Peer reviewed **ORIGINAL RESEARCH**

Description of practices adopted in response to porcine reproductive and respiratory syndrome outbreaks among breeding herds in the United States from 2019-2021

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Summary

Objectives: Describe and benchmark strategies and practices used in the field across the United States to control and eliminate porcine reproductive and respiratory syndrome (PRRS) virus in response to PRRS outbreaks from 2019 to 2021.

Materials and methods: A voluntary survey was used to collect information on practices implemented in response to PRRS outbreaks in different herds from 2019 to 2021. Information about herd demographic characteristics, biomanagement practices, diagnostic test and testing results, and production data were collected, collated, standardized, and described according to the herd's outbreak characteristics.

Results: A diversity of biomanagement practices were observed among 86 herd outbreaks. The median time to stability (TTS) was 38.0 weeks (interquartile range (IQR), 32.0-49.0 weeks), and time to baseline productivity (TTBP) was 22.0 weeks (IQR, 15.0-26.0 weeks). The median total production losses (TL) was 3675 pigs per 1000 sows (IQR, 2356-6845 pigs per 1000 sows); TTS and TTBP were longer and TL higher than a study reported ten years ago (26.6 weeks, 16.5 weeks, and 2217 pigs/1000 sows, respectively). Herd closure strategy, herd interventions such as live virus inoculation and modified-live virus vaccine, and biomanagement strategies to reduce virus transmission among sows and pigs were inconsistent among the studied herds.

Implications: Under the conditions of this study, management practices used during PRRS outbreaks were highly diverse among herds. In addition, herd closure, interventions, and biomanagement strategies were inconsistent. The TTS and TTBP were longer, and TL was higher than reported 10 years ago.

Keywords: swine, porcine reproductive and respiratory syndrome virus, benchmarking, time to stability, total loss

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Resumen - Descripción de las prácticas adoptadas en respuesta a los brotes de síndrome reproductivo y respiratorio porcino en las piaras de cría en los Estados Unidos entre 2019 y 2021

Objetivos: Describir y comparar las estrategias y prácticas utilizadas en el campo en los Estados Unidos para controlar y eliminar el virus del síndrome reproductivo y respiratorio porcino (PRRS) en respuesta a los brotes de PRRS de 2019 a 2021.

Materiales y métodos: Se utilizó una encuesta voluntaria para recopilar información sobre las prácticas implementadas en respuesta a los brotes de PRRS en diferentes piaras entre 2019 y 2021. Se recopiló, cotejó, estandarizó y describió la información sobre las características demográficas de la piara, las prácticas de biomanejo, las pruebas diagnósticas y los resultados de las pruebas, y los datos de producción de acuerdo con las características del brote de la piara.

Resultados: Se observó una diversidad de prácticas de biomanejo entre 86 brotes en las piaras. La mediana del tiempo hasta la estabilidad (TTS) fue de 38.0 semanas (rango intercuartílico [RIC], 32.0-49.0 semanas) y el tiempo hasta la productividad basal (TTBP) fue de 22.0 semanas (RIC, 15.0-26.0 semanas). La mediana de las pérdidas totales de producción (LT) fue de 3675 cerdos por cada 1000 cerdas (RIC, 2356-6845 cerdos por cada 1000 cerdas); la TTS y la TTBP fueron más largas y la LT más alta que un estudio reportado hace diez años (26.6 semanas, 16.5 semanas, y 2217 cerdos/1000 cerdas, respectivamente). La estrategia de cierre de granja, las intervenciones en la piara, como la inoculación con virus vivo y la vacunación con virus vivo modificado, y las estrategias de biomanejo para reducir la transmisión del virus entre hembras y lechones fueron inconsistentes entre las piaras estudiadas.

Implicaciones: En las condiciones de este estudio, las prácticas de manejo utilizadas durante los brotes de PRRS fueron muy diversas entre las piaras. Además, el cierre de la granja, las intervenciones y las estrategias de biomanejo fueron inconsistentes. El TTS y el TTBP fueron más largos, y el TL fue más alto que el reportado hace 10 años.

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Résumé – Descriptions des procédures adoptées en réponse à des poussées de cas du syndrome reproducteur et respiratoire porcin dans des troupeaux de reproducteurs aux États-Unis pour la période 2019-2021

Objectifs: Décrire et comparer les stratégies et pratiques utilisées sur le terrain aux États-Unis pour limiter et éliminer le virus du syndrome reproducteur et respiratoire porcin (SRRP) en réponse aux épidémies de SDRP de 2019 à 2021.

Matériels et méthodes: Une enquête volontaire a été utilisée pour collecter des informations sur les pratiques mises en œuvre en réponse aux épidémies de SRRP dans différents troupeaux de 2019 à 2021. Des informations sur les caractéristiques démographiques des troupeaux, les pratiques de biogestion, les tests de diagnostic et les résultats des tests, ainsi que les données de production ont été collectées, rassemblées, standardisées et décrits selon les caractéristiques épidémiques du troupeau.

Résultats: Une diversité de pratiques de biogestion a été observée parmi 86 troupeaux avec épidémie. Le délai médian jusqu'à la stabilité (TTS) était de 38.0 semaines (intervalle interquartile (IQR), 32.0-49.0 semaines) et le délai jusqu'à la productivité de base (TTBP) était de 22.0 semaines (IQR, 15.0-26.0 semaines). Les pertes de production totales médianes (TL) étaient de 3675 porcs pour 1000 truies (IQR, 2356 à 6845 porcs pour 1000 truies); le TTS et le TTBP étaient plus longs et le TL plus élevé qu'une étude rapportait il y a dix ans (26.6 semaines, 16.5 semaines, et 2217 porcs/1000 truies, respectivement). La stratégie de fermeture des troupeaux, les interventions dans les troupeaux telles que l'inoculation de virus vivants et le vaccin à virus vivant modifié, ainsi que les stratégies de biogestion visant à réduire la transmission du virus entre les truies et les porcs variaient parmi les troupeaux étudiés.

Implications: Dans les conditions de cette étude, les pratiques de gestion utilisées lors des épidémies de SRRP étaient très diverses selon les troupeaux. De plus, la fermeture des troupeaux, les interventions et les stratégies de biogestion n'étaient pas constante. Le TTS et le TTBP étaient plus longs et le TL était plus élevé que celui signalé il y a 10 ans.

Porcine reproductive and respiratory syndrome (PRRS) is an endemic and devastating disease in most swine-producing regions worldwide.[1] The PRRS virus (PRRSV) can persist in individuals and pig populations for several months.[2] Acute disease outbreaks are common and associated with new virus introduction and lack of appropriate herd immunity.[3] Porcine reproductive and respiratory syndrome is among the diseases with the highest economic impact in modern pig production,[4] with generalized estimated annual production losses of $664 million in the United States and $150 million in Canada.[5,6] Different immunologic solutions, including live virus inoculation (LVI) and modified-live virus (MLV) vaccines, or a combination of both, have been used to reduce the impact of PRRSV on production in breeding herds.[7,8]

The time to stability (TTS), defined as the number of weeks to produce negative pigs at weaning, and the total production losses (TL), defined as number of pigs weaned below the herd-specific baseline, normalized by 1000 sows, may be correlated with different PRRS management practices and virus characteristics.[7-9] The use of LVI as part of a whole-herd exposure program to control and eliminate PRRSV contributed to shortening TTS compared to using an MLV vaccine.[8] Intervention with MLV vaccine has been demonstrated to reduce the duration of viral shedding.[10] In addition, breeding herds detected with three or more PRRSV strains or the presence of recombinant variants were associated with increased TTS and TL.[9] Although different interventions have been reported in response to PRRS outbreaks, the results of management practices vary and have been inconsistent across studies.[7,10-12]

Among different biosecurity and management strategies, herd closure, with or without whole-herd exposure (eg, MLV or LVI), is a common practice in North America to manage PRRSV infection in breeding herds.[13] Herd closure is the interruption of animal introduction (eg, replacement gilts) for a determined period (usually until the herd achieves stability); the combined implementation of herd closure and whole-herd exposure using MLV vaccination or LVI is often referred to as load-close-expose.[8,11,14] The concept of load-close-expose is that pig introduction into a breeding herd is interrupted until the pathogen's infection cycle ends; most often when PRRSV is no longer detected in pigs at weaning age,[8,15] The principle is to prevent the introduction of susceptible pigs that, when in contact with PRRSV, become infected and disseminate the virus within the herd, thus perpetuating the within-farm infection.[15]

Despite significant progress in understanding interventions to manage PRRSV infection, achieving consistent results in endemically infected herds varies with no unique or completely effective intervention identified.[1,16] An understanding of practices implemented in the field may help veterinarians and producers standardize PRRS management and control strategies. This study aimed to describe and benchmark strategies and practices used in the field across the United States to control and eliminate PRRSV in response to a PRRS outbreak.

Animal care and use

This study was approved by the Iowa State University Institutional Animal Care and Use Committee under protocol number 19-118. The data was shared anonymously, and disclosure of responses outside the research will not place participants at risk of harm.

Materials and methods

Overview

A voluntary survey was used to collect information on practices implemented in response to a PRRS outbreak in different herds. Herd veterinarians were contacted between 2019 and 2021 and were asked to voluntarily share herd demographic characteristics, biomanagement practices, diagnostic test and testing results, and production data. All collected, collated, and standardized data were described according to the herd's outbreak characteristics.

Eligibility and exclusion criteria

The eligibility criteria included swine breeding herds reporting a PRRS outbreak, working on a plan to manage the infection, and tracking the recovery

from the outbreak using diagnostic testing and productivity data monitoring. A PRRS outbreak was characterized by RNA detection using reverse transcription-quantitative polymerase chain reaction (RT-PCR) and clinical signs of PRRS observed by the veterinarian (eg, increase in abortions, increase in sow mortality, increase in the number of stillborn piglets). The respective herd veterinarians were asked to complete a survey with information on herd demographic characteristics and the interventions implemented in response to the PRRS outbreak. The veterinarians were encouraged to revise the survey quarterly until the herd achieved the desired status according to the American Association of Swine Veterinarians' (AASV) recommendations for PRRSV herd classification.[17,18]

The exclusion criteria included events that would impact the study's outcomes, such as outbreaks of other diseases (eg, porcine epidemic diarrhea), a second PRRS outbreak before achieving stability, or a ≥ 20% change in sow inventory due to factors unrelated to the PRRS outbreak.

Survey and data collection

An Excel-based survey was developed to collect data on the practices implemented in response to PRRS outbreaks (Table 1). Herd demographic characteristics, veterinarians' contact information, and immunologic solutions for gilts and sows were collected. Biomanagement practices adopted, eg, management changes to reduce exposure to bacteria to eliminate losses (McREBEL) like practices,[19] were collected from the herds seeking PRRSV stability. Veterinarians received the survey via email, and follow-up emails and phone calls were used to keep in touch about the initial information provided and interventions applied in the herds until the desired AASV classification status was achieved. All herd-specific information regarding the survey and interventions applied was confirmed after achieving the desired status. An Iowa State University consent form of participation, data handling, and confidentiality was signed to assure agreement and data protection for all parties. Data were collected from farms located in Iowa, Nebraska, Oklahoma, Minnesota, Illinois, Indiana, Texas, Ohio, Colorado, and Kansas.

Monitoring, PRRSV classification, and diagnostic data

Herds were monitored for PRRSV weekly using PRRSV RNA detection by RT-PCR from processing fluid (PF) samples. Processing fluids are obtained from the serosanguinous fluid recovered from piglet castration and tail docking.[20] The veterinarian submitted one pool of PF per week to Iowa State University Veterinary Diagnostic Laboratory (ISU VDL) or the University of Minnesota Veterinary Diagnostic Laboratory (UMN VDL) until the desired AASV herd classification status was achieved. The herds were classified following recommendations from the AASV PRRS classification[17,18]: positive unstable (I), positive stable (II-A), positive stable (II-B [undergoing elimination]), provisional negative (III), and negative (IV). Diagnostic data were shared through the ISU VDL or UMN VDL client web interface applications, and combined data was accessed through the Animal Health Monitoring and Evaluation System (**www.vdl.iastate.edu**) using a standardized and consistent methodology.

TTS, TL, and time to baseline productivity analysis

Three recovery metrics were used in this study: TTS, time to baseline productivity (TTBP), and TL. For each PRRS outbreak, TTS was declared when the herd reached 8 consecutive weeks without PRRSV RNA detection by RT-PCR in weekly PF samples. Time to baseline productivity was defined as the number of weeks the herd took to recover to the number of pigs weaned per week prior to the PRRS outbreak and was calculated using an exponentially weighted moving average with 3 sigmas, 0.4 lambda, and a baseline of 21 weeks prior to the outbreak following a previously reported methodology.[8] The severity of the PRRS outbreak was defined by TL and calculated as the number of pigs weaned below the herd-specific baseline, normalized by 1000 sows from the initial PRRS outbreak to when the herd returned to TTBP.

At 1 to 4 weeks after the PRRS outbreak, the virus was classified according to restriction fragment length polymorphisms and lineages, both based on the open reading frame-5 gene as previously described.[21-23]

Table 1: Survey blocks and requested information about each porcine reproductive and respiratory syndrome (PRRS) outbreak

Survey blocks	Survey information requested	Type of data
Herd demographics information	Herd size (inventory of mated sows)	Farm and veterinarian information captured to follow up until the herd achieved the desired status
	Sow genetics	
	Farm address, state	
	Name of the herd veterinarian	
	Email of the herd veterinarian	
	Phone number of the herd veterinarian	
Information about the PRRS outbreak	Date of previous outbreak	PRRS virus information collected according to current outbreak
	Date of current outbreak	
	Plan for the current outbreak (control or control and eliminate)	
	Accession ID information from the PRRS virus sequencing test	
	Restriction fragment length polymorphisms	
	Open reading frame-5	
	PRRS herd status (AASV classification)	

Table 1: Continued

Immunologic solutions for gilts and sows	Type of whole herd exposure Date of whole herd exposure Age of groups exposed Route of exposure Dose of exposure Number of doses	Information about the type of immunologic solution (live virus inoculation or modified-live virus) used in the current outbreak
Breeding herd flow and herd closure	Implementation of herd closure Date of herd closure Age of youngest gilt at time of herd closure Source of gilts	Gilt flow-related question about implementation or not of herd closure (Yes or No)
Biomanagement strategies	Nurse sows allowed from within a farrowing room. Strict all-in/all-out practice with sows and piglets in farrowing Needle changed between every sow/gilt in the breeding herd when giving injections (vaccines or treatment) Discontinuation of prefarrowing tissue/scour feedback practices Discontinuation of prebreeding tissue/scour feedback practices Cross fostering allowed before 24 hours Poor-doing piglets are euthanized when clinically unresponsive to a repeated treatment (2nd treatment and no response) Pigs that are very thin, lethargic, gaunt, moribund or lightweight, and depressed are euthanized immediately Pigs are worked from youngest to oldest Use of warming tubs/split suckle boxes individually per litter Use of processing carts not allowed Personnel should not step into the farrowing crates to perform anymanagement procedures Change/disinfection of needles and blades between litters when processing Farrowing crates washed and with dry time between litters Alleys in farrowing rooms are cleaned and disinfected Hallways and alleys between rooms are cleaned and disinfected daily Personnel caring for youngest room(s) of pigs are dedicated to those room(s) and are not allowed to enter other rooms Personnel are required to change boots upon entry into each farrowing room Personnel are required to change coveralls upon entry into each farrowing room Personnel are required to wash hands upon entry into each farrowing room Boot baths with fresh disinfectant are used at the entry of farrowing rooms	Biomanagement strategies captured from herds seeking stability from scale 1 to 5, where 1 is not implemented at all and 5 is fully implemented.

Results

Overview

Eighty-six herds experiencing a PRRS outbreak were enrolled in this study, with each herd followed until the desired PRRS herd status was achieved. All the herds provided information about intervention characteristics (Table 2), and 35 herds (40.7%) reported biomanagement practices (Figures 1, 2, and 3). The mean herd size was 3902 sows (range, 765-12,694 sows). Different interventions used to control and reduce losses were identified and described in the survey responses. There was great variation in the interquartile ranges for TTS, TTBP, and TL (Table 3) among herds. No herds met the exclusion criteria defined for this study.

Descriptive results

The states represented by participating herds are presented in Figure 4. Descriptive results of herd characteristics, response levels, and the number of herds in each of the categories are presented in Table 2.

Biomanagement strategies

Forty percent of the respondents (35 of 86) reported recommending and implementing biomanagement strategies to minimize PRRSV transmission among sows and piglets. Figures 1, 2, and 3 demonstrate the level of biomanagement practice implementation within each herd according to the veterinarian respondents, with none being considered as no practice implemented at all, 25%, 50%, and 75% as a percentage of practice implemented over the period of the outbreak, and fully implemented as implemented until achieving PRRSV stability.

Discussion

The median TTS (38.0 weeks), TTBP (22.0 weeks), and TL (3675 pigs/1000 sows) were higher than previously reported in 2014 (26.6 weeks, 16.5 weeks, and 2217 pigs/1000 sows, respectively).[8] The longer TTS may be related to more representation of sampling methods used for PRRSV monitoring (eg, PF) within the herd population in this study compared to ten years ago, where serum from a finite number of animals was used.[20,24,25] In addition, the longer TTS and TTBP and higher TL in this study might be associated with changes in herd size, production flow, PRRSV variants, and other variables not assessed in this study. The number of PRRSV strains and recombination events have been reported to be associated with longer TTS and higher TL.[9] The numerical range of TTS, TTBP, and TL and the variability of practices implemented in the field to control or control and eliminate PRRSV reported in this study emphasize the need to better understand best practices to minimize the PRRSV impact in breeding herds.

Responders who reported seeking elimination and herd closure implementation as part of the PRRSV control and elimination plan varied among the herds. The implementation of herd closure has been reported to control and eliminate PRRSV at the farm level.[14] Beyond herd closure implementation, the PRRSV control and elimination program has been associated with closed-herd internal multiplication, negative gilts introduced into a negative herd, focus on biosecurity methods, use of PRRSV-negative semen, and single-source pig flow.[26] Despite reported rules of success for PRRSV control and elimination, this descriptive study has shown that PRRS management is complex, including desired AASV herd PRRSV classification status and strategies to achieve TTS.

One participant reported using a two-week batch flow, and 3 participants reported using a four-week batch flow as part of a strategy to improve biocontainment and reduce PRRSV transmission through better all-in/all-out management and farrowing room disinfection between batches. Batch farrowing management allows fixed-interval mating groups of sows of equal size, leading to all-in/all-out pig management in which animals in different batches have no contact,[27] and may help to control herd health status.[28-30] The reported median TTS of herds operating in a four-week batch system was 27 weeks.[31] The use of a batch system may be an opportunity to shorten TTS and reduce TL in breeding herds facing a PRRS outbreak.

The interventions used with sows and gilts reported in this study were inconsistent across different herd outbreaks. The use of LVI, MLV, or a combination of LVI and MLV in sows was similarly reported. Different management procedures for PRRSV control at the farm level have been previously reported,[7,8,10,14,15,26] and the use of PRRS MLV vaccines has been predominant in the US breeding herd.[11,32,33] The use of LVI, preparation and administration of LVI, the timing of interventions, and timing of MLV use are practices and interventions that might change according to the control and elimination strategy adopted by the veterinarian. Still, there are limitations regarding intervention assessment and a better understanding of all these factor combinations is needed.

The survey used in this study included various questions regarding biomanagement strategies to reduce virus transmission between sows and piglets. The results were inconsistent among participants. Studies have highlighted the importance of biomanagement practices to avoid PRRSV transmission[1,14,34] and practices, such as limiting cross fostering and avoiding mixing animals from different litters, on PRRSV-positive farms to optimize production have been reported.[35] Biomanagement protocols based on the McREBEL pig flow management implementation system have been reported as an important piece of PRRSV control and elimination.[19,36]

The reported biomanagement strategies adopted following PRRS outbreaks were variable. Biomanagement refers to management practices to mitigate the transmission of pathogens between animals within the same population.[25] In addition, identifying a farm's weak points, prioritizing the items to be improved first, and constantly revising and auditing the implemented biosecurity and biomanagement strategies were essential to prevent and control virus transmission within and among large herds.[32] The variety of biomanagement practices reported in this study demonstrated the need for more consistency among the herds after a PRRS outbreak.

Implications

Under the conditions of this descriptive study:

- Management practices used during PRRS outbreaks were highly diverse among herds.
- Herd closure, interventions, and biomanagement strategies were inconsistent.
- The TTS and TTBP were longer and TL higher than reported 10 years ago.

Table 2: Intervention characteristics used in herds experiencing a porcine reproductive and respiratory syndrome (PRRS) outbreak in this study

Characteristic	Response levels	Number of herds
Targeted management plan	PRRSV control	30
	PRRSV elimination	56
Herd closure	Yes	52
	No	34
Management flow	Weekly batch	82
	Bi-weekly batch	1
	Four-weekly batch	3
AASV classification status at the PRRS outbreak	Positive unstable (I)	21
	Positive stable II-A	15
	Positive stable II-B	24
	Provisional negative	10
	Negative	16
Interventions following the outbreak implemented in gilts	LVI	25
	MLV	24
	LVI + MLV	23
	None	14
Route of gilts exposure	Intramuscular	72
	Intranasal	0
Dose of exposure in gilts	Full dose	72
	Half dose	0
Number of exposure doses in gilts	One intervention	5
	Two interventions	67
	Three interventions	0
Interventions following the outbreak implemented in sows	LVI	27
	MLV	28
	LVI + MLV	24
	None	7
Groups of exposure	All animals in the herd	1
	All breeding females	77
	Group gestation	1
Route of exposure in sows	Intramuscular	79
	Nasal	0
Dose of exposure in sows	Full dose	79
	Half dose	0
Number of exposure doses in sows	One intervention	45
	Two interventions	31
	Three interventions	3

Table 2 continued on page 208

Table 2: Continued

PRRSV Lineage and RFLP	L1A of RFLPs 1-10-4, 1-1-2, 1-1-4, 1-3-4, 1-4-3, 1-6-4, 1-7-2, or 1-7-4	40
	L1H of RFLPs 1-4-4, 1-7-4, 1-8-3, or 1-8-4	17
	L1C.5 (L1C variant) of RFLP 1-4-4	15
	L1C of RFLP 1-2-4, 1-3-2, or 1-4-4	9
	L1E of RFLP 1-3-2 or 1-4-2	2
	L1G of RFLP 1-18-2	1
	L5 of RFLP 2-5-2	1
	Inconclusive	1

PRRSV = porcine reproductive and respiratory syndrome virus; AASV = American Association of Swine Veterinarians; LVI = live virus inoculation; MLV = modified-live virus; RFLP = restriction fragment length polymorphisms.

Figure 1: Level of biomanagement practices implemented within each herd after the outbreak to avoid porcine reproductive and respiratory syndrome virus transmission among sows.

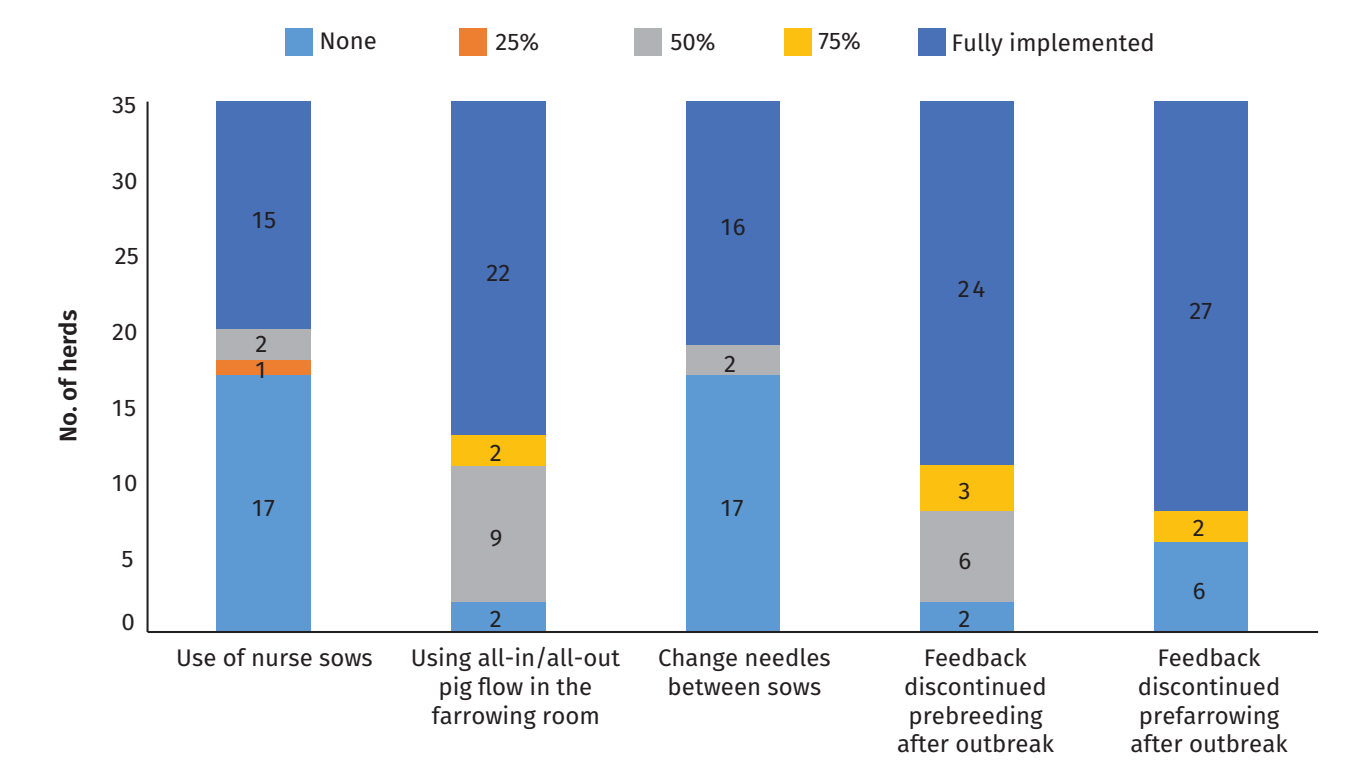
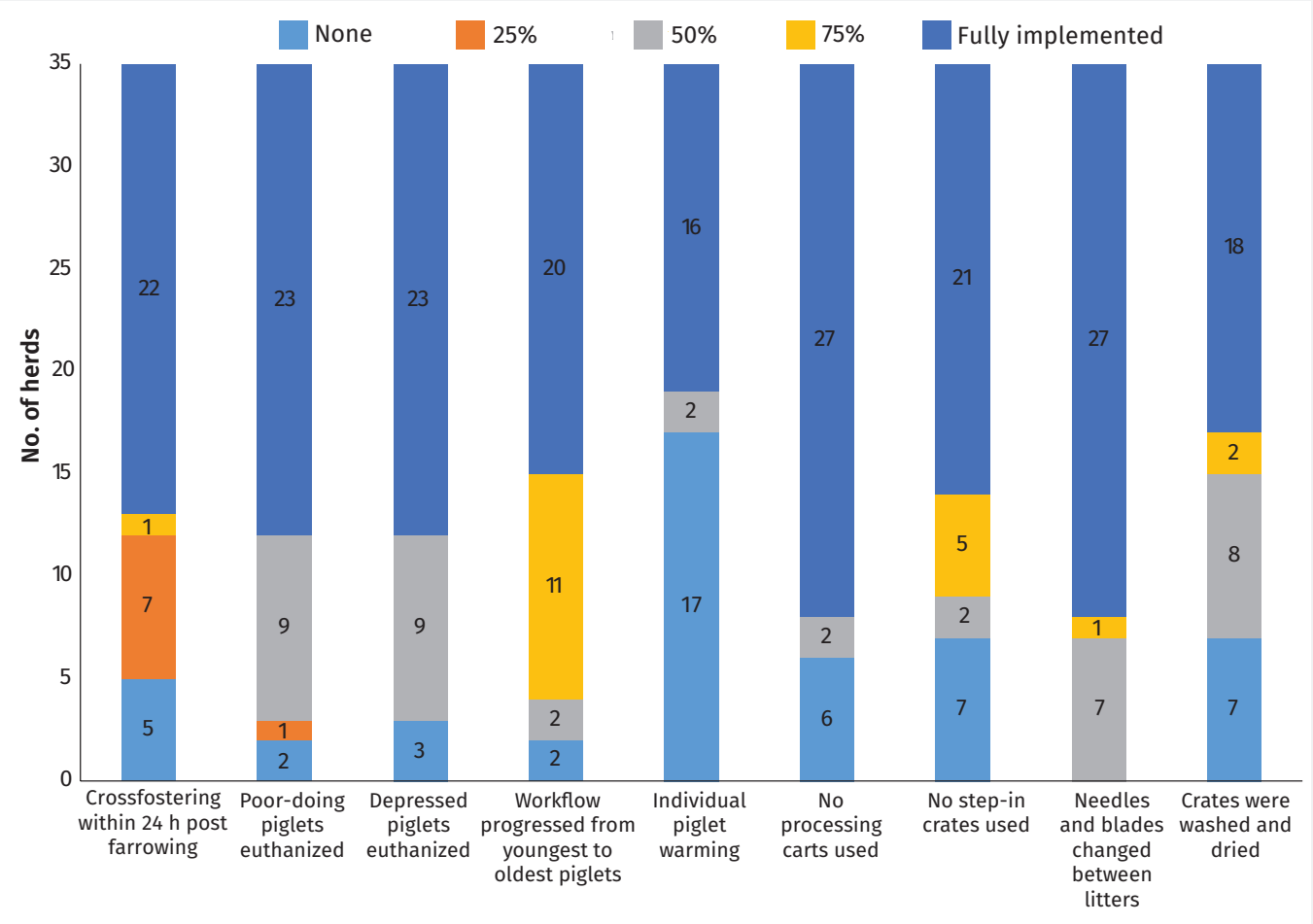


Figure 2: Level of biomanagement practices implemented within each herd after the outbreak to mitigate porcine reproductive and respiratory syndrome virus transmission among piglets.



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Conflict of interest

The authors declare that this research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Disclaimer

Dr Linhares, a member of this journal's editorial board, was not involved in the editorial review of or decision to publish this article.

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Figure 3: Level of biomanagement practices implemented within each herd after the outbreak to avoid porcine reproductive and respiratory syndrome virus transmission among rooms.

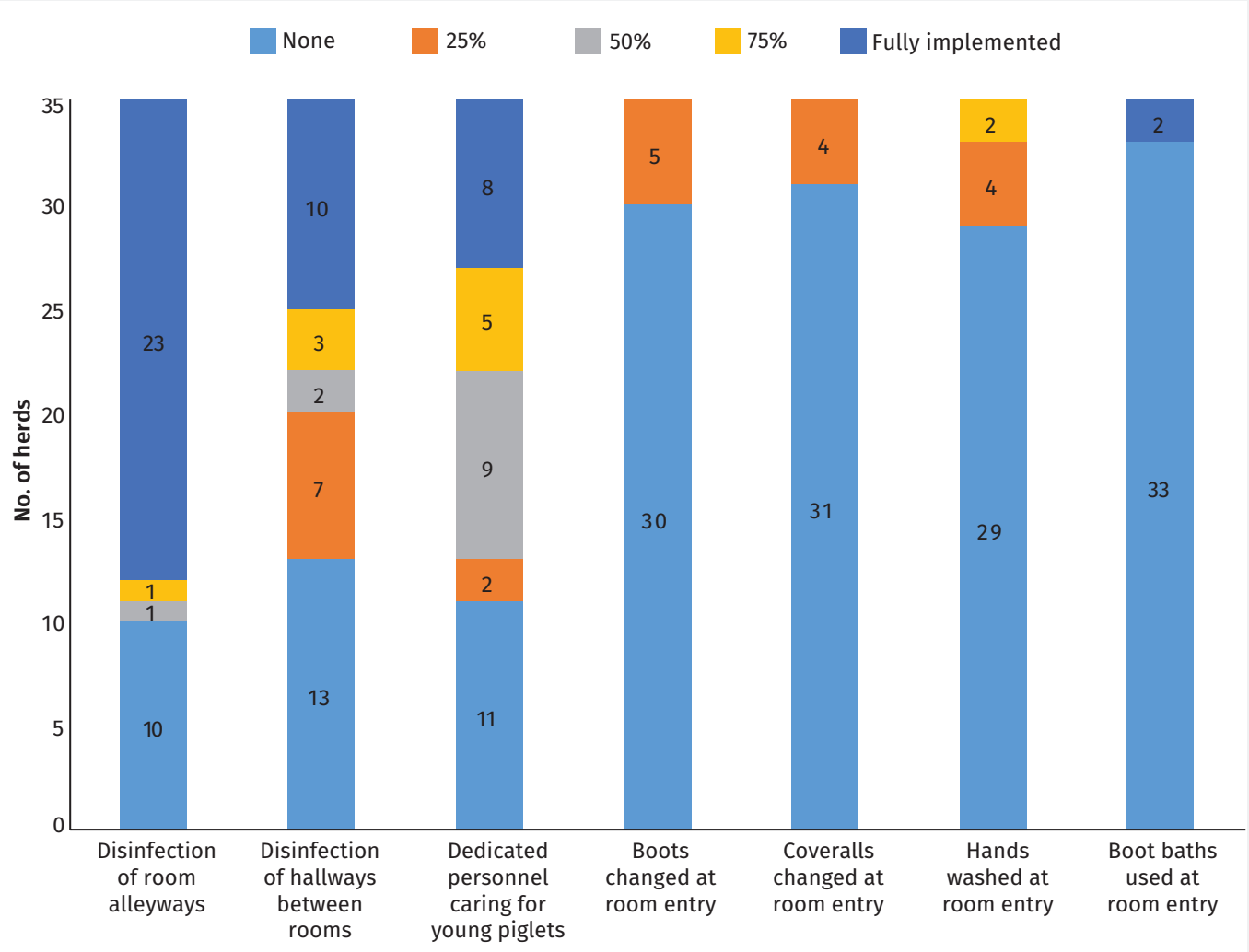
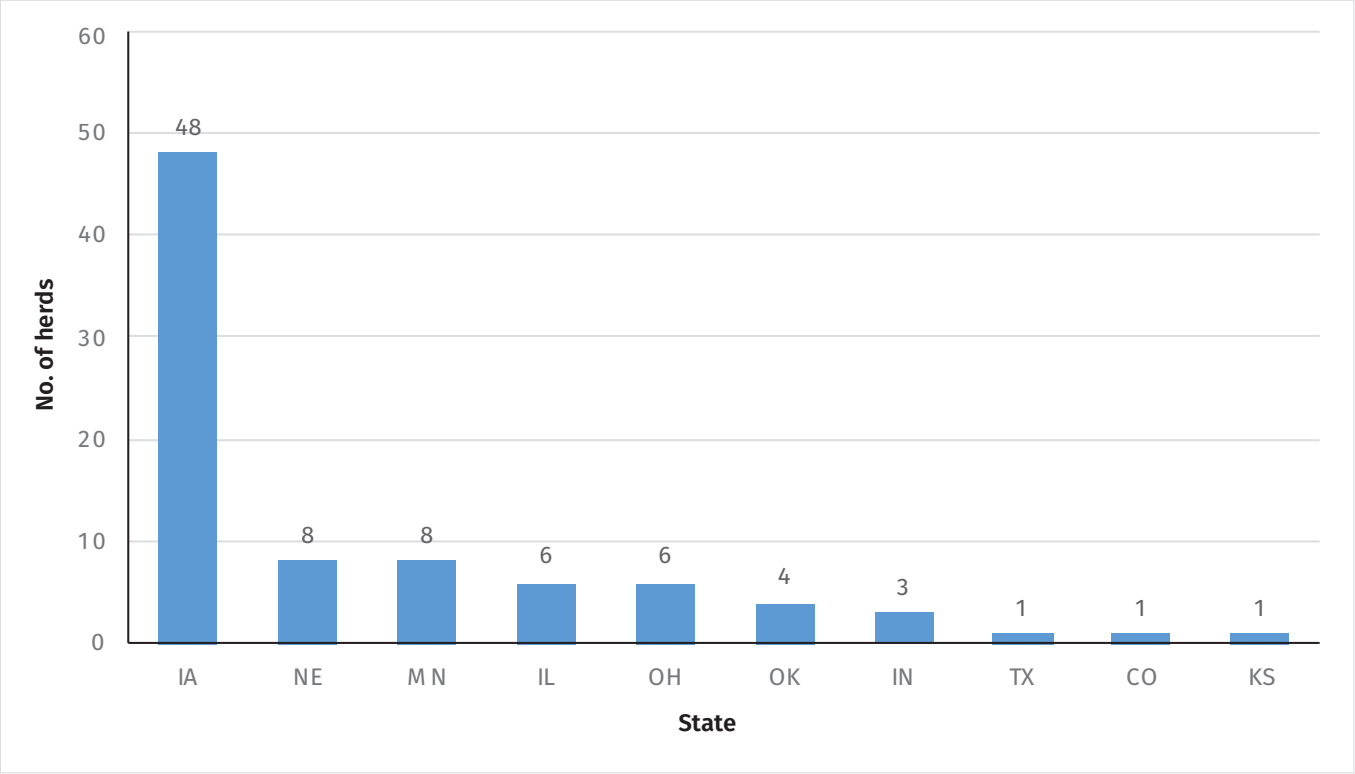


Table 3: The median and interquartile for TTS, TTBP, and TL of herds experiencing a PRRS outbreak, 2019 to 2021

Categories	TTS, wk	TTBP, wk	TL, pigs/1000 sows
First quartile	32.0	15.0	2356
Median	38.0	22.0	3675
Third quartile	49.0	26.0	6845

TTS = time to stability; TTBP = time to baseline productivity; TL = total losses; PRRSV = porcine reproductive and respiratory syndrome virus.

Figure 4: States represented in this study by participating herds



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