FARM MANAGEMENT RISK FACTORS FOR SWINE RESPIRATORY DISEASE

A Thesis Submitted to the Graduate Faculty in Partial Fulfillment of the requirements for the Degree of Master of Science in the Department of Health Management, Faculty of Veterinary Medicine, University of Prince Edward Island

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ABSTRACT

In an attempt to explain the relationship between farm management and respiratory disease, a study was undertaken to look at management practices on Prince Edward Island pig farms. Multivariable analyses were used to define the relationship between farm management variables, enzootic pneumonia, and pleuritis.

Respiratory disease data were obtained from slaughter examination of thoracic viscera. Trained technicians scored the lungs. The sensitivity and specificity of the gross visual examination was determined. The sensitivity of a gross visual score compared to histologic examination was 76 per cent and the specificity was 71 per cent. These figures were considered underestimates, as histology is not an ideal gold standard for the diagnosis of enzootic pneumonia. There was strong agreement in visual scoring between the author and the two technicians, K (kappa) exceeded 0.9 in all cases. It was concluded that gross lung examination of lung viscera at slaughter was an adequate way to screen for respiratory disease, and there was excellent consistency between inspectors.

Farm management data were gathered on visits to 89 swine farms on Prince Edward Island. Farm management variables (43) were recorded after physical measurement and/or visual determination. Factor analysis of data from 76 farms was used to group the management variables into six factors that described different management and housing styles (farm types).

The prevalence of enzootic pneumonia and pleuritis was determined for 69 of the 76 farms that had complete management data. Multiple logistic regression was used to analyze the relationship between the presence of enzootic pneumonia and the six farm types. Three farm types had a significant relationship with enzootic pneumonia. Those farms that tended to mix pigs from different sources, that floor fed their pigs, and larger farms which made their own

feed, and mixed and held slow growing pigs back, all had higher odds of having enzootic pneumonia.

Data from farms with a prevalence of enzootic pneumonia greater than 10 per cent was analyzed by multiple linear regression in order to determine risk factor for the disease. Only two farm types, those that bought pigs from multiple sources, and those that employed floor feeding had a positive significant association with the prevalence of enzootic pneumonia.

Multiple logistic regression was also used to evaluate the relationship between the farm types and the presence of pleuritis. Only one farm type, which featured a below average size, and above average air volume and pen space, had a significantly lower risk of having pleuritis. There was no statistically significant relationship between the farm types and an increase in pleuritis prevalence on farms which had some pigs with pleuritis

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CHAPTER ONE

INTRODUCTION

The economic loss due to respiratory disease in swine has been well documented (1). A growth rate loss of 5 to 25% has been associated with pigs having enzootic pneumonia (1,2,3). However, there are also studies indicating little or no production loss with enzootic pneumonia (4). This discrepancy means the full relationship between pneumonia and production loss has yet to be determined. Wilson et al (4) suggested that different barn environments may mediate the link between enzootic pneumonia and production loss.

The relationship between barn environment and respiratory disease is complex and difficult to study because there are many potentially linked variables to consider. It was the aim of this research to try to further define the relationship between barn environment and respiratory disease of swine.

There were several conditions on Prince Edward Island that facilitated this study. In 1985, a new slaughterhouse was built in Charlottetown (Garden Province Meats), and it processes over 95 % of the island's pig production (5). A joint project was initiated involving Agriculture Canada, Garden Province Meats, and the University of Prince Edward Island, as part of the development of the Animal Productivity and Health Information Network (APHIN) (6). The project allowed carcass information on slaughtered pigs to be electronically gathered, compiled and summarized for all swine producers. Included in the gathered data were observations on the slaughterhouse prevalence of two major swine respiratory diseases - enzootic pneumonia and pleuritis.

This study used the disease prevalence at slaughter and examined the relationship between the prevalence of disease and environment on the farm of origin. Access to the farms was granted by each farmer following a mail survey. A mailing list of swine producers provided by the Prince Edward Island Hog Commodity Marketing Board facilitated the canvassing process. The environmental data was gathered by visiting the farms and viewing and measuring the management variables. The farm visits and the data gathered are described in Chapter Three.

Before the abattoir disease prevalence information was used, the validity of the data was assessed. While evaluation of the lesions at slaughter was easy to perform, the accuracy of such a disease screening test was not known. The sensitivity and specificity of a gross appraisal of lung pathology was determined. Both histology and bacteriology were used as a gold standard. The consistency between technicians evaluating the viscera was also determined. The results of the evaluation are presented in Chapter Two.

The farm management data generated over 40 potentially correlated variables which had to be reduced before analyzing the relationship with disease. The factors were condensed using factor analysis. Factor analysis reduced the data into a smaller uncorrelated set of variables. The resulting variables (factors) described farm types which represented management variables that tended to be correlated together. The factor analysis procedure and results are described in Chapter Three.

Regression analysis between the prevalence of enzootic pneumonia and pleuritis and the farm types was performed. Multiple logistic regression was used to define the relationship between the presence or absence of both diseases. Multiple linear regression was used to assess the relationship between the prevalence of both conditions and the farm types. The relationships between the farm type scores and enzootic pneumonia are in Chapter Four, and pleuritis - management relationships are described in Chapter Five.

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CHAPTER TWO

EVALUATION OF GROSS VISUAL APPRAISAL OF SWINE LUNGS AT SLAUGHTER

INTRODUCTION

With increased interest of the veterinary profession in disease prevention and production medicine, the relationship between respiratory disease and economic loss in swine production is continually under examination. Recent literature summaries and local studies provide a reasonable estimation of the economic loss associated with respiratory disease in swine herds (1-3). The consensus seems to indicate an economic loss associated with respiratory disease, with the range being a 2 to 25% reduction in average daily gain. There also seems to be an indication that the losses are proportional to lung lesion severity (1).

To estimate the impact of disease in a pig herd, it is essential to accurately estimate the prevalence of the condition. Examination of carcasses and viscera at slaughter allows an opportunity to examine lesions due to disease occurrence as the animal grew to market weight. Results from these examinations increase producer awareness of production problems and also provide a mechanism to evaluate effectiveness of disease control measures (4).

Lesion examination of viscera at slaughter was first used as a research tool in examining risk factors for respiratory disease (5). More recently, it has been commonly used to monitor the health of pigs on farms (6-9). Other potential benefits of increased disease surveillance include reduction in the spread of diseases via breeding stock, reduction in the use of antibiotics with the concomitant risk of residues, definition of industry standards for levels of health, and provision of a basis for observational studies to further investigate both disease-performance relationships and risk factor-disease relationships (10).

While there are obvious benefits from estimating disease prevalence at slaughter, there are limitations that need to be understood in the interpretation of the data. First, sample size considerations are paramount. An adequate number of carcasses must be examined before extrapolation to the reference population (11). Second, the scoring method must be standardized and repeatable (12). Third, pigs sampled must be representative of the population. Bias results when runts or good performers are selected for examination (4). Finally, lesions will heal as pigs grow and the age of the pigs at slaughter can affect the estimates of the prevalence of disease (13, 14) and so must be taken into account.

The objectives of this study were threefold. The first was to standardize the examination of lungs for respiratory lesions at slaughter. The second was to determine the operating characteristics (sensitivity and specificity) of rapid gross visual inspection of lungs for enzootic pneumonia compared to a detailed visceral inspection, bacteriologic examination and histologic examination. The third objective was to compare rapid visual inspection scores from lay inspectors with those of the primary investigator. This comparison was done to establish confidence intervals around prevalence estimates of respiratory disease on Prince Edward Island. The data were gathered under the Animal Productivity and Health Information Network (APHIN) program (9), and were used to provide feedback to local swine producers on an ongoing basis, and for research into risk factors for respiratory diseases of swine.

MATERIALS AND METHODS

A series of lungs were examined at a local abattoir on 5 separate days over a 3 week period. Different days of the week were chosen as farmers tend to ship hogs on specific days of the week. Systematic sampling of every tenth hog was used following the random selection of a starting number between 1 and 9.

Lungs were examined, and a rapid gross visual appraisal of enzootic pneumonia lesions was made, using a system that scores the percent of lung tissue affected (2). The lungs were then set aside and examined in more detail. The percent affected in each lung lobe was assessed individually and the total lung area affected was calculated using a weighted average that incorporated the proportion each lung lobe contributes to the total lung mass (12).

A sample of pulmonary tissue was taken from each lung and submitted for bacterial and histologic examination. The bottom 4 cm of the affected lung lobe was chosen. In the case of no visible lesion, the bottom of the right middle lobe was selected, as middle lobes are most likely to have lesions, with the right side more so than the left (15, 16).

The lung samples were placed in clean identified plastic sacs and taken to a diagnostic laboratory. Upon arrival, the samples were split and one half the lung sample was placed in 10 % neutral buffered formalin and the other half was taken in the plastic sac to the microbiology laboratory, where the samples were processed immediately. The lung surface was sterilized and a flamed loop sampled the lung parenchyma two to three times. The loop was streaked for isolation onto a Columbia agar base with 5% sheep blood. A colony of Staphylococcus aureus was streaked at right angles to the loop streaks. The time from lung sampling to arrival and processing at the lab varied from one to not more than three hours. The plates were incubated at 35 ^{0} C and 5% CO_2.

The plates were read at 48 hours after sampling and the identity and quantity of the bacteria isolated was recorded. Cultures were recorded as having one of the following: few colonies (less than 10 colonies on the whole plate), mild growth (more than 10 colonies confined to the first quadrant of the plate), moderate growth (colonies spreading into the second quadrant), and heavy growth (bacterial growth in all the quadrants). Samples were later scored as positive for a specific pathogen if there was moderate or heavy growth of that organism.

The fixed tissues remained in formalin for 2 months, they were cut transversely and processed routinely for histologic examination. Paraffin embedded tissues were sectioned at 6 μm, stained with hematoxylin and eosin and examined microscopically. The lesions were classified by site of reaction: alveolus, peribronchial cuff, or airway. The degree of inflammatory cell infiltration was classified as: minimal, mild, moderate or, marked. The following were the definitions for each category: minimal - inflammatory cell infiltrate detectable histologically, mild - readily detectable histologic infiltrate, moderate - prominent histological change, marked - "wall to wall" inflammatory cell infitrate (i.e. complete consolidation). A lung was later scored as histologically positive for enzootic pneumonia if any one or more of the alveolus, peribronchial cuff or airway had lesions that were moderate or marked.

The principal investigator who had performed the gross and detailed lung scores was then used to assess the accuracy of two inspectors who were scoring lung lesions in the abattoir. The inspectors were trained by the principal investigator to use the previously described system (2). The lung score was subsequently coded as being either positive or negative for enzootic pneumonia. To be considered negative for pneumonia the lungs had to have no visible lesions of enzootic pneumonia, as this is considered the most reliable endpoint (12). Lungs were scored simultaneously with everyone unaware of each others scores.

All statistical analyses were carried out using Statgraphics (STSC Inc, Rockville, Maryland, USA). Pearson's correlation coefficient was used to compare the gross lung score and detailed lung score. A cross tabulation was made between gross lung score and histologic score, and between gross score and bacterial growth. The sensitivity and specificity of using the gross lung score as a measure of pneumonia compared to either histology or bacteriology as the gold standard was calculated. The sensitivity is defined as the proportion of diseased animals that test positive, whereas the specificity is the proportion of non-diseased animals that test negative (17).

Inspection results were cross tabulated, and sensitivity, specificity, and kappa between the principal investigator and the inspectors were calculated.

RESULTS

Pearson's correlation coefficient between grossly scored lungs and a detailed examination was 0.94 based on 87 lungs examined. A scatter plot is presented in Figure 1.

Visually pneumonic lungs had more histologic lesions than normal lungs, and more than 50% of pneumonic lungs had peribronchial and alveolar lesions (Figure 2). Visually pneumonic lungs had a higher recovery rate of bacteria than grossly normal lungs, except for alpha streptococci where normal lungs yielded a similar bacterial recovery rate (Figure 3).

Figure 1.
Relationship between detailed and gross scores of Percent lung affected with enzootic pneumonia

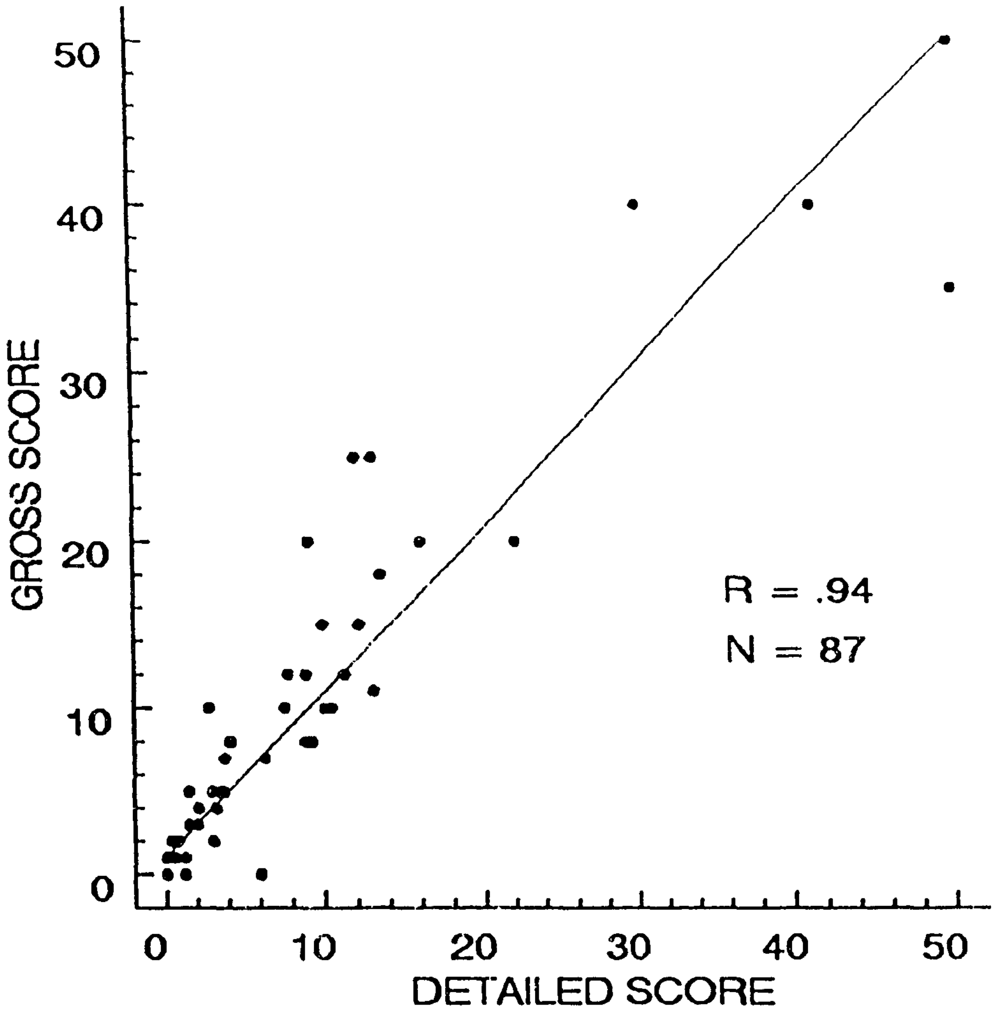


Figure 2
Frequency of histologic findings
In grossly pneumonic and normal swine lungs

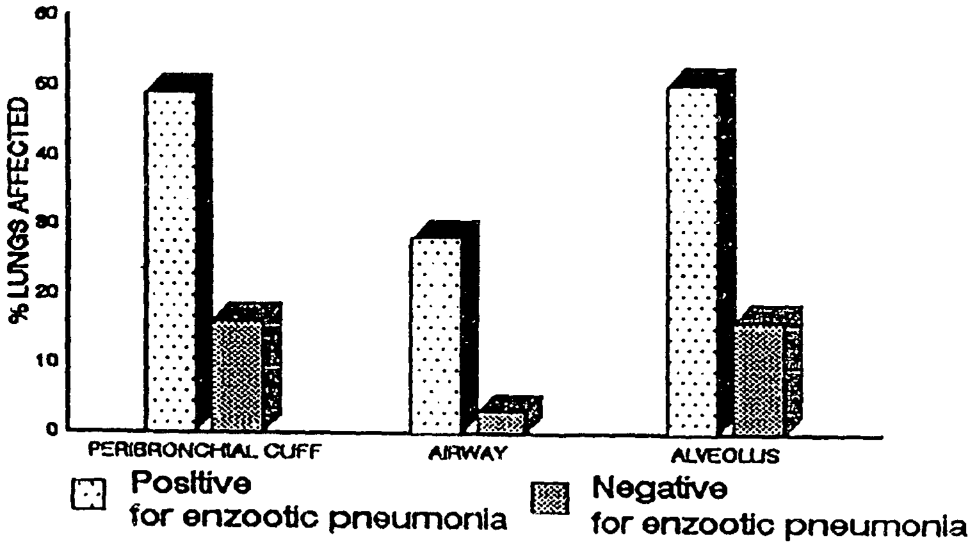
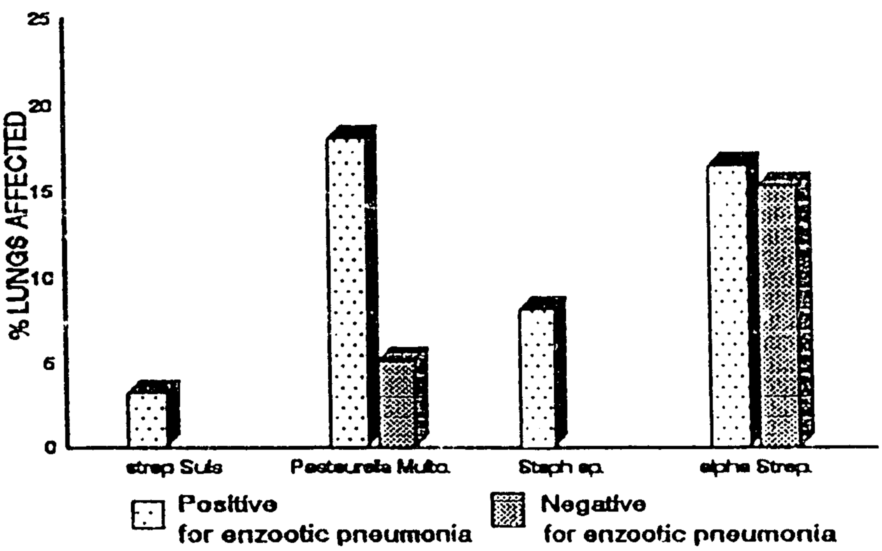


Figure 3
Frequency of bacterial isolations
in grossly pneumonic and normal swine lungs



Cross tabulation of visibly pneumonic lungs with bacterial recovery yielded a sensitivity of 77% with a 95% confidence interval of 68 - 86% and a specificity of 51% (44 - 57%). This tabulation had a chi-square value of 5.25 with $p = 0.02$ (Figure 4).

Cross tabulation of visibly pneumonic lungs and histology findings had a sensitivity of 76% (69-82%) and a specificity of 71% (62-78%) The chi-square value was 18.5 with $p < 0.01$ (Figure 5). Further breakdown of the histology findings show that the majority of the negative histology findings in grossly pneumonic lungs occur in lungs with low lesion severity (less than 5% of the lung affected, (Table I).

The sensitivity and specificity of the designated inspectors 1 and 2 compared to the principle investigator were: sensitivity = 97.5% (95 - 99%) and specificity = 97.4% (95 - 99%) for inspector 1, and for inspector 2 comparable values were: 97 % (95 -99%) and 98 % (91 - 98%) for inspector 2. The kappa values for both of the inspectors compared to the principle investigator were both over 0.9. The tabulations of results from the inspectors compared to the principle investigator are presented in Figures 6 and 7.

Figure 4

Crosstabulation of bacterial recovery

and gross presence of enzootic pneumonia

GROSS INSPECTION	BACTERIOLOGY NEGATIVE	BACTERIOLOGY POSITIVE	
NEGATIVE	33	5	
POSITIVE	32	17	
	65	22	87

	SPECIFICITY	SENSITIVITY
Chi-square = 5.25, p = 0.02	51 %	77%

Figure 5

crosstabulation of histology

and the presence of enzootic pneumonia

GROSS INSPECTION	HISTOLOGY NEGATIVE	HISTOLOGY POSITIVE	
NEGATIVE	26	12	
POSITIVE	11	38	
	37	50	87
	SPECIFICITY	SENSITIVITY	
	71%	76 %	

Chi-square = 18.5

p = 0.00

TABLE I. VARIOUS HISTOLOGIC FINDINGS IN SWINE LUNGS WITH VARIOUS DEGREES OF LUNG SEVERITY

	Percent of Lung Affected							
	0%	1%	2-4%	5-9%	10-19%	20-29%	30-49%	50+ %
histology positive	12	6	9	7	8	5	2	1
histology negative	26	8	1	1	1	0	0	0
peribronchial +ve	9	6	8	1	5	5	2	1
peribronchial -ve	27	7	2	7	2	0	0	0
airway positive	2	1	2	3	6	3	2	1
airway negative	36	4	2	2	1	2	0	0
alveoli positive	9	1	5	7	6	5	1	1
alveoli negative	27	13	5	1	3	0	1	0

(Lesions were not recorded in all regions on every lung.)

Figure 6
Crosstabulation of inspector 1
and the principal investigator

INSPECTOR 1	NEGATIVE	POSITIVE	
NEGATIVE	39	1	
POSITIVE	1	38	
	40	39	79

KAPPA	SPECIFICITY	SENSITIVITY	Chi-square = 70.7
0.95	97 %	98 %	p = 0.00

Figure 7
Crosstabulation of inspector2 and the principal investigator

INSPECTOR 1	NEGATIVE	POSITIVE	
NEGATIVE	37	2	
POSITIVE	1	37	
	38	39	79

KAPPA	SPECIFICITY	SENSITIVITY	
0.93	97 %	95 %	chi-square = 69.4 p = 0.00

DISCUSSION

The high correlation between detailed and gross lung scores indicate that lungs can be visually scored accurately, as they pass by on the kill line. Enzootic pneumonia has distinct lesions that are easily identified and approximating the extent of the pathology can be done quickly.

It is important to confirm that the pulmonary lesions being classified by the principal investigator in this study were truly indicative of enzootic pneumonia. Enzootic pneumonia has long been associated with an infection of Mycoplasma hyopneumoniae, followed and complicated by secondary bacterial infections (18,19). Isolating Mycoplasma hyopneumoniae is expensive and, culture techniques are unreliable (many false negatives). Consequently, the presence of bacteria in lung tissue was used as a microbiological indicator of the presence of enzootic pneumonia. This has the additional advantage that if there is an association between bacterial growth and lung pathology, samples taken from affected lungs at slaughter may help to guide therapeutics on the farm in question. In this study, the samples were handled as any routine submission would be, and could be repeated by practitioners in the field with minimal cost.

Previous bacterial work on abattoir samples has shown an association between lung lesions and bacterial presence (20 - 23), but differences in isolation techniques make comparisons of prevalence estimates difficult. However, in all of these studies including this one, there were cases of bacteria isolated from grossly normal lung samples and cases in which no bacteria were isolated from pneumonic lungs. The relatively low sensitivity indicates that many lungs from which bacteria were isolated did not have grossly detectable lesions of enzootic pneumonia. It has been suggested that cross contamination of flora can occur during the slaughter process (22), which may explain the high number of grossly normal lungs from which bacteria were isolated. In this study there was no differentiation between known pneumonic pathogens, and non-pathogenic bacteria. Some of the isolates that were recovered may have been non-pathogenic flora of respiratory tissue. This may have been the case with the alpha Streptococci in this study (Figure 1), they were found with equal frequency in diseased and normal lungs.

The very low specificity indicates that many bacteriologically negative lungs did have gross visual evidence of enzootic pneumonia. The fact that only a small portion of lung was sampled, no bacterial enrichment techniques (23) were used, nor were samples cultured for Mycoplasmas, may explain why some diseased lungs had little bacterial growth. As well, some of the lungs may have had chronic lesions from which some of the bacteria would have been cleared. If it is accepted that most (or all) of the lungs with gross visible evidence of enzootic pneumonia were in fact affected lungs, then the findings of this study suggest that routine bacterial sampling is a poor way to confirm the presence of enzootic pneumonia.

Enzootic pneumonia has definite histologic findings involving alveolar, peribronchial and/or bronchial lesions (18). Previous work has stated the level of agreement between gross visual score and histologic confirmation as being 91 %, but the sensitivity and specificity were not calculated (24). Although this study found less agreement (74%) than the previous work, there was still significant association between gross lung lesions and histological findings. The majority of the lesions occurred in the peribronchial areas and in alveoli, and somewhat less in the airways (Figure 2). Airway changes, which were more likely in severely affected lungs (Table I), may be lesions indicative of severe or chronic lung damage.

With histology findings as the gold standard for the gross score, there were a similar number of false positives as false negatives. Lungs being positive on histology, but negative on gross score may mean lesions were present but too small to be seen grossly. It can be argued that if the lesions were so small in these pigs, they may have had negligible impact on growth rates and these false negative lung scores may not be economically significant. Of more concern are the false positive scores as they may infer the presence of pneumonia where none appears to exist. The false positive scores tended to appear in lungs where the lesion scores were less than 5 % lung mass affected (Table I). In these lungs only small areas of lung are affected, and those areas may have been lost during bacterial sampling and/or tissue trimming. The specificity would have increased to 92% if lungs had only been considered grossly positive for enzootic pneumonia when they had 5% or more lung tissue affected.

Having confirmed that gross lung lesions at slaughter are generally indicative of enzootic pneumonia, it is important to show that scoring remained consistent between inspectors. It has been stated that only by controlling a small group of inspectors who have some training in veterinary pathology are the data going to be reliable and repeatable (10). In this study, designated inspectors whose sole task was to inspect for enzootic pneumonia, and who were trained and monitored gave very consistent scores.

Kappa values above 0.9 are indicative of an extremely high level of agreement. This suggests that data recorded by these individuals are valid for use by producers and veterinarians in the field as well as for research studies into enzootic pneumonia in pigs.

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CHAPTER THREE

FACTOR ANALYSIS OF FARM MANAGEMENT PRACTICES

INTRODUCTION

Respiratory disease of swine has been recognised for a long time, and it is generally accepted to adversely affect growth performance (1). It has also long been accepted that the prevalence of respiratory disease is influenced by the environment of the pig (2). Medical advances have led to the identification of the agents of respiratory disease (3), but have not been able to describe environmental and husbandry risk factors as definitively. Many environmental factors are thought to be risk factors for respiratory disease (4), but much remains unknown about the role of specific factors in the prevalence or the severity of swine pneumonia (5). Specific risk factors are difficult to quantify, and there may be many factors potentially affecting the pigs on any given farm. There are also many husbandry systems worldwide, and these change over time, so comparison of results from various studies is difficult. Diseases affecting growth rate behave differently in different environments. General conclusions therefore, are not warranted, but require evaluations of individual farms (6).

While there are a number of studies pointing to environmental and management factors as risk factors for pneumonia, most have been carried out by evaluating unconditional associations between factors and disease (7 - 14) . These studies have not accounted for relationships between management factors. Looking at factors in isolation may have little significance when many factors are simultaneously affecting pigs in farm situations. In one study (15) a specific type of multivariable analysis (factorial correspondence analysis) was used to plot various risk factors on a map. This enabled the investigator to simultaneously evaluate multiple risk factors and to identify those which are most important. The concept can be used in different geographical regions (16), but the statistics and the interpretation are difficult.

The objective of this study was to approach the question of evaluating risk factors using a different multivariable technique. Rather than concentrating on individual risk factors, a technique called factor analysis was used to mathematically combine the variables. The aim of factor analysis is to convey all the essential information of the original set of variables in a smaller statistically economic model (17). While originally a psychological research method, factor analysis has been used in varied fields (18, 19). Factor analysis reduces a large number of correlated variables to a smaller number of uncorrelated factors. The procedure creates a small set of weighted sums of the variables. Under ideal conditions, the original variables fall into natural clusters of highly correlated variables. Each of these clusters is in turn highly correlated with a single factor. High scores in certain factors were associated with specific characteristics of certain farm types.

MATERIALS AND METHODS

All pig producers on the P.E.I. Hog Commodity Marketing Board mailing list (n = 416) were mailed an introductory letter, and a questionnaire. The questionnaire covered most aspects of raising pigs from 15 kg to market weight. Questions covered the following areas: annual production, average inventory and starting weights, feedstuffs and feeding methods, medication use, space and pig density, ventilation methods and specifications, manure handling, pig movements, hygiene, water availability, pig sources, disease status, pig genetics, distance from other pig farms, visitors into pig barn, concurrent disease, labour, experience, and job satisfaction. A second letter was sent in 3 weeks to non-responding producers. Further non-responders were contacted by telephone and the reason for not participating was recorded. To encourage responses, a lottery was held with the winner ($250 cash prize) being selected from the first 50 respondents.

Part of the survey asked whether the respondents would be willing to have a farm visit. All producers willing to have a visit were contacted and a visit arranged. On the farm the survey was repeated, but physical measurements were taken wherever dimensions were needed. The pig inventory was counted and verified. The presence and number of physical attributes such as fan type or flooring type were visually appraised. One person carried out all farm visits in a consistent manner.

Survey data gathered from the farm visits were used to calculate a number of farm management variables. For example, the average daily gain was calculated from the weight gain divided by the days on feed. Days on feed were calculated from the barn turnover, which was the number of pigs sold per year divided by the average barn inventory. Descriptive statistics and factor analysis of the variables were carried out using Statgraphics (STSC INC. Rockville, Maryland, USA).

Only data from 76 farms that were visited, were eventually used in the factor analysis. Farms were excluded from the factor analysis if less than 100 market hogs were produced per year, or if the pigs were housed with other farm animals and calculation of room volume and ventilation rates per pig would be distorted.

Six factors were chosen based on the cumulative percentage of variation they explained. A varimax rotation, which maximizes explained variation, while maintaining orthogonality, was used to calculate the factor matrix. Variables in the matrix with a value of greater then 0.30 were flagged (18), and used to describe the factors.

RESULTS

Of the 416 questionnaires sent out a total of 134 responses were received. The reasons of those not responding are presented in Table II. The actual response rate was 51 %, given that 155 (37%) of the producers on the list did not produce market hogs. Contact with 56 was impossible, either because they had moved, gone out of pig production, changed their telephone number, and/or could not be reached at home. If it is assumed that all the producers in the "unable to contact" category were also ineligible because they had moved, then the response rate rises to 65%.

Among the 134 respondents, 97 were willing to have visits, and 85 were eventually visited (Table II). Ten of those willing to have visits were primarily weaner pigs producers, so were not included. One producer could not be contacted to arrange a farm visit, and one producer was unable to identify a suitable time for a farm visit.

Table III lists the farm management variables that were recorded or calculated from the survey data. These were the variables that were thought to be the most reliable and relevant. Many management variables had a wide range of values reflecting a diversity of different conditions found on Prince Edward Island pig farms. Table IV presents the summary statistics of the variables of the 76 farms visited.

The six factors chosen, from the factor analysis explained 43% of the variation in the sample. The eigenvalues drop below 2.0 on the seventh factor. Eigenvalues are proportional to the amount of variance explained by the factor. The scree plot of the eigenvalues and the percent variation explained is presented in Figure 8. Six factors were chosen to be the most statistically economic combination of variables. Table V shows the rotated factor matrix with scores greater than 0.30 and 0.60 flagged. The matrix scores are correlation coefficients between the variables and the computed factor score (17). Each farm was assigned a factor score, which describes how much a farm contributes to each factor. Summary statistics for the factor scores are presented in Table VI.

Factor one had correlations greater than 0.30 with the following variables: (in descending order of magnitude) pen space per grower and finisher pig, volume allotment per pig, farm throughput, size, use of liquid manure, use of straw bedding, use of slatted floors, the use of family as labour, and the use of open pen partitions.

Factor two was correlated with solid pen partitions, pen movements, pig to water ratio, open or half open partitions, liquid manure use, manure mixing, trucker visits, use of feed supplements, the use of dry feeders, presence of manual inlets, the use of hired help, and the owner experience.

Factor three was correlated with solid partitions, farm size, rooms, half solid partitions, medication in the starter feed, ventilation exhaust rates, pig group mixing, extra selenium added to the feed, pen washing, feed sales representative visit, feed supplement use, liquid manure use, and minimal disease sources.

Factor four was correlated with: number of different sources of pigs, farrow to finish operations, veterinary visits, the growth rate, hold back of slow growing pigs, minimal disease pigs, owner labour, straw bedding, the ventilation inlet size, throughput, and neighbours visits. Factor five had higher correlations with: floor feeding, family labour, dry feeders, owners experience, owner labour, and the starter pig pen space.

For factor six the coefficients were: complete feed use, slatted floors, premix use, other pig producers visits, manual inlets, hold back of slow pigs, farm size, distance from other pig farms, feed sales representative visits to the barn, owner labour, and pig group mixing.

TABLE II. A COMPILATION OF THE FARM MANAGEMENT QUESTIONNAIRE RETURN RATE AND THE REASONS FOR NOT RESPONDING

	Number of questionnaires returned	Number of producers not responding
Farm visits permitted	97	
Visits not permitted	37	
Out of production		91
Weaner producer		64
Unknown marketing*		6
Not interested		65
Unable to contact		56
Total	134	282

* Only producers shipping market hogs to Garden Province Meats were eligible to participate, since that was the source of the respiratory disease data for each farm.

TABLE III. FARM MANAGEMENT VARIABLES OBSERVED AND CALCULATED FROM THE FARMS VISITED

VARIABLE	UNITS	FORMULA
Farm size	# pigs shipped/year	from survey
Growth rate	Average daily gain (kg/day)	Market weight - Bought weight 365/((pigs shipped/year)/average inventory)
Throughput	pigs sold/m^2	(pigs sold/year)/m^2 of pen space
Feeding		
Complete feed	yes/no	Use of complete feed for grower/ finisher pigs
Supplement	yes/no	Use of Protein supplement to make feed
Premix	yes/no	Use of a Vitamin/mineral Premix to make feed
Medication in Starter feed	yes/no	Use of medication in starter ration
Added Selenium	yes/no	Use of rations fortified with Selenium >=0.3ppm)
Dry feeders	yes/no	Use of dry feeders to feed pigs
Floor feeding	yes/no	Floor feeding of the pigs
Ventilation		
Number of Rooms	yes/no	number of rooms in the pig barn
Volume per Pig	m^3/pig	barn volume / pig inventory
Ventilation Exhaust Rate	ratio	(liters/second/pig)/(l/sec/pig recommended)
Ventilation Inlet opening	ratio	inlet area/recommended area
Manual inlet	yes/no	manual inlet control
Manure handling		
Manure mixing	yes/no	mixing of manure between pens of pigs
Straw use	yes/no	the use of straw as bedding
Pen washing	frequency	frequency of pen washing
Liquid manure	yes/no	use of liquid manure handling
Flooring type	yes/no	use of slatted floors

VARIABLE	UNITS	FORMULA
Space		
Starter pig space	m^2/pig	total starter pig pen space/starter inventory
Grower pig space	m^2/pig	total grower pen space/ grower pig inventory
Finisher space	m^2/pig	total finisher pen space/ finisher pig inventory
Pen types		
Solid partition	yes/no	use of solid pen dividers
Open partition	yes/no	use of open pen dividers
Half open partition	yes/no	half open dividers
Water availability	pigs/water space	Pig inventory /Watering space
Number of pen changes	frequency	number of pen changes as pig grows to market
Group Mixing	frequency	number of times pig pens are mixed as pigs grow to market
Holdback	yes/no	holding slow growing pigs back, and mixing with younger pigs
Pig sources		
Distance from nearest pig farm	kilometers	distance from nearest pig farm
Home raised pigs	yes/no	Pigs are born and raised on the same farm
Number of sources	count	Number of different pig sources going into the barn
Number of Minimal disease sources	count	number of minimal disease sources

VARIABLE	UNITS	FORMULA
Visitors		
Number of Vet visits/ year	visits per year	number of times a veterinarian has been in the barn in the past year
Feedsales visit/year	visits per year	number of times a feed sales representative has been in the barn in the past year
Neighbour visit/year	visits per year	number of times a neighbour has been in the pig barn in the past year
Other Pig prod. visit	visits per year	number of times another pig producer has been in the barn in the past year
Trucker visit/year	visits per year	number of times a livestock trucker has been in the barn in the past year
Labour		
Owner source of labour	yes/no	owner as a source of labour
Family source of labour	yes/no	family as a source of labour
Hired help use	yes/no	hired help as a source of labour
Years of Pig Experience	years	years of involvement in the pig business by the owner.

TABLE IV DESCRIPTIVE STATISTICS FROM THE FARM MANAGEMENT VARIABLES RECORDED AND CALCULATED FROM THE FARM VISITS

VARIABLE	FORMAT	Mean	Med	St Dev	N
Farm size	Pigs marketed/year	1061	1040	689	
Growth rate	Kg/day	0.57	0.58	0.08	
Throughput	Number pigs sold/m^2	3.36	3.38	1.05	
Feeding					
Complete feed	yes/no				17
Supplement	yes/no				35
Premix use	yes/no				24
Medication in starterfeed	yes/no				55
Added Selenium	yes/no				44
Dry feeders	yes/no				53
Floorfeeding	yes/no				27
Ventilation					
Number of rooms		1.90	1.00	1.41	
Volume per pig	m^3/pig	3.37	2.57	2.51	
Ventilation exhaust rate	farm rate/recommended rate	0.95	1.19	0.64	
Ventilation inlet openning	farm rate/recommended rate	3.50	1.75	5.20	
Manual inlet	yes/no				56

Manure Handling					
Manure mixing	yes/no				51
Straw use	yes/no				40
Pen washing	frequency	1.15	0.00	2.09	
Liquid manure	yes/no				44
Flooring type	solid/slatted				18
Pig Space					
Starter pig space	m^2/pig	0.73	0.57	1.10	
Grower pig space	m^2/pig	0.74	0.72	0.23	
Finisher space	m^2/pig	0.82	0.76	0.26	
Pen Types					
Solid partitions	yes/no				33
Open partitions	yes/no				17
Half open partitions	yes/no				27
Water availability	pigs/waterspace	18.60	17.0	9.50	
Number of pen changes	frequency	1.30	1.00	0.53	
Group mixing	yes/no				18
Hold back	yes/no				50

Pig sources					
Distance from					
Nearest pig farm	kilometer	2.60	1.60	2.40	
Home raised pigs	yes/no				45
Number of sources		2.00	1.00	1.80	
Number of minimal disease					
Sources		0.36	0.00	0.48	
Visitors					
Number of vet visits/year		3.50	1.50	5.00	
Feed sales visits/year		0.42	0.00	1.20	
Neighbour visits/year		6.40	2.00	11.00	
Other pig producer visits		3.40	0.00	11.00	
Trucker visits/year					
Labour					
Owner source of labour	yes/no				66
Family source of labour	yes/no				14
Hired help use	yes/no				16
Years of pig experience		18.60	11.5	12.00	

Figure 8 The scree plot and the Percent variability Explained by a varied number of factors, in the Factor Analysis model

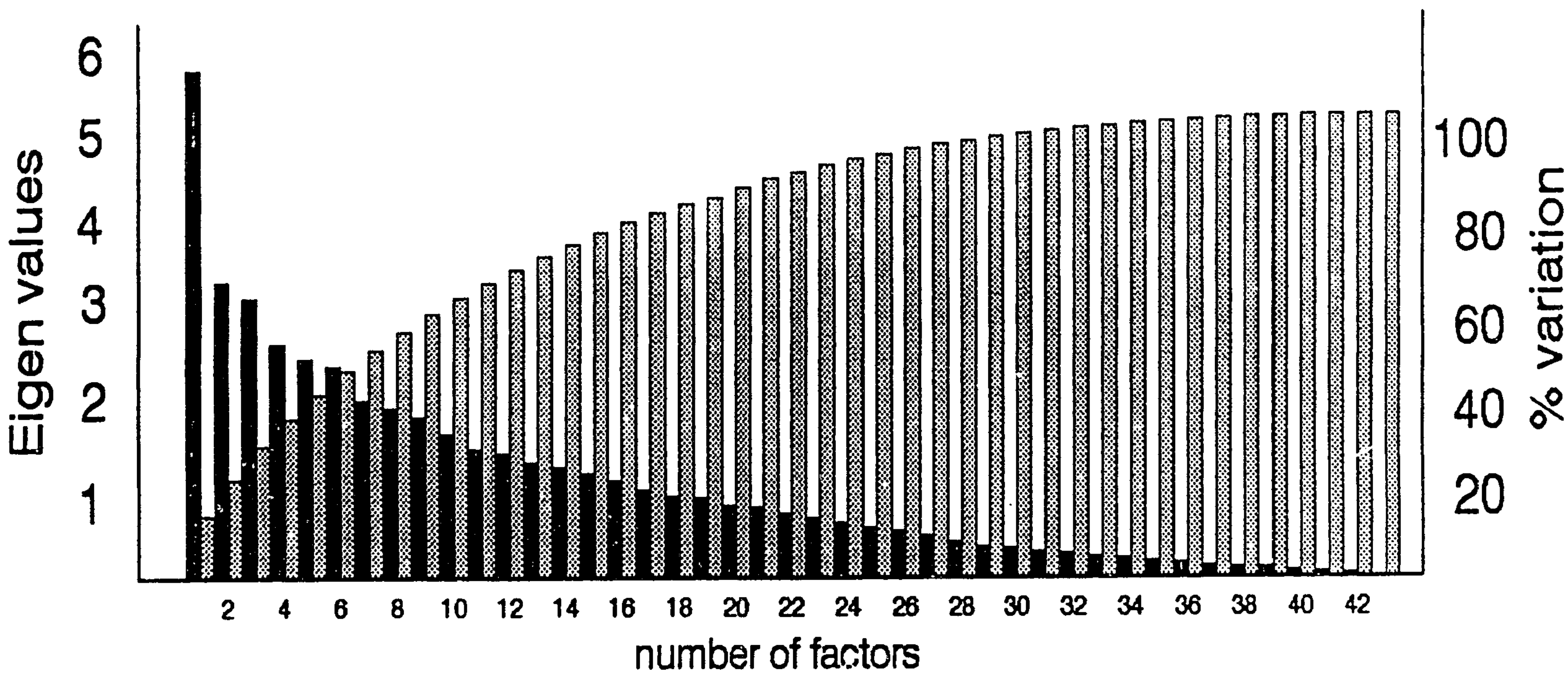

TABLE V. THE CORRELATION COEFFICIENTS BETWEEN THE MANAGEMENT VARIABLES DERIVED FROM THE FARM VISITS AND THE SIX FACTORS DERIVED FROM THE FACTOR ANALYSIS

FACTOR MATRIX

VARIABLES	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
Size	-0.46*	-0.09	0.52*	-0.16	0.29	0.36*
Growth	-0.07	0.04	0.09	-0.49*	0.14	0.05
Throughput	-0.62**	0.13	-0.03	-0.32*	0.27	0.01
Feeding						
Complete feed	0.07	-0.05	0.12	0.06	-0.43*	-0.64**
Supplement	-0.25	0.34*	-0.37*	-0.06	0.30*	0.00
Premix	0.26	-0.28	0.23	-0.06	0.02	0.56*
Starter medication	-0.20	-0.01	0.48*	0.08	-0.09	-0.19
Selenium	-0.14	0.26	0.40*	-0.15	-0.14	0.07
Dry feeder	0.25	0.34*	0.04	-0.10	-0.57*	-0.06
Floor feeding	-0.24	-0.06	0.11	0.11	0.61**	0.12
Ventilation						
Rooms	-0.03	-0.02	0.50*	-0.04	0.13	0.19
Volume	0.79**	0.12	-0.17	-0.10	0.00	0.06
Exhaust rate	0.00	0.05	0.44*	0.24	0.05	-0.11
Inlet size	0.26	-0.01	0.00	0.34*	-0.19	-0.32*
Manual inlet	0.28	0.35 *	0.03	0.19	0.15	-0.46*

FACTOR MATRIX

VARIABLES	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
Manure handling						
Mix manure	-0.01	-0.41 *	-0.10	-0.01	-0.02	0.07
Straw	0.43*	0.27	-0.25	0.35*	0.05	0.00
Pen wash	0.10	-0.17	0.40*	0.08	0.10	0.01
Liquid manure	-0.46*	-0.46 *	0.36*	-0.20	0.06	0.19
Slatted flooring	-0.39*	-0.19	0.19	-0.14	-0.03	0.55*
Pig space						
Starter space	0.23	-0.14	-0.09	-0.09	0.43*	-0.21
Grower space	0.83**	-0.06	-0.09	0.02	0.07	0.12
Finisher space	0.85**	-0.02	0.03	-0.05	0.00	-0.07
Pen type						
Solid partition	-0.02	0.80**	-0.03	0.04	-0.21	-0.10
Open partition	0.34*	-0.40*	-0.54*	0.15	0.12	0.02
Half open partition	-0.29	-0.49*	0.49*	-0.10	0.12	0.11
Water space	0.08	0.52*	0.17	0.16	0.20	0.15
Movement	-0.11	-0.55*	-0.06	0.20	0.08	0.01
Mixing	-0.01	0.16	0.42*	-0.10	-0.18	0.30*
Holdback	-0.09	0.25	-0.09	0.41*	0.18	0.40*

FACTOR MATRIX

VARIABLES	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
Pig sources						
Farm proximity	-0.06	0.07	-0.03	0.01	0.14	-0.33*
Farrow to finish	0.03	0.06	-0.17	-0.69**	-0.02	-0.07
Number of sources	-0.19	-0.14	0.17	0.71*	0.09	0.13
Minimal disease	0.00	-0.11	0.30*	-0.43*	-0.30 *	0.09
Visitors						
Vet visits	-0.19	-0.15	0.15	-0.60*	-0.20	0.07
Feed rep visit	-0.04	0.09	0.39*	-0.02	0.07	-0.32*
Neighbour visit	0.19	0.09	0.15	0.31*	-0.23	-0.14
Pig prod. visit	0.04	0.13	-0.07	0.22	0.01	0.51*
Trucker visit	-0.16	0.39*	-0.13	-0.01	0.11	-0.05
Labour						
Owner labour	0.02	0.13	-0.29	0.35*	-0.47*	0.32*
Family labour	0.36*	0.17	0.02	-0.07	0.58*	-0.04
Hired help	-0.07	-0.33*	0.25	-0.11	0.03	-0.06
Experience	0.01	0.33*	0.15	0.22	0.56*	-0.01

** = coefficient > 0.60 * = coefficient > 0.30

TABLE VI **SUMMARY STATISTICS OF THE FACTOR SCORES DERIVED FROM THE FACTOR ANALYSIS OF THE MANAGEMENT VARIABLES.**

FACTORS	ONE	TWO	THREE	FOUR	FIVE	SIX
AVERAGE	0.00	0.00	0.00	0.00	0.00	0.00
MEDIAN	-0.16	0.14	-0.08	-.06	0.02	-0.01
STANDARD DEVIATION	1.00	1.00	1.00	1.00	1.00	1.00
MINIMUM	-2.16	-2.01	-1.98	-1.51	-2.34	-2.29
MAXIMUM	2.63	2.09	2.16	3.57	3.02	2.82

DISCUSSION

The 51 - 65% response rate exceeds other similar surveys (13), or requests for study (19). When the number of producers no longer in the pig business, is taken into account, the actual number of producers actually choosing not to participate was reasonably low and even some of those producers may have been deemed ineligible if data were available. Considering there was thorough follow up of non-responders, the maximum response rate was probably achieved in this study. Since all known swine producers in Prince Edward Island were canvassed, and the response rate was acceptable, the results obtained from this survey were probably representative of the Prince Edward Island pork producers.

The 43 variables selected to be used in the factor analysis model were ones for which adequate accurate information was available. Since most eligible farmers agreed to a visit and the data obtained from the visit were more complete than those from the mailed questionnaire, it was decided to restrict all analyses to data collected by farm visit. Having one person perform all of the farm visits and physically measure the parameters where appropriate, this maximized the reliability of the variable measurements.

The first step in the factor analysis was to choose the number of factors to create. The smaller the number of variables, the less overall variation the model explains. However, a parsimonious model is easier to interpret. While the six factors explained 43% of the variation in the sample, the amount of variation explained by succeeding factors diminished rapidly. The choice of the number of factors is arbitrary with few guidelines. In this study 6 factors were selected for a number of reasons. First, six factors reached a balance between the percent variation explained, and the need for a simple efficient model. Second, the eigenvalues drop below two with greater than six factors. Finally, there was a substantial drop in eigenvalue (and variation explained) between the sixth and seventh factors. These points argued for six factors being a logical breaking point.

The summary statistics in Table VI indicate the variability in each of the factors. The factor scores are set such that the mean is 0.00, and the standard deviation is 1.00. The widest range in factor scores is in factor four for which the highest ranking farm is more than 5.3 standard deviations above the lowest ranking farm. For all the factors the range from the lowest to the highest was over 4 standard deviations.

Factor one describes a farm type that tends to be small and gives the pigs above average pen space in the grower and finisher pens. With less pig density we could expect a lower throughput of pigs in the facilities. Throughput was indeed negatively correlated with this factor. Straw was used for bedding on these farms types. Straw use tends not be present in farms with liquid manure, as it would increase the viscosity of manure. Similarly, slatted floors in pig barns generally do not have bedding as the straw would fall through the slats. The factor one model had negative correlations with both liquid manure and slatted floor use. Family labour tended to be used on factor one type farms and this may be due to the fact that the farms tended to be small. When assessing the factors it is important that they make biological sense. Factor one seems to describe farm characteristics that are biologically compatible, and describe an older management style, where the pigs are not crowded, and modern advances such as liquid manure handling have not been adopted.

Factor two describes farms that would have dry feeders, and use supplements to make the pig feed. Inlet adjustments are manual. Pig manure is not mixed between pens, and this is likely due to the fact that pen partitions tended to be solid, and the pigs were not moved from pen to pen. There are a high number of pigs per waterer, and hired help is used infrequently. The owners of this type of farm tend to be experienced. These characteristics tend to describe a greater capital investment in facilities than factor one type farms, but do not have some of the more modern features of the other farm types.

Factor three describes farms that tend to be large, do not use supplements, but tend to medicate their starter rations and use extra selenium in the feed. The barns tend to have several rooms, and exhaust rates are above average. The pens contain semisolid partitions and the pens get washed. Manure is handled as a liquid, a characteristic of large farms, that facilitates the pen washing process. Factor three type farms tend to mix pig groups, but the pig sources tend to be from a minimal disease source. Feed sales representatives visit the farms more often, than on other farms, and this may explain increased use of medication and selenium. Some of the variables on factor three type farms are relatively recent advances in pig production. These include liquid manure handling, semisolid partitions, and barns broken into rooms. These all indicate this farm type is employing modern pig farming techniques.

Factor four type farms, on the other hand show a very different pattern. This farm type is characterized by slower pig growth rate, and a subsequent drop in throughput. An increased ventilation inlet rate and the use of straw bedding was a characteristic. Slow growing pigs tend to be held back and mixed with younger ones. The pigs tend not to be born on the farm, but are bought from a number of sources. The sources tend not to include minimal disease pigs. Veterinarians are less likely to visit factor four type farms, but visits by neighbours are more frequent. The farm owners are the primary labour source. The mixing of pigs, purchasing of pigs from multiple sources, avoidance of minimal disease pigs, infrequent use of veterinary services and frequent visits by neighbours all tend to indicate that perhaps a lower priority was put on disease prevention and control.

Factor five farms tend to feed pigs on the floor, and so correspondingly the use of dry feeders would be reduced. The starter pigs are given increased space. Family members rather than the owner provide the labour. The owners tend to have experience in pig farming, so it may be that these farms have not updated their feeding methods, and this farm type may represent older swine raising facilities.

Factor six type farms tend to be larger than the other farm types, do not use complete feed, but use premix instead, and so would be milling their own feed. The inlets tend not to be manual, the floors tend to be slatted, and pig groups tend to be mixed, with slow growing pigs held back and mixed with younger pigs. These farm types are found closer together and other pig producers are likely to visit in the barn. Since complete feed is not used it is not surprising that feed sales representatives tend not to visit these farm types. The owners tend to be the source of labour. This farm type appears to represent a pig facility that mills its own feed and thus possibly integrated as part of a crop growing operation or region. In intensive cropping areas farm density tends to be higher and pig farms are potentially found closer together, than in less agriculturally dense areas.

It is reasonable to assume that the farm types derived by the factor analysis model describe farms in operation at the time of the study. That being the case, it is possible to describe how farm management variables are associated with each other, and in what combination they are found in the field. The factor type farms can then be used in models to test whether any of the farm types have different risks for developing diseases. These investigations are presented in subsequent chapters.

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CHAPTER FOUR

FARM MANAGEMENT AND ENZOOTIC PNEUMONIA

INTRODUCTION

Enzootic pneumonia of swine is one of the three major types of respiratory disease (1), the other two being atrophic rhinitis and pleuropneumonia. Previous studies have concentrated mainly on defining the etiologic agents and production losses associated with disease (2,3). Less emphasis has been placed on defining management and environmental factors that can predispose pigs to respiratory disease. One of the problems with farm management data analysis is that farm based observation requires many herds. It is difficult to compare and build on other studies because pig environments vary with geographic and climatic regions. Husbandry techniques differ worldwide, and change as time passes. Both farm disease prevalence and farm management are difficult to quantify. Finally, data gathered on farms to evaluate pig house environments are difficult to quantify and are easily confounded by factors such as farm size and feeding management (4).

Nevertheless, a number of risk factors for enzootic pneumonia have been identified in previous studies (5 -11). Higher prevalence of enzootic pneumonia has been associated with larger pig group size, presence of drafts, and increased pen area and air volume stocking density (5, 6). In one Swedish study (6), the presence of liquid manure handling and floor feeding was linked to a lower prevalence of enzootic pneumonia. Farm size was found to influence the presence of enzootic pneumonia with larger farms having a higher prevalence, especially if the farm purchased market piglets (7). In a Dutch study, all in - all out pig flows with reduced number of pigs per room was linked to a lower prevalence of respiratory disease (8). The risk of acquiring enzootic pneumonia increases with proximity to other pig farms (9). Other studies confirm some of these findings (10, 11), but all the studies cited above examined management risk factors alone and did not consider interactions between management variables. The objective of this study was to look at how a variety of management and environmental variables together determine which groups of farm characteristics were associated with an increased or decreased risk of pneumonia. Diagnosis of enzootic pneumonia was made at slaughter, as slaughter checks can be a powerful diagnostic technique (1) if carried out properly (12).

Specifically, this chapter will discuss the manner in which the factor scores determined in the previous chapter influence the presence and severity of enzootic pneumonia.

MATERIALS AND METHODS

The viscera of the pigs passing through a local abattoir were examined under the Animal Productivity and Health Information Network (APHIN) (13). The abattoir slaughters over 95% of the pigs produced on Prince Edward Island (14), and viscera are examined on as many pigs as possible as they proceed down the kill line. The lungs were examined by trained inspectors. Techniques and the operating characteristics of the screening test were described previously (Chapter Two)(15). Lungs were recorded as being either positive or negative for enzootic pneumonia. Results of examinations for an 8 month period from May 1 1990 to December 31, 1990 were summarized by calculating an average enzootic pneumonia prevalence for each farm.

The prevalence data was then recoded to a dichotomous variable. A farm having a prevalence of enzootic pneumonia of 10% or more was considered positive for enzootic pneumonia. Farms with an average prevalence of less than 10% were considered not to have significant enzootic pneumonia. Any farm that had fewer than five lungs examined was not included in the data set. A total of 69 farms had sufficient respiratory disease data to be included in the analysis.

The management and environmental factors were recorded and described in a previous study (Chapter Three)(15). The results of the farm surveys were analyzed using factor analysis, the factor scores from that analysis were used as the independent variables in this study.

A multiple logistic regression analysis was carried out with the presence or absence of pneumonia as the dependent variable, and the six factor scores as the independent variables. A full model was specified with all six variables forced into the model. An improvement chi-square was used to determine the significance of each of the factor scores, and the Hosmer-Lemeshow goodness of fit chi-square was used to determine if the data were suitable for logistic regression. The odds ratio and the 95 percent confidence intervals were calculated from the output.

Using the data from the disease positive farms only, a multiple weighted least squares linear regression was used to assess the influence of the factor scores on the severity of pneumonia (expressed as percent of pigs affected). The weight factor was the reciprocal of the variance of the prevalence estimate (16). An overall F test and the coefficient of determination r^2 was used to assess the significance of the model, and a students t test was used to assess the statistical significance of each factor. The logistic regression was carried out using BMDP software (BMDP Statistical Software , 1440 Sepulveda Boulevard, Los Angeles USA.), and Statgraphics (STSC INC. Rockville, Maryland, USA) was used for the linear regression analysis.

RESULTS

The 76 farms used in the factor analysis were matched to the APHIN data. The mean prevalence of enzootic pneumonia on the 69 farms was 0.29, the median was 0.25 and the standard deviation was 0.23. The prevalence ranged in value from 0.00 to 0.89. The distribution is shown in Figure 9, with the normal distribution superimposed. Fourty-eight farms had a prevalence less than 10 % and so were coded as being negative for pneumonia, and 21 were considered positive. The mean prevalence among the positive farms was 0.40, the median was 0.42, the standard deviation was 0.19 and values ranged from 0.10 to 0.89. The distribution of the positive farms, which visually appears to follow a normal distribution pattern, is in Figure 10, with a normal distribution is superimposed.

A list of the farm characteristics associated with each farm factor score is presented in Table VII. Values in the table are the correlation coefficients between the management variable and the factor (farm type). Only correlations greater than 0.3 have been included.

The logistic regression of the presence of pneumonia on the factor scores yielded a Hosmer-Lemeshow goodness of fit chi-square value of 4.00 ($p = 0.86$) (Table VIII), indicating the model is appropriate. Three factors had significant ($p < 0.05$) coefficients: Factor four had a positive coefficient of 0.87 to give an odds ratio of 2.38 with 95% confidence intervals of (1.15 to 4.95). Factors five and six had coefficients of 1.20 and 0.84 respectively resulting in odds ratios of 3.31 (1.50, 7.32), and 2.31 (1.11, 4.78).

The linear regression analysis of the prevalence of enzootic pneumonia on positive farms results in an overall F value of 4.21 ($p = 0.002$), and an r^2 of 0.38. The analysis of variance and the coefficients are presented in Table IX. Factors one, four and five significantly ($p < 0.05$) affect the prevalence of pneumonia on these farms.

Figure 9

Frequency Histogram

of the prevalence of enzootic pneumonia

on positive herds

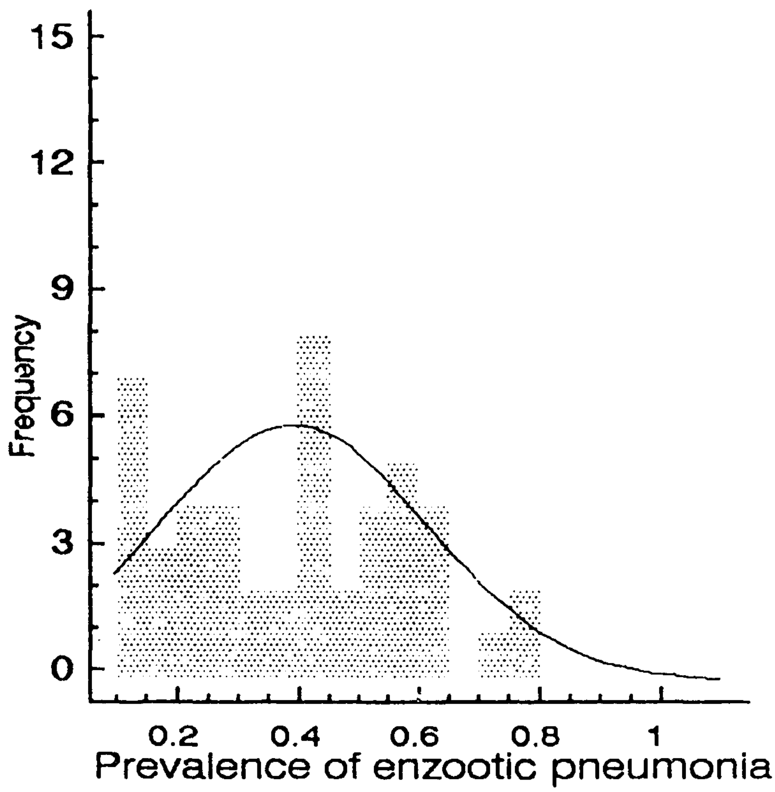

Figure 10

Frequency Histogram
of the prevalence of enzootic pneumonia
on all study farms

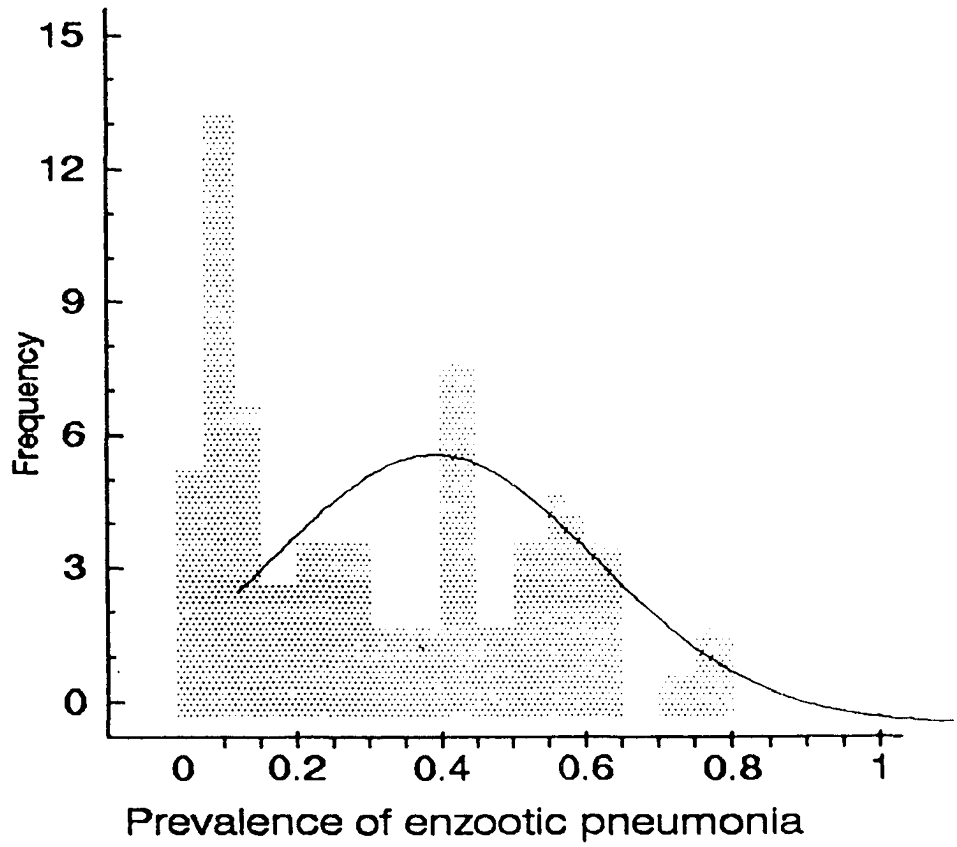

TABLE VII. RELATIONSHIP BETWEEN MANAGEMENT CHARACTERITICS AND THE SIX FARM FACTORS OBTAINED FROM A FACTOR ANALYSIS

FACTOR 1	r[a]	FACTOR 2	r
		solid partition	0.80
finisher space	0.85	movement	-0.55
grower space	0.83	water space	0.52
volume	0.79	half open partition	-0.49
throughput	-0.62	mix manure	0.42
size	-0.46	liquid manure	-0.46
liquid manure	-0.46	open partition	-0.40
straw	0.43	trucker visit	0.39
slatted floor	-0.39	dry feeder	0.34
family labour	0.36	supplement	0.34
open partition	0.34	hired help	-0.33
		experience	0.33

FACTOR 3	r	FACTOR 4	r
open partition	0.80		
size	0.52	number of sources	0.71
rooms	0.50	farrow to finish	-0.69
starter medication	0.48	vet visits	-0.60
half open partition	0.49	growth	-0.49
exhaust rate	0.44	holdback	0.41
mixing	0.42	owner labour	0.35
pen washing	0.40	straw	0.35
minimal disease	0.30	inlet size	0.34
feed rep visit	0.39	throughput	-0.32
liquid manure	0.36		
supplement	-0.37		

FACTOR 5	r	FACTOR 6	r
		complete feed	-0.64
floor feeding	0.61	premix use	0.56
family labour	0.58	slatted flooring	0.55
dry feeder	-0.57	pig producer visit	0.51
experience	0.56	manual inlet	-0.46
owner labour	-0.47	hold back	0.40
starter space	0.43	size	0.36
complete feed	-0.43	farm proximity	-0.33
supplement	0.30	inlet size	-0.32
minimal disease	-0.30	feed rep visit	-0.32
		owner labour	0.32
		mixing	0.30

[a]Values in the table are the correlation coefficients between management characteristics and factor score

TABLE VIII. RESULTS OF LOGISTIC REGRESSION[A] OF FACTOR SCORES ON THE PRESENCE OF ENZOOTIC PNEUMONIA IN 69 P.E.I. SWINE FARMS.

Variable	chi-square p value	Coefficient	Odds Ratio	95% confidence interval
factor 1	0.24 (p=0.62)	-.21	.81	0.34 - 1.91
factor 2	0.01 (p=0.92)	.03	1.03	0.52 - 2.04
factor 3	2.25 (p=0.13)	.54	1.71	0.81 - 3.59
factor 4	6.91 (p=0.01)	.87	2.38	1.15 - 7.32
factor 5	13.44 (p=0.00)	1.19	3.31	1.11 - 4.78
factor 6	6.17 (p=0.01)	.84	2.31	1.50 - 6.56

[a]Hosmer-Lemeshow Goodness of fit Chi-square = 4.00 (p = 0.86)

TABLE IX. **RESULTS OF WEIGHTED LEAST SQUARES REGRESSION[A] OF FACTOR SCORES ON THE PREVALENCE OF ENZOOTIC PNEUMONIA ON FARMS WITH MORE THAN 10% OF PIGS AFFECTED.**

Variable	Coefficient	Students t (p)
factor 1	-0.072	-2.01 (p=0.05)
factor 2	0.034	1.43 (p=0.16)
factor 3	-0.018	-0.69 (p=0.49)
factor 4	0.077	2.86 (p=0.01)
factor 5	0.065	2.39 (p=0.02)
factor 6	-0.002	-0.09 (p=0.93)

[a] = Overall F statistic = 4.21 ($p < 0.01$) $r^2 = 0.38$ adjusted $r^2 = 0.29$

DISCUSSION

Regression analysis depends on an assumption that the dependent variable is normally distributed (17). It was visually evident however, that the prevalence of enzootic pneumonia on the study farms had a skewed, bimodal distribution (Figure 9). There was a peak of farms with a very low prevalence of pneumonia and a second broader flatter peak where the prevalence was higher. It appeared that farms fell into two categories, those with enzootic pneumonia and those with none or a very low level. Consequently the data were split in two with one group of farms having pneumonia, and one group not having the disease.

The most logical cut off value to separate affected and unaffected farms appeared to be at a prevalence of 0.10. It was assumed that farms with a prevalence of lesions less than 0.10 did not have gross evidence of enzootic pneumonia, and the scores were false positives. However, even if some of the lesions observed on the pigs of these farms were real cases of enzootic pneumonia, losses on these farms would be minimal, since losses associated with pneumonia increase as the severity and prevalence of pneumonic lesions increase(18, 19),

On determining sensitivity and specificity of lung examination at slaughter (Chapter Two)(15), using histopathology as a gold standard it was found that the specificity of lung examination was approximately 75%. This suggests that 25% of normal pigs have gross findings indicative of pneumonia. It was discussed in Chapter Two that using histology as the gold standard for the specificity was not entirely valid as it tended to underestimate the specificity. The level of false positives was certainly be less than 25 per cent, and was probably close to the 10 per cent discussed above.

Once the farms were classified as disease positive or negative for enzootic pneumonia, logistic regression was used to analyze the relationship between management and the presence or absence enzootic pneumonia.

The p - value associated with the goodness of fit chi-square indicated that the logistic model was appropriate to analyze this data set. The independent variables were the factor scores described previously (Chapter Two) (15). Factors four five and six were all significantly associated with the presence of enzootic pneumonia.

Farms scoring high in factor four usually bought pigs from multiple sources, rather than raise them and tended not to use veterinary services. Other characteristics less strongly correlated with factor four farms were: holding slow growing pigs back, owner as the primary source of labour, straw use, and above average inlet size. Slow growth, and low throughput was noted for this farm type. Factor four type farms had an odds ratio of 2.38, meaning the odds of having pneumonia on this farm type increased 2.38 for every one unit increase (one standard deviation) in factor four score for any given farm. The range in factor four scores was from -1.51 to 3.57 (Table VI)(Chapter Three) indicating that the farm with the highest score had 11.9 times the odds of having enzootic pneumonia of the farm with the lowest factor four score.

Mixing pigs from different sources is a well recognized risk factor, (7) so much so that it is mentioned whenever swine disease prevention is discussed (1, 20). The underlying factor resulting in mixing pigs from different sources is that farms are not farrow to finish, which implies pigs have to be bought. Lack of veterinary visits have not been identified formally as a risk factor, but this would be very difficult to investigate. In some cases veterinary visits occur before disease episodes in an attempt to prevent disease, but in others they follow an outbreak for therapeutic reasons. Consequently, it would be difficult to attempt to relate disease prevalence to veterinary presence. In this case factor four type farms tended not to use veterinary services, even though they have increased odds of having enzootic pneumonia. This suggests that on this farm type, the owner does not place priority on respiratory disease (enzootic pneumonia). Perhaps the lack of concern is one of the risk factors on this farm type farms.

Some of the other characteristics of factor four type farms are less highly correlated with the factor score, and so contribute less to the factor. They may be risk factors, or they may be characteristics that are also found on these farm types, but ones that do not contribute any risk of having enzootic pneumonia. One example is the use of straw, which has been linked to increased thermal comfort, and health of the pig (21). Straw use was a characteristic of factor 4 type farms where there was a higher chance of having enzootic pneumonia, but it was also a component of factor one which was not significantly associated with the risk of enzootic pneumonia. Similar comments apply to inlet size, where a positive association was found with factor four, yet a negative correlation was found with factor 6 which was also associated with an increased risk of having pneumonia.

It was interesting to note the slow growth on factor four type farms, and the subsequent lower throughput of pigs. Slow growth could be the result of the higher prevalence of disease, or alternately it could be that slow growth is a result of the same risk factors that contribute to disease, or separate risk factors that may be coincidentally found on factor four type farms. None of the other farm types that had higher risk of enzootic pneumonia (factors five and six) had an association with slow growth, making the latter explanations more plausible.

Factor five described a farm type that tended to use floor feeding as opposed to dry feeders. Family labour tended to be used and the owners tended to be experienced. Factor five farms appeared to have the highest chance of developing pneumonia. The odds ratio was 3.31 meaning there is almost a threefold increase risk of this farm being positive for enzootic pneumonia for every unit increase in the farms factor score. Earlier work suggested that a lower prevalence of enzootic pneumonia was found on floor fed farms (6), but the number of farms was small, floor feeding was examined alone, and the study was done over 20 years ago in Europe. The present study suggests the opposite relationship with floor feeding. It has been suggested that dust can play a role in swine respiratory disease (22), but a recent literature review shows it has been difficult to confirm conclusively (23). Since the majority of dust in a pig building is derived from the feed (24), the detrimental effect of floor feeding may be mediated by dust. During floor feeding large amounts of dust are released as the feed is spilled on the floor (23). This release of dust has been suggested as a risk for the workers in the swine barn (25), and the same relationship may exist for pigs, especially as they inhale the dust when they fight for feed. On factor five type farms complete feed tended not to be used, which would indicate little use of pelleted feed. Feed in ..eal form as opposed to pellets would make the feed much dustier (23), strengthening the argument that dust may play a role in the increased risk of enzootic pneumonia. Floor feeding can be a labour intensive task and that may explain why labour is delegated to family members. The effect of floor feeding on enzootic pneumonia deserves more study.

Farms with characteristics of factor six also have higher odds for developing pneumonia (odds ratio = 2.31). Factor six type farms are defined as being larger than average, using a premix (thereby milling their own feed), and have characteristics of modern pig buildings (mechanized inlets, slatted floors). Larger pig farms tend to have modern features because they reduce the amount of labour required to run the farm. However, larger farms are well documented as having an increased prevalence of enzootic pneumonia (1). Larger farms have more pigs in contact with each other, increasing the possibility of transmission of infectious agents (1). Larger farms that had several rooms to house the pigs, to reduce transmission of disease (factor three), did not have the same increased risk as large farms without rooms (factor six). This supports the current recommendations to incorporate multiple rooms when planning pig buildings (8).

Factor six type farms tend to be in close proximity to other pig farms. Proximity to other farms has been defined as a risk factor (9,18) as Mycoplasma hyopneumoniae is thought to spread by aerosol between farms (9,18) if the right weather conditions prevail. Factor six type farms may be more at risk of becoming positive for the mycoplasmal agent responsible for initiating enzootic pneumonia.

Mixing is generally accepted to be a predisposing factor for disease (1,21), and the holding back of slow growing pigs violates the principles of group flow. Both mixing of pigs and holding back slow growing pigs were practiced on factor six type farms. Holding back pigs was also practiced on factor four type farms, where there was also a significantly higher chance of having enzootic pneumonia. However, mixing was also a component of factor three which did not significantly affect the risk of enzootic pneumonia. This suggests that holding back slow growing pigs may be the more important risk factor for enzootic pneumonia, and this tends to reinforce the need to handle pigs as groups to eliminate transmission of disease between age groups of pigs.

Linear regression was used to evaluate the relationships between the factor scores (Table VII) and the prevalence of enzootic pneumonia on positive farms. The dependent variable (prevalence of enzootic pneumonia) was visually close enough to a normal distribution to permit the use of linear regression on the data from this subset of farms. The regression model was statistically significant ($p = 0.002$), and the coefficient of determination was 0.38. Factors one, four and five were statistically significant ($p < 0.05$). The positive coefficient for factors four and five meant that they were both associated with an increase in enzootic pneumonia prevalence. Factor one with a negative coefficient meant it was associated with a lower prevalence.

Factor four and five type farms as described above contained several known risk factors for enzootic pneumonia. The logistic regression showed that farms with these characteristics had a higher chance of being positive for pneumonia. The linear regression showed that farms with these characteristics also tended to have an increased prevalence of enzootic pneumonia as the factor score increased.

Factor six type farms had a higher chance of having pneumonia, but the farm type was not correlated with an increased prevalence. Meaning factor six type farms have a higher chance of being positive for enzootic pneumonia, but are not likely to have an increased prevalence as the factor score is increased.

Factor one type farms which represent an older management style, where the pigs are given extensive space and air volume, were not at increased risk of having enzootic pneumonia compared to other farm types, but, if they did have enzootic pneumonia they tended to have a lower prevalence than other farm types. Crowding and low air volume are generally accepted risk factor for respiratory diseases (1, 21) including enzootic pneumonia (18). This study indicates that by providing above average pen space and air volume, the prevalence of enzootic pneumonia lesions was reduced. One consequence of providing above-average pen space is that the throughput (pigs sold per m^2) was reduced. Throughput is a parameter strongly associated with farm profitability (19, 26), so while providing above average space for the pigs may reduce respiratory disease, it may be economically efficient.

Factor one was also negatively correlated with farm size, reinforcing the belief that farm size is positively associated with enzootic pneumonia.

The results of this study demonstrate that certain combinations of risk factors found on Prince Edward Island pig farms are associated · ith an increased chance of having enzootic pneumonia. Some of those combinations were also associated with an increased or decreased prevalence of the disease if it was present.

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CHAPTER FIVE

FARM MANAGEMENT AND PLEURITIS

INTRODUCTION

The most commonly discussed condition when considering respiratory disease of swine, is enzootic pneumonia, the etiology and economic effects of which have been examined (1,2,3). Pleuritis is another respiratory condition, that has a lesion easily identified at slaughter, but its impact on productivity has been discussed less frequently. The prevalence of pleuritis has been rising in the United Kingdom, and so Hartley et al (4) suggested it receive more research attention.

The etiology of pleuritis is less well-defined than enzootic pneumonia. Pleuritis is defined as an inflammation of the pleural cavity, and several agents are capable of causing the condition. Actinobacillus (Haemophilus) pleuropneumoniae has been associated with an above average prevalence of pleuritis at slaughter (5). Pleuritis has been found in specific-pathogen-free herds associated with Glasser's disease (Haemophilus parasuis) (6). Some toxigenic strains of Pasteurella multocida have been linked to pleuritis (7,8), as has Mycoplasma hyorhinis (9). Strains of Streptococcus suis are capable of causing pleuritis among other lesions (10).

Because pleuritis has such a varied etiology, its economic effect is difficult to define. The presence of diffuse generalized pleuritis was found to be correlated with increased days to market, but prevalence of localized lesions were negatively correlated with days to market (11). The presence of lesions was not necessarily correlated with mortality, suggesting that the most serious economic effects may be associated with the subclinical disease. Lesion prevalence, serology, and clinical disease do not always correlate well together, so an environmental and management component has been suggested (11). This appears especially so in the case of pleuropneumonia due to Actinobacillus pleuropneumoniae, where the incidence of the disease in various countries depends on the local (on farm) management systems (12). Increases in prevalence of pleuritis at slaughter is generally considered to be associated with increased intensification of the pig production (4).

The management factors thought to be associated with increased prevalence of pleuritis at slaughter are: season (5), crowding (13), herd size (14,15), continuous flow of pigs (15). Ventilation, particularly temperature changes are important in preventing pleuritis, as is access to water (16). As pointed out previously (17), there is a need to look at which management factors are commonly found together on farms in order to understand which combination of management factors create farm situations conducive to developing pleuritis.

The aim of this study was to use the methods developed earlier to classify management variables into factors (Chapter Three) (17). Factor analysis was used to examine 43 management variables on Prince Edward Island pig farms. Factor analysis groups variables which are closely correlated into a smaller more statistically efficient group of uncorrelated variables. A more detailed explanation the factor analysis used to generate the farm type factors was presented earlier (Chapter 2) (17). Relationships between the farm factors and the prevalence of pleuritis at slaughter was assessed.

MATERIALS AND METHODS.

Under the Animal Productivity and Health Information Network (APHIN) program (18), all pigs going through the local abattoir are monitored, and the viscera from as many pigs as possible are examined. The local abattoir is the only major slaughter house on Prince Edward Island, and processes 95% of the island pork production. Consequently, pigs examined as part of this study were representative of the total pig population of the province.

The lungs were examined as they passed by trained technicians on the kill line. Pleuritic lesions were coded as follows: generalized pleuritis, localized pleuritis, pericarditis, or normal (i.e. no pleuritis visible). For this study, pigs that had any of the above lesions were considered positive for pleuritis. Pigs classified normal were considered to be free of pleuritis. Results of examinations for an eight month period from, May 1 1990, to Dec 31, 1990 were summarized, by calculating an average pleuritis prevalence for each farm.

The data on the prevalence were then recoded in order to classify farms as having or not having pleuritis. To be considered free of pleuritis there had to be no lesions present over the eight month period. A farm had to have at least 5 pigs examined to be included in the study. The pleuritis prevalence data were then matched to the factor scores obtained from the factor analysis (17). Of the 76 farms for which there was management data, there were 69 farms which had adequate pleuritis data recorded. The farms that did not have data were ones that happened not to have enough pigs examined, either because they did not ship pigs to the slaughterhouse during the examination period, and/or due to the chance that none of the pigs sent to slaughter happened to be examined.

Logistic regression was used to determine the relationship between farm factor scores and the presence of pleuritis. All analyses were done using BMDP software (BMDP Statistical Software, 1440 Sepulveda Boulevard, Los Angeles USA.), with the maximum likelihood ratio method. The Hosmer-Lemeshow goodness of fit chi-square was used to determine the appropriateness of the logistic model. Chi-square of improvement values were used to assess the significance of individual variables.

The subset of farms that had pleuritis was identified and weighted least squares regression was used to determine the linear relationship between factor scores and the prevalence of pleuritis on farms having pleuritic lesions. The weighting factor was the reciprocal variance of the prevalence estimate of pleuritis on each farm. An overall F test and the coefficient of determination r^2 was used to assess the overall fit of the regression, Students t test was used to determine the significance of the factors. The linear regression was performed using Statgraphics (STSC INC. Rockville, Maryland, USA).

RESULTS

Of the 76 farms for which factor scores were available, 69 farms had adequate pleuritis data to be included in this study, and of these 54 farms had some evidence of pleuritis. The average pleuritis prevalence was 7%, with a range in prevalence from 0.0 to 50%. The distribution of the pleuritis prevalence is presented in Figure 11.

The logistic regression yielded a statistically significant model. The Hosmer-Lemeshow goodness of fit chi-square was ($p = 0.334$), suggesting the model was appropriate for the data (Table XI). However only one significant coefficient was present. Factor one had an odds ratio of 0.33 with 95% confidence of (0.14 - .76). A list of the farm type characteristics is in Table X. Factor one represents a farm type that tends to be small, has large air volume per pig, with low pig densities and low pig throughput. Straw bedding tended to be used along with solid manure handling.

The distribution of the pleuritis prevalence on farms with evidence of the condition is presented in Figure 12. The mean prevalence was 9 %, and a range from 0.77 % to 50 %. The least squares regression of the prevalence of pleuritis positive farms had an overall F statistic of 1.80 and $p = 0.12$ (Table XII). The r^2 value was 0.21.

Figure 11

Frequency Histogram of the prevalence of pleuritis on all study herds

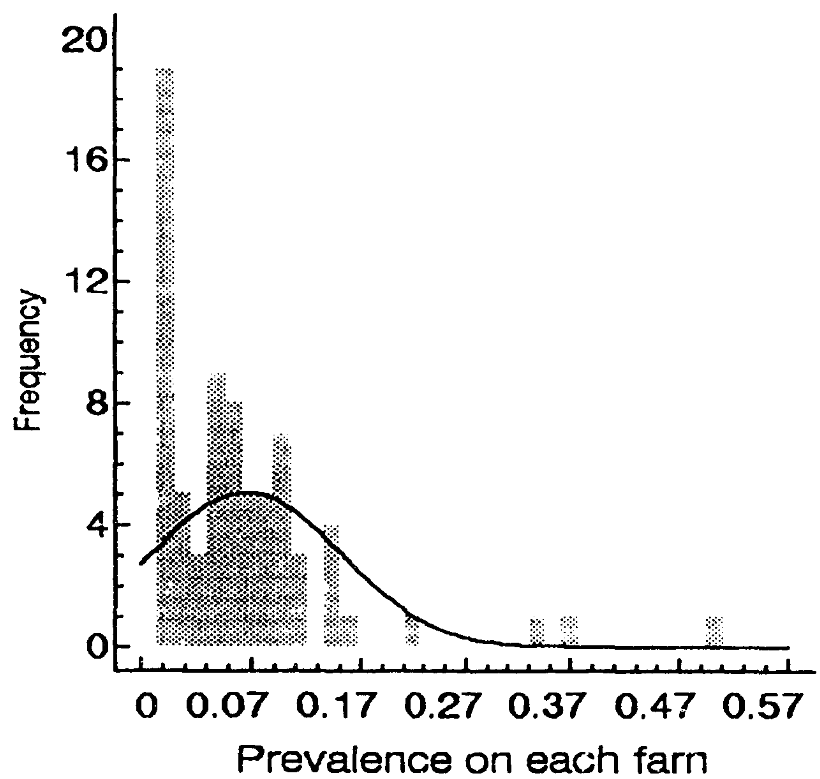

Figure 12

Frequency Histogram of the prevalence of pleuritis on farms positive for pleuritis

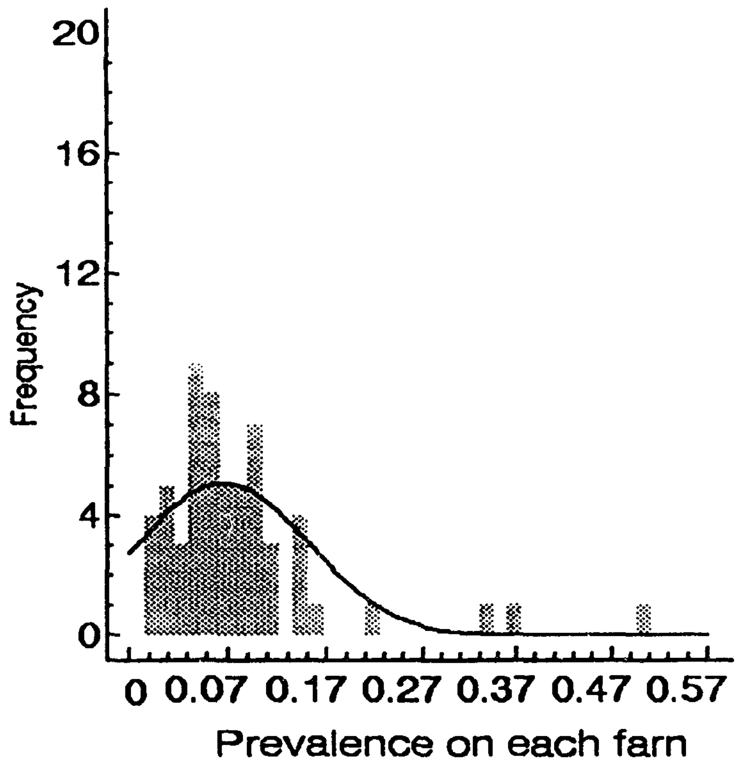

TABLE X. **RELATIONSHIP BETWEEN MANAGEMENT CHARACTERITICS AND THE SIX FARM FACTORS OBTAINED FROM A FACTOR ANALYSIS**

FACTOR 1	r[a]	FACTOR 2	r
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grower space	0.83	water space	0.52
volume	0.79	half open partition	-0.49
throughput	-0.62	mix manure	0.42
size	-0.46	liquid manure	-0.46
liquid manure	-0.46	open partition	-0.40
straw	0.43	trucker visit	0.39
slatted floor	-0.39	dry feeder	0.34
family labour	0.36	supplement	0.34
open partition	0.34	hired help	-0.33
		experience	0.33

FACTOR 3	r	FACTOR 4	r
open partition	0.80		
size	0.52	number of sources	0.71
rooms	0.50	farrow to finish	-0.69
starter medication	0.48	vet visits	-0.60
half open partition	0.49	growth	-0.49
exhaust rate	0.44	holdback	0.41
mixing	0.42	owner labour	0.35
pen washing	0.40	straw	0.35
minimal disease	0.30	inlet size	0.34
feed rep visit	0.39	throughput	-0.32
liquid manure	0.36		
supplement	-0.37		

FACTOR 5	r	FACTOR 6	r
		complete feed	-0.64
floor feeding	0.61	premix use	0.56
family labour	0.58	slatted flooring	0.55
dry feeder	-0.57	pig producer visit	0.51
experience	0.56	manual inlet	-0.46
owner labour	-0.47	hold back	0.40
starter space	0.43	size	0.36
complete feed	-0.43	farm proximity	-0.33
supplement	0.30	inlet size	-0.32
minimal disease	-0.30	feed rep visit	-0.32
		owner labour	0.32
		mixing	0.30

[a]Values in the table are the correlation coefficients between management characteristics and factor score

TABLE XI. RESULTS OF LOGISTIC REGRESSION[A] OF FACTOR SCORES ON THE PRESENCE OF PLEURITIS IN 69 P.E.I. SWINE FARMS.

Variable	Improvement chi-square to remove	Coefficient	Odds Ratio	95% confidence interval
factor 1	8.37 (p=0.004)	-1.12	0.33	0.14 - 0.76
factor 2	0.30 (p=0.58)	-0.02	0.84	0.45 - 1.59
factor 3	0.90 (p=0.34)	0.30	1.35	0.71 - 2.55
factor 4	2.12 (p=0.15)	0.52	1.68	0.82 - 3.52
factor 5	0.01 (p=0.92)	-0.03	0.97	0.53 - 1.76
factor 6	0.19 (p=0.66)	1.45	1.16	0.59 - 2.28

[a]Hosmer-Lemeshow Goodness of fit Chi-square (p= 0.33)

TABLE XII. RESULTS OF WEIGHTED LEAST SQUARES REGRESSION[A] OF FACTOR SCORES ON THE PREVALENCE OF PLEURITIS ON FARMS WHERE PLEURITIS WAS PRESENT.

Variable	Coefficient	Students t (p)
factor 1	-0.02	-0.66 (p=0.51)
factor 2	-0.00	-0.42 (p=0.67)
factor 3	0.01	2.14 (p=0.03)
factor 4	0.00	0.95 (p=0.34)
factor 5	-0.01	-2.43 (p=0.01)
factor 6	0.01	0.16 (p=0.87)

[a]Overall F statistic = 1.80 ($p = 0.12$) adjusted $r^2 = 0.21$

DISCUSSION

Upon examination of the distribution of the prevalence of pleuritis it was evident that the distribution was not normal. There appeared to be a bimodal distribution with a peak in farms that were free of pleuritis and, a second lower peak for farms with pleuritis. Consequently the data was then dichotomized to classify farms as having or not having pleuritis.

The goodness of fit p - value of 0.86 indicated that the model adequately explained the data. The only factor that was significant was factor one. Pigs on this farm type were extensively housed. Factor one type farms had an odds ratio of 0.33 (95% confidence intervals of 0.14 to 0.76), meaning the odds of factor one type farms having pleuritic lesions were only one third lower for every one unit (standard deviation) increase in factor one score.

Factor one type farms represented an older production style, with more than the average space allotment for the pigs, and a large air volume per pig. This strongly supports the hypothesis that pleuritis is a disease of intensive production. While this has been widely speculated, it has been difficult to prove conclusively without adequate controls. In this study it is possible to compare farms with modern intensive production and compare them over the same time and geographical region to farms with a more extensive housing and management system.

One feature of factor 1 farms was the low throughput of pigs (ie. a below average number of pigs shipped per square meter of pen space). Throughput has been identified as a key biologic predictor of profitability in two separate Canadian studies (3 ,19). Consequently, while concluding that factor 1 type farms have a lower pleuritis prevalence, and so presumably lower losses due to respiratory disease, it may not follow, that less disease makes this farm type more profitable than other farm types.

The linear regression of the factor scores against the prevalence of pleuritis yielded an insignificant result ($F = 1.80$ $p = 0.12$). This means the farm factor variables do not predict prevalence of pleuritis on farms which have the condition.

Similar analyses were done using enzootic pneumonia as the dependent variable, which also yielded other significant relationships (Chapter 3)(17). It is interesting to note that farm types (types four, five, and six) all of which have a higher odds of having enzootic pneumonia do not also have an increased risk of having pleuritis. Similarly farm type one which had a lower risk of being positive for pleuritis did not have lower odds of being positive for enzootic pneumonia. It seems to indicate that the factors influencing the risk of having the two major respiratory diseases may not be the same. This fact should be considered when implementing preventive medicine strategies to control respiratory disease on pig farms.

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CHAPTER SIX

SUMMARY

Respiratory disease of swine has been the focus of many studies with emphasis put on both the etiologic agents and the economic loss associated with lesion presence. The effect of barn environment, housing, and management skill has always been recognized as important in the pathogenesis of respiratory disease, but the relationship between environment and disease has been difficult to determine. The barn environment has to be measured on a farm basis, and requires study of many herds. There are many confounding factors which make analysis difficult, and barn environments change with time and geography, making extrapolations from other studies difficult.

Initial field studies of barn management concentrated on examining suspected risk factors individually and assessing their role in swine respiratory disease. The shortcoming of this approach was that risk factors were often affecting pigs in unison and the true environmental effect is one where many risk factors affect a pig simultaneously. This study examined the role of many environmental factors. It used multivariable analysis to describe the role of the environment in respiratory disease of swine.

A key problem in field studies of respiratory disease is the test used to measure the condition. In this study gross lesion interpretation at slaughter was used in diagnosing respiratory disease. While this technique is not new, there are errors associated with the screening test. It was determined that the sensitivity of grossly scoring lungs for enzootic pneumonia was 77%, compared to a histological examination, and the specificity was 71%. These figures are underestimates of the true sensitivity and specificity as histology was not an ideal gold standard. The usefulness of the screening test depends also in part on the consistency and agreement between different technicians. Agreement between two different technicians and a trained investigator was found to be very high (kappa > 0.90). From this it was concluded that a gross examination of lungs at slaughter was an adequate method of establishing the prevalence of enzootic pneumonia, and the skill needed to perform the examinations can be easily be taught and can remain consistent between inspectors.

Environmental effects acting on a pigs were assessed by visiting 76 pig farms on Prince Edward Island. Management areas examined were farm size, growth rate, feeding styles and feedstuffs, manure handling and bedding, ventilation, pen space and flooring, moving and mixing pigs, sources of pigs, people contact in the barn, labour source and experience. Data were gathered by physically measuring dimensional parameters, and by visual determination of other characteristics. One person performed the farm visits in a consistent manner. From the examination of the 76 farms 43 management variables were calculated. The 43 variables were condensed using factor analysis into six factors. The factors were six uncorrelated variables that described the 43 correlated management variables in a more statistically efficient manner. The six factors describe farm types based on which management variables score highly with each factor.

The farm types that emerged were as follows: one, smaller farms that had high volume and space per pig and used straw as bedding. Two, a farm type that used solid pen partitions, did not move pigs between pens, and had experienced owners. Three, a farm type that was large, was farrow to finish and had modern facilities. Factor four type farms were ones that bought pigs from different sources, did not seek veterinary advice, and had slow growing pigs. Factor five was a farm type that primarily had pigs that were floor fed. Factor 6 was a farm type that was larger than average, made their own feed, was close to other farms and had other farmers as primary visitors. The six farm types were biologically plausible descriptions of farm management.

The farm type descriptions derived from the factor analysis were analysed using regression with prevalence estimates of enzootic pneumonia on 69 swine farms. Farms were dichotomized into farms positive for enzootic pneumonia (prevalence greater than 10%) and farms that were negative(less than 10%). Multiple logistic regression analysis of the dichotomized data revealed 3 farm types to have an increased risk of having enzootic pneumonia. Farm type four had an odds ratio 2.38 meaning farms that bought pigs from different sources were over twice as likely to have enzootic pneumonia for every one unit increase in the factor score. Factor four scores ranged from - 1.51 to 3.57 for farms in this study.

Factor five describing farms with floor fed pigs had an odds ratio of 3.31 suggesting that floor feeding may be a contributing factor in enzootic pneumonia. Factor six had an odds ratio of 2.31 for having the condition suggesting large farms that mill their own feed and are close to other farms have a greater chance of having enzootic pneumonia.

A linear regression of the prevalence estimates of enzootic pneumonia on positive farms revealed only factor four and five farms were associated with a higher prevalence of enzootic pneumonia. Factor one farms were associated with a lower prevalence, suggesting farms with ample pen space and air volume had fewer pigs with enzootic pneumonia.

A similar analysis for pleuritis had a lower odds of lesions on factor one farms, meaning extensively housed pigs had a lower risk of having pleuritis.

This study confirmed that many commonly accepted risk factors in combination did indeed increase the likelihood of enzootic pneumonia. One previously unrecognized risk factor that was identified was floor feeding of pigs. Dust was perhaps a mediator of the increased risk, and this deserves further study. Dust may have also played a role on factor six farms that mill their own feed, this farm type also had an increased risk of enzootic pneumonia.

Factors affecting enzootic pneumonia appeared to be different than those affecting pleuritis. Environmental influences are often discussed generally, with references to many diseases. This study indicates that the environment-disease interactions are different for the two diseases.