

Evaluation of biosecurity measures for predicting *Salmonella* herd status

Baptista, F.M.^{(1),(2)*}, Alban, L.⁽³⁾, Nielsen, L.R.⁽¹⁾, Domingos, I.⁽²⁾, Gouveia, S.⁽²⁾, Pomba, C.⁽²⁾, Almeida, V.⁽²⁾

⁽¹⁾ Department of Large Animal Sciences, Faculty of Life Sciences, University of Copenhagen, Frederiksberg, Denmark

⁽²⁾ CIISA, Faculdade de Medicina Veterinária, TULisbon, Lisboa, Portugal

⁽³⁾ Danish Meat Association, Kjellerup, Denmark

*baptista@life.ku.dk

Abstract

Biosecurity refers to the set of practices that limits the entry, persistence and spread of pathogenic agents. Biosecurity practices are believed to be associated with disease occurrence in a herd.

The aim of this study was to develop and validate a factor analysis model to classify industrial farrow-to-finish pig herds according to biosecurity measures and evaluate its usefulness as a cost-effective indicator of *Salmonella* risk.

Three factors were identified that were labelled as “general” biosecurity (factor 1), herd size (factor 2) and sanitary gap implementation (factor 3). Farms in the highest biosecurity category implemented preventive measures related to visitors and workers, control of biological vectors, hygiene procedures, water quality assessment and sanitary gap (fattening and growing sectors). *Salmonella* prevalence data was used to validate the model of biosecurity categorization as an indicator of *Salmonella* occurrence in farrow-to-finish pig herds in Portugal.

Preliminary results indicate that the overall *Salmonella* prevalence is lower in herds with high biosecurity, suggesting a potential use of this model for the design of risk-based surveillance strategies for *Salmonella*. However, data are required on the *Salmonella* status of more herds to be able to gain better model validation and understanding of which biosecurity measures are most important.

Introduction

In agreement with EU Community targets (in the pipeline) and international trade requirements, surveillance and control programmes should be in place aiming to reduce *Salmonella* prevalence in the swine production (Anonymous, 2003). In the context of disease surveillance, risk-based strategies emerge as a tool to assure an appropriate and cost-effective data collection. Among the different risk factors associated with *Salmonella*, farm biosecurity is considered to be the most important factor to prevent *Salmonella* introduction and spread at the farm level. Biosecurity profiling might be used to prioritise surveillance activities, targeting sampling to high risk herds.

Livestock data have already been used to classify cattle herds according to the risk profile for disease presence (Ortiz-Pelaez & Pfeiffer, 2008). Several studies have characterized biosecurity practices in pig herds in different countries (Julio Pinto & Santiago Urcelay, 2003; Boklund et al, 2004; Casal et al, 2007; Ribbens et al, 2008). However, to our knowledge, no surveys have been conducted to evaluate biosecurity as an indicator of *Salmonella* occurrence in pig herds.

The aim of this study was to investigate the potential use of on-farm management and biosecurity practices as a tool to classify herds according to their biosecurity profile.

Moreover, it was our intention to develop and evaluate the effectiveness of a biosecurity profiling model as a cost-effective indicator of *Salmonella* for the future development of risk-based surveillance schemes. *Salmonella* prevalence data was used to assess the model validity. Preliminary results indicate that herds in the highest biosecurity category have a lower *Salmonella* prevalence compared to the other herds.

Material and Methods

From September to December 2008, 250 questionnaires were distributed to 50 veterinarians working for industrial pig herds located in Lisbon and Tagus Valley region, in Portugal. The questionnaire assembled 77 questions under six main topics: herd characteristics, production parameters, hygiene, feed, husbandry and health. A total of 139 questionnaires were received, corresponding to a response rate of 56%, of which 134 were valid. Out of these, 109 were industrial farrow-to-finish pig herds.

In 2007, pig lymph nodes were collected from 659 pigs from 353 herds at slaughter and tested for *Salmonella* in the EU baseline survey on slaughter pigs. A herd was considered positive if at least one pig was positive for *Salmonella*.

From May to July 2009, a cross-sectional study was conducted on 21 of the herds participating in the questionnaire survey. In each herd, 10 pens housing pigs aged 6-10 weeks were randomly selected and pooled faecal samples were collected. In this field study, a herd was classified as positive if *Salmonella* was detected in at least one pen (unpublished data).

Bacteriological examination was conducted according to standard microbiological culturing methods.

Data analysis was performed using SAS® v. 9.1.3. (SAS Inst., Inc., Cary, NC). A factor analysis model with orthogonal rotation was used to identify underlying factors that could explain intercorrelation among the different biosecurity variables (Sharma, 1996). Nominal data were scaled using the maximum-total variance method.

Results

Biosecurity practices in 109 Portuguese industrial farrow-to-finish pig herds were investigated, by use of the questionnaires. Due to missing observations six herds were excluded from the analysis.

A three-factor model explaining 44.6% of the variation in the data was developed. The variance explained by each factor was 27.0% (factor 1), 9.3% (factor 2) and 8.3% (factor 3). Variables scoring high on factor 1 were related to general biosecurity, while factor 2 was associated with herd size-related variables and factor 3 with sanitary gap implementation in the farrowing and growing sectors (Table 1). A high score on the three factors can be described as follows (a site with a low score can be described as the opposite):

- Factor 1: other livestock species present in the herd; dogs/cats present in the herd; no slurry drain per pen; no footbaths at the building entrances; no bath when entering the herd; no footwear for visitors; no cleaning and disinfection of the loading bay after loading the pigs; dogs/cats access to the herd clean area; dogs/cats access to the building interior; no rodent control plan implemented; no insect control implemented; no water tested. Thus, scoring high in factor 1 was consistent with poor biosecurity.
- Factor 2: high number of sows in the herd; people dedicated to specific units; the driver that transports pigs do not enter the clean area in the herd. Thus, scoring high on factor 2 was related to larger herds.
- Factor 3: sanitary gap implemented in the farrowing and growing sectors.

Factor 1 and Factor 3 were further used as a scale to classify herds according to their biosecurity profile (Figure 1).

Salmonella data on 51 herds from either the baseline study or the field study were used to validate the biosecurity profiling model. Out of the total, 20 herds were *Salmonella* positive. For herds with good general biosecurity (factor 1 < 0) 28.6% were positive for *Salmonella*, and 46.7% of herds with poor biosecurity (factor 1 > 0) were positive. For herds in the highest biosecurity category (factor 1 < 0; factor 3 > 0) 23.1% were positive; 44.7% of herds in the lowest biosecurity category (factor 1 > 0; factor 3 < 0) were positive for *Salmonella*.

Table 1 - Rotated factor pattern for a factor analysis model of biosecurity in Portuguese industrial farrow-to-finish pig herds surveyed from September to December 2008

	Factor 1	Factor 2	Factor 3
Other livestock species present in the herd	0.48	0.05	0.13
Dogs/cats present in the herd	0.58	-0.07	0.03
Each pen has each own slurry drain	-0.50	0.39	-0.17
Foot bath at the buildings entrance	-0.48	0.25	0.22
Bath when entering the herd	-0.44	0.003	0.15
Footwear for visitors	-0.54	0.35	0.16
Sanitary gap farrowing	-0.15	-0.03	0.52
Sanitary gap growing	0.08	-0.007	0.53
Sanitary gap fattening	-0.11	0.26	0.21
Clean and disinfect the loading bay after loading the pigs	-0.55	0.40	-0.04
Dogs/cats have access to the herd clean area	0.79	-0.05	-0.004
Dogs/cats have access to the buildings	0.72	-0.08	-0.01
Rodent control plan implemented	-0.47	0.35	0.22
Insect control plan implemented	-0.45	0.34	-0.19
No. of sows in the herd	0.01	0.75	0.02
Water tested	-0.48	0.30	-0.29
People dedicated to specific units	-0.08	0.66	-0.17
Small/weak pigs kept back to mix with younger pigs	0.39	-0.33	0.22
Transporting pigs driver enters the herd clean area	0.40	-0.52	0.001
Breeders replacement	-0.26	-0.004	0.04
Number of veterinary visits per year	0.13	0.35	0.24

Factor loadings > |0.40| are highlighted in bold.

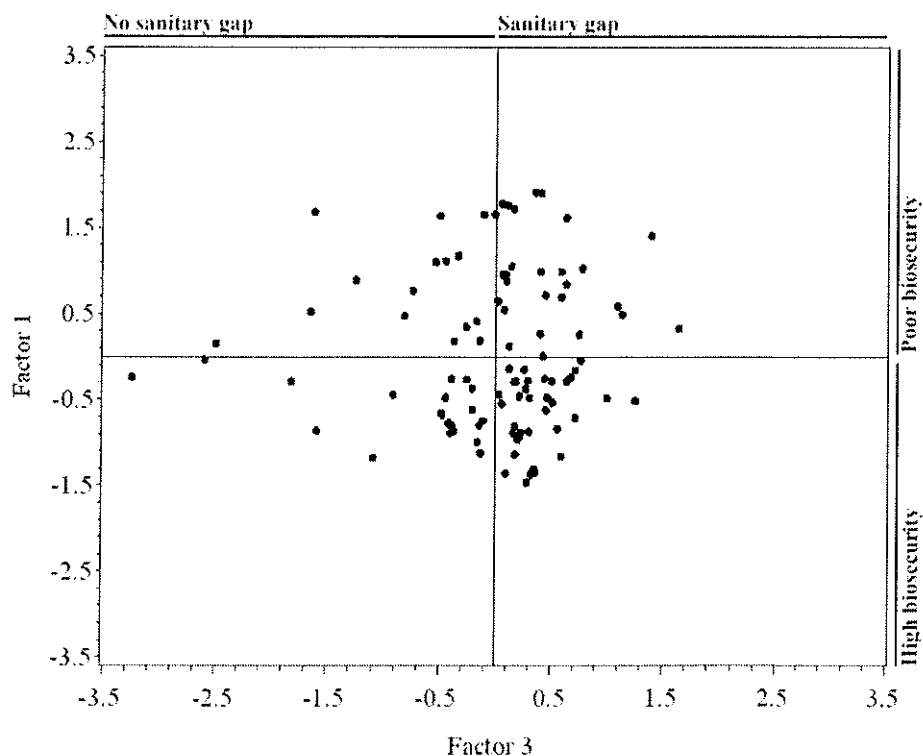


Figure 1 – Plot of the 103 Portuguese industrial farrow-to-finish pig herds surveyed from September to December 2008, according to their biosecurity profile (factor 1 vs. factor 3).

Discussion

A mailed questionnaire survey was chosen due to practical and economical constraints since it would not be feasible to visit all farms. Moreover, most of the questions were related to herd routines and some could not be observed during a herd visit.

For our dataset, a KMO measure of 0.8 suggested that the correlation matrix was appropriate for factoring. For our residual matrix a RMSR of 0.07 was computed, implying an acceptable factor solution. The interpretability of the factors and a scree plot were the criteria used for determining the number of factors (Sharma, 1996). The eigenvalue-greater-than-one rule suggested that eight factors should be extracted, accounting for 72% of the variation. We found that it might be difficult to explain eight factors, and the scree plot also indicated that three factors would make sense. Furthermore, the addition of more factors than the selected three would account for less than 7% of the variation each.

Preliminary results might indicate an association between the biosecurity category and herd prevalence, suggesting that biosecurity profiling might be used to target surveillance activities to *Salmonella* high risk herds. However it should also be taken into account that test sensitivity is different for lymph nodes and faecal sampling and might reflect different stages of infection, influencing herd classification. Further research is needed to validate the presented model.

Conclusion

A first approach to develop a way of scaling biosecurity in Portuguese industrial farrow-to-finish pig herds is presented here. A three-factor model explaining 44.6% of the correlation among different biosecurity related variables enabled to classify herds according to their practices.

Further, preliminary results indicate that biosecurity scoring might be used as part of a risk assessment to classify herds according to the risk of *Salmonella* occurrence and use it to prioritise surveillance activities.

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