A case–control questionnaire survey of risk factors for porcine reproductive and respiratory syndrome (PRRS) seropositivity in Danish swine herds

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Abstract

Sixty-eight case herds seropositive to porcine reproductive and respiratory syndrome (PRRS) were compared to 128 seronegative controls in a double-blinded questionnaire survey. The study indicated no increased risk of PRRS seropositivity for herds using artificial insemination with semen from PRRS seropositive AI-stations. Also the herd-size was non-related to the risk of PRRS seropositivity, indicating that air-borne spread of PRRS may not have been a predominant feature in Denmark. Introduction of replacement breeding animals from seropositive breeding- and multiplying herds significantly increased the risk of a herd being PRRS seropositive, as did introduction of 25 kg pigs for feeding. PRRS seropositivity was in the farmers' opinions associated with abortions in sows, early farrowing, high postweaning mortality and low weight gain in fattening pigs. However, the reported frequencies of problems were relatively low. © 1997 Elsevier Science B.V.

Keywords: Porcine reproductive and respiratory syndrome; PRRS; Risk

1. Introduction

PRRS was first diagnosed in Denmark in February 1992, on the Island of Als close to the Danish–German border. We noted that the first 20–30 index clinical cases were about twice the size of other herds on the island, and also found a high frequency of

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closed herds with a good zoosanitary status among these. In the summers of 1994 and 1995 we conducted serological screenings based on slaughterhouse blood sampling of slaughterpigs. We found an increasing sero-prevalence in fattening pig producing herds from 16% in 1994 to 27% in 1995. Danish artificial insemination (AI) stations have been detected serologically positive since late 1993, and at the summer of 1994 all 8 cooperatively owned AI-stations were PRRS seropositive. A screening of 340 breeding and multiplying herds (20 serum samples/month) has been carried out since May 1994, and in these herds we have detected an annual incidence of sero-conversion at 4%.

The primary objective of the present epidemiological study was to evaluate potential herd-level risk factors for association to herd-level PRRS seropositivity. The secondary objective was to assess farmers' opinions concerning the implications of PRRS on herd health.

2. Materials and methods

The case–control study was based on a slaughterhouse-based screening, conducted in June to August 1994, of slaughterswine producing herds. Samples from 525 batches of slaughterpigs were obtained from 8 slaughterhouses (Blans, Esbjerg, Herning, Sæby, Horsens, Odense, Ringsted and Rønne), representing most parts of Denmark. The slaughterhouses volunteered to chose herds that represented different geographical regions, and from selected herds we blood sampled 6 pigs from a batch (due to practical constraints, no systematical randomization could be attempted).

Serum samples were tested using an ELISA method, originally described by Albina et al. (1992). The test has been modified by using a Danish isolate of PRRS-virus for the production of antigen in porcine pulmonary alveolar macrophage cultures. Sixty-eight herds from 86 seropositive batches (≥ 1 seropositive pig), for which herd identification could be satisfactorily obtained were defined as cases. 128 herds with no seropositive pigs were defined as controls. The case:control ratio was set at 1:2 for each slaughterhouse whenever possible, but otherwise no matching was performed.

The same veterinarian performed all interviews via telephone. Neither the veterinarian nor the herd owner was aware of the herd status (as case or control) at the time of the interview. The questionnaire (data obtained listed in Tables 1 and 2) was administered from June to August 1994.

A modified herd size measure, the number of 'heat producing units' (HPU), was used in the statistical analysis. An HPU (1 HPU = 1000 W at 20°C) is an estimate of the heat loss at various temperatures, and hence the ventilation requirement (Strøm, 1978). The formula used was HPU = 0.17 × (fatteners > 25 kg) + 0.45 × (sows) + 0.30 × (boars). HPU was transformed by the natural logarithm to obtain an approximately normally distributed variable.

Herds were categorized according to specific pathogen free (SPF) diseases. In the Danish system, herds are free from *Actinobacillus pleuropneumoniae* (several serotypes), *Mycoplasma hyopneumoniae*, toxin producing *Pasteurella multocida*, *Serpulina hyodysenteriae*, lice and mange. An MS-herd is a herd with SPF status but infected with *M.*

Table 1

A 1994 case–control study of PRRS risk factors in Danish swine herds. Frequency of risk factors among cases and controls. Logistic regression results indicating odds ratio (OR) for parameters with $P < 0.15$

Risk factor	% cases	% controls	OR (95% C.I.)
(a) All herds (64 cases / 124 controls)			
Feeder-to-finish herd (versus herd with sows)	57.8	34.7	2.6 (1.4–4.8)
Conventional herd (versus SPF/MS [a])	71.9	70.2	not significant
ln(HPU) [b]	4.8 (0.9) [c]	4.8 (0.9)	not significant
(b) Herds with frequent production of fattening pigs (64 cases/119 controls)			
Feeder-to-finish herd (versus farrow-to-finish herd)	57.8	36.1	– [d]
Conventional herd	71.9	70.8	not significant
ln(HPU)	4.8 (0.9)	4.8 (0.9)	not significant
Purchase of 25 kg pigs	59.4	39.5	2.3 (1.2–4.3)
(c) Herds with sows (27 cases/81 controls)			
Conventional herd	85.2	71.6	not significant
ln(HPU)	5.0 (1.0)	4.9 (0.9)	not significant
Purchase of replacement gilts	74.1	61.7	–
Do., from PRRS positive herd	14.8	3.7	–
Purchase of replacement boars	92.6	81.5	–
Do., from PRRS positive herd	22.2	9.9	–
Purchase of gilts or boars	92.6	85.2	–
Purchase of gilts or boars from PRRS positive herd	29.6	12.3	3.0 (1.0–8.6)
Use of artificial insemination (AI)	70.4	67.9	not significant
(d) Customers in the cooperative AI stations (25 cases/73 controls)			
Purchase of gilts or boars from PRRS positive herd	32.0	12.3	3.5 (1.0–12.7)
Doses of semen introduced October 1993–April 1994	159 (231)	124 (227)	not significant

[a] Refer to Section 2.

[b] Natural logarithm to the number of heat producing units. Refer to Section 2.

[c] Mean and (standard deviation).

[d] Not used as explanatory variable in the logistic regression modelling.

hyopneumoniae. All herds were free from Aujeszky's disease (Pseudorabies) (Christensen et al., 1990).

98 herds were detected as customers in the cooperative artificial insemination company. For these, the numbers of AI doses received from 1 October 1993 to 30 April 1994 were calculated.

The herd-level risk analyses assessed the odds of PRRS seropositivity as functions of several risk factors, using the procedure PROC LOGISTIC (SAS Institute Inc., 1989), by fitting multiple logistic regression models. Four models were evaluated (Table 1a–d). Each model was tested in a forward as well as a backward stepwise selection process, with P for entry into or removal from the model set at 0.15, employing a likelihood-ratio test at each step. In the resulting model, the significance of slaughterhouse was tested similarly. Significance of the remaining effects were evaluated by Wald's test, odds ratio (OR) values calculated as e^{β}, with 95% confidence intervals of the OR as $e^{(\beta \pm 1.96 SE\beta)}$. (In herds with regular production of fattening pigs, the two variables 'feeder-to-finish

Table 2

A 1994 case–control study of PRRS risk factors in Danish swine herds. Frequency of reported herd health problems among cases and controls. Logistic regression [a] based odds ratio values for reporting health problem when PRRS seropositive, corrected for possible herd-size (ln(HPU) [b]) and herd disease status (conventional herd or SPF/MS [c] herd)

Health problem	% cases	% controls	OR (95% C.I.)
(a) Herds with frequent production of slaughter pigs (64 cases/119 controls)			
Low daily gain in fatteners [d]	29.7	16.8	2.2 (1.0–4.5)
High frequency of deaths in fatteners	14.1	10.9	not significant
Many pigs condemned at slaughter	1.6	0.1	– [e]
Nature of recent health problems in fattening pigs:			
– Respiratory	35.9	31.1	
– Gastroentestinal	9.4	8.4	
– Other problem	7.8	2.5	
(b) Herds with sows (27 cases/81 controls)			
Many abortions	29.6	13.6	2.7 (0.9–7 6)
Many early farrowings	18.5	6.2	3.5 (0.9–13.0)
Many stillborn or weak piglets	18.5	9.9	not significant
High preweaning mortality	14.8	9.9	not significant
High postweaning [f] mortality	25.9	4.9	6.7 (1.8–25.3)
Pneumonia among weaned pigs	7.4	4.9	–
Many sows with repeated services	11.1	21.0	not significant

[a] Logistic regression analysis restricted to health problems reported in ≥ 10 herds.

[b] Natural logarithm to the number of heat producing units. Refer to Section 2.

[c] Refer to Section 2.

[d] Above and [f] below 25 kg live weight.

[e] The risk of this outcome not subjected to logistic regression modelling.

herd' (relative to farrow-to-finish) and 'purchase of 25 kg pigs' (yes/no) were strongly correlated, so only the latter variable was included in the modelling procedure.)

The analyses of reported herd health problems assessed the odds of each problem as functions of ln(HPU), SPF/MS or conventional status, and PRRS seropositive or -negative status. However, the analyses were restricted to problems reported in ≥ 10 herds. For each group of herds, two (Table 2a) and six (Table 2b) models were evaluated. A stepwise selection process as previously described was used.

3. Results

4–12 serological samples/herd were examined with an average of 5.3. Among case herds, the average seroprevalence of within-herd reactors was 0.8. The lowest prevalence at 0.2 was found in 21%. 79% had within-herd prevalences at ≥ 0.6, and 62% at 1.0.

At the time of interview, 8 herds rejected to participate. Among the remaining 188 herds (64 cases and 124 controls), 6 herds were breeding or multiplying herds (no regular production of pigs for slaughter), and 102 herds had farrow-to-finish production.

Accordingly, 108 herds had sows. 80 herds practised feeder-to-finish production. Thus, 182 herds had regular production of fattening pigs.

For all herds ($n = 188$) the mean and range of pigs per herd were: For cases 980 (77–4,170); for controls 829 (62–7,325). For the 108 herds with sows the mean and range of sows per herd were: for cases: 190 (30–670); for controls 183 (5–1,300).

The risk factor analyses are shown in Table 1. No effect of slaughterhouse was detected. In addition, we found for 94 herds with sows that reported any purchase of replacement gilts or boars, that the OR associated with introducing replacement boars or gilts from PRRS positive herds was 2.7 (95% confidence interval: 0.9–8.1). 6 cases and 23 controls reported no purchase of 25 kg pigs, no introduction of boars or gilts from PRRS positive herds, and no use of AI. Among these there was no difference in ln(HPU) (means and standard deviations: for cases 4.6 (0.4); for controls 5.0 (0.8)).

The analyses of reported health problems are shown in Table 2. Increasing ln(HPU) was found also to increase the risk of reporting 'low daily gain in fatteners' ($P = 0.07$), 'high frequency of deaths among fatteners' ($P = 0.02$) and 'many stillborn and weak piglets' ($P = 0.08$).

4. Discussion

Besides the traditional 'backwards reasoning' problem (from disease to exposure) related to any case–control study (Kleinbaum et al., 1982), this study includes the following methodological aspects: The survey is based on prevalent cases of PRRS seropositive herds, and not incident cases. Thus it cannot be ascertained whether exposure occurred prior to or after the herd becoming PRRS seropositive. The questionnaire information was retrieved during telephone interviews, relying entirely on the farmers' recollection of events and inventories. Also the sample of herds investigated was not obtained randomly. As an effect of this, the average study herd size was considerably larger than the current Danish average at approximately 50 sows (Landbrugsstatistik, 1992). On the other hand, the masking process (in which neither the interviewing veterinarian nor the pig producer were aware of the herd PRRS serological status) and the high response rate (96%) are both improving the internal validity of the study.

Spread of PRRS through infected boars has been experimentally proven as a qualitative risk (e.g. Yaeger et al., 1993), but quantitatively we were not been able to detect a measurable effect. This is supported by a low incidence of PRRS in our breeding and multiplying herds, that among all Danish herds exercise the most intensive use of AI, even using predominantly younger boars. We believe that the AI stations probably had been PRRS seropositive for several month prior to the study, so that this chronical infection have not contributed to the spread of PRRS at this stage.

Theoretically it has been postulated that for airborne infections, the logarithmic herd-size is proportional to the risk of the herd becoming infected (Willeberg et al., 1994). Danish studies have been able, on an empirical basis, to support this view (e.g. Christensen et al., 1990 and Flori et al., 1995). But in the present study the log herd-size was not (even marginally) significantly related to PRRS seropositivity, despite of great

variability of herd-sizes in the sample. $3\frac{1}{2}$ years after the introduction of PRRS to Denmark (only) about 27% of the slaughterswine producing herds have become seropositive, which also does not indicate widespread airborne transmission. On the other hand, the index cases occurring in 1992 were twice the size of other herds in the area initially infected, and also it should be recalled that the selection process for herds to the present case–control study has favoured large-sized herds. Thus, longitudinal studies are recommended to further investigate the herd-size relationship.

The 'excess' percent-units of reported herd health problems in cases compared to controls were relatively low, yet the detrimental clinical effect of PRRS was clear for several herd health problems. The validity of the farmers' opinions about the clinical importance of PRRS is enhanced by the blinding of the interview. Also the time of onset of reported disease problems among case herds were concentrated around the winter of 1993–1994, whereas reported disease problems among control herds appeared more scattered (data not shown). However, the results were brought about by re-arranging the original case–control sample of PRRS seropositive and -negative herds into case–control samples of herds with and without given health problems, with subsequent statistical analysis.

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