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A retrospective study of factors associated with eliminating circulating pseudorabies virus in sow herds

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Summary

Objective: To define risk factors associated with sow herds that have not been successful in stopping circulation of pseudorabies virus (PRV, Aujeszky's disease).

Methods: Officials in charge of eradicating PRV in the major swine-producing states in the United States completed surveys to compare herds in which virus circulation had been successfully stopped (cases) to those in which it was not (controls) in an unmatched case-control design. Unsuccessful herds were defined as breeding herds that were diagnosed with PRV but that continued to have replacement animals become infected. The diagnostic and vaccination methods, characteristics of the farm and livestock, and eradication methods attempted were investigated. Multiple logistic regression analysis was used to compare and select statistically significant variables.

Results: Offsite and all-in–all-out (AIAO) finishing was more frequent among successful than unsuccessful herds. The frequency of other practices, such as sorting back pigs from one AIAO group to another, did not differ between successful and unsuccessful herds. In a higher proportion of successful herds, sows were culled directly from the farrowing room and conversely, a lower proportion of successful herds mixed cull sows with the finishing pigs. Unsuccessful herds were more likely to have other infected herds within 3.2 km (2 miles). Unsuccessful farms were more likely to raise gilts in their own facilities and did not cull out of the farrowing room but instead retained the sows. They also did not regularly clean and disinfect the livestock trucks or use a syringe dedicated to PRV vaccinations.

Implications: The picture of the problem herd that develops from this analysis is of a herd that is slow to take up new technologies, particularly biosecurity and disease control technologies.

Keywords: swine, pseudorabies virus, Aujeszky's disease virus, eradication

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Although the pilot phase of a nationwide program to eradicate pseudorabies virus (PRV, Aujeszky's disease) was initiated in 1987, many herds in the United States are still infected with PRV. Moreover, despite the use of various vaccines since 1976,[1] PRV has continued to spread to uninfected swine herds in the United States. To reduce the economic impact on producers that have infected herds, a number of methods other than depopulation have been recommended and used for eliminating PRV in the swine industry.[2] Cost effective strategies include:

- vaccination along with segregating young PRV-free offspring (offspring segregation), or
- removing seropositive animals (test and removal).

Although these methods were used successfully in individual herds in pilot PRV-eradication project areas (Hallam. Proc Livest Conserv Inst. 1986:69–79),[3] and in other large herds,[4] they have not been successful in eradicating PRV from some herds.[2]

To initiate a successful eradication program, producers and practitioners must be aware of methods that effectively eliminate the circulation of virus within infected herds. Duffy, et al., reported that eradication in vaccinated herds is most likely to be successful when replacement gilts remain uninfected.[5] DeJong, et al.,[6] demonstrated that PRV vaccination can decrease the duration and titer of virus excretion and increase the necessary infective dose, thus decreasing PRV transmission. However, vaccination is not reliable in controlling virus circulation when a large challenge is present and it also appears to differ between vaccines.[7]

Previous studies have relied on comparisons of relative prevalence to determine whether virus transmission was successfully controlled in the herd.[6,8,9] However, seroprevalence is not always consistent with the likelihood of continued disease transmission within a herd. Other factors, such as the presence of finishing pigs on site, and the density of pigs in the area, have also been associated with PRV in herds.[9] Our study examined herds in which virus was actively circulating to identify characteristics that might be associated with the failure to eradicate PRV.

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Materials and methods

In 1993 and 1994, surveys were sent to the official in charge of PRV eradication in the major swine-producing states, including North Carolina, Iowa, Nebraska, Illinois, Indiana, and Minnesota. The selection of herds was limited to the states in question, but did not involve any other criteria.

The survey was designed and produced by the Biologics and Diagnostics Subcommittee of the Pseudorabies Committee of the United States Animal Health Association (USAHA). This subcommittee identified putative factors involved in unsuccessful attempts to stop the circulation of PRV in the breeding herd to be used in the survey. The selection of these factors was subjective and based on the collective experiences of committee members. These factors included:

- vaccination strategy,
- measures to prevent PRV from entering the herd, and
- herd and farm characteristics.

Officials involved in the study were asked to identify herds of various sizes that fit one of two profiles to create an unmatched case control design:

- "unsuccessful" PRV-infected breeding herds (n = 45), defined as those using eradication programs that included PRV vaccines but in which replacement animals continued to become infected, or
- "successful" herds (n = 28), herds in the same size range as the unsuccessful herds in which the replacement animals remained uninfected over their lifetime in the herd. These herds were also using commercial PRV vaccines.

All possible successful herds were solicited from officials and they were also asked to provide characteristics of at least one similarly sized unsuccessful herd. No sampling frame was available for successful herds and the selection of unsuccessful herds was up to state officials.

The owners of both the successful and unsuccessful herds were given identical questionnaires to investigate:

- their diagnostic and vaccination methods (the type of vaccine used, administration technique, and vaccination schedule),
- the characteristics of the farm and livestock (biosecurity methods, building type, the flow of pigs within the facilities, PRV herds in the vicinity, and the age groups on the farm), and
- the eradication methods attempted.

Data on the methods used to confirm the continuation of PRV circulation were also collected. The questionnaire was not pretested.

Statistical analysis

Difference in proportions of successful and unsuccessful herds possessing specific herd or management characteristics were compared with the χ^2 statistic using Statistix 4.1 (Analytic Software, Tallahassee, Florida) and Quattro Pro 5.0 (Borland Inc., Scotts Valley, California). The variables that emerged with $P<.25$ from the χ^2 analysis then entered a multivariate logistic regression model, developed to clearly differentiate successful and unsuccessful herds. The first model attempted to predict the outcome based only on controllable variables. The second model predicted outcome for all the variables selected using the χ^2 analysis, including noncontrollable variables such as building type. Both models were developed using Statistix 4.1 and used a backwards stepwise method.

Results

The average size of herds was 383 sows for the successful herds and 404 sows for unsuccessful herds. Herd sizes ranged from 25–1200 sows. Several different types of vaccines were used (Table 1). The results of the χ^2 analysis identified six herd attributes that differed significantly between successful and unsuccessful herds (Table 2); these attributes were the ones chosen to enter the logistic regression model.

Four variables remained in the first logistic regression model that included only controllable factors (Table 3). This model correctly classified 79% of the herds. The logistic regression model demonstrated that unsuccessful herds were more likely to raise gilts in their own facilities and tended not to cull out of the farrowing room but instead moved the sows to finishing. They also did not regularly clean and disinfect the livestock trucks or use a syringe dedicated to PRV vaccination.

The second logistic regression model that also included factors that are not controllable, such as the proximity of the herd to another infected herd, correctly identified 84% of the herds as either unsuccessful or successful (Table 4). This model shows that unsuccessful herds tended not to use GG-deleted vaccines or to finish the pigs offsite. They tended to have other PRV-infected herds within a 3.2 km (2 mile) radius. Again, the unsuccessful herds in the second logistic regression model tended not to use a dedicated syringe for vaccination.

Table 1

Comparison of types of vaccines used

Type	Unsuccessful	Successful	Odds ratio	*P* value
GE-deleted vaccines	93%	100%		
Bioceutic™	2%	14%	0.14	.04
PRV/Marker Gold™	58%	46%		
PRVac MLV™	36%	57%	0.64	.07
PRVac Killed™	4%	4%		
Solvay (Bartha)™	2%	0%		
GG-deleted vaccines	7%	23%	0.30	.03
PRV/Marker Blue™	7%	23%	0.30	.03
Tolvid™	4%	11%		

Totals may exceed 100% because more than one vaccine type is used on many farms.

Table 2

Significant ($P < .05$) differences in successful and unsuccessful herds based on simple associations

Type	Unsuccessful	Successful	Odds ratio	*P* value
Service personnel routing from youngest to oldest pig	62%	37%	1.68	.04
Equipment disinfection	2%	30%	0.07	.001
Dedicated syringe	52%	89%	1.63	.002
24-hour downtime between farms for personnel	12%	41%	0.29	.005
Truck cleaned and disinfected between deliveries	16%	61%	0.26	.001
Pigs are not allowed to come back off truck	18%	48%	0.38	.01

Table 3

Logistic regression model of controllable factors on the prediction of problem herds

Variable	Coefficient	*P* value	Odds ratio	Odds ratio 95% Lower limit	Odds ratio 95% Upper limit
Constant	2.39	.08			
Cull out of farrowing	-1.70	.06	0.18	0.03	1.11
Gilts raised in finisher	2.13	.04	8.44	1.15	61.72
Truck cleaned and disinfected between deliveries	-2.15	.02	0.02	0.12	0.74
Dedicated syringe	-2.67	.03	0.01	0.07	0.82

Table 4

Logistic regression model of controllable and noncontrollable factors on the prediction of problem herds

Variable	Coefficient	*P* value	Odds ratio	Odds ratio 95% lower limit	Odds ratio 95% upper limit
Constant	0.91	.361			
GG vaccine	-3.38	.008	0.03	<0.005	0.41
Finisher offsite	-3.26	.005	0.04	<0.005	0.38
Other PRV infected herds within 1 mile	3.98	.001	53.38	5.03	566.2
Dedicated syringe	-2.10	.021	0.12	0.02	0.73

Odds ratio is defined as the odds of a herd being a problem herd based on that variable, with the other variables held constant.

Discussion

This study found a number of factors to be statistically associated with continued virus circulation in sow herds. It should be cautioned that a significant statistical association in this study should not be interpreted as a causal relationship. Technologies in herds tended to be "bundled," and certain bundles tended to be associated with herds that have difficulty eradicating PRV. No one specific technology was likely to be the cause of the problem, and thus the bundles associated with problem herds should be interpreted as descriptions rather than as prescriptions.

The characteristics of the problem herd depicted in this analysis tended to be slow to take up new technologies, particularly biosecurity and disease control technologies. Even simple steps, such as using a dedicated syringe, were more common in successful herds.

Our logistic regression model is similar to one generated in the Netherlands of seroprevalence,[9] where the risk factors that emerged as significant from their multivariate regression analysis of prevalence included:

- the presence of finishing pigs on site,
- the density of pigs in the area,
- breeding stock raised onsite, and
- the strain of the vaccine virus used.

The risk factors in our study associated with continued circulation often corresponded with the risk factors of infection in other studies. For example, our observation that successful eradication was more likely to occur in herds when trucks were cleaned between trips off the farm coincides with the findings of a study by Austin, et al.[10] The presence of finishing pigs onsite is also consistent with another study by Duffy, et al.[8] Raising gilts in finishing can continue the cycling of PRV back to the sow herd.

There have been previous reports in the United States of increased risk of infection in areas where other infected herds exist.[11] The proximity of infected herds may provide an increased infectious challenge that contributes to virus circulation between and among herds, although this seems less likely than virus circulation within a herd. It may be that the high numbers of farms infected in an area may induce a sense of fatalism and thereby reduce a producer's efforts in an eradication project. A third possible reason is that it may reflect common technologies within a geographic area that increase the risk of continued circulation but are not included in this model.

The same can be said for other biosecurity methods such as cleaning trucks. Culling seropositive sows out of the farrowing house can be an expensive procedure, but it is an intuitively attractive process as it eliminates pigs that are possibly shedding. The second logistic regression model of controllable and noncontrollable factors suggests that the use of gG vaccine may be protective, which seems to reflect the clinical impressions of many producers in discussions with the authors (Deen, personal communication, 1997). The differentiation of degrees of protection or prevention of shedding is difficult to measure when comparing vaccines, but they appear to exist.[7]

The bundle of technologies that are associated with successful PRV eradication are currently innovations in the swine industry. The factors that influence the likelihood that an individual will adopt an innovation[12] include:

- whether that individual has adopted previously introduced innovations;
- the demographic profile of the individual. Younger and more highly educated individuals are more likely to adopt innovations. Demographic studies may be useful to predict the success of PRV eradication; and
- the output of labor necessary to achieve the innovation. Labor is major constraint in the willingness of an individual to adopt an innovation.

Economic impact studies indicate that PRV infection in a herd causes substantial financial loss to the producer.[13] The financial benefit of a PRV-free status is a compelling reason to pursue a cleanup effort. The factors presented by this study may help identify risk factors and possible interventions in pursuing beneficial interventions.

Implications

- Eradication appears to be more difficult in areas of high animal density, for a number of reasons.
- To increase the likelihood of eradicating PRV, steps should be taken to reduce virus circulation within the herd.

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