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Research Article

Field Evaluation of a Lineage 7 PRRS MLV in Mitigating the Impact of Nadc34-Like PRRS Infection in Korean Pig Farm

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Abstract

Porcine Reproductive and Respiratory Syndrome (PRRS) causes major economic losses, and cross-protection of Modified-Live Vaccines (MLV) against emerging heterologous strains remains uncertain. This study reports a field based, longitudinal before-after intervention study evaluating the impact of a Lineage 7 PRRS MLV (PrimePac® PRRS) during an acute NADC-34 like PRRS outbreak in a commercial 1200-sow farrow-to-finish farm in South Korea.

Following a confirmation of an NADC-34 like PRRSV outbreak, a whole-herd mass vaccination program was implemented using intradermal administration (0.2ml) of PrimePac® PRRS. Reproductive performance indicators (farrowing rate, abortions, stillbirths and mummification), vertical transmission dynamics (PRRSV qPCR testing of processing fluids), and post-weaning health outcomes (nursery and grow-finish morbidity and mortality, piglet viremia by qPCR) were monitored longitudinally before and after vaccination.

After implementation of the vaccination program, key breeding-herd performance parameters progressively returned toward pre-outbreak baseline levels. PRRSV became undetectable in the processing fluid samples within one month, indicating rapid interruption of vertical transmission. Improvement in nursery and grow-finish pig performance occurred more gradually, consistent with ongoing virus circulation in a continuous-flow production system.

This findings demonstrate that, although complete virus elimination was not achieved, a strategic mass vaccination program using a Lineage 7 PRRS MLV substantially mitigated the reproductive and early-life impacts of an NADC-34 like PRRS outbreak. Vaccination combined with biosecurity measures remains a critical component of integrated PRRS control strategies in farrow-to-finish systems where eradication is difficult.

Keywords: PRRS; NADC34-like virus; PrimePac PRRS; Vertical Transmission; Modified Live Vaccine; Farrow-to-Finish Herd.

INTRODUCTION

Porcine Reproductive and Respiratory Syndrome (PRRS) remains one of the most economically devastating diseases affecting the global swine industry. Caused by the PRRS virus (PRRSV), an enveloped, single-stranded RNA virus of the Arteriviridae family, this pathogen emerged in the 1980s and rapidly spread to major pig-producing regions such as the USA [1], China [2], and Korea [3]. Despite extensive control measures, PRRSV continues to persist on many farms due to its high mutation rate and extensive genetic diversity, which frequently leads to the emergence of heterologous strains capable of evading the immunity induced by conventional vaccines [3,4]. Two species exist in PRRSV: Betaarterivirus suid 1 (PRRSV-1) and Betaarterivirus suid 2 (PRRSV-2). In 2010 a phylogenetic classification based on 8,624 global ORF5 sequences was proposed to describe PRRSV-2 genetic diversity. Based on this, nine lineages (L1–L9) and 37 sublineages were proposed [5]. The emergence of new lineages or sub-lineages is usually associated with increases in outbreaks and mortality until herd immunity emerges [6]. As of 2025, lineage 1 has become the most prevalent and diverse lineage in Asia [7] and the United States [8]. In South Korea [9], sub-lineages 1.5 and 1.8 are dominant.

Both sub-lineages 1.5 (NADC-34) and 1.8 (NADC-30) have demonstrated varying levels of pathogenicity, depending on isolate. For example, a study by Tu et al [10]. Demonstrated that a NADC-30 isolate in challenge studies was able to cause prolonged fever and reduced appetite, leading to decreased weight gain and growth rates. Other studies have

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also similar results in NADC-34 isolates [11]. Different results were found however in a study by Zhou et al, where a challenge was not only able to cause clinical symptoms but also mortality [12], suggesting the highly varied nature of pathogenicity of PRRS isolates, even within the same sub-lineage.

Vaccination is considered a cornerstone of PRRS management, and various PRRSV Modified-Live Vaccines (MLV) have been shown to reduce clinical symptoms, lung lesions, viremia, and the duration of viral shedding [13,14]. Several authors have advocated for MLV selection based on genetic or antigenic matching between field strains and the MLV strain [15,16], commonly performed by determining genetic similarity based on ORF5 sequences. In practical terms, this is increasingly difficult to perform in the field. Additionally, the period for a vaccine to obtain a commercial license is long, in some instances up to 5-10 years [17]. This means that in the field, commercial vaccines are not able to match with emerging genetically distinct isolates such as Lineage 1 NADC34-like PRRSV [7-9]. Previous studies have found that vaccination of swine with MLV was able to induce good protection in pigs exposed to genetically diverse PRRSV strains post vaccination [7-18]. Other authors have found that in the face of heterologous challenge, vaccination is able to reduce clinical signs but cannot stop vertical transmission or reduce viral shedding significantly [19-21]. In the face of conflicting findings, it is therefore of value to veterinary practitioners to evaluate PRRS MLV vaccines individually to assess their ability to cross-protect against contemporary PRRS field isolates.

Apart from vaccination, biosecurity measures are another important measure to control PRRSV infection on farm. Measures such as reducing the movement of infected animals, increased disinfection of facilities and moving to All-In-All-Out (AIAO) production are indicated. In farrow-to-finish farms in Asia, the management of facilities on AIAO basis is often not possible and continuous flow production is a more common situation [22]. Producers in such situations thus rely more on vaccination compared to biosecurity.

PrimePac PRRS (MSD Animal Health, Rahway, NJ, USA) is a PRRS Modified-Live Vaccine (MLV) that has recently obtained a commercial licence in South Korea. This vaccine can be administered either via intramuscular or intradermal route through a purpose designed injector. Intradermal administration of vaccine has several important safety advantages, namely reducing needles and iatrogenic transfer of disease [23-25], and reducing shedding of PRRS virus compared to intramuscular injection [24]. By administering vaccine in proximity to dermal antigen-presenting cells, the volume of vaccine needed can be reduced while still providing similar or improved efficacy [26].

Our study objective was therefore to evaluate the efficacy of the Lineage 7 PRRS MLV (PrimePac PRRS) vaccine in a commercial Korean pig farm challenged by a heterologous NADC34-like PRRSV outbreak. Specifically, the study aimed to improve breeding production parameters by assessing the vaccine's impact on abortion rates, premature births, mummification, and stillbirths; to evaluate its efficacy in blocking vertical transmission through PCR testing of processing fluids collected from litters; and to enhance respiratory health in nursery and finisher pigs by monitoring morbidity and mortality rates following vaccination. By integrating these objectives into a comprehensive herd health management program, this investigation seeks to determine whether a vaccination strategy using PrimePac PRRS and biosecurity can restore production metrics and reduce virus circulation in the face of an acute PRRS outbreak.

MATERIALS AND METHODS

Animal Welfare and Ethical statement

Approval to use the animals on farm was obtained from the farm owner and all procedures were done in full consultation with the farm consulting veterinarian. The Animal Care and Use Committee of Dankook University, Cheonan, Korea, authorized the research protocol (DK-4-2439) of the study.

Vaccine

The vaccine used was a commercially available lineage 7 PRRS MLV (PrimePac® PRRS, MSD Animal Health, Rahway, NJ, USA). The vaccine was prepared according to the instructions of the manufacturer and injected via Intradermal (ID) injection (reconstituted to 0.2ml, minimum 4.0 log10 TCID50 per dose) using a purpose built intradermal injector supplied by the vaccine manufacturer (IDAL®, MSD Animal Health, Rahway, NJ, USA).

Farm Profile and Study Period

The study was a single-herd, longitudinal before-after field intervention conducted in a commercial sow farm located in Gyeonggi Province, South Korea, with approximately 1,200 sows managed in a farrow-to-finish style production system during an acute PRRS outbreak. The farm operated under a two-step pig movement protocol, with piglets weaned at 4 weeks and reared in nursery and grow-finish units in close proximity to the sow herd. After confirmation of an NADC34-like PRRSV outbreak, a whole-herd mass vaccination program using a lineage 7 PRRS modified-live vaccine was implemented. Production and virological data obtained before vaccination served as the pre-intervention reference, and the same parameters were monitored longitudinally after vaccination to evaluate changes in reproductive performance, vertical transmission, and post-weaning health. Because of the severity of the outbreak and the need for immediate herd-level disease control, an untreated contemporaneous control group was not included. Production data was collected from the period of January 2023 (Week 1, January 2023) until December 2024 (Week 52, December 2024). The breeding section of the farm was operating on a one-week batching system. Therefore, records were kept of all sows and gilts mated on a weekly basis. Animals that successfully farrowed at least one piglet were marked as successfully farrowing in the batch. Animals that experienced an abortion were marked as having an abortion in the batch. The total numbers of piglets born to each batch were also recorded and numbers of mummies, stillborn piglets and live piglets were recorded on a weekly basis. For the purpose of recording, a stillborn piglet was classified as a piglet that was not alive at birth and confirmed by visual inspection by the farm staff. Similarly for the suckling piglet mortality, piglets born to a batch of sows were recorded, and at weaning all piglets that died from that batch would be recorded as mortality. The nursery, grower and finisher were managed on a monthly continuous flow basis. Over the course of one month, animals would be continuously added into the nursery, grower and finisher barns. Any deaths from animals associated with this group would be recorded as a mortality. Because this study was conducted as an emergency field intervention in a single commercial herd, analyses were primarily descriptive and exploratory.

During the period of January 2023 to January 2024, the herd veterinarian confirmed that no major outbreaks of PRRS occurred. This farm was previously using a different MLV PRRS vaccine (ORF5 Lineage 5), administered every three months to all sows, gilts and boars on farm and as a continuous program to 2-week-old piglets. From February 2024, a sudden spike in abortions and sow deaths was observed. 8 sows died in Feb 2024 and 30 sows experienced abortions. In the nursery and grow-finish area, a combined peak mortality of 32.9% was observed in the month of February 2024. The vaccination program started on Week 9 after the onset of the outbreak and all sows, gilts and boars were concurrently vaccinated each time on the same day. The previous PRRS MLV vaccine was last administered in January 2024 and was not administered again after the onset of the outbreak in February 2024.

Sow Vaccination and Sampling Protocol

The herd underwent two initial rounds of mass vaccination, administered four weeks apart followed by serological testing and production monitoring to assess stability. For the purposes of this trial, sow herd stability was defined as a lack of PRRS virus detection in the processing fluid samples. If stability was confirmed, a subsequent mass vaccination was scheduled three months later. However, if stability was not achieved, a contingency plan was implemented, administering a third vaccination four weeks after the second dose. Once stability was established, mass vaccinations continued every three months, maintaining herd immunity. The vaccination and sampling schedule implemented in sows is shown in Figure 1. A sample size of thirty sows was chosen based on standard veterinary epidemiological practices, allowing for the detection of disease at a 10% expected prevalence with 95% confidence in a large herd. During each sampling timepoint, blood samples were collected through jugular venipuncture from thirty sows in the gestation building to monitor PRRS viremia. In addition to serological testing, production parameters, including abortion rates, premature births, stillbirths, and mummy rates, were recorded according to the established schedule. To assess vertical transmission, processing fluids [27,28], from thirty litters were collected monthly and tested by PCR to quantify PRRS levels. Processing fluids were collected during tail docking and castration, as close to birth as possible and all efforts were made to process piglets immediately to avoid the possibility of infection by the sow in the interim time period.

Piglet Vaccination and Sampling Protocol

Piglets received their primary vaccination at 2 weeks of age with 0.2 mL of PrimePac PRRS, administered intradermally. To homogenize the immunity inside the nursery, an additional mass nursery vaccination protocol was implemented for pigs already inside the nursery that had already received the previous MLV used on farm. The vaccination and sampling schedule for piglets is outlined in Figure 2. The processing fluids from 30 litters were collected monthly, and groups of at least 30 piglets were sampled at each age/time point. Also, groups of at least thirty piglets were subjected to blood sampling testing at 6, 9, 12, 15, and 18 weeks of age, with qPCR to assess blood viremia levels of PRRSV. Where piglets tested positive for PRRS (with Ct values below a predetermined threshold), PCR sequencing was conducted to confirm the identity of the virus as NADC34-like using the method outlined by Tu et al [18]. The forward primer was N34-F (5′-CCTGTGTTGACTCATATTGTCTCC-3′); and the TaqMan probe was N34-P (FAM-5′-CGCCCTCACCACCAGCCATTTCCT-3′-BHQ1); the reverse primer was N34-R (5′-CGGCGTAAATGCTACTCAAGAC-3′). The length of the amplicon was 130 bp. Mortality rates were monitored and compared between the pre- and post-vaccination periods for both the farrow-to-wean and wean-to-finish stages. Additionally, processing fluids at birth were gathered from at least thirty litters monthly to monitor vertical transmission of the virus via qPCR. If any samples showed Ct values below 25, they were subjected to sequencing to confirm the specific strain of the virus present.

Figure 1: Schedule of vaccination and samplings in sows

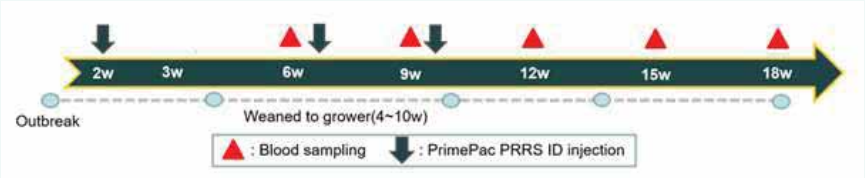

Figure 2: Schedule of vaccination and samplings in piglets.

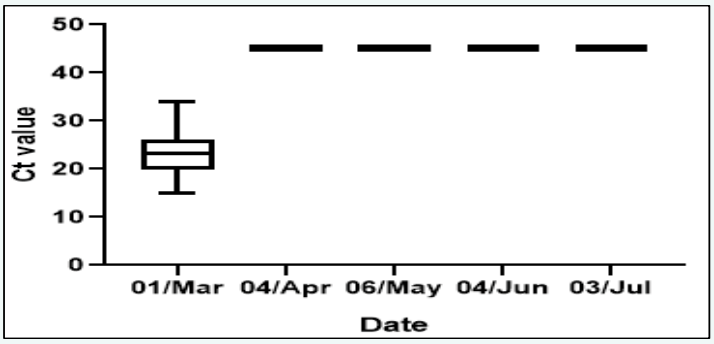

Figure 3: Viremia in processing fluid samples at different timepoints. The average qPCR cycle threshold (Ct) values for PRRSV from testicular fluid at five sampling dates (Mar. 01, Apr. 04, May. 06, Jun.04, and Jul. 03). Higher Ct values indicate lower levels of viral RNA, while lower Ct values reflect higher viral loads. The limit of detection of the assay was a CT value of 45.

RESULTS

Pre-Vaccination Analysis

In early February 2024, sows began showing signs of reproductive failure, including elevated abortion rates. Subsequent testing of lung tissue from aborted piglets isolated a strain of PRRSV with 95.85% ORF5 homology with the NADC34 strain of PRRSV. In addition, pooled processing fluid samples collected from stillborn piglets tested positive for PRRSV. During this same period, 6- and 9-week-old piglets were also found to be PRRSV-positive by PCR, with sequencing also confirming 95.85% homology to the NADC34 strain. In practical terms, this means that the field virus was closely related to NADC34 but not identical to it; therefore, it was classified as an NADC34-like PRRSV strain. These findings collectively indicated a farm-wide outbreak of NADC34-like PRRS.

Post-Vaccination Viremia Analysis

Mass vaccination of sows commenced on Week 9, 2024. At the first processing-fluid sampling after implementation of the vaccination program (1 March), 30/30 samples (100.0%) were PRRSV qPCR-positive. At subsequent monthly sampling points, PRRSV RNA was no longer detected in processing fluids, with 0/30 samples (0.0%) testing positive on 4 April, 6 May, 4 June, and 3 July (Figure 3). Clinically, symptoms such as respiratory distress and reproductive failures began to subside in parallel with the loss of detectable PRRSV in processing fluids.

Over four specific sampling dates, February 29, July 3, October 19, and December 27—qPCR cycle threshold (Ct) values for PRRSV were measured in five piglet age groups, specifically 6, 9, 12, 15 and 18 weeks (Figure 4). At the first-sampling time point, PRRSV was detected in 30/30 (100.0%) of 6-week-old pigs and 30/30 (100.0%) of 9-week-old pigs, whereas 3-, 12-, 15-, and 18-week-old pigs were negative (0/30, 0.0% each). On 3 July, the same pattern was observed, with positivity restricted to the 6- and 9-week-old groups (30/30, 100.0% each). On 19 October, PRRSV was detected in 3-, 6-, and 12-week-old pigs (30/30, 100.0% each), whereas the 9-, 15-, and 18-week-old groups were negative (0/30, 0.0% each). On 27 December, PRRSV was detected in 3-, 6-, and 9-week-old pigs (30/30, 100.0% each), while 12-, 15-, and 18-week-old pigs were negative (0/30, 0.0% each). These findings indicate that PRRSV circulation persisted mainly in specific younger post-weaning age groups rather than uniformly across all sampled ages.

Production Data

1. Farrowing, Abortion, Mummified and Stillborn Rates

The outbreak initially manifested as decreased farrowing rates (Figure 5), and increased abortion (Figure 6), mummified and stillbirth rates (Figure 7). Following the implementation of the stabilization protocol, which included the mass vaccination in Week 9, these parameters began to return to 2023 baseline levels over a period of several months.

Suckling piglet mortality peaked in February 2024, reflecting the acute impact of PRRS on younger animals. After vaccination, mortality progressively declined, moving closer to the 2023 average and indicating improved herd health and management (Figure 8).

2. Nursery, Grower and Finisher Performance

Nursery, grower and finisher mortality continued to be affected despite the intervention measures. Nursery mortality took several months to return to 2023 baseline but continued to see periodic episodes of increases. Grower finisher mortality did not return to 2023 baseline over the monitoring period. Overall production performance metrics, including farrowing rates, sow mortality, and piglet growth parameters, showed a marked decline in February 2024, at the height of the outbreak. However, following the March 2024 vaccination program, these metrics gradually rebounded, converging toward 2023 baseline values (Figure 9).

DISCUSSION

The current study documents a PRRS outbreak in a Korean farrow-to-finish farm, characterized by widespread reproductive failures and increased piglet mortality. Molecular analysis confirmed that the outbreak was associated with a NADC34-like PRRSV strain, as evidenced by high sequence homology (95.85%) in both aborted fetuses and piglet samples. The observed 95.85% ORF5 similarity supports classification of the outbreak strain as NADC34-like, indicating close genetic relatedness to the reference strain while also confirming that the field isolate was genetically distinct. Based on our analysis of farm history, it is likely that this was a new isolate introduced into the farm, and the timing of introduction coincides with the first appearance of NADC34 PRRS isolates across Korea in 2023 [29]. The introduction of novel strains is often accompanied by high levels of mortality and production losses due to the lack of existing immunity [30].

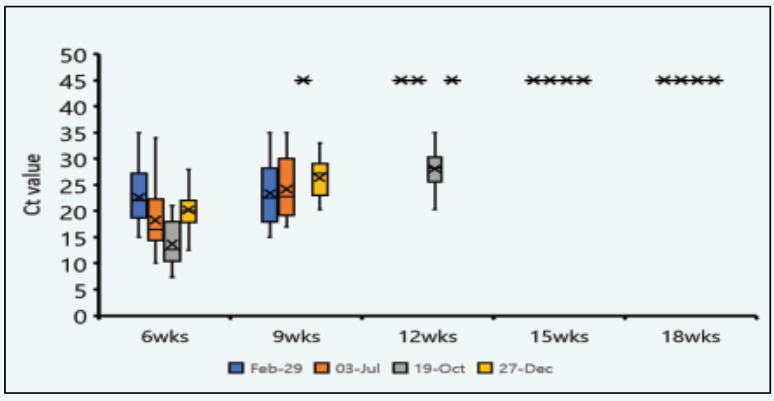

Figure 4: qPCR Detection of PRRSV Viremia Post-Vaccination in Different Ages. The average qPCR cycle threshold (Ct) values for PRRSV were measured at four sampling dates (Feb. 29, Jul. 3, Oct. 19, and Dec. 27) in piglets aged 6, 9, 12, 15, and 18 weeks. Higher Ct values indicate lower levels of viral RNA (reduced viremia), while lower Ct values reflect higher viral loads.

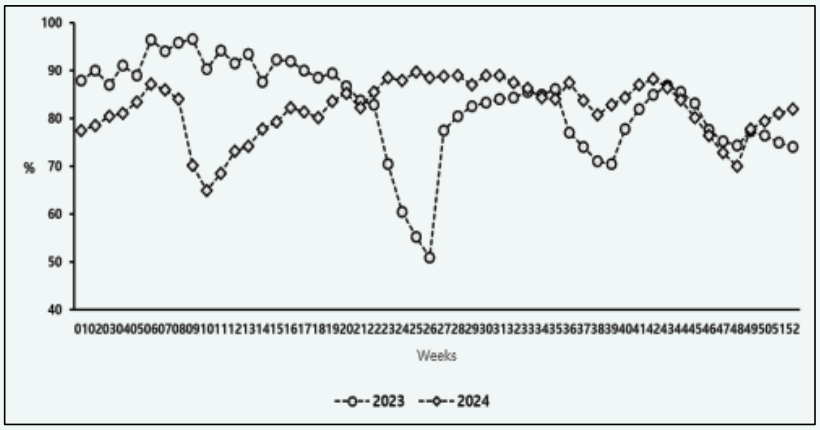

Figure 5: Weekly farrowing rate. A PRRS outbreak occurred in February 2024, followed by mass vaccination in March 2024. Values from 2024 are compared to 2023 values.

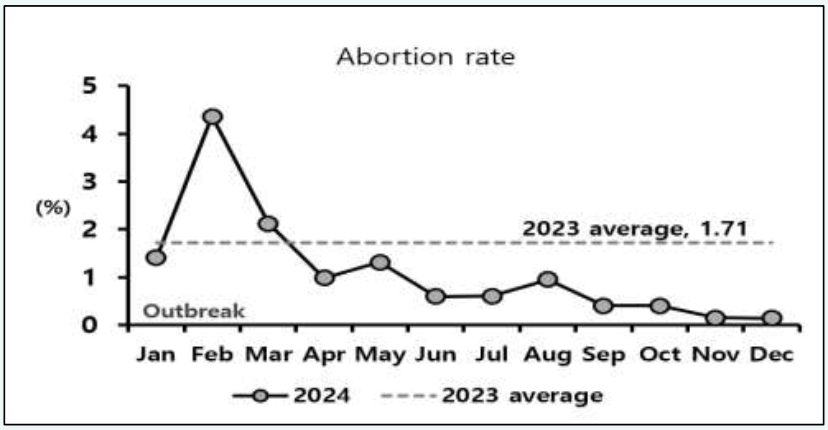

Figure 6: Monthly Abortion Rate. A PRRS outbreak occurred in February 2024, followed by mass vaccination in March 2024. The dot line represents the average value recorded in 2023.

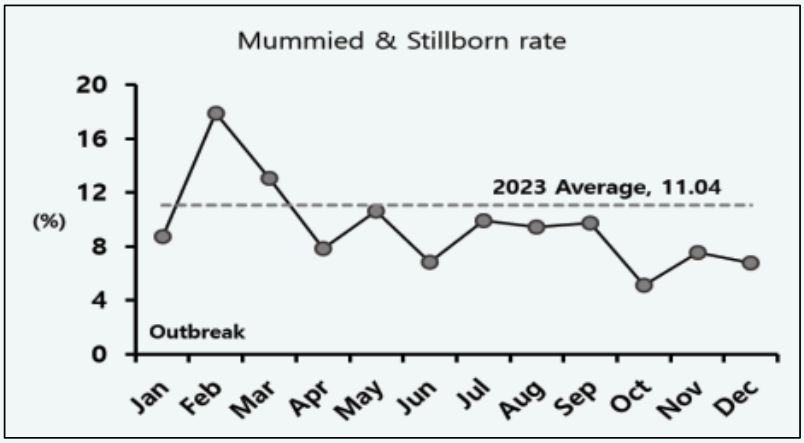

Figure 7: Monthly Mummified and Stillborn rate. A PRRS outbreak occurred in February 2024, followed by mass vaccination in March 2024. The dot line represents the average value recorded in 2023

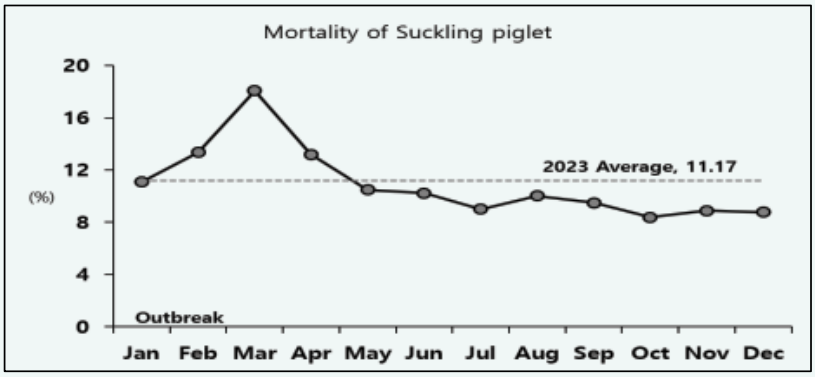

Figure 8: Monthly mortality of Suckling pigs. A PRRS outbreak occurred in February 2024, followed by mass vaccination in March 2024. The dot line represents the average value recorded in 2023.

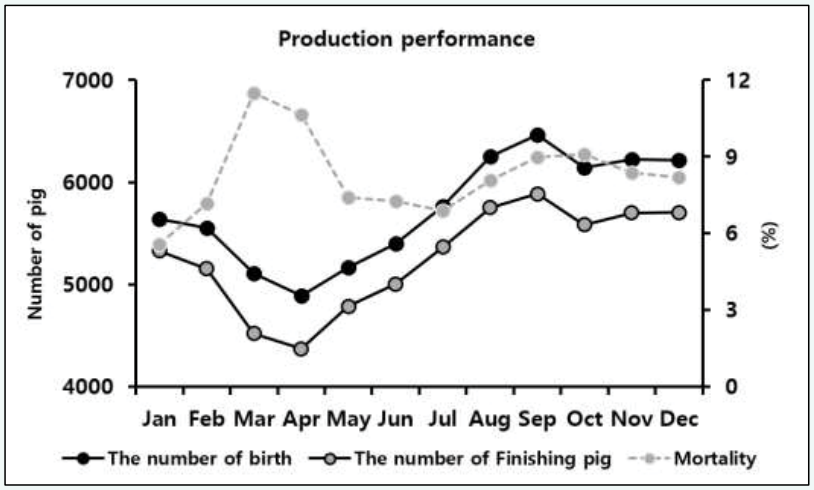

Figure 9: Monthly production performance and mortality of grower and finisher pigs. A PRRS outbreak occurred in February 2024 followed by mass vaccination in March 2024..

In a full-blown outbreak, mass vaccination functions to reduce virus circulating in the population and reduce the numbers of susceptible individuals. Evidence of this exists in both human and animal pandemics [31,32]. In the case of PRRS, MLV vaccines have been demonstrated to reduce the duration of shedding and volume of virus shed in vaccinated and challenged animals [33,34]. Our post vaccination results found that despite the persistence of viremia in piglets' post-vaccination, the reproductive performance of sows and the survival of piglets before movement into the nursery improved markedly. Our data show that, following the outbreak, the farrowing rate dropped from an average of 81.89% (2023 average) to 71.11% (Feb 2024 average), and abortion rates increased sharply. After mass vaccination, these reproductive parameters began to recover, returning toward baseline levels over several months. Likewise, suckling piglet mortality which spiked significantly during the outbreak, decreased post-vaccination, indicating an overall improvement in herd health and management. These results are consistent with previous reports that while the Modified Live Vaccine (MLV) may not completely eliminate PRRSV [7-35], it can substantially mitigate its impact on production performance [26-36].

One key finding in our study is the rapid interruption of vertical transmission. The detection of PRRSV in processing fluid samples from newborn piglets, which serve as an accurate indicator of in utero PRRSV exposure [28-37], returned to undetectable levels within one month of vaccination. Stopping vertical transmission is critical because in utero infection can lead to abortions, early farrowing, and the subsequent dissemination of the virus to nursery piglets, thereby perpetuating the outbreak. Our findings suggest that homogenizing the immunity of the breeding herd through mass vaccination not only reduces clinical disease but also effectively prevents the passage of the virus from sow to offspring—a key factor in controlling PRRS outbreaks.

The persistence of PRRSV detection and impact post-vaccination in the nursery highlights the inherent difficulty in completely eradicating the virus from a farm environment. Factors such as a continuous flow nursery, the continuous introduction of naïve gilts (with a replacement rate exceeding 50% in 2023 in this farm), and the complex dynamics of virus circulation in farrow-to-finish systems contribute to this challenge [14-46]. These findings indicate that even an aggressive vaccination program cannot fully eliminate PRRSV, but it can reduce its prevalence and mitigate its impact. Specifically, to this farm, the nursery was operated in a continuous flow method with multiple age groups within the same airspaces, greatly contributing to the PRRS recirculation in the nursery. It is noteworthy that the nursery pigs at the 6-week of age mark continued to show marked PRRS viremia, as demonstrated by the low Ct values. This suggests continued viral circulation in the nursery. The continued impact

of PRRSV in the nursery also had flow on effects to the grow-finish period. PRRSV infection can predispose pigs to other secondary infections such as Actinobacillus pleuropneumoniae and Pasteurella multocida.

In summary, while the mass vaccination strategy did not fully eliminate PRRSV from the herd, it led to significant improvements in sow reproductive performance and reduced suckling piglet mortality. Moreover, the cessation of vertical transmission within one month post sow vaccination underscores the value of vaccination as a critical component of a comprehensive PRRS management program. Thus, although complete eradication of PRRSV remains elusive, strategic vaccination can meaningfully reduce its detrimental impact on production and herd health, supporting both commercial operations and smallholder livelihoods. In the nursery, vaccination serves as an adjunct to control and biosecurity improvements are also critical to help mitigate the impact of PRRSV in the nursery and grow-finish period.

CONCLUSIONS

Our study demonstrates that while complete eradication of PRRSV remains challenging, a strategic mass vaccination program can substantially improve herd health in a farrow-to-finish operation. These findings underscore the critical role of vaccination as part of an integrated PRRS management strategy, particularly in systems where diverse age groups and frequent introductions of naïve animals facilitate continuous virus circulation.

STUDY LIMITATIONS

We note that our study has at least two limitations. Firstly, we were not able to include a control group in the study. Due to the severity of the outbreak on the farm, in the interest of animal welfare and financial well-being of the producer, we had to vaccinate all animals on the farm with the vaccine and were not able hence to include a control group. We note however that immediately post vaccination, both production metrics and vertical transmission showed improvement, supporting our conclusion of the critical role of vaccination to control acute PRRS outbreaks. Secondly, we used the absence of PRRS virus detection in processing fluids to suggest that a lack of vertical transmission occurred from sows to piglets. While all attempts were made to collect processing fluids at birth, we cannot discount the possibility that piglets may have suckled the sow if born overnight as staff were not in the farrowing house. However, the fact that we did not find any positive findings in processing fluid samples after the first sampling may help to exclude this possibility.

AUTHOR CONTRIBUTIONS

HYK, OYK, HYL, LE and SC conceived the manuscript and designed the methodology. Herd data and farm samples were collected by HYK and OYK. Analysis of herd data and samples was conducted by HYK, OYK, HYL and SC. Draft manuscript was written by SC, IHK with all authors contributing to edits and reviewing. All authors have read and agreed to the published version of the manuscript.

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INSTITUTIONAL REVIEW BOARD STATEMENT

The Animal Care and Use Committee of Dankook University, Cheonan, Korea, authorized the research protocol (DK-4-2439) for the current study.

DATA AVAILABILITY STATEMENT

The data presented in this study are available on request from the corresponding author.

ACKNOWLEDGMENTS

We thank all members of the farm involved for assistance with data collection and animal access.

CONFLICTS OF INTEREST

MSD Animal Health Korea Co., Ltd is the sponsor of the project. S.Y Choi, O.Y.Kwon and J.Y Lee are employees of MSD Animal Health South Korea Ltd. These authors declare that the research was conducted with integrity, following all ethical guidelines and without fear or favour. All other authors declare no competing interests.

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