche Porcine*. 1982;14:405-12.

24. Goodwin RF, Hodgson RG, Whittlestone P, Woodhams RL. Some experiments relating to artificial immunity in enzootic pneumonia of pigs. *J Hyg(Lond)*. 1969;67(3):465-476. **https://doi.org/10.1017/s0022172400041887**

25. Goodwin RF, Whittlestone P. Enzootic pneumonia of pigs: Immunization attempts inoculating *Mycoplasma suipneumoniae* antigen by various routes and with different adjuvants. *Br Vet J*. 1973;129:456-464. **https://doi.org/10.1016/s0007-1935(17)36386-8**

*26. Piffer IA, Brito JRF. Descricao de um modelo para avaliacao e quantificacao de lesoes pulmonares de suinos e formulacao de um indice para classificacao de rebanhos [Description of a model for evaluation and quantification of lung lesions in swine and formulation of an index for classification of herds]. Concordia: EMBRAPA-CNPSA.

27. Hannan PC, Bhogal BS, Fish JP. Tylosin tartrate and tiamutilin effects on experimental piglet pneumonia induced with pneumonic pig lung homogenate containing mycoplasmas, bacteria and viruses. *Res Vet Sci*. 1982;33:76-88. **https://doi.org/10.1016/S0034-5288(18)32364-6**

28. Morrison RB, Hilley HD, Leman AD. Comparison of methods for assessing the prevalence and extent of pneumonia in market weight swine. *Can Vet J*. 1985;26:381-384.

29. Williamson PR, Altman DG, Blazeby JM, Clarke M, Devane D, Gargon E, Tugwell P. Developing core outcome sets for clinical trials: issues to consider. *Trials*. 2012;13:132. **https://doi.org/10.1186/1745-6215-13-132**

30. Webbe J, Sinha I, Gale C. Core outcome sets. *Arch Dis Child Educ Pract Ed*. 2018;103(3):163-166. **https://doi.org/10.1136/archdischild-2016-312117**

31. Prinsen CA, Vohra S, Rose MR, Boers M, Tugwell P, Clarke M, Williamson PR, Terwee CB. How to select outcome measurement instruments for outcomes included in a "Core Outcome Set" - a practical guideline. *Trials*. 2016;17(1):449. **https://doi.org/10.1186/s13063-016-1555-2**

32. Gargon E, Gorst SL, Williamson PR. Choosing important health outcomes for comparative effectiveness research: 5th annual update to a systematic review of core outcome sets for research. *PLoS One*. 2019;14(12):e0225980. **https://doi.org/10.1371/journal.pone.0225980**

33. Doit H, Dean RS, Duz M, Finch NC, Brennan ML. What outcomes should be measured in feline chronic kidney disease treatment trials? Establishing a core outcome set for research. *Prev Vet Med*. 2021;192:105348. **https://doi.org/10.1016/j.prevetmed.2021.105348**

34. Olivry T, Bensignor E, Favrot C, Griffin CE, Hill PB, Mueller RS, Plant JD, Williams HC, International Committee of Allergic Diseases of Animals (ICADA). Development of a core outcome set for therapeutic clinical trials enrolling dogs with atopic dermatitis (COSCAD'18). *BMC Vet Res*. 2018;14(1):238. **https://doi.org/10.1186/s12917-018-1569-y**

35. Huang Y, Henry S, Friendship R, Schwartz K, Harding J. Clinical presentation, case definition, and diagnostic guidelines for porcine periweaning failure to thrive syndrome. *J Swine Health Prod*. 2011;19:340-344.

36. Holtkamp D, Torremorell M, Corzo CA, Linhares DCL, Almeida MN, Yeske P, Polson DD, Becton L, Snelson H, Donovan T, Pittman J, Johnson C, Vilalta C, Silva GS, Sanhueza J. Proposed modifications to porcine reproductive and respiratory syndrome virus herd classification. *J Swine Health Prod*. 2021;29:261-270.

37. Clavijo MJ, Galina Pantoja L, Holtkamp DJ, Yeske P, Johnson C, Sprague M, Fano E, Main R, McDowell E, Painter T, Becton L, Baumert D, Glowsenski L, Snelson H, Maschhoff A. Establishing *Mycoplasma hyopneumoniae* herd status classification criteria for breeding herds. *J Swine Health Prod*. 2021;29:319-326.

38. Baysinger A, Webb S, Brown J, Coetzee J, Crawford S, DeDecker A, Karriker LA, Pairis-Garcia M, Sutherland MA, Viscardi A. Proposed multidimensional pain outcome methodology to demonstrate analgesic drug efficacy and facilitate future drug approval for piglet castration. *Anim Health Res Rev*. 2021;22:163-176. **https://doi.org/10.1017/S1466252321000141**

* Non-refereed reference.

Conversion tables

Weights and measures conversions

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

Temperature equivalents (approx)

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

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

Conversion 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
1 ppm = 1 mg/L

National Pork Board, US Swine Health Improvement Plan further industry collaboration for FAD preparedness

The National Pork Board (NPB) continues its commitment to improving our producers' ability to prevent and respond in the event of a foreign animal disease (FAD) outbreak and mitigate its potential effects. Through hands-on work and collaboration with key partners such as academia, National Pork Producers Council, and American Association of Swine Veterinarians, NPB has built or supported an arsenal of tools to use against FAD threats, including AgView, Certified Swine Sample Collector training, and the Secure Pork Supply.

The US Swine Health Improvement Plan (US SHIP), another example of NPB-supported collaboration, advanced its work in the second half of 2022 as more than 250 producers, veterinarians, swine health officials, and state pork association officials representing 31 states met as delegates in Bloomington, Minnesota. Voting delegates approved 8 resolutions for further assessment and consideration of 4 standards related to traceability, feed biosafety (2), live haul sanitation, surveillance (2), feral pig risk mitigation, and governance.

"As a major funding partner of US SHIP using Pork Checkoff funds, we're encouraged to see the level of industry engagement and solidarity behind the core objectives of the plan to help improve the nation's foreign animal disease readiness and protect our ability to maintain continuity of business in the face of a potential foreign animal disease outbreak," said Dr Dusty Oedekoven, NPB's chief veterinarian.

Per US SHIP's original intent, the plan is to mitigate risks of disease introduction and provide a practical means for demonstrating evidence of freedom of disease outside of FAD control areas in support of ongoing interstate commerce and a pathway towards the resumption of international trade. When fully implemented, the program is designed to be applicable across the full spectrum of US pork industry participants, from the small show pig farmer to the large commercial producers and slaughter facilities.

The US SHIP Official State Agencies across the United States began the process of enrolling sites March 2022. Producers of all sizes are encouraged to contact their official state agency and enroll in US SHIP. To date, approximately 40% of the US breeding herd and growing pigs across 31 states have enrolled. The pilot program is on an expedited path towards becoming a US Department of Agriculture program by 2024.

In addition to support of US SHIP, NPB is also working to update the Foreign Animal Disease Preparation Checklist for pig farmers.

To stay up-to-date on the latest FAD resources available through the NPB, visit **porkcheckoff.org** and sign-up for the organization's weekly email.

54th AASV ANNUAL MEETING

March 4-7, 2023 | Aurora, Colorado

AMERICAN ASSOCIATION SWINE VETERINARIANS

Register today!
aasv.org/annmtg

A virtual attendance option is not available. BE THERE!

It's time to vote!

Are you a veterinarian member of AASV who resides in Canada, Mexico, or the United States? If so, it is time to exercise your "civic duty" to elect your association leaders. Here's how:

Vice president and president-elect

Balloting for the vice President and president-elect begins in January. Dr Locke Karriker of Ames, Iowa is this year's candidate for vice president, and his candidate's message appears in this issue. The current AASV Vice President Dr Angela Baysinger is on the ballot to ascend to the president-elect position. Both are unopposed. All balloting is conducted electronically. Voting members may access their ballot by logging into their member account at **aasv.org/members**. **Friday, February 24 is the last day to submit or change a vote**.

District directors

Voting members in 4 AASV districts may nominate in January and vote in February for their district's representative on the AASV Board of Directors. Nominations are being sought for candidates in Districts 2 (southeastern US), 5 (Illinois and Wisconsin), 9 (Minnesota and North Dakota), and 11 (Canada). Current directors Drs Sara Hough (District 2), Attila Farkas (District 5), and Susan Detmer (District 11) have each served one, 3-year term of office and are eligible to serve a second term if nominated and re-elected. In District #9, Dr Chase Stahl is not eligible for re-election.

Nominations must be submitted electronically. Members in districts 2, 5, 9, and 11 can log into **aasv.org/members** to nominate a candidate in their district. Potential candidates must be Active (veterinarian) AASV members residing in the district to be represented. Affiliate, Associate, and Student Members are not eligible to hold office or vote. In each district, the 2 nominees receiving the most nominations will be placed on the ballot, subject to their consent to serve. **Friday, January 20 is the last day to submit or change a nomination**.

Electronic balloting will open for the district director positions after the candidates have been confirmed. District members can access their ballot by logging into **aasv.org/members**. **Friday, February 24 is the last day to submit or change a vote**.

The election results will be announced during the AASV Annual Meeting in Aurora, Colorado.

AASV committees to meet virtually before Annual Meeting

The AASV's membership and issue-based committees will meet virtually this year during the winter months before the Annual Meeting, in addition to meeting in person in Aurora, Colorado. Meeting times are posted on the AASV committee webpage at **aasv.org/aasv/committee.php**. Agendas will be posted on each committee page as they become available.

Learn about each committee, read their reports and workplans, and review committee guidelines on the AASV committee webpage. All AASV members and student members are welcome to attend any committee meeting, but only committee members are eligible to vote. If you are interested in joining a committee, please contact the committee chair or Dr Abbey Canon. Not sure which to join? The AASV staff can help you fill an open seat!

The AASV Board of Directors relies on the committees as topic experts and seeks their input regarding issues of importance to swine veterinarians. Committees are called upon to examine an issue and advise the board on official positions the association should take or to develop additional resources to educate membership.

AVMA Committee and Council positions open

The AASV designates representatives for several committees of the American Veterinary Medical Association. Current representatives are listed at **aasv.org/members/only/AVMAreps**.

Visit **avma.org/membership/volunteering-avma/avma-volunteer-opportunities-vacancies** for more details and descriptions of each committee.

Some committees have openings; please contact the AASV office if you are interested in representing AASV.

AASV Board of Directors meet

The AASV Board of Directors met on October 6 to conduct official business. The following are highlights from the meeting.

The Board took the following actions:

- Amended the AASV Bylaws to appoint the AASV president-elect as chair of the Budget Committee and continue to include the vice president on the committee.
- Established a Telemedicine Task Force to draft a position on telemedicine for consideration by the board.
- Renamed the AASV Practice Tips seminar in honor of Dr Max Rodibaugh.
- Allowed tracking/collection of aggregate e-Letter click-through information to facilitate reporting of metrics to e-Letter sponsors.
- Approved a request from the Early Career Committee for $2995 to provide 5 scholarships for AASV-member, early-career veterinarians (2018-2022 DVMs) to participate in the spring 2023 cohort of the MentorVet program.
- Approved an increase in nonmember veterinarian registration fee for the Annual Meeting to $875.
- Selected Las Vegas (2026) and Orlando (2027) as Annual Meeting locations.

Dr Harry Snelson presented the financial report. The AASV had to pay nearly $24,000 in hotel attrition fees (negotiated down from over $40,000) as a result of AASV's failure to fill the contracted room block during the 2022 Annual Meeting held in Indianapolis. **He emphasized the need for attendees to stay at the conference hotel to avoid these additional fees in the future**. The AASV depends upon a profitable meeting as one of its primary sources of operating funds.

The program for the 2023 AASV Annual Meeting, *Be There,* chaired by Dr Bill Hollis, is available online at **aasv.org/annmtg**. Planning continues for an in-person Annual Meeting in Aurora, Colorado March 4-7, 2023.

Dr Snelson anticipates the 2023 Annual Meeting will be expensive to conduct for several reasons, including the loss of the Monday luncheon sponsorship. To help offset the cost of the luncheon and provide greater visibility to the AASV Foundation, the foundation board will cosponsor (50%) the Monday luncheon with AASV in lieu of holding a separate foundation luncheon on Sunday. The announcement of foundation grants and recognitions will take place during the Monday luncheon, along with the usual student scholarship awards.

Dr Locke Karriker was nominated to run for the office of AASV vice president.

Read the complete minutes of the Board meeting at **aasv.org/members/only/board/board_f22.php.**

Salary Survey 2023

The AASV plans to conduct its 8th survey of swine-veterinarian income and benefits in 2023. Active members of AASV (nonretired veterinarians) in the United States and Canada are asked to watch for information regarding the 2023 survey in the AASV e-Letter, and to participate by using the electronic survey form on the AASV website.

Similar surveys have been conducted every 3 years since 2002. Members have found the resulting salary and benefit summary useful when seeking employment or preparing to hire veterinary professionals in the swine industry. The survey results have also been used to inform veterinary students about the career opportunities available in swine medicine.

Members of AASV are divided into 2 survey groups according to their employment type. The *practitioner* survey should be completed by members engaged in private practice, as well as those who oversee pig health for a production or genetics company. Members who work for a university, corporation, or government and are engaged in education, research, technical services, public health, or regulatory work should complete the survey for *public/corporate* veterinarians.

In addition to 2022 income and benefits, the survey requests information about education and training, employment type, and hours worked. Responses are confidential and the results are reported in a manner to assure participant anonymity.

The overall results of the salary and compensation survey will be published and distributed for use by AASV members and students. Previous survey results are available for members to access on the AASV website.

AASV Early Career Committee launches partnership with MentorVet

The American Association of Swine Veterinarians and MentorVet will be collaborating to launch a new mentorship program for young swine veterinarians in 2023. For this partnership, AASV will be awarding 5 full scholarships to early-career swine veterinarians within AASV to participate in the spring 2023 MentorVet Program.

The MentorVet Program is a 6-month, virtual, evidence-based, mentorship and professional development program that aims to promote well-being and decrease burnout during the transition into veterinary practice. The mentorship program has been adapted to meet the needs of early-career swine veterinarians including swine-specific case examples and paired mentorship with a more experienced swine veterinarian.

Dr Megan Inskeep, AASV District 4 Director, has been a MentorVet Mentor for over a year and shared, "The training and support that MentorVet provides to both mentees and mentors is very beneficial. This program has given me the opportunity to give back to the profession by providing formal structures for mentoring that are based in evidence. Burnout is an issue in all areas of veterinary medicine, including swine medicine, and we are excited about this partnership with MentorVet so AASV can continue to grow our support structures for swine veterinarians in their early careers."

In addition to paired mentorship, the program provides holistic support to veterinarians through a combination of professional skills training, financial and mental health coaching, and peer mentorship. Mentees engage in a self-paced online curriculum then meet monthly with other early-career veterinarians to discuss shared challenges and share perspectives on how to create a sustainable career path.

Dr Abbey Canon, AASV director of public health and communications, commented "Part of AASV's mission is to mentor students, encouraging life-long careers as swine veterinarians. The AASV Early Career Committee identified the need for a mentorship program to continue supporting swine veterinarians in those first few years after graduation to ensure a high retention of talented colleagues in the profession. We are excited to pilot a partnership with MentorVet to provide professional development and well-being resources to swine veterinarians early in their careers."

"Research shows that our youngest professionals are at the highest risk for experiencing burnout or other mental health challenges," stated Addie Reinhard, DVM, MS, founder and CEO of MentorVet. "We are so excited to be collaborating with AASV to provide additional resources, community, and support to swine veterinarians starting out their careers. Promoting career sustainability in the swine industry is vital for ensuring we have a safe and healthy food supply."

AASV members who have graduated from veterinary school in the past 5 years (classes of 2018-2022) can apply for a scholarship to participate in the MentorVet Program by visiting **mentorvet.net/scholarships.**

The deadline to apply for the spring 2023 scholarship is February 3, 2023.

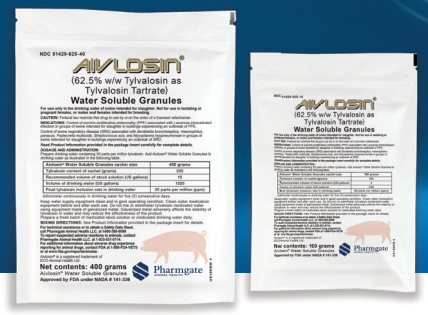
For more information visit **mentorvet.net**.

New resource directory for early-career veterinarians

The Early Career Committee has compiled a list of veterinarians and others who may be able to offer expertise, knowledge, or serve as a resource for early-career veterinarians should they have questions about a specific topic. Example topics include diseases, diagnostics, ventilation, finances, and leadership. This resource directory is available to all AASV members at **aasv.org/members/only/committee/EarlyCareer.php**. Contact information for AASV members on the resource list can be found in the AASV Member Directory at **aasv.org/directory/**.

HERD HEALTH

YOUR PROTOCOL. OUR PORTFOLIO.



Aivlosin® WSG works fast to control swine respiratory disease (SRD) including *M. hyo*.

Select the effective choice with a low pig treatment cost compared to other control options.

AIVLOSIN®
(62.5% w/w Tylvalosin as Tylvalosin Tartrate)
Water Soluble Granules
Scan the code for label indications.

Pharmgate
ANIMAL HEALTH

To learn more, visit **pharmgate.com**

Important Safety Information: Available under prescription only. AIVLOSIN is indicated for control of porcine proliferative enteropathy (PPE) associated with *Lawsonia intracellularis* infection in groups of swine intended for slaughter in buildings experiencing an outbreak of PPE. Control of swine respiratory disease (SRD) associated with *Bordetella bronchiseptica, Haemophilus parasuis, Pasteurella multocida, Streptococcus suis*, and *Mycoplasma hyopneumoniae* in groups of swine intended for slaughter in buildings experiencing an outbreak of SRD. For use only in drinking water of pigs. Not for use in lactating or pregnant females, or males and females intended for breeding. People with known hypersensitivity to tylvalosin tartrate should avoid contact with this product. When used in accordance with label directions, no withdrawal period is required before slaughter for human consumption.

Research proposals due January 12

The AASV Foundation plans to award up to $100,000 in 2023 to support research with direct application to the swine veterinary profession and is now receiving proposals to be considered for funding.

Proposals are due by 12:00 PM Central Time on **January 12, 2023** and may request a maximum of $30,000 per project. The announcement of projects selected for funding will take place during the AASV Annual Meeting on Monday, March 6, 2023.

Proposed research should fit one of the five action areas stated in the AASV Foundation mission statement (see sidebar). The instructions for submitting proposals are available on the AASV Foundation website at **aasv.org/foundation/2023/research.php**. A panel of AASV members will evaluate and select proposals for funding, based on the following scoring system:

- Potential benefit to swine veterinarians/swine industry (40 points)
- Probability of success within timeline (35 points)
- Scientific/investigative quality (15 points)
- Budget justification (5 points)
- Originality (5 points)

A summary of the research previously funded by the foundation is available at **aasv.org/foundation/research.htm**.

For more information, or to submit a proposal:

AASV Foundation
830 26th Street, Perry, IA 50220-2328
515-465-5255; **foundation@aasv.org**

AASV Foundation Mission Statement

The mission of the AASV Foundation 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.

Early career swine practitioners, apply for debt relief by January 31

Applications are now being accepted for three, $5000 scholarships to be awarded to early-career swine practitioners through the Dr Conrad and Judy Schmidt Family Student Debt Relief Endowment. The scholarship recipients will be announced during the 2023 AASV Annual Meeting.

The scholarships are available to AASV members who are between 2 and 5 years post graduation from veterinary school (DVM/VMD graduation years 2018, 2019, or 2020), engaged in private practice, and who carry a significant student debt burden.

The scholarship program was initiated in 2019 with a $110,000 contribution to the foundation by the Conrad Schmidt and Family Endowment. Strong interest by applicants prompted the foundation board to increase the number of scholarships awarded to 3, beginning in 2021.

The scholarship application form is available at **aasv.org/foundation/debtrelief.php**. Applications are due **January 31, 2023**. The following criteria will be used to select the scholarship recipient:

1. Joined AASV as a student enrolled in an AVMA-recognized college of veterinary medicine.
2. Attended the AASV Annual Meeting as a student.
3. Maintained continuous membership in AASV since graduation from veterinary school.
4. Is at least 2 years and at most 5 years post graduation from veterinary school (2018, 2019, or 2020 DVM/VMD graduates).
5. Has been engaged in private veterinary practice, 50% or more devoted to swine, providing on-farm service directly to independent pork producers. Veterinarians who work for production companies, pharmaceutical companies, or universities are not eligible for the scholarship.
6. Has a significant student debt burden.

For more information, contact the AASV Foundation: **foundation@aasv.org**.

Hogg Scholarship available to practitioners seeking MS or PhD; apply by January 31

The American Association of Swine Veterinarians Foundation is now accepting applications for the prestigious Hogg Scholarship, established to honor the memory of longtime AASV member and swine industry leader Dr Alex Hogg.

The intent of the $10,000 scholarship is to assist a swine veterinarian in his or her efforts to return to school for graduate education (resulting in a master's degree or higher) in an academic field of study related to swine health and production. Seventeen swine practitioners, recognized at **aasv.org/foundation/hoggscholars**, have been awarded the scholarship since it was established in 2008.

Applications for the scholarship will be accepted until **January 31, 2023**. The scholarship recipient will be announced Monday, March 6 during the 2023 AASV Annual Meeting.

Dr Alex Hogg's career serves as the ideal model for successful applicants. After 20 years in mixed animal practice, Dr Hogg pursued a master's degree in veterinary pathology. He subsequently became Nebraska's swine extension veterinarian and professor at the University of Nebraska. Upon "retirement," Dr Hogg capped off his career with his work for MVP Laboratories. Always an enthusiastic learner, at age 75 he graduated from the Executive Veterinary Program offered at the University of Illinois.

The scholarship application requirements are outlined below, and on the AASV website at **aasv.org/foundation/hoggscholarship.htm**.

Hogg Scholarship application requirements

An applicant for the Hogg Scholarship shall have:

1. Three or more years of experience as a swine veterinarian, either in a private practice or in an integrated production setting
2. Five or more years of continuous membership in the AASV

Applicants are required to submit the following for consideration as a Hogg Scholar:

1. Current curriculum vitae
2. Letter of intent detailing his or her plans for graduate education and future plans for participation and employment within the swine industry
3. Two letters of reference from AASV members attesting to the applicant's qualifications to be a Hogg Scholar

Applications and requests for information may be addressed to:

AASV Foundation
830 26th Street
Perry, IA 50220
foundation@aasv.org

Hey bidder, bidder!

Hey bidder, bidder – Whatcha gonna bid? It is almost time for the AASV Foundation auction to be held in conjunction with the 2023 AASV Annual Meeting. But you do not need to attend the meeting to participate in the auction and lend your support to the AASV Foundation! This event is the key fundraiser to support the foundation's annual disbursements of research grants, scholarships, externship grants, and more.

Hey bidder, bidder – Look what's up for bid! Check out the many items donated for the auction at **aasv.org/foundation/2023/auctionlist.php**. There is something for everyone, from trips, sporting events, and household décor to artwork, handcrafted items, and pig collectibles. Thanks to the many generous item donors, the full proceeds of the winning bid will benefit the AASV Foundation!

Hey bidder, bidder – What are you *REALLY* bidding on? When you bid in the foundation auction, you are bidding on much more than a trip to a fun event or an item to display in your home. You are bidding to support research that will open a window on new information to help you understand and address the latest disease challenges. You are bidding on developing a veterinary student into a colleague ready to join your practice or research team. You are bidding on reducing the debt of the young swine veterinarian getting started in their career. You are bidding on helping a seasoned colleague (or yourself!) pursue advanced training. Look past the "market value" of the auction item to see the true value of your bid: Priceless!

As in the past couple of years, the silent auction will be conducted entirely online using the popular ClickBid site. Bidding will open in February at **aasvf.cbo.io**. Anyone can bid anytime until the auction closes at 7:00 PM MST on March 6. Donors will ship or deliver items to the winning bidders after the auction.

The live auction will be conducted on site at the Gaylord Rockies Resort immediately following the Awards Reception

Monday, March 6. "BE there" to bid in person or submit bids for live auction items to **foundation@aasv.org**.

Hey bidder, bidder – Whatcha gonna bid?

New Heritage Video featuring KT Wright

A new Heritage Video, featuring Dr KT Wright, is now available. The Heritage Video Series is an ongoing project of the AASV Communications Committee, with support from the AASV Foundation and the creativity of Dr Sarah Probst Miller and Ag Create, to record and preserve AASV history through the recollections of its members. The video is available for viewing by AASV members at **aasv.org/members/only/video**.

A new year, a new face, a new email address

The beginning of a new year is frequently a starting point for change, and the AASV Foundation has a couple of recent changes to report.

The foundation is pleased to announce that it has contracted with Rhea Schirm to serve as part-time foundation manager. Under the auspices of AASV, Rhea will be performing the day-to-day administrative duties of the foundation, including receiving and acknowledging applications for grants and scholarships as well as contributions. She will be working closely with the AASV Foundation Board of Directors to carry out the many projects currently administered by the foundation, while at the same time making an effort to expand its funded programs as well as its giving opportunities.

While Rhea may be new to the foundation, there is a good chance she is already familiar to many. Last year, she was contracted to fill the part-time role of JSHAP publications manager. Prior to that, she worked for the National Pork Board for 10 years. In her role at the National Pork Board, she worked extensively to coordinate their research grant process. Her skills will be put to good use for the AASV Foundation! You can learn more about Rhea in her Publication Manager's message in the September/October issue of JSHAP.

The foundation also reports that it has established a dedicated email address, separate from that of AASV. The address **foundation@aasv.org** is intended for all communications directed to the AASV Foundation, including contributions, applications, and questions or suggestions regarding foundation programs or activities.

As 2023 gets underway, please take a few moments to update your email contact list with the AASV Foundation's new email address and send a quick message to welcome Rhea to her new role. Happy New Year!

AASV Foundation to cosponsor Annual Meeting luncheon

Attendees will see an exciting change at the 2023 AASV Annual Meeting Monday luncheon. Seizing an opportunity to increase its exposure and broaden its outreach, the AASV Foundation Board of Directors recently voted to cosponsor the Monday luncheon with AASV. The luncheon is included with meeting registration and will take place on Monday, March 6 in Aurora, Colorado.

As in the past, the veterinary student scholarship recipients will be announced during the luncheon. In addition, the recipients of other foundation-funded programs will be recognized, including the Hogg Scholarship, debt-relief scholarships, and research grants. The foundation will also honor its newest Heritage and Legacy donors and highlight its recent and upcoming activities.

Previously, the "Foundation Luncheon" was hosted on Sunday for Leman, Heritage, and Legacy donors to attend. By cosponsoring the well-attended luncheon on Monday instead, the foundation will be able to increase the visibility of its many activities and giving opportunities across a broader cross-section of the AASV membership while also providing support for the Annual Meeting.

Build a productive herd with a healthy gut.

Lawsonia and *Salmonella* work together to destroy the microbiome of a pig's gut, which can slow ADG. If you only protect from one, profit may be left on the table. Vaccinate against *Lawsonia* with PORCILIS® ILEITIS and *Salmonella* with ARGUS® SC/ST to complete your herd's gut protection and help establish operation efficiency.

Porcilis® ILEITIS

Argus® SC/ST

Talk to your Merck Animal Health representative about updating your operation's gut health protocols.

DRIVEN BY PREVENTION™
drivenbyprevention.com

MERCK Animal Health

merck-animal-health-usa.com 800-521-5767

US-ARG-19040001

When hoofbeats really are from zebras

Differential diagnosis rule number one: When you hear hoofbeats, think horses. In an ever-changing global environment and the severe consequence of a foreign animal disease introduction, we must always consider those hoofbeats *could* be from zebras.

This past October, 156 stakeholders, including representatives from the American Association of Swine Veterinarians, registered to attend the hybrid Japanese Encephalitis Virus (JEV) Symposium, hosted by the Center for the Ecology of Infectious Disease at the University of Georgia and sponsored, in part, by the Swine Health Information Center (SHIC). Stakeholders gathered to learn more about the Australian experience with JEV, discuss the known and unknown of JEV introduction and spread, and consider the potential animal and human health consequences if JEV were diagnosed in the United States.[1]

Japanese encephalitis virus is a zoonotic flavivirus in the same genus as dengue, yellow fever, and West Nile virus. It is transmitted primarily by the *Culex* mosquito species. Natural reservoirs include waterbirds from the Ardeidae family, such as herons and egrets. Clinical illness predominately occurs in equids, pigs, and humans; illness and asymptomatic infections have been documented in other species. Equids and humans are dead-end hosts while pigs are amplifying hosts.[2]

Dr Mark Schipp, Australia's Chief Veterinary Officer, described 3 ways in which JEV might be detected. Animals or humans may present with clinical signs, or the virus may be identified through mosquito surveillance. In Australia, JEV was first diagnosed by multiple different veterinarians on different farms in different states simultaneously. It was subsequently identified in humans and mosquitoes.[2]

As with African swine fever, early detection of JEV and any other foreign animal disease relies on producers and veterinarians to react to and report anything out of the ordinary. During the 2022 JEV outbreak in Australia, swine veterinarians Drs Kirsty Richards and Bernie Gleeson observed delayed farrowing, reduced litter size, increased return to service, late term abortions, and mummified, stillborn, and shaking piglets.[2]

With these clinical signs, Dr Schipp cautioned of the likelihood of detection bias. Clinical manifestation of JEV may be noticeable in large sow farms, but it may be easily missed in smaller farms or when only a small percentage of animals is infected. In fact, JEV was likely circulating in Australia for at least 1 year before it caused a major outbreak in 2022.[2]

Dr Michael Neafsey, One Health Coordinator for the US Department of Agriculture's Animal and Plant Health Inspection Service, also expressed concerns about delayed detection because of JEV's nonspecific clinical presentation.[3]

"Be vigilant, investigate every unusual health event, report anything different, and question the result."

JEV could have been introduced into Australia via migratory waterbirds, microbats or fruit bats, wind dispersed mosquitoes, or mosquitos in shipping vessels or aircraft. Previous risk assessments indicated aircraft and cargo ships as the most likely pathways for the introduction of JEV into the United States. Climate and geography likely impacted the sylvatic lifecycle and sustained transmission in Australia.[2]

Observed risk factors for JEV in Australian farms included the presence of standing water, water birds, and mosquitoes. Pig movement and semen movement, due to high quality control, did not seem to be risk factors.[2]

All presenters from Australia emphasized the importance of a One Health approach for a coordinated and efficient response. Dr Richards acknowledged time and resources spent on preparing for an African swine fever incursion was crucial to the JEV response. "It might not have been African swine fever that arrived, but nothing in that preparation was wasted. The work that we've done for African swine fever absolutely underpinned the collaboration we had with government during this response. We've learned that relationships, understanding, and credibility between government and industry stakeholders is pivotal to having a successful emergency disease response."[2]

Further, Australian consumer impact was minimal largely in part because of messaging. The public was reassured that pork is safe, JEV is a mosquito-borne disease, and pigs are incidental hosts.[2]

A key action item from the symposium was to further educate swine veterinarians about JEV. In 2022, Dr Harry Snelson

Advocacy in Action continued on page 49

UNITED ANIMAL HEALTH

STRESS HAPPENS TO US ALL.

Your corn is no different.

You can't control the weather, but you can control mycotoxins.

HUMIDITY & RAIN
Increases the risk of fungal growth and mycotoxin production

HEAT
Creates the perfect environment for molds to grow

DROUGHT
Causes grain damage and facilitates fungal spores' entrance

TAKE THE STRESS OUT OF MYCOTOXIN MANAGEMENT.

UnitedAnH.com/Stress

M-Mobilize®

Advocacy in Action continued on page 47

challenged veterinarians to report more often when things are unusual. "Everyone who sees pigs in the field must be empowered to raise the alarm when there are suspicions that things just aren't normal."[4]

Be vigilant, investigate every unusual health event, report anything different, and question the result.

There is still much to learn about JEV and its potential to impact human and animal health in the United States. If we can at least recognize the hoofbeats might be coming from a zebra, we will be ahead.

Presentations from the symposium have been archived and are freely available at **ceid.uga.edu/jev2022/archive/**.[2] Additionally, information about the Australian JEV outbreak and response was featured in episode 10 of the SHIC Talk podcast (**swinehealth.org/podcasts/**) and the March 29, 2022 SHIC/AASV webinar (**aasv.org/members/only/video/webinars/#v11**).

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

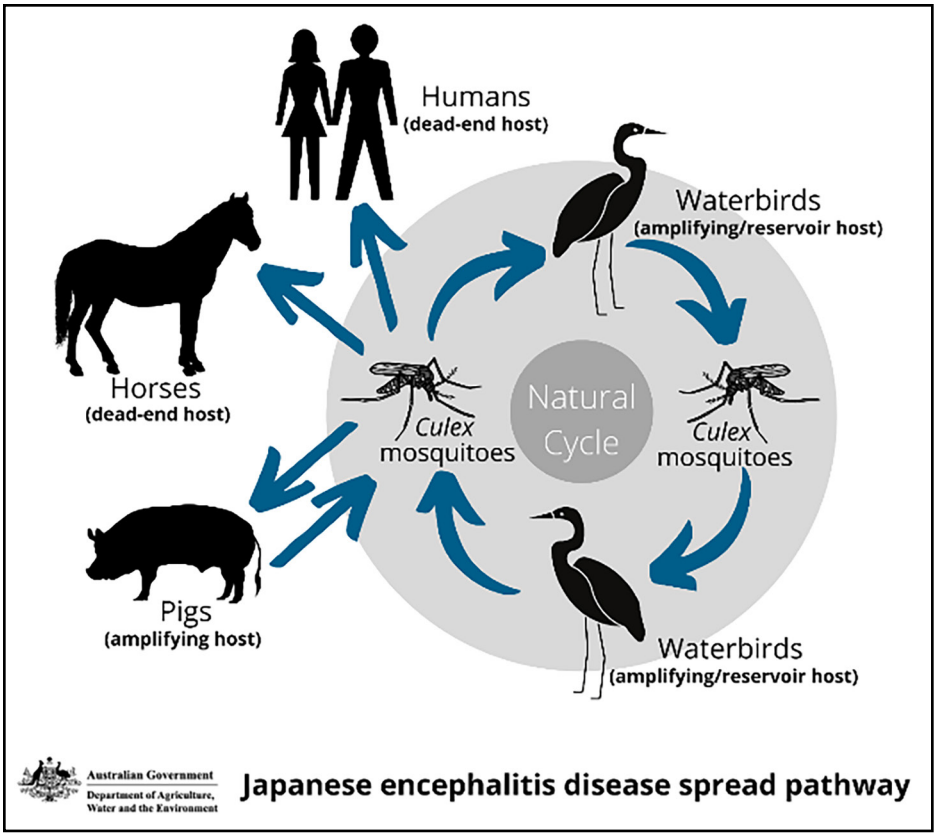


Image Credit: Image courtesy of the Australian Department of Agriculture, Water and Environment.

References

*1. Sundberg P. JEV Symposium: Australian experience informs US preparedness. AASV. November 2, 2022. Accessed November 14, 2022. **https://aasv.org/news/story.php?id=15233**

*2. Symposium on Japanese Encephalitis Virus Emerging Global Threat to Humans & Livestock. University of Georgia Center for the Ecology of Infectious Diseases. October 17-19 2022. **https://www.ceid.uga.edu/jev2022/**

*3. Sundberg P. JEV Symposium: US preparedness underway. AASV. November 9, 2022. Accessed November 14, 2022. **https://aasv.org/news/story.php?id=15277**

*4. Snelson H. It's probably nothing [Editorial]. *J Swine Health Prod*. 2022;30(4):207.

* Non-refereed references.

Journal of Swine Health and Production Author Guidelines

Journal description

The *Journal of Swine Health and Production* (JSHAP) is published bi-monthly by the American Association of Swine Veterinarians (AASV) and is freely available online. The journal accepts manuscripts for peer review that encompass the many domains of applied swine health and production, ie, the diagnosis, treatment, management, prevention and eradication of swine diseases, swine welfare and behavior, nutrition, public health, epidemiology, food safety, biosecurity, pharmaceuticals, antimicrobial use and resistance, reproduction, growth, systems flow, economics, and facility design.

Types of papers

The *Journal of Swine Health and Production* currently accepts manuscripts that meet the descriptions and formatting requirements defined in Table 1.

Policies and procedures

Animal care and use

For animal experiments performed in research facilities or on commercial farms, include a statement indicating that the studies were reviewed and approved by an institutional animal care and use committee or equivalent. For case reports and studies performed under field conditions, in which animals are not manipulated beyond what would be required for diagnostic purposes, it must be clear that housing was adequate and that the animals were humanely cared for. If the study is exempt from animal care and use approval (eg, use of diagnostic records), authors need to clearly state the reasons in the manuscript. Place animal care and use statements in a separate section labeled with an "Animal care and use" heading. This section should immediately precede the "Materials and methods" heading or equivalent position depending on genre.

Authorship

According to the International Committee of Medical Journal Editors, all listed authors must have participated sufficiently to take public responsibility for the work. Individuals should only be listed as authors if contributions have been made in each of the following areas[1]:

1) Conception and design, acquisition of data, or analysis and interpretation of the data,
2) Drafting the manuscript or revising it critically for important intellectual content,
3) Approval of the version of the manuscript to be published, and
4) Agreement to be accountable for all aspects for the work, ensuring questions related to accuracy and integrity are investigated and resolved.

Ethics

Authors are expected to observe high standards with respect to research and publication ethics. Fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results is considered research misconduct.[2] All cases of research misconduct will be investigated and addressed accordingly.

Conflict of interest

Authors are required to declare the presence of any personal, professional, or financial relationships that could potentially be construed as a conflict of interest for the submitted manuscript, regardless of genre. This declaration is placed just before the reference section, and provides information concerning authors who profit in some way from publication of the paper. For example, one or more of the authors may be employed by a pharmaceutical company that manufactures a drug or vaccine tested in the study reported. Other examples include consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. If there is no conflict of interest to declare, the statement under the "Conflict of interest" heading is "None reported."

Copyright transfer

When a manuscript is submitted to the JSHAP, a pre-review copyright agreement and disclosure statement must be signed by all authors. It is the responsibility of the corresponding author to secure these signatures. This form is available from the publications manager. Scan and email signed copies to **jshap@aasv.org**. When the manuscript is accepted for publication, the corresponding author will be required to transfer copyright to the AASV, with the exceptions of US government employees whose work is in the public domain and portions of manuscripts used by permission of another copyright holder. Anyone acknowledged by name in the manuscript will need to sign an acknowledgment permission form.

Prior publication

We do not republish materials previously published in refereed journals. Sections of theses and extension publications that may be of value to our readership will be considered. Prior publication of an abstract only (eg, in a proceedings book) is generally acceptable.

Permissions

If copyrighted material is used, advise the editors of this at the time of manuscript submission. Authors are responsible for securing permission to use copyrighted art or text, including the payment of fees.

Publication fees

There is no fee for publication of manuscripts in the JSHAP.

Manuscript preparation

File types

All manuscripts must be submitted as a Microsoft Word document using 1-inch margins, Times New Roman 12-point font (unless otherwise specified), and left justification with double-spacing throughout. Include continuous page and line numbers. Do not use numbered or bulleted lists in the summary or the text. Do not include tables or figures in

Table 1: Manuscript genres and formatting requirements currently accepted by the *Journal of Swine Health and Production*

		Maximum words		Maximum No.		
Genre	**Description**	**Abstract**	**Manuscript body**	**Figures and Tables**	**References**	**Other requirements***
Original Research	Reports the results of original research on topics that are within journal scope.	250	4000	As needed	35	–
Brief Communication	Documents observations made in a narrowly defined research area or a mini-review of a subject area.	50	2000	2	15	–
Case Report	Describes an unusual or interesting case.	100	3000	As needed	As needed	Manuscript should not exceed 20 pages including figures, tables, and references.
Case Study	Describes unusual or interesting cases occurring on two or more farms.	100	3000	As needed	As needed	Manuscript should not exceed 20 pages including figures, tables, and references.
Literature Review	Review of the published scientific literature about a specific topic area in which important advances have been made in the past five years and is of current interest.	200	5000	As needed	As needed but most references should be recent (within 5 yrs) and avoid use of non-refereed references and personal communications.	Manuscript should not exceed 30 pages including figures, tables, and references.
Production Tool	Describes a practical, state-of-the-art technique for improving an individual swine enterprise or the swine industry at large.	100	3000	As needed	As needed	Manuscript should not exceed 20 pages including figures, tables, and references.
Diagnostic Note	Describes methods of diagnosis for swine diseases. A brief literature review may be included and use of non-refereed references and personal communications is not restricted.	100	3000	As needed	As needed	Manuscript should not exceed 20 pages including figures, tables, and references.
Practice Tip	Describes new technological methods likely to be of use to swine practitioners.	100	3000	As needed	As needed	Manuscript should not exceed 20 pages including figures, tables, and references.

Table 1: Continued

Genre	Description	Maximum words		Maximum No.		Other requirements*
		Abstract	Manuscript body	Figures and Tables	References	
Peer-reviewed Commentary	Commentary on diagnostic, research, or production techniques used in the field of swine health and production.	100	3000	As needed	As needed	Manuscript should not exceed 20 pages including figures, tables, and references.
Letter to the Editor (LTE)	Offers comment or useful critique on materials published in the journal.	-	500	0	5	The decision to publish an LTE rests solely with the executive editor. Letters referring to a published article will be forwarded to the author of the article, and both the original letter and the response will be published in the same issue if possible. Letters to the Editor are not peer-reviewed but are subject to editorial changes.

* Page limits are for Microsoft Word documents using 1-inch margins, Times New Roman 12-point font (unless otherwise specified), and left justification with double-spacing throughout.

this file, but do include table and figure references, such as (Table 1) or (Figure 1), within the text. Software programs that automatically create endnotes, footnotes, and references should be avoided in the final submitted version of the manuscript as the embedded formatting cannot be read by the publication software.

If the manuscript includes tables, create and submit them in a second Microsoft Word document titled "Art". Multiple tables can be submitted in a single Word document.

If the manuscript includes figures (graphs or images), submit each figure in a separate file titled as the respective figure number. Graphs created in Microsoft Excel should be submitted in the original .xls file(s). A graph created in statistics software can be submitted as a .pdf file. Photographs and images need to be high resolution .jpg files. Figure caption and legend texts should be submitted in a Microsoft Word file titled "Art" (included with Tables if applicable).

Sample templates have been created for each genre to assist authors in formatting their manuscript and can be accessed at **aasv.org/shap/guidelines**.

Supplementary materials

Supplementary materials are additional materials that are not essential to the understanding of the manuscript but provide important context to the manuscript and may be submitted for online only publication. Examples of materials accepted include extended descriptions of experimental methods or statistical analysis, extended bibliographies, additional supporting tables and figures, reporting checklists, copies of surveys or questionnaires, handouts, and forms.

For supplementary materials that are too large or in a format not consistent with JSHAP publication (eg, data sheets, presentations, audio, or video), authors are encouraged to upload and publish these files to a repository, such as FigShare, and reference the DOI within the manuscript.

Supplementary materials must be formatted according to the JSHAP Author Guidelines. There is no word or page limit for supplementary materials, but they should be succinctly presented to facilitate peer review. Acceptance of supplementary materials for publication is at the discretion of the editor. All JSHAP published supplementary materials are subject to copyright.

General style

Manuscripts must be written in English and use American spelling and usage. The JSHAP uses the AMA Manual of Style for guidance on general style and form.[3] Please review the complete author guidelines and author checklist at **aasv.org/shap/guidelines** for full details on journal formatting requirements for submitted manuscripts.

Manuscript submission

Submission instructions

All submissions must be accompanied by a cover letter. The cover letter should be on official letterhead, not exceed 1 page, and include the following information:

- a statement acknowledging the manuscript is not currently under consideration for publication elsewhere,
- a statement that all co-authors have reviewed and approve the manuscript submission,
- the intended genre of the submitted manuscript,

- a brief description of how the manuscript relates to the scope of JSHAP (optional),
- suggestions for potential reviewers of the submitted manuscript (optional), and
- signature of the corresponding author.

All manuscript files should be submitted to the JSHAP publications manager via email: **jshap@aasv.org**.

Unless given alternate instructions at the time of submission, we will correspond with the corresponding author.

Questions about manuscript submission or status can be directed to the JSHAP publications manager:

Rhea Schirm
Journal of Swine Health and Production
c/o American Association of Swine Veterinarians
830 26th Street
Perry, IA 50220
Email: **jshap@aasv.org**

References

1. International Committee of Medical Journal Editors. Recommendations for the conduct, reporting, editing, and publication of scholarly work in medical journals. **http://www.icmje.org/icmje-recommendations.pdf**. Updated December 2017. Accessed June 20, 2018.

2. Office of Science and Technology Policy. Federal policy on research misconduct. *Fed Regist*. 2000;65(6):76260-76264.

3. Christiansen SL, Iverson C, Flanagin A, Livingston EH, Fischer L, Manno C, Gregoline B, Frey T, Fontanarosa PB, Young RK, eds. *AMA Manual of Style: A Guide for Authors and Editors*. 11th ed. New York, New York: Oxford University Press. 2020.

JSHAP Author Guideline Checklist

Updated January 2022

Title page

- □ My manuscript is a Word document with double spacing, footer page numbers, continuous line numbers, and Times New Roman 12 pt font.
- □ I have provided a short title of 90 characters or less (including spaces).
- □ I have included the genre of publication.
- □ I have created a title that is concise, specific, and informative without using abbreviations.
- □ I have properly formatted the author byline.
  - ○ Alpha B. Charlie, degree, degree; Juliett K. Lima, degree; Mike N. Oscar, degree
  - ○ List only the highest level of degree or professional certification except if additional degree denotes a different field of study or a specialty degree, license, certification or credentials.
- □ I have properly formatted the author affiliations.
  - ○ ABC, MNO: department, college, institution, City, State or Country. (State only if in the United States)
  - ○ JKL: company, City, State or Country. (State only if in the United States)
- □ I have properly formatted the Corresponding Author information.
  - ○ Corresponding author: Dr Alpha B. Charlie, street address, City, State Zip; Tel: 555-555-5555; Email: **email@email.com**.

Summary

- □ I have included a Summary not exceeding the word limit for the genre:
  - ○ 250 words for original research including these subheadings – Objective(s), Materials and methods, Results, and Implication(s).
  - ○ 200 words for literature review. No subheadings needed.
  - ○ 100 words for case report, case study, production tool, diagnostic note, practice tip, or peer-reviewed commentary. No subheadings needed.
  - ○ 50 words for brief communication. No subheadings needed.
- □ I have defined abbreviations at the first mention of the term being abbreviated in the summary.
- □ I have only introduced abbreviations if they are used again in the summary and have used the abbreviation whenever the term is mentioned in the summary except at the beginning of a sentence.
- □ I have included "swine" as the first keyword with up to 4 additional words or phrases for a total of 5 keywords.

Manuscript body

- □ I have included the required sections for the genre of manuscript.
- □ I have defined abbreviations at the first mention of the term being abbreviated in the body of the manuscript except in titles, headings, and subheadings.
- □ I have only introduced abbreviations if they are used again in the manuscript body and have used the abbreviation whenever the term is mentioned in the manuscript body except at the beginning of a sentence or as the sole term in headings and subheadings.
- □ I have included an animal care and use statement in a separate section preceding the Materials and methods section.
- □ I have provided the manufacturer's name for all equipment and reagents used in my study.
- □ When *P* values are reported, I have capitalized and italicized the *P* and have not included a zero to the left of the decimal point. The numerical value is rounded to 2 or 3 digits to the right of the decimal point with the smallest being $P < .001$.
- □ I have included spaces around signs of operation (+, <, >, =, etc).
- □ I have used commas to separate all parts of a series (eg, green, red, and yellow).
- □ I have spelled out all units of measure unless they are accompanied by a numerical value.
- □ I have not used numbered or bulleted lists in the manuscript.
- □ I have used brackets to indicate a parenthetical expression within a parenthetical expression: ([ ]).

Implications

- □ I have included up to 3 bulleted implications, each with a maximum of 80 characters or less (including spaces). This section is exempt only for literature review and practice tip manuscripts.

Acknowledgments

- □ I have mentioned any individuals, companies, or funding sources that I would like to acknowledge.
- □ I have disclosed all conflicts of interest for this paper. If none exist, I have included the statement "None reported."
- □ I have included the JSHAP disclaimer.

References

- □ I have checked that all reference numbers in the manuscript are listed in sequential order.
- □ I have formatted reference numbers in the manuscript as superscripts placed after periods and commas and before colons and semicolons.
- □ I have properly formatted references according to the table in the author guidelines.
- □ I have italicized and abbreviated all journal titles according to the US National Library of Medicine rules (**www.nlm.nih.gov/pubs/factsheets/constructitle.html**) and catalog (**www.ncbi.nlm.nih.gov/nlmcatalog/journals**).
- □ I have provided complete page numbers in all references (eg, 120-128, not 120-8).
- □ I have used a hyphen to separate page numbers in all references.
- □ I have identified all non-refereed references with an asterisk (*) to the left of the reference list number and have included the following notation at the end of the reference list.
  - ○ * Non-refereed references.

Tables

- □ I have included all tables in an "Art" file separate from the manuscript (may include figure legends).
- □ I have created tables that stand alone from the manuscript (ie, they do not rely on explanatory materials from the manuscript) and are numbered in the order they are referenced in the text.
- □ My table titles are brief, in sentence case with only the first word capitalized, and do not end with a period.
- □ I have created my tables using Microsoft Word.
- □ I have included the appropriate unit of measure for each row and column.
- □ I have no missing data in my tables (eg, empty cell, hyphen, period) and used the numeral "0" to indicate the value of the data is zero or "NA" to denote not available, not analyzed, or not applicable and have defined the abbreviation accordingly in the abbreviations footnote.
- □ I have used parentheses instead of the ± symbol throughout my table (eg, "1 (3.5)" rather than 1 ± 3.5").
- □ I have used footnotes to explain data in the table using symbols in the designated order (*†‡§¶) and doubled the symbols in that order if more were needed.
- □ When appropriate, I have provided a footnote to describe the level of significance and the statistical method of analysis used.
- □ When appropriate, I have used lower case letters as superscripts to designate significant differences and have created a footnote to explain the level of significance and the statistical method used.
- □ I have defined all abbreviations used in the table in the last footnote, which does not use a footnote symbol.
- □ I have ensured the abbreviations used in the table are consistent with any abbreviations used in the manuscript.

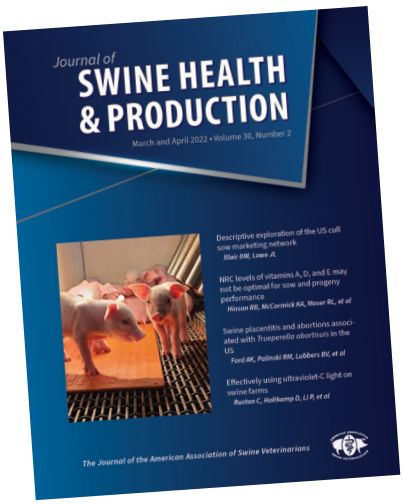
Figures

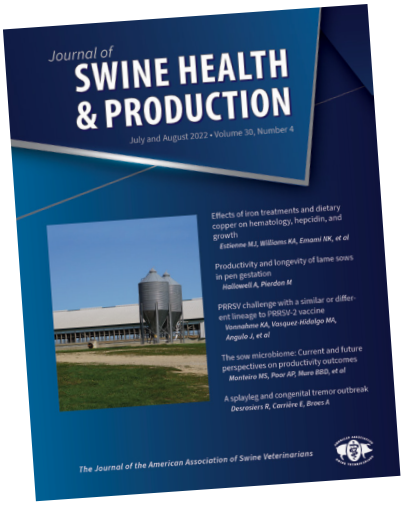
- □ I have included all figure legends in an "Art" file separate from the manuscript (may include tables).
- □ I have created figures that stand alone from the manuscript (ie, they can be understood without referencing information from the manuscript) and are numbered in the order they are referenced in the text.
- □ My figure title is descriptive, brief, and followed by the legend and abbreviations. The legend includes a brief description of treatments, level of significance, *P* values, and the statistical method used. All abbreviations used in the figure are defined.
- □ I have created a separate file for each figure in the acceptable file types (ie, .xls, .pdf, or .jpg).
- □ All axes are labeled with a description followed by the unit of measure, when needed, separated by a comma.

Manuscript submission

- □ I have included my manuscript file and a separate art file with my submission.
- □ I have included a cover letter that does not exceed 1 page and includes the requested information.

Pigs of #instaham





Share your pig photos for the JSHAP cover

Submissions by readers are welcome!

- Photos must represent healthy pigs and modern production facilities and not include people.
- Photos must be taken using the camera's largest file size and highest resolution.
- Please send the original image(s); do not resize, crop, rotate, or color-correct the image prior to submission.
- Submit photos with your name and affiliation to **tina@aasv.org**.

Dr Locke Karriker

I am truly honored to be nominated for vice president and for the chance to serve an organization of peers for whom I have so much respect and owe so much. I grew up on a small, diversified farm in Eastern North Carolina in the late 1980's through early 1990's that mirrored the transitions in the industry at the time. We started with a few sows outdoors, eventually built a small wooden farrowing house, and later a modern sow farrowing unit and nursery. Four important values born out of that time on the farm influenced my professional development and approach today:

- High-quality challenges are opportunities, and they develop problem-solving skill sets that are valuable in swine medicine and beyond. You had to own the problems on a small farm. "Not my problem" was not an acceptable answer – the problem would still be there tomorrow.
- Work ethic is critical to success and includes BOTH working smarter and harder.
- It is important to be generous with your time, effort, and knowledge and be willing to help when needed without expectations or conditions.
- Treat everyone respectfully, as individuals, regardless of title or background. Being respectful includes acknowledgement and sincere appreciation.

I attended the University of North Carolina as a Morehead Scholar enroute to Mississippi State University College of Veterinary Medicine, where a case-based teaching format was used to jump start the clinical thought processes on day one. I took advantage of a concurrent Master of Science program with food-animal focus to expand my epidemiology and financial toolbox.

I began practice in an integrated production system, a great place for a new graduate because there were plenty of opportunities to contribute and constant opportunities to learn about all facets of pig farming and pork production. Later, during trips to China, Serbia, Mexico, and other destinations, I gained appreciation for the valuable resources we have and a lot of respect for effective veterinarians around the world that do with less.

I joined the faculty at Iowa State University intent on researching solutions to some of the challenges that confounded me in practice 19 years ago. The challenges continue and the complexity grows, but I get to teach, do applied research, and work with clients as part of a great team devoted to service. Since 2011, I have had the privilege of serving as the Director of the Swine Medicine Education Center with a mission to teach every swine medicine or research clinical skill and provide a place for students to practice those skills in modern farm environments.

Being a swine veterinarian in an academic environment impacts my perception of the challenges and future opportunities for our association. To be a good teacher, you must be an efficient and effective student and our organization has a fine history of this integration. Our formal engagement of students in programs and governance is a respected model. However, we must urgently expand our influence on swine medicine training beyond AASV activities. There has been a precipitous decline in the number of schools teaching swine medicine and the scope of that training. Our association generates meaningful information, but we need to facilitate a faster knowledge economy and shorten the distance between discovery and the pig without compromising scientific rigor. There are many references to the "information superhighway" which expedites our access to knowledge. With expanding broadband access, emerging telehealth tools, and smart barn technologies, that highway has finally built an exit ramp at the farm. It is time to push forward with point-of-care reference systems that are flexible and able to engage in new topics quickly. Evidence-based medicine does not preclude anecdotes when it is the best information available, it simply requires that we identify them as such.

If we engage these challenges and continue to maintain and expand pathways into the profession, the future is unlimited. The best and brightest students of today are some of the best in the professions' history. Trust me, at times it is tough to stay ahead of them to provide value!

I appreciate your consideration and I look forward to opportunities to tackle high-quality challenges and learn together.

Locke Karriker, DVM, MS, DACVPM

uniferon®
Iron(III) Dextran

The #1 iron dextran (III) for baby pigs

1,400

200 mg = 1,109

2 x 200 mg = 427

x (-$2.77) = ?

Opitmal*	≥ 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)

us.uniferon.com

PHARMACOSMOS

PM-060-00

UPCOMING MEETINGS

AVMA Leadership Conference

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

Hosted by the American Veterinary Medical Association

For more information:
Web: **avma.org/events/veterinary-leadership-conference**

Banff Pork Seminar

January 10 - 12, 2023 (Tue-Thu)
Fairmont Banff Springs Hotel
Banff, Alberta, Canada

For more information:
Web: **banffpork.ca**

AVMA Humane Endings Symposium

January 27 - 29, 2023 (Fri-Sun)
Chicago, Illinois

Hosted by the American Veterinary Medical Association

For more information:
Web: **avma.org/events/avma-humane-endings-symposium**

Pig Ski Conference

February 8 - 10, 2023 (Wed-Fri)
Copper Mountain, Colorado

For more information:
Dr Paul and Lori Yeske
Tel: 507-381-1647
Web: **pigski.com**

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**

Animal Agriculture Alliance Stakeholders Summit

May 4 - 5, 2023 (Thu-Fri)
Arlington, Virginia

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

Safepork 2023

May 15 - 17, 2023 (Mon-Wed)
New Orleans, Louisiana

For more information:
Web: **regcytes.extension.iastate.edu/safepork**

World Pork Expo

June 7 - 9, 2023 (Wed-Fri)
Iowa State Fairgrounds
Des Moines, Iowa

For more information:
World Pork Expo
10676 Justin Drive
Urbandale, Iowa 50322
Web: **worldpork.org**

AVMA Convention

July 14 - 18, 2023 (Fri-Tue)
Denver, Colorado

For more information:
Web: **avma.org/events/avma-convention**

Allen D. Leman Swine Conference

September 16 - 19, 2023 (Sat-Tue)
Hosted by the University of Minnesota College of Veterinary Medicine
Saint Paul, Minnesota

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

Pig Research Summit - THINK Piglet Health & Nutrition 2023

September 21 - 22, 2023 (Thu-Fri)
Crowne Plaza Copenhagen Towers
Copenhagen, Denmark

For more information:
Danish Agriculture & Food Council
Web: **tilmeld.dk/thinkpiglet2023/conference**

27th International Pig Veterinary Society Congress & 15th European Symposium of Porcine Health Management

June 4 - 7, 2024 (Tue-Fri)
Leipzig, Germany

Organized by IPVS, ESPHM, and Universitat Leipzig
Congress Centre Leipzig

For more information:
Web: **ipvs2024.com**

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:**

JSHAP Resources

AASV resources _____ aasv.org

Author guidelines _____ aasv.org/shap/guidelines

Journal of Swine Health and Production _____ aasv.org/shap

Membership information _____ aasv.org/aasv/membership

Subscription information _____ ecom.aasv.org/journal

Upcoming meetings _____ aasv.org/meetings

Industry Support Council member info _____ aasv.org/shap/advertising.php