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Factors associated with pleurisy in pigs: A case-control analysis of slaughter pig data for England and Wales

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ABBREVIATIONS

A. suis	*Actinobacillus suis*
AI/AO	All-in/All-out
APP	*Actinobacillus pleuropneumoniae*
AUC	Area under the curve
BPHS	British Pig Health Scheme
BPEX	British Pig Executive
EP	Enzootic pneumonia
HP	Haptoglobin
LRT	Likelihood ratio test
MAP	major acute phase protein
M. hyo	*Mycoplasma hyopneumoniae*
M. hyorhinis	*Mycoplasma hyorhinis*
N	Non-missing observations
OR	Odds ratio
OVS	Official Veterinary Surgeon
P. multocida	*Pasteurella multocida*
PCV-2	Porcine Circovirus type 2
PRRSv	Porcine Reproductive and Respiratory Syndrome virus
S.P.E.S.	Slaughterhouse Pleurisy Evaluation Scheme
SPF	Specific pathogen free
SIV	Swine Influenza Virus
S. suis	*Streptococcus suis*

I. INTRODUCTION

Pleurisy or pleuritis is one of the most common pathological conditions found in slaughter pigs (SORENSEN et al., 2006; BPEX, 2008). In the UK over 8 Million pigs are slaughtered per year (BPEX, 2011). The British Pig Health Scheme (BPHS), a national abattoir monitoring scheme, found 12.5% of pigs affected by pleurisy highlighting the extent of this condition. Prevalence in other EU countries was even twice as high (21% Belgium, 27% Denmark, 27% Spain) and was showing an increasing trend (CLEVELAND-NIELSEN et al., 2002; FRAILE et al., 2010; MEYNS et al., 2011).

Pleurisy affects economics and efficiency of the entire pig industry. Producers suffer from increased production costs through reduced growth rate (LINDQUIST, 1974), decreased weight at slaughter (MOUSING et al., 1990), increased days to slaughter (LINDQUIST, 1974; HARTLEY et al., 1988b), medication costs and lost income through increased condemnations. Abattoirs suffer from increased production costs because pleurisy requires trimming of the carcase causing disruption, reducing line speed and increasing labour and wastage costs. Processors no longer want to bear these costs and have threatened to penalize producers that keep submitting consignments with high pleurisy prevalence.

There is an emerging need of the pig industry to solve this problem, but the multifactorial nature of pleurisy makes diagnosis and control difficult. BPEX (the British Pig Executive) as the pig industry's body funded this study to generate an evidence-based approach to the investigation and control of pleurisy in the UK pig population.

The aim of the study was the assessment of risk factors associated with pleurisy in pigs in the UK by comparing characteristics of fattening herds with consistently high (case herds) and consistently low (control herds) pleurisy prevalence thereby informing new preventive strategies.

II. LITERATURE OVERVIEW

1. Anatomy and Physiology of the Pleura

A serosal membrane lines the inside of all body cavities and surfaces of all organs lying within these cavities. The serosa of the thoracic cavity, cavum thoracicum, is called pleura. The pleura lining the thorax is called parietal pleura originating from somatopleura. The pleura covering the lungs is called visceral pleura and originates from splanchnopleura. Due to their origin, innervation of parietal and visceral pleura is different, thus mechanical, thermal or chemical irritation to the parietal pleura results in severe pain, whereas the same irritation to the visceral pleura does not, only strong tension or strain will cause pain (FREWEIN, 1999).

Histologically, the pleura is a monolayer of mesothelial cells with microvilli of significant absorptive potential (WIESNER and RIBBECK, 2000). These microvilli can vary between ~0.1 and 3 µm (DECRAMER and ROSSI, 2003) and are more numerous on visceral than on parietal mesothelial cells (HERBERT, 1986).Below the mesothelial cells are several layers including the basil lamina, an elastic layer, a loose connective tissue layer with nerves, blood vessels and lymphatics and a deeper fibro-elastic layer (DECRAMER and ROSSI, 2003).

There is a capillary gap between organs and the thoracic wall containing a small amount of serous fluid produced by the pleura. The normal amount is 0.5 to 1 ml with 1500 to 4500 cells in 1 ml which are mostly macrophage-like cells (DECRAMER and ROSSI, 2003). The fluid acts as a lubricant to reduce friction between the lungs and other structures of the thorax (FRANDSON, 1974). The serous fluid plays an important role in pathological reactions with amount and components changing according to the irritation (FREWEIN, 1999).

The pleura is characterised by its great capacity to drain liquids and particles from the pleural space and by its strong inflammatory potential (DECRAMER and ROSSI, 2003).

2. Pleurisy

Inflammation of the parietal or visceral pleura is called pleurisy or pleuritis. Pleural tissue is readily susceptible to injury caused by haematogenous dissemination of infectious organisms in septicaemias or by direct extension from adjacent inflammatory processes such as fibrinous bronchopneumonia (LOPEZ, 2007).

There are primary and secondary inflammatory processes. Primary inflammation of the pleura occurs when an infectious agent spreads haematogenously with a certain affinity to the pleura and affects the pleura directly like in the case of polyserositis (Glässer's Disease) caused by *Haemophilus parasuis* (HPS). This can occur without obvious lung involvement. The most common type is secondary inflammation when inflammation of lungs affects the pleura subsequently. Inflammation of the pleura may also be caused by physical irritations such as tumours, operations or ruptured abscesses, but these are rather uncommon in commercial slaughter pigs (LOPEZ, 2007).

2.1. Morphology

Like any other inflammation, pleurisy can be described in more detail by the degree of severity, duration, distribution and exudate (Table 1)

Table 1: Nomenclature of a morphologic diagnosis (ACKERMANN, 2007)

Degree	Duration	Distribution	Exudate
Minimal	Acute	Focal	Serous
Mild	Subacute	Multifocal	Catarrhal
Moderate	Chronic	Locally extensive	Fibrinous
Severe	Chronic-active	Diffuse	Suppurative
		Cranioventral	Granulomatous

The most common form of pleurisy found in slaughter pigs is fibrinous pleurisy. During acute inflammation fluid accumulates in the pleural space with a high concentration of plasma protein (specific gravity >1.02) which is called exudate. As there is severe endothelial cell injury, proteins of high molecular weight such as fibrinogen can leak from blood vessels. It polymerises outside the vessels to fibrin. These lesions are most commonly formed by infectious microbes (ACKERMANN, 2007). Grossly the surfaces of affected tissue are red (active hyperaemia) and covered

with a thick, elastic, white-grey to yellow exudate that can be removed from the surface of the tissue (in contrast to fibrous pleurisy) (ACKERMANN, 2007). A classic example of fibrinous pleurisy is Glässer's Disease (polyserositis) caused by HPS. The serofibrinous exudate is often rapidly infiltrated by neutrophiles resulting in fibrinosuppurative inflammation (RAPP-GABRIELSON et al., 2006; ACKERMANN, 2007). Other types of acute inflammation are serous, catarrhal and suppurative. In the case of serous inflammation, tissue leaks fluid with a low concentration of plasma protein and no to low numbers of leucocytes. This watery fluid is released from small gaps between endothelial cells and from hypersecretion of inflamed serous glands. It is essentially a transudate (specific gravity <1.012) and is seen with thermal injury to skin or in acute allergic responses such as serous rhinitis (ACKERMANN, 2007).

In the case of catarrhal inflammation exudate consists of thick gelatinous fluid containing abundant mucous and mucins from a mucous membrane. It is seen in chronic allergic or autoimmune gastrointestinal diseases and with chronic inflammation of airways (ACKERMANN, 2007).

In suppurative inflammation exudate is marked by high concentration of plasma protein and high numbers of neutrophiles, commonly known as pus. A circumscribed collection of pus visible grossly is called an abscess, most commonly caused by bacteria such as staphylococcus, streptococcus and *Escherichia coli*. In the pig, suppurative inflammation occurs typically in bronchi of lungs (bronchopneumonia) or nasal cavities (rhinitis) (ACKERMANN, 2007).

If acute inflammation response fails, chronic inflammation follows which results in healing by fibrosis or abscess formation like in the case of chronic pleuropneumonia caused by *Actinobacillus pleuropneumoniae* (APP). These lesions cause problems in slaughter pigs when strong fibrous adhesions between lungs and chest wall form that require trimming of the carcase and disposing of lungs with abscesses (GOTTSCHALK and TAYLOR, 2006). Granulomatous inflammation is a distinct type of chronic inflammation in which cells of the monocyte-macrophage system are predominant. It occurs secondarily in response to endogenous or exogenous antigens or idiopathically. It requires multiple factors: an inciting agent with indigestible, poorly degradable, persistent agents (e.g. Mycobacterium), a host immune response and interplay of various cytokines produced by cells within the chronic inflammation (ACKERMANN, 2007).

2.2. Prevalence

Pleurisy prevalence in pigs has been evaluated in many studies in many different countries over the past 25 years (Table 2).

Abattoirs in England were already concerned about increasing pleurisy prevalence requiring laborious pleural stripping in 1986. HARTLEY et al. (1988a) studied five abattoirs in Eastern England in autumn 1986 and found a prevalence of 15% as assessed by meat inspectors. BPHS data (2005-2008) showed 12.5% pleurisy prevalence at individual level and 80% pleurisy at batch level as assessed by pig veterinarians. Since the start of BPHS in 2005 the trend was slightly falling, but is now unchanged (BPEX, 2008).

Pleurisy prevalence in Scotland has been documented with 11.5% in 2003, 12.4% in 2004 (STRACHAN et al., 2006) and 11% in 2007 (SANCHEZ-VAZQUEZ et al., 2007).

Prevalence in other EU countries (Table 2) such as Belgium (2000: 16%), Denmark (1987: 14%), Netherlands (1990: 12%) and Switzerland (13-21%) were similar (STÄRK et al., 1998), but had increased a lot more recently than England (Belgium 2007: 21%, Denmark 2000: 27% and Netherlands 2004: 23%). One of the highest prevalence has been found in Spain with 27% (FRAILE et al., 2010).

In the US, pigs at slaughter showed 14% prevalence in the nineties (BAHNSON et al., 1992).

Pigs in New Zealand had a similar prevalence as pigs in the EU with 19% (STÄRK et al., 1998). An increasing trend could also be observed in other parts of the world such as Korea where pleurisy in pigs increased from 8-11% to 15% in 2005 (JEONG et al., 2006).

Table 2: Pleurisy prevalence in different countries

Country	Year of study	Pleurisy prevalence	Reference
Belgium	2000 2007	16% 21%	(MAES et al., 2001) (MEYNS et al., 2011)
Denmark	1987 2000	14% 27%	(ENOE et al., 2002) (CLEVELAND-NIELSEN et al., 2002)
Germany	1995 2004	14-21% 5%	(JENSEN and BLAHA, 1997) (MEEMKEN, 2006)
Korea	2005	15%	(JEONG et al., 2006)
US/Minnesota	1992	14%	(BAHNSON et al., 1992)
Netherlands	1990 2004	12% 23%	(AUGUSTIJN et al., 2008)
New Zealand	1995/1996	19%	(STÄRK et al., 1998)
Scotland	2003 2004 2007	11.5% 12.4% 11%	(STRACHAN et al., 2006) (SANCHEZ-VAZQUEZ et al., 2007)
Spain	2012	27%	(FRAILE et al., 2010)
Switzerland	1993	13-21%	(WUNDERLI and LENZINGER, 1993)
England	1986 2008	15% 12.5%	(HARTLEY et al., 1988a) (BPEX, 2008)

The within herd prevalence has been studied by several authors. BÄCKSTRÖM and BREMER (1976) found that prevalence of pleurisy increases from 4% in 30kg pigs to 10% in 60 kg pigs and declines to 2-3% in pigs >100 kg. MOUSING (1988) suggested that pleurisy found at slaughter does not develop prior to three to four months of age and cited MARTINSSON and LUNDHEIM (1986) who found very low levels at 2.5 months. MOUSING (1988) found the greatest odds of having pleurisy in five months old pigs.

2.3. Aetiology

Respiratory disease must be seen as the result of a complexity of events, including infectious, environmental, managemental and genetic factors. Because the aetiology of respiratory diseases is multifactorial, one should consider not just specific infectious agents, but other relevant factors as well (SORENSEN et al**.,** 2006). The aetiology of pleurisy is not fully understood (ANDREASEN et al., 2000; AUGUSTIJN et al., 2008), but is believed to be multifactorial with infectious and non-infectious factors involved (ENOE et al., 2002; CLEVELAND-NIELSEN et al., 2002).

A given pathogen or environmental risk factor will tend to increase the incidence of disease. In quantifying this increase, the ratio between the incidence (or prevalence) among pigs exposed to the factor and the incidence (or prevalence) among pigs not exposed to the factor can be calculated. This ratio is often referred to as relative risk. The higher the relative risk, the stronger is the association between the risk factor and disease. When two or more factors act simultaneously, the total relative risk will often be greater than the relative risk of the individual factors (MOUSING et al., 1990). But in retrospective case-control studies the relative risk can not be calculated due to the nature of the study and therefore one uses the odds ratio (OR).

2.3.1. Infectious factors

According to LOPEZ (2007) pleurisy is most frequently caused by bacteria, which cause polyserositis reaching the pleura haematogenously. These bacteria include HPS, *Streptococcus suis* (*S. suis*) type II and some strains of *Pasteurella multocida* (*P. multocida*). Other than HPS and *S. suis*, also *Mycoplasma hyorhinis (M. hyorhinis)* and APP can cause acute fibrinous pleurisy with or without pneumonia and have been identified as risk factors for pleurisy (FALK et al., 1991; CLEVELAND-NIELSEN et al., 2002; VAN ALSTINE**,** 2012).

APP is the most common studied infectious agent in connection with pleurisy in slaughter pigs and was usually confirmed in epidemiological studies by serology (MOUSING et al., 1990; VAN TIL and DOHOO, 1991; ANDREASEN et al., 2000; ANDREASEN et al., 2001; ENOE et al., 2002; SANCHEZ-VAZQUEZ et al., 2007; AUGUSTIJN et al., 2008; MEYNS et al., 2008; FRAILE et al., 2010; MEYNS et al., 2011), culture (JIRAWATTANAPONG et al., 2010) and PCR (FABLET et al., 2012c). FABLET et al. (2012c) found in particular seropositivity to APP serotype 2 associated with extensive pleurisy. ENOE et al. (2002) also found serotype 2

associated with chronic pleurisy in conventional herds, and in addition serotype 6. FRAILE et al. (2010) found that 50% of lung lesions affected by pleurisy were consistent with APP lesions.

At the same time, these studies found other agents and seroprevalence to other agents in association with pleurisy (AUGUSTIJN et al., 2008; JIRAWATTANAPONG et al., 2010), most commonly *M. hyo* (ENOE et al., 2002; MEYNS et al., 2011) and Porcine Reproductive and Respiratory Syndrome virus (PRRSv) influencing development and severity of pleurisy (FABLET et al., 2012c). This is consistent with findings from Denmark where pigs seroconverting early to *M. hyo* had a larger extent of cranioventral pleurisy at slaughter (ANDREASEN et al., 2001).

Progressive atrophic rhinitis (PAR) was associated with pleurisy in Denmark in conventional herds interacting with APP serotype 7 (MOUSING et al., 1990; ENOE et al., 2002). More recently pigs with IgM antibodies to Porcine Circovirus type 2 (PCV2) at 16 weeks of age have been found to be associated with lower probability of having pleuritis at slaughter (WELLENBERG et al., 2010).

Herd health status and therefore infectious diseases are important for the aetiology of pleurisy as pigs from specific pathogen free (SPF) herds were less susceptible to chronic pleurisy compared to MS (=SPF herds, but *M. hyo* positive) and conventional herds (CLEVELAND-NIELSEN et al., 2002). Also supporting the infectious nature of pleurisy was a finding of a small study from Greece, where KRITAS and MORRISON (2007) found a significant association between the severity of tail biting and the prevalence of lungs with pleurisy and abscesses (KRITAS and MORRISON, 2007).

2.3.2. Non-infectious factors

Herd characteristics

With regards to the type of pig production system, farrow-to-finish units as compared to finishing units had increased odds of chronic pleurisy in SPF herds in Denmark (ENOE et al., 2002). Increased herd size was found to be a risk factor for pleurisy in several studies (MOUSING et al., 1990; ENOE et al., 2002; FABLET et al., 2012a). Also herds that operated an intensive system and herds with higher stocking densities had a higher risk for pleurisy (HURNIK et al., 1994; MAES et al., 2001).

An important factor that has not been looked at very intensively is the pig farmer. Some studies found less respiratory disease where farmers were interested in disease prevention and continued education (BÄCKSTRÖM and BREMER, 1978). HURNIK et al. (1994) identified a lack of veterinary visits as a risk factor for pneumonia and explained this association with a lack of concern.

Management

Management has an important role in determining the course and severity of porcine respiratory disease (DONE, 2005). Previous studies of management factors associated with pleurisy in pigs have identified some common management factors, as well as some regional differences.

Practising All-in/All-out (AI/AO) was protective for pleurisy when done by unit or compartment without movements between batches (CLEVELAND-NIELSEN et al., 2002; FRAILE et al., 2010), but was a risk factor when AI/AO was operated by room (FRAILE et al., 2010). Mingling of pigs increased the risk for pleurisy (CLEVELAND-NIELSEN et al., 2002) where stress may also play a role, affecting the defence mechanism of the pig (KELLEY, 1985) as usually mingling means moving to a different environment, fighting and establishing a new hacking order (BLECHA et al., 1985).

Even feed management may be linked to pleurisy. Feeding dry feed was a protective factor for chronic pleurisy and it was presumed that dry feed may be linked to the type of flooring and herd size (CLEVELAND-NIELSEN et al., 2002).

Lack of disinsection of the farrowing accommodation, tail docking later than five days and castration later than 14 days after birth have been identified as risk factors in a recent study (FABLET et al., 2012c). Indeed, insects can act as mechanical vectors of pathogens and insect control is one of the biosecurity measures aimed to reduce disease spreading within and between herds (AMASS and CLARK, 1999). This agrees with the finding that pleurisy risk was reduced if good hygiene was practised on farm (STÄRK et al., 1998).

FABLET (2012c) speculated that castration may impair the piglet's immune response, making it susceptible to infections then and later in life. This is in line with male pigs being more likely to have lung lesions and suffering more frequently from chronic inflammation (POINTON et al., 2006).

MEYNS et al. (2011) found increased weaning age protective for pleurisy in slaughter pigs and suggested that this may be due to pigs weaned later having reduced post-weaning infections. However, stress at weaning was not found to be a predictor for chronic pleurisy (DYBKJAER et al., 1998).

Vaccination for EP increased the risk for pleuropneumonia in a study in New Zealand. In the same study, medication of feed for growers was strongly protective (STÄRK et al., 1998).

With regards to biosecurity the distance to the next pig unit was important and if >1.6 km away had a strong protective effect (STÄRK et al., 1998). Prevalence of chronic pleurisy increased in herds by 1.3% when pig density increased in a 5 km radius (CLEVELAND-NIELSEN et al., 2002). Severity of pleurisy increased in herds with poor biosecurity measures and with increasing number of pigs in the municipality (MAES et al., 2001). The importance of stocking density in pig production and its influence on welfare and health is well recognised and supported by EU legislation (EU COUNCIL DIRECTIVE 2008/120/EC, 2012). It is well accepted that stocking density and the number of pigs per pen have an influence on the occurrence of respiratory diseases (DONE, 1991). Also MEYNS et al. (2011) associated increased stocking density in nursery pens with higher pleurisy score. Related to stocking density is the airspace per pig which increased pleurisy in finishing units when it was reduced (MAES et al., 2001). Susceptibility of the respiratory tract is affected by noxious gases and dust and the overall load with which the respiratory tract has to deal (DONE, 2005).

Environment

Environmental influences on respiratory diseases are often discussed generally, but impact on lungs developing pleurisy or pneumonia seem to be different (HURNIK et al., 1994; FABLET et al., 2012a). This is supported by an earlier study from ELBERS et al. (1992) in the Netherlands where he found highest prevalence of pleurisy in June/August and highest prevalence of pneumonia in January/February. However, contradictory to this are findings from MAES et al. (2001) in Belgium where he detected a higher prevalence of pleurisy in slaughter pigs in January/February, with more severe lesions in March/April.

Environmental factors act on the pathogen load, i.e. the amount of microorganisms to which the pig is exposed, and on the pig, by modulating the defence mechanisms through which the pig handles the pathogen challenge (GONYOU et al., 2006). HURNIK et al. (1994) concluded from his studies that pleurisy is a disease of intensive pig production when he compared intensive and extensive housing of pigs (HURNIK et al., 1994).

Pigs within a building should preferably be of similar age and weight so that the environmental requirements for each group are similar (DONE, 2005) .

If the range of temperatures controlling ventilation rate in the farrowing room was set less than 5 ºC tolerance before fans are activated, pigs were more likely to have pleurisy at slaughter. As the room temperature increases, this parameter determines the progression of fan rotation speed from minimum to maximum. Small values such as under 5 ºC indicate that the fan will increase or decrease quickly which may cause draughts at pig level (FABLET et al., 2012a). Chilling due to cold draughts may influence the pig's immune system and increase susceptibility to respiratory disease (STÄRK, 2000).

In the same study mean inside temperature below 23 ºC in finishing accommodation was associated with increased risk for pleurisy (FABLET et al., 2012a). These results agree with the findings of previous studies where low setpoint temperatures during the growing and finishing phase were associated with respiratory lesions (MADEC and JOSSE, 1984; STÄRK et al., 1998). Low air temperatures, below the comfort threshold, influence the pig's ability to clear bacteria from the respiratory tract (CURTIS et al., 1976). This in turn may enhance the susceptibility of pigs to infection (FABLET et al., 2012a).

2.4. Diagnosis of pleurisy in slaughter pigs

2.4.1. Ante mortem

Diagnosis of pleurisy in pigs is an issue because pathological disorders of the respiratory system will often be without clinical signs (or signs typical for respiratory disorders) (ANDREASEN et al., 2001; STRAW et al., 2001). A clinical diagnosis can only be tentative since visible signs from the respiratory system may be the result of dysfunction of other organs such as the heart. Understanding the health associated factors and clinical signs in live pigs with pleurisy would permit more effective and timely targeting of control measures, since often the disease is only apparent at slaughter. Work in this area has been limited, coughing and lethargy were considered to be indicative, but not specific for pleurisy in a study from AUGUSTIJN (2008). His attempts to identify pigs suffering from pleurisy ante mortem based on pyrexia and dyspnoea have not been successful (AUGUSTIJN et al., 2008).

The table below (Table 3) lists the variety of clinical signs pigs with pleurisy may express. In case of complicated bronchopneumonia and many agents involved, pigs usually have a productive cough, particularly when moved, abdominal ‘thumping’, periodically high fever and decreased appetite. With peracute fibrinous/necrotising pneumonia (pleuropneumonia) there can be depression, prostration, pyrexia, severe dyspnoea, open-mouth breathing, dog-sitting and sternal recumbency. With acute/subacute fibrinous/necrotising pneumonia (pleuropneumonia) clinical signs may be varying depression, normal to superficial respiration, depressed or no coughing, normal to high temperature and decreased appetite. In case of chronic necrotising pneumonia (pleuropneumonia) pigs may show slight depression, coughing and decreased appetite if there are secondary infections. Otherwise chronic pneumonia, pleuritis and acute/subacute pleuropneumonia will often be without clinical signs or typical respiratory disorders. Pigs suffering from mild pleuropneumonia, subacute or chronic pleurisy may only show signs such as slight depression or decreased appetite (Table 3).

This may not be noticed during the brief ante mortem inspection which is usually done when all pigs walk or run past the inspector from the pig transport to the lairage. Acute pleuropneumonia may be widespread in a herd before disease is revealed at slaughter. Therefore, depression and decreased appetite in fatteners, often misinterpreted and attributed to bad feed, should remind the observer of the possibility of an outbreak of acute pleuropneumonia (SORENSEN et al., 2006).

If pigs show clinical signs of disease at ante mortem inspection, they are not fit to travel or for human consumption and would not be allowed to be slaughtered (THE FRESH MEAT (HYGIENE AND INSPECTION) REGULATIONS, 1995; THE WELFARE OF ANIMALS (TRANSPORT) (ENGLAND) ORDER, 2006).

Table 3: Clinical signs (and possible causative agent) of pigs with pleurisy based on post mortem findings (SORENSEN et al., 2006)

Pathology	Clinical signs	Causative agents
Complicated bronchopneumonia: • Cranioventral lesions • Purulent exudate • Eventual formation of abscesses • firm fibrous structure • often associated with pleurisy	• Productive cough, often when pigs are moved • Abdominal 'thumping' • Periodically high fever • Decreased appetite	*M. hyo* *M. hyorhinis* Streptococci *P. multocida,* *Bordetella bronchiseptica,* staphylococci, *Arcanobacterium pyogenes* Salmonella and viral infections may act as primary agents
Peracute fibrinous/necrotising pleuropneumonia (PP): • extensive dissemination • blood-tinged fluid in pleural cavity • extensive fibrinous pleurisy	• Depression • Prostration • Pyrexia • severe dyspnoea • open-mouth breathing • dog-sitting • sternal recumbency	APP
Acute/subacute fibrinous/ necrotising PP: • predominantly caudodorsal • fibrinous pleurisy	• varying depression, • respiration normal to superficial • depressed coughing or no cough • normal to high temperature • decreased appetite	APP
Chronic necrotising pneumonia PP: • Caudodorsal, firm capsulated process with necrosis and abscesses • local fibrous pleurisy	• Slight depression • Cough • decreased appetite if secondary infections	APP Secondary infection with pyogenic bacteria
Fibrinous pleurisy • peritonitis • percarditis • meningitis • Arthritis • Also associated with Glässer's Disease	Similar to peracute PP • lameness • central nervous signs	APP HPS
Fibrous pleurisy	No signs	APP HPS

In the UK, animals intended for slaughter for human consumption shall undergo ante-mortem health inspection at the slaughterhouse before slaughter by an official veterinarian and such inspection shall take place not more than 24 hours after arrival; and not more than 24 hours before slaughter (THE FRESH MEAT (HYGIENE AND INSPECTION) REGULATIONS, 1995). Effective ante mortem inspection requires good lairage conditions, such as raised platforms for adequate observation of groups of animals (EDWARDS et al., 1997). The effectiveness of ante mortem inspection may be restricted by cramped conditions, large numbers of animals, poor lighting and excessive soiling of hides (GRACEY, 1988).

Diagnosis of pleurisy in other animals such as horses is based on auscultation and percussion of the chest. Percussion is usually painful and sounds dull when exudate accumulates in the ventral part of the chest. There may be oedema along the ventral part of the chest, front limbs and belly. Splashing sounds and far heart beats may be heard during auscultation. Radiology can be used to confirm pleural effusion, ultrasound may be used to explore the extent and content of the effusion and any adhesions. Thoracocentesis can confirm pleurisy by analysing exudate for inflammatory cells and pathogens (FEY, 2006). Unfortunately, in the commercial slaughter pig, auscultation and percussion of the chest are not feasible. Pigs are not used to be handled by humans and get stressed when restrained which increases respiration rate and usually causes strong vocalisation making auscultation difficult. Furthermore, these methods would not be economically justifiable in the commercial pig. Nevertheless, even if these diagnostic methods and tools could be used, the challenge of identifying affected pigs in the first place remains.

SACO (2011) looked at the relationship between pleurisy and acute phase proteins in serum and found that Pig-MAP (pig major acute phase protein) and Hp (haptoglobin) can be used as unspecific markers for the presence of pleurisy at slaughter. These proteins may be useful to demonstrate the presence of pathological chronic lung lesions, but they are not specific to pleurisy and therefore would not help in ante mortem diagnosis of pleurisy in pigs (AMORY et al., 2007).

2.4.2. Post mortem

Typically, pleurisy in pigs is identified post mortem, during examination of the lungs at slaughter as many cases are subclinical as explained above. Diagnosis of respiratory disease in pigs is usually based upon a combination of history, clinical observations, laboratory tests and necropsies including slaughter checks (SORENSEN et al., 2006).

Pathology to be found

In case of inflammation, the pleura thickens and becomes opaque. It may present a granular appearance with adhesions to the ribcage. The pleura can be covered with a thick, stringy, elastic, white-grey to yellow exudate that can be removed (KOBISCH and MADEC, 2012).

APP lesions are normally focal and in acute cases firm, dark red, irregular shaped, raised areas scattered throughout the lung, particularly in the caudal (diaphragmatic) lobes. More commonly found at slaughter are chronic cases where necrotic areas become encapsulated with overlying fibrous pleurisy (TAYLOR, 2006). As lesions age, the fibrinous pleurisy over the affected areas of lung become fibrous and may adhere so strongly to the parietal pleura that lung parenchyma may remain attached to the parietal pleura when the lungs are removed post mortem (GOTTSCHALK and TAYLOR, 2006). Fibrous pleurisy affecting larger areas is often associated with similar lesions in the pericardial sac (chronic pericarditis) (SORENSEN et al., 2006). Post mortem lesions of massive pleurisy and pericarditis are suggestive and firm lung infarcts are characteristic of this disease, but should be confirmed by demonstration of the agent (TAYLOR, 2006).

Other lesions that can be found in slaughter pigs with pleurisy are listed in Table 3 (SORENSEN et al., 2006). In the case of complicated bronchopneumonia, these are cranioventral lesions with purulent exudate, eventual formation of abscesses with firm fibrous structure and pleurisy. With peracute fibrinous/necrotising pneumonia, there is extensive dissemination, associated with blood-tinged fluid in the pleural cavity and extensive fibrinous pleurisy. With acute/subacute fibrinous/ necrotising pneumonia (pleuropneumonia) there is predominantly caudodorsal, fibrinous pleurisy. With chronic necrotising pneumonia (pleuropneumonia) lesions are found caudodorsal and are firm and encapsulated with necrosis and abscesses and there is local fibrous pleurisy. Fibrinous pleurisy is seen in pigs with Glässer's Disease and fibrous pleurisy is typically the result of chronic lesions.

2.5. Pleurisy Scoring Systems

Different scoring systems for pleurisy have been developed which are outlined below and summarised in Table 4. The system of CHRISTENSEN et al. (1999) is not listed due its dissimilarity.

MADEC and KOBISCH

The first scoring system for pleurisy was devised by MADEC and KOBISCH (1982). This scoring system has the advantage of defining a class for highly advanced stages that could induce growth retardation or carcass condemnations. Nevertheless, its use is not without disadvantages. It should be ensured that a non-evisceration is due to pleural adhesions and not to incorrect carcass preparation. Interlobar pleurisy, score 1, is easily identified by handling the lungs. However, localised pleurisy smaller than a 2 € coin, score 2, requires good attention and may only be visible in good light. Sensitivity of scoring mild pleurisy cases may vary more between assessors. This finding was also reported by Davies et al. (1996) and emphasises on the need for training for quality assurance. Extensive pleurisy, score 3, and partial or total ribcage condemnations, score 4, are obvious and in most cases don't need palpation, but it is necessary that the carcase can be inspected in relation to the pluck.

The CTPA system

The CTPA (Centre Technique des Productions Animales) uses a simplified scoring system from 0 to 2 for on-farm trials (PAGOT et al., 2007). It is a simple system for clinical trials with score 0 for absence of pleurisy, score 1 for fibrinous pleurisy and score 2 for severe pleurisy with adhesions to the ribcage.

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In North America and Australia, a system is used that specifically takes into account interlobar pleurisies. For other pleurisies, the scores take into account whether or not the pleurisy is associated with pneumonia. The scoring system is used in the American (PigMON) and Australian (PHMS, Pig Health Monitoring Schemes) monitoring schemes. Pleurisy lesions associated with the typical appearance of APP are not recorded as pleurisy but counted separately as lesions of pleuropneumonia (POINTON et al**.,** 1992).

Slaughterhouse Pleurisy Evaluation System (S.P.E.S.)

In Italy, a team from the Zootechnical Institute of Lombardy and Emilie Romania recently devised a new scoring system entitled SPES (Slaughterhouse Pleuritis Evaluation System) (DOTTORI et al., 2007). It aims to determine the extension and localisation of the lesions by focusing on the diaphragmatic lobes. It is also used in Belgium (MEYNS et al., 2008)

The Danish system of CHRISTENSEN et al. (1999)

In Denmark, a scoring system out of 100 is used, which is much more precise (CHRISTENSEN et al**.,** 1999). It involves careful examination of the lungs and sketching of the lesions in a record form and is therefore not suitable for use on the slaughter line. The score is proportional to the damaged surface area on each lobe and for each side of the lungs (cranioventral and craniocaudal). Thus, pleurisy that covers half of the dorsal surface of a diaphragmatic lobe will be attributed a score of 15 out of 100 and 0 out of 100 on the cranioventral side.

Table 4: List of pleurisy scoring systems (Danish system not listed)

	System			
Score	**Madec and Kobisch**	**CTPA**	**Pointon**	**S.P.E.S.**
0	Absence			
1	Interlobar pleurisy (visceral pleurisy)	Fibrinous pleurisy	Interlobar pleurisy	Ventrocranial lesion: interlobar pleurisy or at ventral border of caudal lobes
2	Localised pleurisy < 2 € coin	Extended pleurisy: lungs cannot be removed from the carcass	2N:Visceral pleurisy without lesions of pneumonia	Caudodorsal monolateral focal lesion
			2P:Visceral pleurisy with lesions of pneumonia	Type 2 lesion present on two diaphragmatic lobes or very extensive pleurisy but only affecting one diaphragmatic lobe
3	Extensive pleurisy > 2 € coin with adhesions to ribcage			Bilateral lesion of type 2 or extended monolateral lesion (at least 1/3 of one diaphragmatic lobe)
4	Partial or total ribcage condemnation			Severe extensive bilateral lesion (at least 1/3 of both diaphragmatic lobes)

3. Slaughter pig surveillance

Slaughter checks can be a profitable supplementary tool for pig health monitoring in general (SANCHEZ-VAZQUEZ et al., 2011) and for handling respiratory problems in particular (PIJOAN and LEMAN, 1986). For the swine practitioner examination of the thoracic organs at slaughter is an important diagnostic tool as a means of surveillance and evaluation of the economic impact of respiratory disease (ANDREASEN et al., 2001). Abattoir inspections are used routinely in the surveillance of the health status of SPF herds (KELLER, 1988) and have also been used as a data source for epidemiological studies (SANCHEZ-VAZQUEZ et al., 2011). Recording disease data at slaughter defines herd health status for subclinical conditions, enabling veterinarians to link disease rates associated with certain environmental conditions and husbandry practices with biologic and financial performance (POINTON et al**.,** 1992). Through surveillance schemes, researchers have identified 'risk factors' associated with disease complexes enabling them to manipulate management practices to maximise profit while minimising disease (POINTON et al**.,** 1992).

Besides detecting disease, the other principal reason for monitoring disease at slaughter is to estimate the prevalence of a condition with a desired level of confidence and accuracy (POINTON et al**.,** 1992). To get a sufficient sample and thus a reliable picture of the herd problem, a representative number of animals has to be examined and a minimum of 30 animals has been suggested previously (MORRISON et al., 1985). However, the number of pigs that must be examined to detect diseases varies with the percentage of diseased animals in a population, herd size and desired accuracy of the estimate (POINTON et al**.,** 1992).

EU countries are obliged to perform post mortem inspections at the slaughterhouse of every pig to guarantee fitness for human consumption (EU COUNCIL DIRECTIVE OF 26 JUNE 1964 ON HEALTH PROBLEMS AFFECTING INTRA-COMMUNITY TRADE IN FRESH MEAT (64/433/EEC), 1964). The inspection shall be done by an official veterinary surgeon (OVS) or inspector acting under his supervision. In the UK, THE FRESH MEAT (HYGIENE AND INSPECTION) REGULATIONS (1995), which implement COUNCIL DIRECTIVE 64/433/ECC, state that inspection shall include visual examination of the slaughtered animal and the organs belonging to it; palpation of the organs and incisions of organs and lymph nodes.

In the UK, traditional meat inspections have been criticised for not being appropriate anymore (EDWARDS et al., 1997). The quality of meat hygiene services, i.e. specificity and sensitivity, may not always be consistent and sufficient as was shown in the studies from ENØE (2003) and BONDE (2010). An apparent increase in chronic pleurisy turned out to be due to less time for the slaughtermen to remove the pluck. In the case of BONDE (2010) a lack of sensitivity of meat inspectors to detect disease provoked a lower prevalence of disease. Quality of data may vary depending on knowledge of the inspector, line speed and sophistication of the recording equipment. A limiting factor for quality of the assessment is also accessibility of the pluck. SØRENSEN (2006) even suggested that careful slaughter checks of thoracic organs cannot normally be performed at the slaughter line.

Therefore, pig health schemes were developed focusing on herd health and less so on fitness for human consumption of every pig. While the European schemes vary in design, they each have the same basic objectives (POINTON et al., 1987). The primary aim of disease monitoring at slaughter is the diagnosis of subclinical disease to improve herd health. The secondary aim is to reduce losses in the growing and fattening phase and to reduce the spread of disease via ongoing monitoring of breeding stock source herds (POINTON et al**.,** 1992). National herd health monitoring programs by means of slaughter inspection are designed for long-term surveillance of herd heath (SORENSEN et al**.,** 2006).

Conditions monitored are gross lesions including those conditions commonly associated with economically significant subclinical herd infections such as sarcoptic mange, ascarid liver spots, pneumonia, pleurisy, pericarditis, peritonitis, pleuropneumonia, ileitis and atrophic rhinitis (POINTON et al**.,** 1992).

The Danish pig health scheme from 1978 (WILLEBERG et al., 1984) was an earlier attempt at establishing a structured operating system to standardise collection of pig abattoir inspection data and to use them to improve the health of the herds of origin (SANCHEZ-VAZQUEZ et al., 2011). In the Netherlands, an integrated quality control system to record and report the abattoir post-mortem information was developed contemporaneously to the Danish scheme (ELBERS et al., 1992).

4. The British Pig Health Scheme (BPHS)

In the UK, an abattoir monitoring system was established in 2005 by BPEX. To guarantee quality of inspections, specialist pig veterinarians, were trained to assess a range of pathologic conditions including pleurisy (Table 5). The major difference to routine meat inspection is concentration on a maximum number of pigs and specific organs to guarantee accuracy of the inspection (SANCHEZ-VAZQUEZ et al., 2011).

Fourteen abattoirs across the UK take part in the scheme, covering 92% of all pig slaughterings. Assessment days rotate to allow for each producer to have at least one batch assessed in a quarter. Always half of the batch submitted on the day is assessed up to a maximum of 50 pigs. The report is sent to the producer and the herd veterinarian 48 hours later, so management changes can be done in a timely manner.

The scheme is supported by commercial sponsorship which reduced the membership fee in the first years significantly (BPEX, 2008). Since 2011 membership is free for producers that joined the pig health improvement project, a nationwide scheme to improve national pig health by improved collaboration of producers and allied industries (BPEX, 2012).

4.1.1. Pathological conditions inspected

Table 5: Conditions assessed by BPHS

	Score
Lung pathology	
EP-like lesions	0-55
Pleurisy	0 - 2
APP acute	0 or 1
APP chronic	
Abscesses	
Viral–type pneumonia	
Pyaemia	
Other pathology	
Pericarditis	0 or 1
Peritonitis	
Milk spots	
Hepatic scarring	
Tail lesions	
Papular dermatitis	0 - 3

Conditions were mostly selected because of their impact on performance such as enzootic pneumonia (EP), APP, pleurisy and milk spots or on the welfare of pigs such as tail biting and papular dermatitis (SANCHEZ-VAZQUEZ et al., 2011).

4.1.2. Methods of assessment

BPHS assessors use different scoring systems for the different pathological conditions inspected (Table 5). Each carcase is scored individually. EP-like lesions, pleurisy and papular dermatitis are scored in gradients that represent the severity and extent of the lesions. All other lesions are scored in a binary form, recording just presence or absence of the lesion.

EP-like lesions are scored according to Goodwin & Whittlestone (1969) from 0 to 55 where the four lobes, left cranial and middle and right cranial and middle can each get a maximum score of 10. The intermediate lobe and each cranial part of the caudal lobe can get a maximum score of 5. The maximum score of the entire lung is 55 approximately equivalent to 55% of the lungs affected. The Goodwin method is adequate for EP lesions as it primarily affects cranioventral aspects of the lungs (BURCH, 2004).

Pleurisy presence can be scored with 1 or 2. Initially, the score indicated the type of pleurisy. Score 1 was visceral pleurisy, i.e. adhesions between lung lobes and score 2 parietal pleurisy, i.e. adhesions between lungs and the chest. Since July 2008 the pleurisy score describes the extent of pleurisy. If up to 25% of the lungs are affected, the score is 1. Pleurisy score 2 now indicates pleurisy affecting more than 25% of the lungs.

Papular dermatitis, indicating sarcoptic mange, can be scored from 1 to 3, where score 1 is a localised distribution, predominantly on head, belly and buttocks. Score 2 is a mild to moderate form with generalised distribution. Score 3 is the severe generalised form with intensely affected areas (POINTON et al**.,** 1992).

4.1.3. Objectives of the scheme

Improving animal health surveillance and the identification of simple and reliable indicators for animal health are priorities in the current agenda of the EU animal health strategy (EUROPEAN COMMISSION, 2007). In addition, health schemes have been used to define industry problems and provide a basis for case-control studies to quantify the determinants of disease, so that economically sound management practices can be implemented (POINTON et al., 1992).

The scheme provides feedback of prevalence and severity of assessed conditions to the producer and their herd veterinarian aiding awareness and encouraging control of diseases. For the individual producer data may be used to assess treatment and prevention strategies or changes in management (BPEX, 2008). For the industry, the BPHS database provides invaluable data for epidemiological studies and surveillance of the national pig herd.

The British scheme could be a model for other industries. Records from the health scheme are being incorporated into the national surveillance system as part of the Rapid Analysis and Detection of Animal–related Risks system (DEFRA, 2012). The British pig health system provides high quality data that offers opportunities for analysis in animal health and production research projects (SANCHEZ-VAZQUEZ et al., 2011).

III. RESULTS

1. Additional non-published results

Table 6 shows results of the independent regression model fitted to each management variable in turn and Table 7 for each health variable. Raw and adjusted likelihood ratio tests (LRT), the area under the ROC curve (AUC) and the number of non-missing observations (N) for the variables are shown. The variables highlighted in red correspond to those that are statistically significant at the 5% level after correction and those in blue correspond to those that are statistically significant before correction.

The LRT were used to screen the data set for associations and any variable with a corresponding p-value of <0.15 was then made available for a final multiple regression analysis. However, the extent and distribution of missing values in the data set precluded the development of a sensible multiple regression model, since model choice procedures require competing models to be fitted to the same data set, and in order to do this too many observations or variables would have had to be cut out to make a valid comparison. Instead, the results from a series of simple logistic regression models were reported, fitted to each explanatory variable in turn, and was corrected for multiple comparisons using a Bonferroni correction. To assess the predictive capacity of each variable the area under the Receiver Operating Characteristic (ROC) curve (AUC) can be calculated. This gives a measure of how good the model is at correctly predicting the outcome variable (case or control). The AUC ranges between 0.5 - 1, with a value of 0.5 indicating no discriminatory power and a value of 1 indicating perfect discriminatory power.

Table 6: Results of LRT for management associated variables

Variable	LRT p-value	LRT (Bonferroni)	AUC	N
Herd management – growers	0.00	0.00	0.75	112
Shared air	0.00	0.00	0.68	121
# moves	0.00	0.00	0.73	119
Production type	0.00	0.00	0.72	121
Herd management – finishers	0.00	0.00	0.71	117
Clean between batches – finishers	0.00	0.00	0.69	84
Partial slatted – weaners	0.00	0.01	0.65	80
# sources	0.00	0.01	0.70	116
Downtime – growers	0.00	0.01	0.77	81
Herd management – weaners	0.00	0.01	0.75	77
Feed origin – growers	0.00	0.02	0.67	104
Disinfect between batches – finishers	0.00	0.02	0.69	84
# mixes	0.00	0.03	0.66	120
Downtime – finishers	0.00	0.05	0.72	82
Feed origin – finishers	0.00	0.06	0.65	108
Downtime – weaners	0.00	0.12	0.74	63
Total # finisher places	0.00	0.12	0.58	118
Clean between batches – growers	0.00	0.16	0.61	84
Feed type – growers	0.01	0.23	0.65	108
Feed origin – weaners	0.01	0.40	0.61	66
Bedding – weaners	0.01	0.43	0.64	80
Disinfect between batches – growers	0.01	0.48	0.62	83
Feed type – finishers	0.02	0.88	0.63	113
Slatted – weaners	0.02	0.90	0.63	80
Partial slatted – finishers	0.02	1.00	0.59	121
Assisted ventilation	0.05	2.00	0.58	121
Frequency of feed – finishers	0.06	2.41	0.57	110
Bedding – finishers	0.09	3.52	0.57	121
Slatted – finishers	0.10	4.04	0.57	121
Straw yards – finishers	0.11	4.51	0.57	121
Pen with indoor run – weaners	0.16	6.36	0.57	80
Single or mixed acc. - weaners	0.16	6.49	0.58	80
Pen with kennel and indoor run – finishers	0.24	9.76	0.55	121
Single or mixed acc. - finishers	0.30	12.20	0.55	121
Pen with kennel and indoor run – weaners	0.39	16.01	0.55	80
Max. # shared air	0.55	22.38	0.53	113
Pen with kennel and outdoor run – finishers	0.60	24.67	0.51	121
Sex separation	0.73	29.89	0.51	121
Straw yards – weaners	0.82	33.58	0.51	80
Pen with indoor run – finishers	0.86	35.34	0.51	121
Pen with kennel and outdoor run – weaners	0.87	35.76	0.51	80

Table 7: Results of LRT for health associated variables

Variable	LRT p-value	LRT (Bonferroni)	AUC	N
Mortality – 07	0.00	0.00	0.81	117
APP	0.00	0.00	0.73	92
Mortality – 08	0.00	0.00	0.78	114
Mortality – 06	0.00	0.00	0.71	111
Dyspnoea – old – 07	0.00	0.00	0.68	121
Dyspnoea – old – 08	0.00	0.01	0.67	121
Cough – old – 07	0.00	0.03	0.64	121
# group meds	0.00	0.04	0.68	117
Cough – old – 08	0.00	0.04	0.64	121
Dyspnoea – young – 07	0.00	0.05	0.68	80
SD – young – 07	0.00	0.09	0.66	80
# ind. Meds	0.00	0.09	0.69	119
Reason for group med	0.00	0.11	0.68	66
Sneeze – old – 08	0.00	0.14	0.61	121
Waste – young – 08	0.00	0.16	0.66	79
Dyspnoea – young – 08	0.01	0.23	0.65	80
Sneeze – young – 07	0.01	0.40	0.65	80
Reason ind. Med	0.01	0.53	0.66	83
Sneeze – old – 07	0.01	0.55	0.60	121
PRRS	0.01	0.57	0.62	101
Sneeze – young – 07	0.02	0.69	0.64	80
SD – young – 08	0.02	0.73	0.63	80
# EP shots	0.03	1.40	0.57	96
Glaessers	0.04	1.56	0.60	94
Cough – young – 08	0.04	1.68	0.61	80
Waste – young – 07	0.04	1.79	0.61	80
EP	0.05	2.04	0.59	105
Cough – young – 07	0.06	2.55	0.60	80
Waste – old – 08	0.07	2.72	0.58	121
Waste – old – 07	0.10	4.18	0.57	121
PDNS – 07	0.11	4.31	0.56	121
Meningitis – 08	0.20	8.33	0.56	121
Scour – young – 08	0.32	13.15	0.55	80
Scour – old – 08	0.48	19.48	0.53	121
SD – old – 08	0.48	19.65	0.52	120
PDNS – 08	0.50	20.68	0.53	121
PMWS	0.51	20.73	0.52	115
Scour – young – 07	0.75	30.62	0.52	80
Meningitis – 07	0.81	33.06	0.51	121
SD – old – 08	0.83	34.07	0.51	121
Scour – old – 07	0.85	34.98	0.51	121

2. Publication

FACTORS ASSOCIATED WITH PLEURISY IN PIGS: A CASE-CONTROL ANALYSIS OF SLAUGHTER PIG DATA FOR ENGLAND AND WALES

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Abstract

A case-control investigation was undertaken to determine management and health related factors associated with pleurisy in slaughter pigs in England and Wales.

Methods: The British Pig Executive Pig Health Scheme database of abattoir pathology was used to identify 121 case (≥10% prevalence of pleurisy on 3 or more assessment dates in the preceding 24 months) and 121 control units (≤5% prevalence of pleurisy on 3 or more assessment dates in the preceding 24 months). Farm data were collected by postal questionnaire. Data from respondents (51 cases and 70 controls) were analysed using simple logistic regression models with Bonferroni corrections. Limited multivariate analyses were also performed to check the robustness of the overall conclusions.

Results and conclusions: Management factors associated with increased odds of pleurisy included no all-in all-out pig flow (OR 9.3, 95% confidence interval [CI]: 3.3-29), rearing of pigs with an age difference of >1 month in the same airspace (OR 6.5 [2.8-17]) and repeated mixing (OR 2.2 [1.4-3.8]) or moving (OR 2.2 [1.5-3.4]) of pigs during the rearing phase. Those associated with decreased odds of pleurisy included filling wean-to-finish or grower-to-finish systems with piglets from ≤3 sources (OR 0.18 [0.07-0.41]) compared to farrow-to-finish systems, cleaning and disinfecting of grower (ORs 0.28 [0.13-0.61] and 0.29 [0.13-0.61]) and finisher (ORs 0.24 [0.11-0.51] and 0.2 [0.09-0.44]) accommodation between groups, and extended down time of grower and finisher accommodation (OR 0.84 [0.75-0.93] and 0.86 [0.77-0.94] respectively for each additional day of downtime). This study demonstrated the value of national-level abattoir pathology data collection systems for case control analyses and generated guidance for on-farm interventions to help reduce the prevalence of pleurisy in slaughter pigs.

Key words:

Respiratory, pleuritis, risk factors, swine.

Introduction

Pleurisy is defined as inflammation of the pleural membranes, the serosal surfaces of the lung and chest cavity that facilitates smooth inflation of the lung. It is a particular problem in the pig industry [1] and is evident at necropsy or slaughter as fibrinous or fibrous adhesions between the lung lobes (visceral pleurisy) and/or the lungs and chest wall (parietal pleurisy). Interest in the economic and welfare impacts of pleurisy has increased since the high prevalence of this condition in finisher pigs has become apparent [1]. The economic impacts require further investigation, but chronic pleurisy is associated with increased time to slaughter [2]. It also causes problems in abattoirs because carcases require trimming causing extra labour, slower production line speeds, and result in increased waste. Respiratory disease is known to have significant negative impacts on indicators of pig welfare [3]

Pleurisy is a common finding in slaughter pigs in the UK, as evidenced by data from the systematic abattoir pathology recording under the British Pig Executive's (BPEX) Pig Health Scheme (BPHS); data provided to us from 14 abattoirs showed that of 15,237 slaughter consignments between July 2005 and October 2008, 80% were affected by pleurisy. Within these consignments, at the individual pig level 12.5% of 641,763 pigs were affected. Studies in other countries have found similar and even increasing pleurisy prevalence over the last 20 years (Table 1). Pleurisy is a multifactorial syndrome that can be caused by a number of different infections and which is predisposed to by a range of different management factors.

Previous studies of management factors associated with pleurisy in pigs have identified some common management factors, as well as some regional differences. The most important risk factors found in previous studies were related to transmission of infections at herd or pig level such as pig density in neighbourhood [4,5], poor biosecurity [5], increased herd size [6] or number of pigs per pen [7], lack of complete all-in/all-out practice [4,8], and mixing of pigs in the finishing stage [4]. But whereas Maes (2001) detected a higher prevalence of pleurisy in slaughter pigs in January/February in Belgium, with more severe lesions in March/April, in the Netherlands Elbers (1992) found highest prevalence in June/August.

The presence of antibodies to *Actinobacillus pleuropneumoniae* (APP) is associated with pleurisy either alone [6,7,9,10] or in combination with Porcine Reproductive and Respiratory Syndrome virus (PRRSV) [8]. Also *Mycoplasma hyopneumoniae* (M. hyo) [7,2], *Mycoplasma hyorhinis* [11] and Swine Influenza virus (SIV) [6] have been shown to be associated with higher frequency of pleurisy. More recently PCV2 has also been suggested to be associated with increased levels of pleurisy [12], and in addition porcine atrophic rhinitis (PAR) has been associated with pleurisy in Denmark [6,9].

Understanding the health associated factors and clinical signs in live pigs with pleurisy would permit more effective and timely targeting of control measures, since often the disease is only apparent at slaughter. However, work in this area has been limited—coughing and lethargy are considered to be indicative, but not specific for pleurisy, but attempts to identify pigs suffering from pleurisy pre-mortem based on pyrexia and dyspnoea have not been successful [13].

The present analysis focused on management and health-related associative factors for pleurisy and took into account the three main types of slaughter pig production systems relevant in the European Union (farrow-to-finish, wean-to-finish, grow-to-finish). Most previous studies looked at only one [5] or two types of production systems [8,9]. A case-control analysis was conducted, using retrospective abattoir pathology data collected at national level within the BPHS over the previous two years. Due to the ubiquity of pleurisy in the UK, pig units were defined as cases or controls based on consistently high or low pleurisy prevalence at unit level. One goal was to demonstrate the value of a nation-wide abattoir pathology database in identifying these consistent case and control units since it provided objective data representing around 80% of the farm assurance accredited English and Welsh production base. Herd specific information on management practices and health observations were gathered by a postal questionnaire from units that met the criteria for case or control.

Materials and Methods

Selection of target units based on pre-existing abattoir pathology data

The British Pig Executive (BPEX), representing English and Welsh levy paying pig producers, launched the BPHS abattoir pathology monitoring scheme database in 2005 [14]. BPHS is considered a comprehensive representation of the slaughter pig population in England and Wales since it captures data from approximately 75% of all commercial slaughter herds (1036 of a total 1400 herds, based on 2010 data) [15]. For a given consignment of slaughter pigs, each containing from 10 to >200 pigs, assessments are recorded from every second pig on the slaughter-line up to a maximum sample size of 50 pigs per consignment. The scheme operates at the 14 largest pig abattoirs in England and Wales using 37 specialist veterinarian assessors to collect on-line pathology data on 1 to 4 assessment days per month depending on the size of the abattoir. Assessment days rotate ensuring each day of the week is represented allowing every herd to be assessed at least once a quarter. Standardisation of assessment data between abattoirs and assessors is monitored by the scheme and includes regular training and rotation of assessors [14,15].

Criteria for case and control definitions were developed from this pre-existing database, taking into account the distribution of the data, and aiming to avoid data collected from small sample populations or from producers that recorded highly variable pleurisy prevalence over time. The database was used to identify all producers that had 50 slaughter pigs assessed on at least three occasions in the 24 months prior to October 2008 (778 (56%) producers of a total of approximately 1400 commercial herds) (Table 2). Fifty nine percent of consignments assessed for these producers had at least a 5% prevalence of pleurisy during the 24 month period but the prevalence was highly variable on some units. As such it was felt important to define a case-control measure based on *consistency* of prevalence of pleurisy over time, in order to attempt to separate units with endemic pleurisy problems from those that exhibited more transient occurrences.

Cases were defined as those that had > 10% of pleurisy-affected pigs in each of the three most recent consignments in the 24 month period prior to October 2008, and *controls* were those that had ≤ 5% of pleurisy-affected pigs in each of the three most recent consignments in that same period. Selection of these cut-offs was based on examining the distribution of the full dataset while attempting to balance study power and maximum discrimination of case and control groups. Indicative sample size calculations were done on the basis of a single factor analysis and indicated that data would be needed from 105 case units and 105 control units to detect statistical significance ($p<0.05$) of a risk factor found in 20% of the control units that had an odds ratio of 2.5, with a desired study power of 80%.

Questionnaire to collect farm-level information

Herd health and management data were gathered by a closed-question postal questionnaire (Annex) sent to 242 units (121 cases, 121 controls) followed up by telephone liaison with the farm manager and the appropriate private veterinarian. Respondents were not informed of their case/control categorisation in order to minimise selection bias. A pilot questionnaire was validated at three units before dispatch. The questions were composed to ensure clarity for producers and sufficient detail for statistical analysis. An outline of investigated variable factors is presented in Table 3.

Processing and statistical analysis of data

Data were stored and manipulated in Microsoft Access and Excel (Microsoft 2007). All statistical analyses were conducted in the R statistical language (R Core Development Team 2008).

The questionnaire was stratified into a series of categories, representing different characteristics of a unit. These were: general farm information (including production type), mortality and productivity, health status, herd environment and herd management. To explore the data in a systematic manner we stratified the variables into two main groups: those that corresponded to farm management characteristics (for which the influence is possibly independent of the disease status), and disease associated factors (those factors that were directly dependent on the disease status of the farm).

It was necessary to re-categorise some of the categorical variables to ensure that there were >5 observations in any level of the factor and also to aid interpretation. Variables having large numbers of missing values (>60) were removed at the outset, as were those categorical variables that had <5 samples in a group and could not be easily re-categorised. Within each group of variables (e.g. management characteristics and disease associated characteristics) the data were screened by applying a simple logistic regression model to each variable in turn, using a chi-squared likelihood ratio test (LRT) [16], and correcting for multiple comparisons using Bonferroni step-down procedures. The extent and distribution of missing values precluded the development of a comprehensive multivariable regression model. However, it was possible to produce a limited multivariable model examining relationships between pleurisy and some of the more important management related factors obtained from the univariate analyses (see results sections for further discussion). Variable selection was conducted using forwards stepwise selection routines and Akaike Information Criterion (AIC) (using the MASS package in R[17]), including only those variables where p=0.05 or less in the Bonferroni corrected LRT results. Collinearity between variables was assessed by examining the standard errors. As such, in addition to the univariable results we also present some further discussion regarding associations between some of the explanatory variables based on the constrained multivariable models. As a result of the aforementioned limitations, we did not explore interaction effects in this instance. Goodness-of-fit was assessed using the le Cessie-van Houwelingen normal test statistic for the unweighted sum of squared errors [18,19], as implemented in the "Design" package in R [20]. Discriminatory power was assessed using the Area Under the Receiver Operating Characteristic Curve (AUC), using the "verification" package [21]. Each observation with a standardised Pearson residual of >2 was removed from the final model in turn to check for undue influence due to outliers.

Results

Recruitment of respondent farms

Overall there were 126 respondent farms from the original 242 targeted: 51 cases, 70 controls, with 2 questionnaires unusable due to incorrect herd identification. Three had ceased business. Hence the overall usable response rate was 50%. The mean, minimum and maximum pleurisy prevalences across case producers were 29.5%, 12% and 76.7%. Across control producers the mean pleurisy prevalence was 1.6%, ranging from a minimum of 0% to a maximum of 3.3%.

Management factors

The univariable results for management related risk factor analysis are shown in Table 4. Absence of all-in/all-out (AIAO) pig herd management was an important factor associated with increased pleurisy (OR 9.3) compared to complete AIAO. All-in/all-out by room was similar to no all-in/all-out practice (OR 0.96). Keeping pigs of more than one month age difference in the same airspace was associated with increased pleurisy prevalence (OR 6.5). In addition there was an association between moving and mixing of pigs on farms and higher levels of pleurisy (OR 2.2 and 2.2 per move/mix respectively). Partial slatted flooring for weaners was a strongly associated factor (OR 21.4), but had a very wide confidence interval (3.7-400).

Factors associated with reduced prevalence of pleurisy included wean-to-finish and grow-to-finish production systems compared to farrow-to-finish systems (OR 0.10 and 0.45 respectively), cleaning and disinfection on finishing batches (ORs 0.24 and 0.20 for cleaning and disinfecting respectively), and on grower batches (ORs 0.28 and 0.29 respectively). Also associated was purchasing feed for growers as compared to home-mixing of feed (OR 0.22). Farrow-to-finish production was associated with higher levels of pleurisy than multisite operations that sourced pigs from other breeding units. However, the protective effect became less strong (and statistically insignificant) when these grow-outs sourced from >3 units (ORs 0.18 for ≤3 sources compared to 0.69 for >3 sources). Finally, longer periods of downtime between grower and finisher batches were associated with reduced pleurisy prevalence (ORs 0.84 and 0.86 for each additional day of downtime respectively).

Due to the stratified nature of some of the variables (e.g. grow-to-finish units do not have weaner accommodation), and the within-unit heterogeneity (particularly with regards to some of the accommodation types), it was difficult to design a sensible multivariable model that included all of the variables, such that there were sufficient samples to produce reasonable statistical power. Instead, we restricted attention to some of the more important variables identified in Table 4. Since we needed complete data in order to use stepwise selection, we excluded variables that had more than 5 missing values (leaving 10/15 variables). Then we excluded all batches that had any missing values across these 10 remaining variables (leaving 110 batches). We then fitted a forward stepwise selection model and report the results in Table 5.

Interestingly, the strongest variable from the univariable analysis (herd management) was the first to be added, and remained in the model until the final step, where it seems that the combination of cleaning between batches (growers), air-space shared by multiple age groups, and number of moves rendered herd management unnecessary to remain in the model. There was a strong association between shared air and herd management (only 2/30 herds with shared air=true practiced AIAO, compared to 57/80 herds with shared air=false), and also between the number of moves and herd management (median of 1 move for AIAO systems and 3 moves for non-AIAO systems). The association with cleaning between batches and herd management was less pronounced. This final model showed no statistically significant lack-of-fit ($p=0.15$) and showed a relatively good discriminatory power (AUC=0.83). Overall, three observations had an absolute standardised Pearson residual of >2 and <2.5, and three more of >2.5. Removing these in turn made negligible difference to the parameter estimates.

Disease associated factors

Case units had an increased post-weaning mortality, dyspnoea (both < 30 kg and > 30 kg in weight), coughing (> 30 kg) and increased odds of farmer declared positive status for APP. Also, increased frequency of group medication was associated with pleurisy (Table 6).

The median post-weaning mortality rate between 2006 and 2008 (Figure 1) was consistently higher in case units (by 3.3%) (2006: case=7.7%, control=5%; 2007: case=7.7%, control=4%; 2008: case=6%, control=4%. All figures are median values).

Discussion

The BPHS database, which represents approximately 74% of slaughter pig production in England and Wales, proved suitable for the purpose of identifying case and control units. However, many units within it had a large variation in pleurisy prevalence over the 24 month period studied. Because of this we imposed a strict definition of *consistency* in pleurisy levels over time in our case/control definitions. Hartley (1988) made the same observation regarding pleurisy variability and concluded that this was due to disease dynamics and variation in susceptibility of disease influenced by the environment and management [22]. This may also be impacted by differences from batch to batch in sourcing and mixing of pigs that comprise a batch on entry to a given wean- or grow-to-finish system such that the same unit could have a history of highly variable pleurisy prevalence over time. Chance variation in the infections introduced with different pig batches could be important. The case/control definitions used here provided a metric for distinguishing between *consistently* higher or lower risk units, and must be interpreted as such.

Within responding units there were varying degrees of missing data. This was partly to do with unforeseen heterogeneity in management practices. For example, many units used multiple accommodation types, sometimes for different age groups. These relationships were not clear before the study, but meant that it was difficult to stratify these variables in a sensible manner without incorporating missing information (e.g. stratifying accommodation by age group meant that grow-to-finish units would have missing values for weaning-age variables). Furthermore, there was also a tendency for respondents not to complete all questions. These limitations emphasise the importance of designing data capture questionnaires in a way that maximises the collection of relevant data but minimises the potential for missing data.

Since the definition of cases and controls was determined before recruitment, and the classification was unknown to the respondent, this should reduce the impact of selection bias. Nonetheless, more control farms replied than cases (59% and 41% respectively). We were unable to identify any systematic bias in terms of explanatory variables since we had no data from non-responders. However, the differing response rates suggest that there may be a relationship between producers' 'attitudes' to

communication about this on-farm health issue and the prevalence of pleurisy. Similar future studies should take account of these differing response rates and factor in the need for follow-up phone calls to responders. Finally, the analysis only included units that had 50 pigs assessed (i.e. 100 or more pigs submitted) on each of 3 successive occasions and, although this means that the results might not extrapolate to small-scale producers, it nevertheless provides information about farm management and health characteristics that are associated with consistently high or low levels of pleurisy in larger, more economically significant, units.

We used a series of univariable logistic regression models using a conservative Bonferroni step-down multiple adjustment procedure [23]. One limitation of this approach is that it is difficult to assess the impact of confounding and effect interactions. As such the individual factors obtained from the univariable analyses that were associated with increased or decreased odds of pleurisy must be viewed in terms of providing information about potential foci for control and intervention that could be tested, and are discussed in the context of other studies and/or prior knowledge. Due to the stratified nature of some of the variables, and the degree-of-missing data, it was only possible to fit a multivariable model to a subset of the data to explore limited associations. However, caution must be used in the interpretation of these results, due to the limited scope of the variables included in the analysis. Nonetheless they further highlight the importance of the variables that were also identified in the univariable analysis.

The results of univariable analysis indicated that failure to implement strict AIAO (by unit or building) was strongly associated with increased pleurisy and this was in line with previous studies [4]. In contrast, the final multivariable model contained cleaning between batches (growers), air-space shared by multiple age-groups, and number of moves but not AIAO. Interestingly AIAO remained in the multivariable analysis until the final step of the procedure before dropping out. Cleaning between batches and avoidance of sharing airspace by pigs of different ages, factors that are both present in the final multivariable model, are important contributory elements of effective AIAO management. Not practising AIAO potentially allows diseases to circulate because susceptible pigs are continuously introduced and older pigs can pass on infections to the younger generation [2]. The univariable analysis findings that repeated mixing, moving, the co-existence of pigs of > 1 month age difference in the same air space, and failures in cleaning or disinfection were also factors associated with increased

pleurisy reinforced the biological relevance of this observation since these are key practical components of an AIAO management system.

Conversely, implementing AIAO by room, as opposed to by building or unit, was associated with increased pleurisy in the univariable analysis. It seems that there is sometimes confusion about the definition of AIAO – a management system that segregates pigs of a defined age span (e.g. 3 weeks) in an airspace that is separate from groups of other aged pigs throughout their life. A key part of AIAO is that the segregated airspace or accommodation is fully emptied before repopulation occurs. AIAO can break disease cycles, but only if the entire population is included in the process. Our data suggested that AIAO by room cannot be regarded as effective AIAO. In most cases, although the situation varies from farm to farm, a room is not separated enough from other pigs to allow calling the process of emptying a room 'all-out' or filling a room 'all-in'.

The odds of pleurisy increased each time pigs were mixed (univariable analysis) or moved (univariable and multivariable models). Moving and mixing are stressors for pigs which may impact on immunity [24], and are opportunities for pathogens such as APP to spread to susceptible pigs [25]. Although identifying the role of specific infections in causing pleurisy was not a central aim of the current work, vet or farmer-declared presence of clinical APP on the farm was associated with higher levels of pleurisy. APP status might have been determined by clinical or serological status. Vaccination against APP might have impacted on the serological status, or masked clinical disease, but vaccination against this organism is very uncommon in England and Wales. The role of APP in pleurisy is supported by several serological studies [6,7,8,9,10].

A number of previously undescribed protective factors were identified in this analysis. Firstly, cleaning and disinfection of grower and finisher accommodation between batches was identified in the univariable model, with cleaning of grower pens remaining in the final multivariable model. Secondly, increased "down time" between batches for finisher and grower accommodation was identified in the univariable model. These are issues that have previously been identified as important associative factors relating to enteric disease [26] but less so in the context of respiratory disease. Nevertheless, cleaning might be expected to contribute to respiratory health through reduced levels of dust, environmental bacteria and fungal spores. Resting buildings

allows complete drying after disinfection and would be expected to optimise killing of important respiratory pathogens. This has been demonstrated in pig transport trailers for PRRSV [27] but studies of total aerobic bacterial counts were unable to show an effect of down time (Amass 2007). This is nevertheless an important area for future investigation since the presence of organic matter can significantly affect environmental survival of respiratory pathogens such as APP (Gottschalk 2006).

Compared to farrow-to-finish (FF) operations, grow-to-finish (GF) but especially wean-to-finish (WF) systems showed lower levels of pleurisy (GF OR = 0.45; WF OR = 0.1) according to the univariable analysis. The continuous presence of breeding and growing pigs on FF units may be responsible for continuous circulation of infections. Strict AIAO production, at building level, on FF units in the UK is extremely unlikely to occur and pigs must progress through what is often a closely located set of buildings. On the other hand, WF and GF units are more suited to strict AIAO, in spite of the fact that their population usually involves the mixing of pigs from different breeding sources. The observed additional protective effect of WF units over GF units is worthy of further investigation. Of potential importance might be the residual colostrally derived passive immunity at mixing during population in WF units. Population (and mixing of sources) on GF units takes place after the decline of passive immunity with, potentially, a consequential increase in the effective population of susceptible pigs. Also, or alternatively, if infections causing pleurisy spread soon after mixing on AIAO WF units, pigs have a longer period until slaughter during which lesions may resolve.

Another apparently protective factor identified in the univariable analysis was sourcing of piglets to WF or GF sites from ≤ 3 units in comparison to the single sourcing associated with farrow-finish (no external sources). This association was weaker when a batch was sourced from > 3 breeding units. The protective effect over FF may be in part a proxy for the management conditions of WF and GF farms, although the reduced protective effect when more than 3 sources are taken is consistent with the notion that an increase in the likelihood of introduction of disease occurs when sourcing piglets from higher numbers of different units. The use of purchased grower feed versus home mixed feed was found to be associated with lower prevalence of pleurisy (OR = 0.2) but the absence of associations relating to feed at the finisher or weaner stages suggests that this finding may be an artefact, or may be correlated to other factors such as production type (home mixing is more common on FF units in the UK) but this could not be ascertained in the current project.

Regarding associations between pleurisy prevalence and disease related factors, the univariable study differentiated clinical signs by age group (< and > 30 kg) and year (2007 and 2008). Similar to previous studies where observable respiratory disease in late finishing was associated with the presence of pleurisy [8], the present study found dyspnoea and coughing in pigs > 30 kg were associated with pleurisy in 2007 and 2008. In 2007 dyspnoea in pigs <30 kg could also be related to increased pleurisy in slaughter pigs, but this effect was not observed in 2008. However, these clinical observations are not specific for pleurisy and may indicate other, co-existent, respiratory diseases. Previous research has indicated a link between pleurisy prevalence and prevalence of pneumonia [28], but more recent work suggests this relationship may not be straightforward since lesions of pneumonia were negatively associated with pleurisy lesions [5,10]. Much opportunity remains to understand how pleurisy relates to pneumonia in pigs and how it might be detected ante mortem.

Increased mortality was consistently and strongly associated with the units being defined as cases in each of the 3 years for which data was requested. This basis of this association is worthy of further investigation because, on one hand, it is another indication that pleurisy is a disease of generally lower health status units and, on the other, an indication of the economic consequences of pleurisy on units where it is a consistent problem. As a proxy for the overall health of a unit, increased numbers of group level medication periods in the post-weaning period were associated with units with consistent pleurisy. While this observation would be consistent with a tendency for pleurisy to occur on units of generally lower health status and with higher consequent production costs, it is probable that some of these additional medications would have been a direct consequence of pleurisy.

In conclusion, this study identified management and health related factors associated with pleurisy based on a questionnaire across 121 respondent units producing slaughter pigs and a national abattoir pathology surveillance database – demonstrating the value of this national disease surveillance system. The identified factors were mostly related to transmission of infectious diseases and the analyses highlighted the importance of AIAO but also a group of management factors associated with it. In addition, farrow-finish management systems were shown to be particularly at risk of consistent pleurisy, in part likely due to the difficulty in implementing strict AIAO in these systems in the UK.

Since implementation of complete AIAO management, for example at the building or unit level, has significant cost implications a better understanding of the relative importance of specific management factors that contribute to AIAO and which can be implemented in any production system, is of value to the industry.

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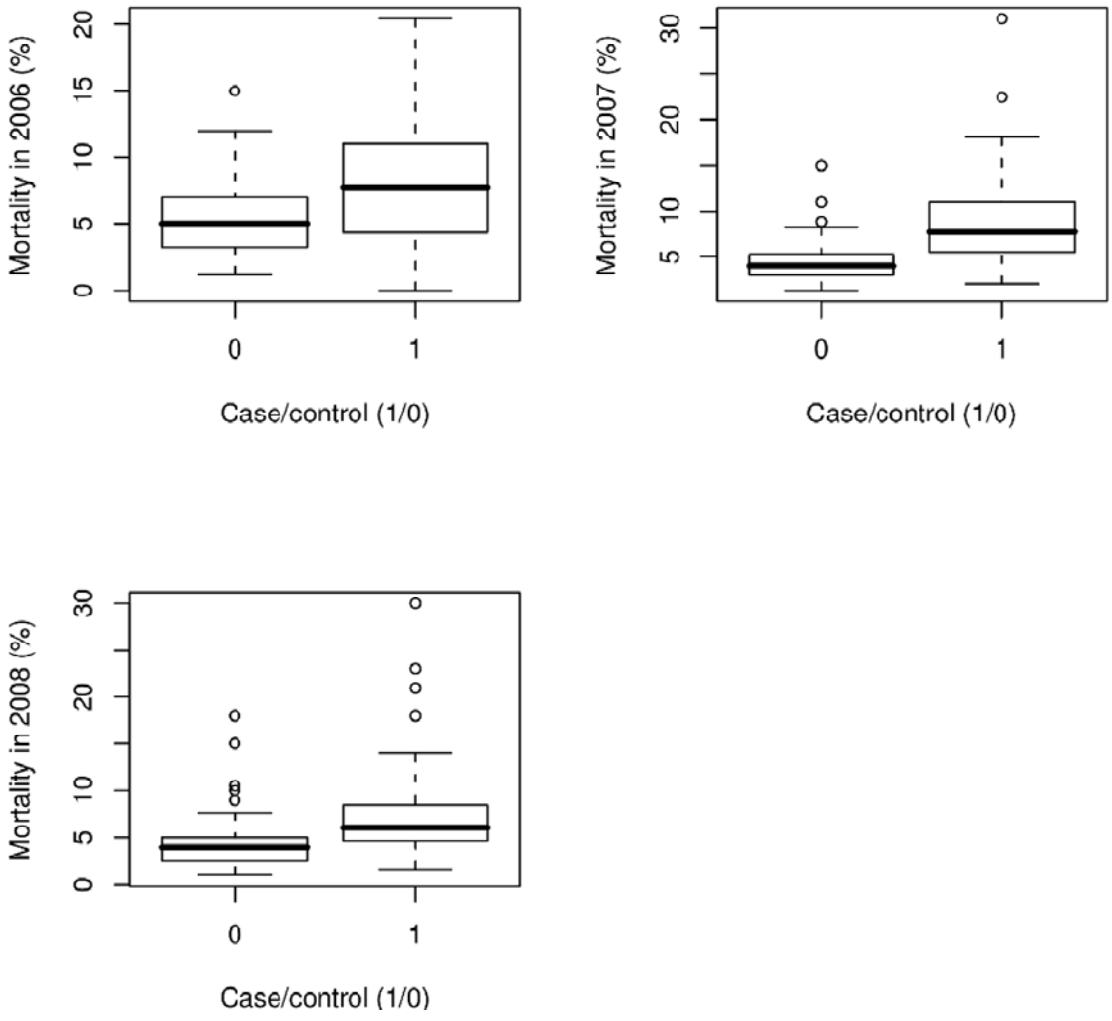
Figure legends

Figure 1

Post-weaning mortality distributions, shown as percentages, for pig farms categorised as pleurisy affected (case) or less affected (control) for 2006 - 2008.



Tables

Table 1

Pleurisy prevalence, presented as percentage of individual affected pigs, in EU countries.

Country	Period	Prevalence
Belgium	2000	16% [5]
	2009	20.8% [7]
Denmark	1987	14 [9]
	1998	24% [29]
	2000	25% [4]
Netherlands	1990	12% [14]
	2004	22.5% [14]
Norway	1991	41% [12]
Spain	2009	26.8% [8]
UK	1988	16% [1]

Table 2

The number (%) of herds at each level of the sampling strategy, including the number of eligible case and control herds, as a proportion of the total number of commercial slaughter-pig herds in England and Wales.

Herds (cases and controls)	Number (%)
Commercial slaughter-pig holdings in England and Wales	1400 (100%) [16]
Herds sampled by BPHS scheme (data for 2010)	1036 (74% of 1400) [16]
Herds with 50 pigs sampled by BPHS on at least 3 occasions prior to October 2008	778 (56% of 1400)
Number of eligible cases	121(16% of 778)
Number of eligible controls	306 (39% of 778)
Total number of eligible herds	427 herds (55% of 778; 31% of 1400)
Number of dispatched questionnaires	242 (121 cases, 121 controls)
Number of completed questionnaires	121 (50% of 242; 16% of 778; 9% of 1400)
	51 cases (7% of 778)
	70 controls (9% of 778)
Number of herds included in univariable model	121
Number of herds included in multivariable model	121

Table 3

Outline of variables included in a questionnaire addressed to pig farms defined as case (pleurisy prevalence consistently >10%) or control (pleurisy prevalence consistently <5%) to seek relationships between pleurisy and production unit type, key indicators of general management, and health observations.

Variable	Levels (if applicable)
Production unit type (and number of sources where applicable)	Farrow-finish / wean-finish / grow-finish
All-in/All-out pig flow	By unit / building / room / pen
Number of finisher places	value
Distance to next pig unit (km)	value
Experience of senior stockman (years)	value
Ongoing training of stockmen	Yes/No
Accommodation systems (for weaning -30kg, and 30kg – slaughter)	Fully slatted / part slatted / straw yards / assisted ventilation
Number of times pigs moved after weaning	value
Number of times pigs mixed after weaning	value
Is airspace shared by pigs of >1 month age gap?	Yes / no
Maximum number of pigs in shared airspace	value

Table 3 continued:

Variable	Levels (if applicable)
Feeding regime (for 7-30kg, for 30-50kg, and for 50kg – slaughter)	Meal / pellets / wet feed
	Home-mixed / purchased compound / by-product
	Ad libitum / restrict fed
Medication: number at group level	Product / duration / in feed or water / reason
Medication: individual treatments:	Number in past week / reason
Farmer observations of disease (main effect: none, few, many; where an age effect requested this is 7-30 kg & >30kg; data requested for 2008 & 2007)	Scours (by age) / sneezing (by age) / coughing (by age) / dyspnoea (by age) / meningitis / wasting (by age) / sudden deaths (by age) / porcine dermatitis and nephropathy syndrome (PDNS) / other
Farmer or herd vet knowledge of specific disease status (believed present, confirmed by vet, believed absent, not known)	porcine reproductive and respiratory syndrome (PRRS)) / A. pleuropneumoniae (APP) / Glasser's Disease / enzootic pneumonia (EP) / post-weaning multisystemic wasting syndrome (PMWS)
Vaccination of finisher pigs	Absence of any vaccination / EP (one or 2 dose regime) / Porcine circovirus type 2 (PCV2) / PRRS / Glasser's Disease / Ileitis / Other
Post-weaning mortality	Values for 2008, 2007, 2006
Mortality recording system type	Computer / other
Vet health plan in place on unit	Yes/No

Table 4
Analysis of management related factors related to pleurisy in slaughter pigs.

Variable	Adj. LRT p-value	n	Type	Levels	OR	Lower 95% CI	Upper 95% CI
Herd management	0.00	117	-	AIAO	-	-	-
			-	By room	0.96	0.05	7.2
			-	Mixed	8.2	3.0	24
			-	None	9.3	3.3	29
Shared air	0.00	121	-	False	-	-	-
			-	True	6.5	2.8	17
Number moves (per move)	0.00	119	-	-	2.2	1.5	3.4
Production type	0.00	121	-	Farrow-to-finish	-	-	-
			-	Wean-to-finish	0.10	0.03	0.28
			-	Grow-to-finish	0.45	0.18	1.1
Disinfect between batches	0.00	121	Finisher	False	-	-	-
				True	0.20	0.09	0.44
Downtime (per add. day)	0.00	81	Grower	-	0.84	0.75	0.93
Partial slatted	0.01	80	Weaner	False	-	-	-
				True	21	3.7	400
Number source units	0.01	116	-	0	-	-	-
			-	<=3	0.18	0.07	0.41
			-	>3	0.69	0.13	4.0
Clean between batches	0.01	121	Finisher	False	-	-	-
				True	0.24	0.11	0.51

Table 4 continued:

Variable	Adj. LRT p-value	n	Type	Levels	OR	Lower 95% CI	Upper 95% CI
Downtime (per add. day)	0.01	83	Finisher	-	0.86	0.77	0.94
Feed origin	0.02	104	Grower	Homemix Purchased	- 0.22	- 0.09	- 0.52
Number mixes (per mix)	0.03	120	-	-	2.2	1.4	3.8
Disinfect between batches	0.04	121	Grower	False True	- 0.29	- 0.13	- 0.61
Clean between batches	0.04	121	Grower	False True	- 0.28	- 0.13	- 0.61

Results of independent logistic regression models fitted to each management variable in turn, showing odds ratios (OR) and 95% confidence intervals for the variables shown to be statistically significant at the 5% level from univariable logistic regression models using likelihood ratio tests (LRT) with Bonferroni adjustments. Continuous and discrete variables are shown with a dash in the “Levels” column, with the OR corresponding to the OR per unit increase; for the categorical variables the OR is relative to the referent level, which is always shown first.

Table 5:

Results from a constrained multiple regression model.

Variable	Type	Level	OR	Lower 95% CI	Upper 95% CI
Clean between batches	Grower	False	-	-	-
		True	0.33	0.11	0.89
Number of moves (per move)	-	-	2.3	1.5	3.8
Shared air	-	False	-	-	-
	-	True	4.0	1.4	12

Results from a constrained multiple regression model fitted to ten variables across 110 batches to further investigate the relationship between management factors and pleurisy in slaughter pigs. Continuous (or discrete) variables are shown with a dash in the “Levels” column, with the OR corresponding to the OR per unit increase; for the categorical variables the OR is relative to the referent level, which is always shown first.

Table 6:

Analysis of health related factors related to pleurisy in slaughter pigs.

Variable	Adj. LRT p-value	n	Levels	OR	Lower 95% CI	Upper 95% CI
Mortality 2007	0.00	117	-	1.5	1.3	1.9
APP(farmer or vet declared)	0.00	92	Absent	-	-	-
			Present	8.8	3.4	25
Mortality 2008	0.00	114	-	1.3	1.1	1.6
Mortality 2006	0.00	111	-	1.3	1.1	1.5
Dyspnoea (>30kg) 2007	0.00	121	Absent	-	-	-
			Present	4.8	2.2	11
Dyspnoea (>30kg) 2008	0.01	121	Absent	-	-	-
			Present	4.1	1.9	9.0
Cough (>30kg) 2007	0.03	121	Absent	-	-	-
			Present	4.4	1.8	12
Number of group medications	0.04	117	0	-	-	-
			1-2	3.6	1.5	10
			>=3	9.6	2.7	40
Cough (>30kg) 2008	0.05	121	Absent	-	-	-
			Present	4.0	1.7	10.4
Dyspnoea (<30kg) 2007	0.05	80	Absent	-	-	-
			Present	4.9	1.9	14

Results of independent logistic regression models fitted to each disease associated variable in turn, showing odds ratios (OR) and 95% confidence intervals for the variables shown to be statistically significant at the 5% level from likelihood ratio tests (p-value) with Bonferroni adjustments. Continuous (or discrete) variables are shown with a dash in the “Levels” column, with the OR corresponding to the OR per unit increase; for the categorical variables the OR is relative to the referent level, which is always shown first.

IV. EXTENDED DISCUSSION

The objective of the study was the investigation of health and management factors associated with high and low pleurisy levels in slaughter pigs in the UK. Pleurisy has affected economics of producers and processors for a long time. Since several abattoirs in the UK have threatened producers in 2011 with significant penalties if pleurisy prevalence remains high in their pigs, prevention of pleurisy is now a priority. The study described aimed to optimise the use of existing pig abattoir data, collected by the British Pig Health Scheme, BPHS, by linking them to farm characteristics collected through a questionnaire.

While results were already discussed in chapter III. 2., some findings will be discussed in more depth below.

1. Use of BPHS database

Slaughter pig data are useful in many ways, for example for national health monitoring, epidemiological studies and assessing large numbers of pigs routinely repeatedly as fattening units have a similar output in a certain period. Pig veterinarians were specifically trained for BPHS to guarantee better quality of inspections than from the meat hygiene service by using the knowledge of their veterinary background and by recording data immediately into a handheld computer. The database of BPHS has some limitations which have to be taken into account when interpreting results from this study. Twenty-five percent of commercial pig units were not represented in the BPHS database (BPEX, 2008) and their pleurisy prevalence is not known. It may be possible that these 25% would have influenced the findings. But, at the same time, all large pig producers of the country were represented and their impact on pleurisy prevalence for the industry is presumably more significant.

With regards to population sampled case and control units were only selected if pleurisy prevalence was consistently low or high, i.e. for a minimum of three assessments in the two years prior to October 2008 and if units had 50 pigs assessed (min. 100 pigs delivered) on each assessment. A minimum of 30 animals has been suggested previously as a representative number of animals to be examined (MORRISON et al., 1985).

Affected herds may have not been assessed under the BPHS if they missed the assessment day at the abattoir or their pigs were not assessed at least three times or they submitted less than 100 pigs which may have selected for larger herds. It was necessary to select for consistently affected or unaffected herds because case and control definition as well as questions were based on historical data. Crucially, herds that consistently submit pigs with pleurisy have a bigger impact on the industry and therefore are more important to study. Moreover, it would be expected that herds with consistent levels of pleurisy also have consistent farm characteristics that should allow more reliable answers to the questionnaire.

2. Prevalence

The repairing of fibrous pleural lesions is a long process with a duration of at least one month, more often two to three months (SORENSEN et al**.,** 2006). Therefore prevalence depends on the time of slaughter. If pigs are slaughtered earlier and lesions have less time to resolve, prevalence may appear higher which happened in Denmark where pleurisy prevalence doubled as days to slaughter dropped by 20 days (POINTON et al**.,** 1992). At the same time, pigs with pleurisy suffer reduced growth rate and pigs requiring pleural stripping increased as days to slaughter lengthened (POINTON et al**.,** 1992). On the other hand, as lung lesions progress and regress throughout the lives of pigs, they may have resolved by the time of slaughter (NOYES et al., 1987; MEYNS et al., 2011) leading to an underestimation of herd prevalence of pleurisy. It can be seen that herd diagnosis based on slaughter checks is subject to bias. For herd diagnosis slaughter checks should be compared to and combined with other methods of monitoring (e.g. serological detection of antibodies) (ANDREASEN et al., 2001). However, the slaughter pig database of BPHS was perfectly suitable for the purpose of this study as slaughter pigs with pleurisy were the focus.

Some of the difficulties in controlling pleurisy may be explained by the considerable variation in prevalence between batches of pigs from the same producer which has been found by others as well and may be an indication of disease dynamics on farm (POINTON et al**.,** 1992) or/and of the season (ELBERS et al., 1992).While most pathogens are ubiquitous, susceptibility varies with other factors such as sudden change in temperature or stress due to mixing.

Therefore several batches should be monitored to obtain a reliable measure of pleurisy prevalence (HARTLEY et al., 1988a). This explains why our strict selection criteria were justified although limiting the population studied. Most studies determined prevalence of farms based on one visit to the abattoir (JIRAWATTANAPONG et al., 2010; FABLET et al., 2012b) or once in winter, once in summer (STÄRK et al., 1998).

3. Questionnaire

In this study, information on possible risk factors was collected using a mailed, self-completed questionnaire (Annex). Interviews may have been advantageous with respect to clarification and completion of questions, but would have been more costly, time consuming and each interview would have been slightly different (HULLEY et al., 2001). A questionnaire was chosen as an efficient, uniform and much less expensive method to collect farm information. The response rate of 50% was poorer than expected, but more disturbing for data analysis was the fact that different questions were not answered which prevented multivariate analysis. One issue was the heterogeneity of accommodation which was even different for the same age group. Due to this, the questionnaire could not offer sufficient options, but it also meant that data was difficult to stratify for analysis. Subsequently only a subset of factors was available for multivariate analysis. It was interesting that more control than case units responded which could be an incidental finding, but may be an indication that there is a relationship between communication of on farm health issues and pleurisy prevalence.

4. Factors associated with pleurisy

An important step in tackling respiratory problems in pigs is the identification of risk factors. Many studies have been conducted with the objective to identify risk factors and their relative importance (STÄRK et al., 1998).

4.1. Management factors

Care has to be taken when comparing results from different studies because herd characteristics and populations investigated were often different. ENOE (2002) re-analysed data from MOUSING (1990) accounting for clustering through conventional and SPF herds and found subsequently different risk factors. Other studies have not differentiated between production systems or only looked at farrow-to-finish systems (MAES et al., 2001) or large herds (MERIALDI et al., 2011). This study accounted for the different common production systems in the UK and found that wean-to-finish and grow-to-finish units had lower levels of pleurisy compared to farrow-to-finish systems. Farrow-to-finish systems typically consist of a set of buildings often grown over generations, meaning pigs of different ages and production stages live in close proximity which may well facilitate diseases to circulate in the herd.

All-in/All-out (AI/AO) is a well established management system to control infectious diseases on a pig farm (SCHEIDT et al., 1995). Pigs move through production stages as a group (batches) which is usually defined by age and weight. Once a batch has been moved to the next stage, accommodation is kept empty for some time to allow cleaning, disinfection and drying, reducing pathogen load for the next batch. In accordance with the findings from FRAILE (2010) AI/AO by room compared to AI/AO by unit or building was identified as a risk factor for pleurisy which shows the importance of correct understanding of this control measure. Usually, rooms can't be separated adequately to call it AI/AO. A building with different rooms is usually connected via a door allowing sharing of the same airspace and a common slurry channel. Not practising AI/AO potentially allows circulation of diseases from older to younger age groups (SORENSEN et al., 2006). Interestingly, the risk factors 'sharing of the same airspace', 'number of moves' and 'cleaning between grower batches' remained in the multivariable model, but 'AI/AO' dropped out. These factors characterise an AI/AO management system which may explain why AI/AO itself dropped out.

Also most factors associated with pleurisy from the univariable model such as ‘mixing’, ‘cleaning between finisher batches’, ‘disinfection between grower and finisher batches’ and ‘downtime for growers and finishers’ are characteristics of AI/AO systems. It is worth mentioning that ‘downtime for weaners’ was significant after the first LRT, but just not made it into the univariable model after Bonferroni correction (0.12), but with an AUC of 0.72 indicating good discriminatory power. AI/AO measures aim at reducing transmission of infectious diseases (SORENSEN et al., 2006; AMASS and BASINGER, 2006) which seems to be true for reducing the risk for pleurisy and indicates an association between pleurisy and infectious diseases. This was confirmed by the finding that APP positive herds as declared by the farmer or the herd veterinarian were at higher risk of having pleurisy. The role of APP in pleurisy is furthermore supported by several serological studies (MOUSING et al., 1990; ENOE et al., 2002; FRAILE et al., 2010; MEYNS et al., 2011).

Another protective factor for pleurisy was sourcing weaners from ≤ 3 sources for wean-to-finish and grow-to-finish herds as compared to ‘single’ sourcing of farrow-to-finish herds. If sourced from ≥ 3 units, the association was weaker. This agrees with findings from JORSAL und THOMSEN (1988) that the risk for a pig herd of contracting respiratory disease increases with the number of animal groups introduced and the number of source units. Also herd size (‘number of finishing places’) looked like a significant factor in association with pleurisy, but dropped out after Bonferroni correction.

The use of purchased grower feed versus home mixed feed was found to be protective (OR 0.22). The absence of associations relating to feed at finisher or weaner stage suggests that this finding is artefactual or correlated to other factors such as production type (farrow-to-finish units are more likely to be home mixer), but this could not be ascertained.

Of all factors related to the occurrence of respiratory disease, management factors are particularly important to identify and quantify because they can alter the prevalence of respiratory disease in herds otherwise exposed equally and because preventive management measures can be adapted by the pig producers (CHRISTENSEN and MOUSING, 1999).

4.2. Clinical signs

It is a problem that no typical clinical signs have been identified yet for pigs with acute pleurisy; as most cases will go unrecognised without intervention by the farmer. In the present study coughing and dyspnoea in pigs over 30 kg was associated with pleurisy in 2007 and 2008. In 2007 dyspnoea in pigs less than 30 kg was also related to pleurisy, but not in 2008. It may be speculated that pigs under 30 kg were of better health in 2008 as PCV2 vaccination for piglets and sows was practiced nationwide in the UK, involving more than 75% of the national herd, supported and partly funded by BPEX (WHITE, 2008). However, coughing and dyspnoea are not specific for pleurisy and may be due to pneumonia which has been associated with pleurisy in some studies (ELBERS et al., 1992; JÄGER et al., 2010), but could not be confirmed in others (MEYNS et al., 2011). It may be hypothesised that pigs only show clinical signs if parietal (innervated) pleura is involved as only this is painful, unless pleurisy is severe (FREWEIN, 1999), but this requires further investigation.

Increased mortality was consistently and strongly associated with high pleurisy levels in herds defined as case units in each of the three years data was requested. This finding may be worthy of further investigation as it shows that herds with higher pleurisy prevalence suffer higher economical losses. The number of group medications in finisher pigs was associated with higher pleurisy levels which may be a proxy for the overall (poorer) health of the unit and higher production costs. This could have been supported by ‘number of individual medication’ and ‘Swine dysentery in 2007’ being significantly associated with pleurisy, but these factors were not significant anymore after Bonferroni correction.

4.3. Environment factors

Factors associated with the environment of pigs such as flooring type, indoor or outdoor run, kennel, bedding and type of ventilation were interestingly not significant in relation to pleurisy right from the first analyses and only ‘partial slatted – weaners’ was taken into the univariable model.

Partially slatted flooring in the nursery was associated with pleurisy (OR 21.36), but the large confidence interval suggests that this is not a reliable finding. This may be due to a fairly even distribution of cases and controls for those pigs that were housed in partially slatted accommodation leading to a large standard error which occurs when proportions get close to 0.5.

V. CONCLUSION

In conclusion, this study identified management and health related factors associated with pleurisy based on a questionnaire across 121 respondent units producing slaughter pigs in the UK. The value of the national abattoir pathology surveillance database, BPHS, for risk factor analysis was demonstrated. The identified factors were mostly related to transmission of infectious diseases and the analyses highlighted the importance of all aspects characterising AI/AO but also a group of management factors associated with it. In addition, farrow-to-finish management systems were particularly at risk of having consistently high levels of pleurisy, in part likely due to the difficulty in implementing strict AI/AO in these systems in the UK. Since implementation of complete AI/AO management, for example at the building or unit level, has significant cost implications, a better understanding of the relative importance of specific management factors that contribute to AI/AO and which can be implemented in any production system, is of value to the industry.

With regards to health related factors coughing and dyspnoea as well as higher mortality and increased medication was associated with pleurisy, indicating that farms with high pleurisy levels are of lower health status and suffer increased production costs.

This study demonstrated the value of national-level abattoir pathology data collection systems for case control analyses and generated guidance for on-farm interventions to help reduce the prevalence of pleurisy in slaughter pigs.

VI. SUMMARY

A case-control investigation was undertaken to determine management and health related factors associated with pleurisy in slaughter pigs in England and Wales.

The British Pig Executive Pig Health Scheme database of abattoir pathology was used to identify 121 case (≥10% prevalence of pleurisy on 3 or more assessment dates in the preceding 24 months) and 121 control units (≤5% prevalence of pleurisy on 3 or more assessment dates in the preceding 24 months). Farm data were collected by postal questionnaire. Data from respondents (70 cases and 51 controls) were analysed using simple logistic regression models with Bonferroni corrections. Limited multivariate analyses were also performed to check the robustness of the overall conclusions.

Management factors associated with increased odds of pleurisy included 'no all-in all-out pig flow' (OR 9.3, 95% confidence interval [CI]: 3.3–29), 'rearing of pigs with an age difference of >1 month in the same airspace' (OR 6.5 [2.8–17]) and 'repeated mixing' (OR 2.2 [1.4–3.8]) and 'moving' (OR 2.2 [1.5–3.4]) of pigs during the rearing phase. Those associated with decreased odds of pleurisy included 'filling wean-to-finish or grower-to-finish systems with piglets from ≤3 sources' (OR 0.18 [0.07–0.41]) compared to farrow-to-finish systems, 'cleaning and disinfecting' of grower (ORs 0.28 [0.13–0.61] and 0.29 [0.13–0.61]) and finisher (ORs 0.24 [0.11–0.51] and 0.2 [0.09–0.44]) accommodation between groups, and 'extended down time' of grower and finisher accommodation (OR 0.84 [0.75–0.93] and 0.86 [0.77–0.94] respectively for each additional day of downtime). This study demonstrated the value of national-level abattoir pathology data collection systems for case control analyses and generated guidance for on-farm interventions to help reduce the prevalence of pleurisy in slaughter pigs.

VII. ZUSAMMENFASSUNG

Die vorliegende Arbeit beschreibt eine Fall-Kontroll-Studie, deren Ziel es war, Management- und Gesundheitsrelevante Faktoren für Pleuritis bei Schlachtschweinen in England und Wales zu bestimmen.

Zur Identifizierung der 121 Fall- und 121 Kontrollbetriebe wurde die Datenbank für Schlachtkörperpathologie des British Pig Executive Pig Health Scheme genutzt. Betriebe mit ≥10% Pleuritis Prävalenz in den letzten 24 Monaten an 3 oder mehr Terminen, galten als Fallbetriebe, und Betrieb mit ≤5% Prävalenz als Kontrollbetriebe. Informationen über den Mastbetrieb wurden mit Hilfe eines Fragebogens gesammelt. Die Daten von 51 Fall- und 70 Kontrollbetrieben wurden mit Hilfe einfacher logistischer Regressionsmodelle mit Bonferroni Korrektur analysiert. Limitierte Multivariat-Analyse wurde durchgeführt, um die Robustheit der Ergebnisse zu testen.

Mit Bezug auf Managementfaktoren, waren ‘kein AI/AO’ (OR 9.3, 95% confidence interval [CI]: 3.3–29), ‘gemeinsame Aufzucht von Schweinen mit über 1 Monat Altersunterschied’ (OR 6.5 [2.8–17]), wiederholtes Regruppieren (OR 2.2 [1.4–3.8]) und wiederholtes Umstallen (OR 2.2 [1.5–3.4]) von Schweinen während der Aufzucht mit erhöhten Odds für Pleuritis assoziiert.

Betriebe mit Aufzucht und Mast, sowie reine Mastbetriebe (OR 0.18 [0.07–0.41]) hatten ein verringertes Risiko für Pleuritis, wenn sie ihre Tiere von ≤ 3 Betrieben bezogen, verglichen mit Betrieben, die Zucht, Aufzucht und Mast auf dem selben Hof hatten. Auch ‘Reinigen und Desinfizieren von Läufer- und Mastschweineställen’ zwischen Gruppen (ORs 0.28 [0.13–0.61] und 0.29 [0.13–0.61], ORs 0.24 [0.11–0.51] und 0.2 [0.09–0.44]), sowie ‘verlängerte Leerzeit’ von Läufer- und Mastställen (OR 0.84 [0.75–0.93] und 0.86 [0.77–0.94] je zusätzlichen Tag ohne Schweine), waren Faktoren, die geringere Odds für Pleuritis aufwiesen.

Abschließend läßt sich sagen, daß die vorliegende Arbeit den Nutzen von landesweiten pathologisch-anatomischen Untersuchungsdaten vom Schlachthof für Fall-Kontrollstudien aufgezeigt hat. Außerdem wurden Faktoren generiert, die für Interventionen auf dem Hof eingesetzt werden können und zur Verringerung der Prävalenz von Pleuritis bei Schlachtschweinen beitragen.

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IX. LIST OF TABLES AND FIGURES

List of tables and figure of the publication:

Factors Associated with Pleurisy in Pigs: A Case-Control Analysis of Slaughter Pig Data for England and Wales

X. ANNEX

Questionnaire:
RISK FACTORS FOR PLEURISY IN SLAUGHTER - PIGS

A survey conducted by: The Pleurisy Study Team, Department of Vet Medicine, University of Cambridge, Madingley Road, Cambridge, CB3 0ES.

You can call us at any time with queries about this questionnaire:
Dan Tucker 01223 330885 (0788 795 1447); Henrike Jäger 01223 764961 (07914 717109).

Owner's name:	
Manager's name:	
Farm Address:	
Postcode:	
Telephone:	
CPHH Number(s):	
Marketing Group:	
Slap mark:	
Farm Assurance:	
Vet. name and practice:	
Vet. contact tel. number:	

Signature	Date

Unit owner/manager signature to permit sharing of data between Cambridge and RVC

Comments

1. GENERAL FARM INFORMATION

1.1. What type of production is your farm? Please tick

Type of production		✓
Farrow-to-finish unit		☐
Wean-to-finish unit over the last year each batch was supplied by:	1 breeding unit	☐
	2 breeding units	☐
	3 breeding units	☐
	>3 breeding units	☐
	varied	☐
Grow-to-finish unit over the last year each batch was supplied by:	1 weaner unit	☐
	2 weaner units	☐
	3 weaner units	☐
	>3 weaner units	☐
	varied	☐

1.2. Please indicate the total number of finishing places on your unit: _____ places

1.3. How close is the nearest pig farm in miles? _____ miles

1.4. How many years has the senior stockperson worked with pigs? _____ years

1.5. Do any of the stockpeople participate in:

- ☐ Local pig discussion groups
- ☐ BPEX knowledge transfer meetings or visits
- ☐ National events such as the Pig and Poultry Fair
- ☐ None of the above

1.6. Breeding units: Has the unit undergone a depopulation / repopulation program in recent years? Yes ☐ No ☐

1.6.1. If yes, how many years ago? _____

2. MORTALITY AND PRODUCTIVITY

2.1. Please supply the following data on post-weaning mortality in % where applicable to your unit and the recording system you use.

Type of unit	**Mortality in %**			**Recording system** (please tick)	
	2008	**2007**	**2006**	**Computer**	**Other system**
Farrow-to-finish unit				☐	☐
Wean-to-finish unit				☐	☐
Grow-to-finish unit				☐	☐

Comments

3. HEALTH STATUS

3.1. Does your unit have a veterinary health plan? Yes ☐ No ☐ Don't Know ☐

3.2. What pig diseases were present on your farm in the past? (Please tick)

Few = some cases, but not resulting in intervention at herd level (treatment, vaccine)
Many = numerous cases, resulting in intervention at herd level

Disease	In 2008			In 2007		
	Not seen	Few	Many	Not seen	Few	Many
Scours:						
Younger pigs (7-30 kg)						
Older pigs (>30 kg)						
Sneezing:						
Younger pigs (7-30 kg)						
Older pigs (>30 kg)						
Coughing:						
Younger pigs (7-30 kg)						
Older pigs (>30 kg)						
Heavy breathing:						
Younger pigs (7-30 kg)						
Older pigs (>30 kg)						
Meningitis (pig paddling)						
Wasting:						
Younger pigs (7-30 kg)						
Older pigs (>30 kg)						
Sudden deaths:						
Younger pigs (7-30 kg)						
Older pigs (>30 kg)						
PDNS-type						
Other: (please specify)						

3.3. Please indicate the health status of your finishing herd for the following respiratory diseases (you may wish to check with your vet at the next visit)**:** (Please tick)

Disease	Believed present	Confirmed by vet	Absent	Don't know
Enzootic pneumonia				
Glässer's disease				
Pleuropneumonia (APP)				
PRRS (Blue Ear)				
PMWS (Wasting disease)				

Comments

3.4. For 2008, what <u>vaccines</u> will finishers on your unit have received in their life?

Vaccine to prevent	Information unavailable	Name of product	Age at administration
Enzootic pneumonia One shot			
Enzootic pneumonia Two shots			
PRRS - live			
PRRS - killed			
PMWS / PCV2 Sow vaccination			Not applicable
PMWS / PCV2 Piglet vaccination			
Glässer's disease			
Ileitis			
Other (please state)			

3.5. Which medicines are <u>currently</u> used at group level on the unit including routine medication?

Product	Age of medicated pigs (weeks)	Anticipated duration of medication (weeks)	Methods of medication Please tick		Reason for medication
			In feed	In water	
			☐	☐	
			☐	☐	
			☐	☐	
			☐	☐	
			☐	☐	

3.6. How many pigs were given antibiotics by injection in the last week?
Note: For breeding units, please don't count breeding or unweaned pigs.

Number of pigs	Please tick
0	☐
1-5	☐
6-10	☐
11-20	☐
>20	☐

3.6.1. What was the main reason for treatment? _____.

Comments

4. HERD ENVIRONMENT

4.1. Select the closest description of accommodation for each applicable stage of production (tick more than one box where you have a mixture of housing for the same age-group).

Accommodation type		**Weaning – 30 kg** Please tick	**>30 kg – slaughter** Please tick
Fully slatted		☐	☐
Partly slatted		☐	☐
Straw yards		☐	☐
Pen without kennel	no straw + indoor run	☐	☐
	no straw + outdoor run	☐	☐
	+ straw + indoor run	☐	☐
	+ straw + outdoor run	☐	☐
Kennel	no straw + indoor run	☐	☐
	no straw + outdoor run	☐	☐
	+ straw + indoor run	☐	☐
	+ straw + outdoor run	☐	☐
Outdoor tent	no paddock	☐	☐
	+ paddock	☐	☐
Other accommodation		☐	☐
Assisted ventilation		☐	☐

5. HERD MANAGEMENT

5.1. How many times are pigs moved to different accommodation on your farm (count the arrival move / move from farrowing to weaning accommodation, but not to slaughter)?.....times.

5.2. a) Farrow-to-finish unit: How many times are pigs mixed (not split) into new groups between weaning and finishing?.....times.

b) Finishing units: How many times are pigs mixed (not split) into new groups after arrival on your unit (count any mixing at point of arrival) ?.....times.

5.3. Are gilts and boars separated in the finishing stage?

Yes ☐ No ☐

5.4. Do you operate an All-in/All-out (AIAO) system?

	7-30 kg	30-50 kg	50 kg-Slaughter
No AIAO			
AIAO by pen			
AIAO by room			
AIAO by building			
AIAO by paddock			
AIAO by unit			
Approximate downtime (days)			
Cleaning between batches			
Disinfection between batches			

5.5. Do pigs with an age difference of more than 1 month share the same airspace in any of the buildings on your unit?

☐ **Yes** ☐ **No**

5.6. Considering all the buildings on your unit, what is the maximum number of pigs that share the same airspace? _____ pigs

5.7. Feeding regime (please tick)

	Meal	Pellets	Wet feed	Home - Mix	Purchased Compound	By-product	Ad lib	Restricted
7-30 kg	☐	☐	☐	☐	☐	☐	☐	☐
30-50 kg	☐	☐	☐	☐	☐	☐	☐	☐
50 kg-Slaughter	☐	☐	☐	☐	☐	☐	☐	☐

Thank you for taking your time to provide this valuable information!

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