



SWINE HEALTH MANAGEMENT

*Guide to prevent and control porcine
reproductive and respiratory syndrome*

Volume 2



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Guide to prevent and control porcine reproductive and respiratory syndrome

Food and Agriculture Organization of the United Nations
Regional Office for Asia and the Pacific
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Foreword

With the increase in worldwide demand for meat, fast-growing species with efficient feed conversion rates – such as pigs – are likely to account for a major share in the growth of the livestock sector. The increase in animal numbers is not spread evenly round the globe: Asia leads the increase, whereas pig numbers in North America and Europe are increasing more slowly or holding steady. In Africa, pig numbers have recently grown more rapidly, reflecting increased adoption of pig husbandry in a continent where “livestock” has traditionally been taken to mean “ruminants”.

Commercial pig production has intensified significantly in recent decades. More pigs of the same few breeds are kept on fewer farms, with increased output of animal products. Large-scale production systems have achieved a high level of uniformity because they are based on the same genetic material and therefore provide similar feed and infrastructure for the animals.

In developing countries, half of the current pig population is still kept in traditional small-scale, subsistence-driven production systems in which pigs provide much more than meat. Pigs in such low-input systems provide value-added for farmers by consuming feed that would otherwise be lost. Hence pork might contribute to food security and provide protein, but the animals might also constitute a financial safety net, fulfil a role in cultural traditions, or provide additional cash for school fees, medical treatment or small investments.

The swine growth trend across Asia is characterized by an increase in production stemming from an increase in herd size. As more and more gilts and young sows populate herds, the risk of disease from these young animals increases. These problems are compounded by the growing movement of animals and the risks of the introduction of new diseases. Hence there are a greater number of reports of swine disease outbreaks such as foot and mouth disease (FMD), porcine reproductive and respiratory syndrome (PRRS) and classical swine fever (CSF). Smallholders and even larger producers face major constraints in actively participating in livestock development opportunities due to the heavy burden imposed by such diseases. The adverse socio-economic impacts of such diseases are significant, particularly in developing countries where the livestock sector shapes prospects for economic growth, poverty alleviation and food security.

This publication is a three-volume set showcasing effective swine disease management in smallholder settings through field surveillance, diagnostic support and the application of good herd health management. The first volume – Volume 1: Handbook on swine health field surveillance – aims to guide national animal health frontline staff in conducting field surveillance in swine herds. This volume – Volume 2: Guide to prevent and control porcine reproductive and respiratory syndrome – provides examples on how to prevent, control and respond to outbreaks of PRRS,

which have been reported in at least six countries in Southeast Asia. The third volume – Volume 3: Frequently asked questions on pig biosecurity and disease reporting – is a compilation of answers to questions raised by pig producers in the course of doing field work on swine health management. These three volumes are an attempt by the Food and Agriculture Organization of the United Nations (FAO), in consultation with other swine health experts, to provide practical information for animal health frontline staff in responding to the needs of smallholder pig producers.

It is hoped that collective action to control and eradicate or manage swine diseases through sharing of information on regional disease control efforts, tools and methods will result in preventing the occurrence and spread of swine diseases in the region.

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Abbreviations and acronyms

CARD	Collaboration for Agriculture and Rural Development
CSF	Classical swine fever
DLF	Department of Livestock and Fisheries
EDTA	Ethylenediaminetetraacetic acid
FAO	Food and Agriculture Organization of the United Nations
GPS	Global Positioning System
MLV	Modified live virus vaccines
OIM	Outbreak investigation and management
PCV-2	Porcine circovirus type 2
PRRS	Porcine reproductive and respiratory syndrome
RT-PCR	Reverse transcription polymerase chain reaction
SIV	Swine influenza virus

Introduction

Porcine reproductive and respiratory syndrome (PRRS) is an easily transmitted infectious disease of pigs affecting the pig industry worldwide. It is characterized by reproductive failure in sows and respiratory distress in piglets and fattening pigs and is the cause of significant production and economic losses (Beltran-Alcrudo *et al.*, 2007). In the United States alone, PRRS is estimated to cause about US\$560 million in losses per year to the swine industry (Neumann *et al.*, 2005).

Since 2006, the pig industries in China, the Philippines, Thailand and Viet Nam have been affected by atypical highly virulent strains of PRRS. Unlike other PRRS outbreaks in China and historical PRRS outbreaks worldwide, this form of PRRS virus is more virulent and many adult pigs and pregnant sows died. In 2010, other countries in Southeast Asia reported the disease, including Cambodia and the Lao People's Democratic Republic.

For any disease control measures to be effective, knowledge of the disease is crucial. This handbook presents the most important features used to recognize PRRS. The section on outbreak investigation and management (OIM) identifies the steps to effectively investigate and manage outbreaks. It is intended for use by veterinary staff on the frontline of defence. It also aims to inform farmers and traders about good practices to prevent and manage PRRS. Although the focus is on PRRS, the handbook presents information and measures that are also applicable to other pig diseases.

The different measures recommended in this handbook are based on publications, manuals and reports which are listed for further reading. This handbook will be periodically reviewed and revised as more information is obtained on PRRS and its control and as more practical, applicable biosecurity practices have been tried and proven effective in the field.

The disease

What is porcine reproductive and respiratory syndrome?

Porcine reproductive and respiratory syndrome or PRRS is a pig disease caused by a virus. PRRS weakens the pig's immunity and makes it susceptible to bacteria and other viruses. This is why infections with other diseases like Classical Swine Fever (CSF) and Porcine Circovirus Type 2 (PCV-2) can occur at the same time, causing more serious problems in affected farms. There is no specific treatment for PRRS (Animal Health Australia, 2004).

Common Concurrent Infections with PRRS

- *Streptococcus suis*
- *Haemophilus parasuis*
- *Mycoplasma hyopneumoniae*
- *Pasteurella multocida*
- *Actinobacillus pleuropneumoniae*
- *Pseudorabies virus (Aujeszky's disease)*
- *Classical swine fever (CSF)*
- *Porcine circovirus type 2 (PCV-2)*
- *Swine influenza virus (SIV)*

PRRS is also known as mystery swine disease, blue ear disease, porcine endemic abortion and respiratory syndrome (PEARS) and swine infertility respiratory syndrome (SIRS).

Clinical signs of PRRS

The clinical signs may differ between herds depending on the strain of the PRRS virus that caused the disease, the health status of the pigs (presence or absence of other infections) and farm management practices. In general, reproductive failures in the breeding stock and respiratory problems in pigs of all ages are seen (FAO, 2008). Younger pigs are more often affected than older animals, with unbred boars and sows frequently showing no signs of the disease (OIE, 2010). The incubation period ranges from 3 to 37 days (Benfield *et al.* 1999, Meredith 1995).

The clinical signs of PRRS are similar to other viral or bacterial pig diseases, thus the diagnosis should not be based only on clinical signs and post-mortem examinations. A diagnosis should be confirmed by laboratory tests (FAO, 2011).

Clinical signs in breeders

- Inappetence in sows and boars lasting up to four days,
- Fever (normal temperature is 39°C),
- Premature farrowing and abortion,
- Death in up to 10 percent or more of sows,
- Mastitis and agalactia (no milk),
- Sometimes loss of balance or circling, and
- Reddening of the skin or purple/blue discolouring (cyanosis) of the ears occurs in 1 to 2 percent of affected animals.



Figure 1 Reddish to blue discoloration (cyanosis) and blotching of the skin can be observed, most often of the ears. This gives PRRS the name “blue ear disease”
Photo courtesy of Department of Animal Health, Viet Nam



Figure 2 Sow with severe weight loss and agalactia
Photo courtesy of Department of Animal Health, Viet Nam

Clinical signs in affected litters

- Mummified piglets or “mummies”,
- Stillborn piglets,
- Weak piglets that die shortly after birth because of secondary bacterial infections,
- Edema of the eyelids, and
- Pre-weaning mortality up to 33 percent.



Figure 3 Progressive death of foetuses in a litter can be seen in infection with the PRRS virus
Photo courtesy of Chulalonghorn University, Faculty of Veterinary Science, Thailand



Figure 4 Stillbirths require investigation
Photo courtesy of Department of Livestock and Fisheries, Lao PDR



Figure 5 Edema in the eyelids of a piglet
Photo courtesy of Chulalonghorn University,
Faculty of Veterinary Science, Thailand



Figure 6 Some piglets are born weak and easily
succumb to secondary bacterial infections
Photo courtesy of Chulalonghorn University,
Faculty of Veterinary Science, Thailand

Clinical signs in weaned and growing pigs

- Loss of appetite,
- Sluggish movement,
- Laboured or rapid breathing (pneumonia),
- Blotchy reddening of the skin (haemorrhages),
- Rough hair coat, and
- Huddling.



Figur 7 High fever and blotchy reddening of the
skin are observed in PRRS infection (sometimes
called “blue ear disease” or “red pig disease”)
Photo courtesy of DAH, Viet Nam



Figure 8 Skin haemorrhages on the posterior and hind legs
Photo courtesy of BAI, Philippines



Figure 9 Pigs exhibit “huddling” or crowding together to find warmth. This could be a sign of fever
Photo courtesy of DAH, Viet Nam

Behaviour of PRRS virus in the herd

The PRRS virus is highly infectious and persists in infected pigs which shed the virus for an extended period of time. Adult pigs shed the virus for 14 days, while growing pigs can excrete it for 1 to 2 months (The PigSite.com, 2011). Most infected pigs eventually become immune, however, the infection will remain in the farm as long as there are uninfected pigs or when new animals are introduced to the farm that can get infected from shedding animals. When this happens, the cycle of infection and transmission to susceptible animals will continue and PRRS may remain active indefinitely. To prevent this from happening, some breeding farms “stabilize” the infection by assuring immunity in all breeding stock, practice segregated rearing of offspring and acclimatization of replacement breeding stock, or a combination of these strategies (Iowa CVM, 2011).

The next section describes the clinical symptoms of different age groups and how the disease progresses when PRRS infects a herd.

Breeding herd

The initial phase of inappetence and fever will often take 3 to 6 weeks to move through the breeding herd. Cyanosis or blueing of the ears is not common and less than 5 percent of sows show it. Coughing occurs in some sows and a few pneumonia cases may occur. This acute phase lasts for up to six weeks and is characterized by early farrowings, increase in stillbirths, weak pigs and an increase in the number of large mummified pigs that have died in the last three weeks of pregnancy. In some herds, these indications may be seen in up to 30 percent of the total pigs born.

Stillbirths, abortions and piglet mortality peaks at 70percent in week 3 or 4. Reproduction and fertility rates return to pre-infection levels off after 8 to 12 weeks. The reproductive problems may persist for 4 to 8 months before returning to normal.

Piglets

Sows infected with PRRS virus during pregnancy can abort or carry full term. The piglets are mummified, born dead (stillborn), or very weak. Many are unable to suckle. Splay leg, diarrhoea, pneumonia and coughing are commonly observed. Some newborn piglets may have a sticky brown material over their eyelids and very occasionally small blisters on the skin. Over time, health improves and more piglets survive.



Figure 10 Acute PRRS outbreaks cause a dramatic increase in weak-born piglets, stillbirths and mummified piglets
Photo courtesy of VLA, UK



Figure 11 Piglets look in poor condition and some eventually die
Photo courtesy of CU-FVS, Thailand



Figure 12 Piglet with splayleg
Photo courtesy of PORTEC Veterinary Service

Weaned and growing pigs

When the PRRS virus infects a naive herd for the first time, there are no, or very mild, clinical signs (reduced feed intake and mild coughing). The clinical signs become severe when other diseases like enzootic pneumonia are also present in the farm.

Once the acute period has passed through the breeding and finishing herd, PRRS virus infection only then becomes of significance in the growing period. Pigs become infected as maternal antibodies disappear and then remain viraemic for 3 to 4 weeks, continually excreting virus. The disease is seen in pigs from 4 to 12 weeks of age and is characterized by inappetence, wasting, coughing and pneumonia. Secondary bacterial infections become evident in pigs from 12 to 16 weeks of age, many showing lameness. Mortality rates are up to 12 to 15 percent.



Figure 13 Swollen eyelids and nasal discharge are commonly seen in pigs affected with PRRS
Photo courtesy of DAH, Viet Nam

Figure 14 Lameness in animals infected with PRRS
Photo courtesy of DLF, Lao PDR



Does PRRS affect humans?

The PRRS virus only causes disease in wild or domestic pigs. However, sick animals, regardless of the cause, should not be slaughtered for human consumption. Carcasses or scraps from sick or dead animals should not be fed to other animals and should be disposed of in a proper manner (FAO, 2008). PRRS infected animals may also be co-infected with other bacteria like *Streptococcus suis*, which can infect humans when they handle infected pig carcasses or meat (Huang *et al.*, 2005).

PRRS prevention

The primary means of control is to prevent infection. Critical measures to prevent viral introduction are understanding the PRRS status of replacement gilts and boars, and isolation and acclimatization of incoming stock.

Trading pigs

The main source of the PRRS virus is an infected pig (The Merck Veterinary Manual, 2011). The other pigs can get sick when they come into contact with the infected pig and its mucus, saliva, urine, milk, colostrum, and faeces.

Once this happens, the disease can quickly spread, especially if biosecurity measures are not in place. It is important to separate (quarantine) newly introduced animals from the old stock for a minimum of 30 days to prevent the introduction of diseases through replacement animals.

It is not uncommon for owners to sell animals as soon as disease is suspected. This should be discouraged. The marketing of sick animals is a serious risk. (FAO/OIE/WB, 2010). In addition to infecting other pigs in the market, people and materials may be virus carriers and spread the disease as well. Farm staff, farm owners and people working with pigs should avoid visiting other pig farms, slaughterhouses and live animal markets (or adhere to strict biosecurity measures).



Figure 15 Direct contact (especially nose-to-nose contact) between sick and healthy pigs is the main mode of transmission of PRRS
Photo courtesy of ITCPH, Philippines

Figure 16 Most live animal markets do not have biosecurity measures in place and diseases can easily be transmitted from one animal to the other
Photo courtesy of afistfulofgears.co.uk



The uncontrolled movement of infected animals is one of the reasons for the spread of PRRS. The virus spreads to susceptible pigs during transportation and at the destination. Drivers and pig traders can act as mechanical carriers of the virus and so spread the disease.



Figure 17 Close contact between pigs during transportation also allows for the transmission of viruses and bacteria between sick and healthy pigs
Photo courtesy of NFMDTF, Philippines

Semen

The virus is infectious in semen for up to 43 days after infection of the boar (Hill, 1996). Infected semen can transmit the virus to gilts or sows. Do not use boars with an unknown health status. Boars to be used either as a source of semen or for natural mating must be certified free of PRRS and other diseases. If this is not possible, they should come from areas with no known cases of PRRS.

Biosecurity

Vehicles and equipment

- Assign separate vehicles for use within and outside the farm.
- Transport vehicles must be carefully cleaned and disinfected before leaving and entering the farm.
- Loading zone location must be located outside the farm to prevent disease entering the farm. Close contact with the animals in the farm.
- Truck drivers and traders should not enter the farm.
- Wheel baths if vehicles have to enter the farm; make disinfectant wheel baths at each entrance; a disinfectant sprayer can be used as a substitute for a wheel bath.
- Clean and disinfect tools and equipment before and after use. Clean and disinfect between pens to prevent transfer of disease. Do not use equipment from another farm.



Figure 18 Contaminated vehicles can be a source of the PRRS virus and must be thoroughly cleaned and disinfected
Photo courtesy of UMCVM, USA

Visitors and workers

- **Visitors.** Limit the number of visitors and do not allow unnecessary contact with farm animals.
- **Farm-specific clothing and footwear.** Visitors and workers must change their clothes before entering the farm. Specific coveralls and boots should be available in all facilities and washed regularly. Boots should never leave the farm and should be washed and disinfected thoroughly.
- **Foot baths.** Installing footbaths at every pen entrance can help reduce the risk of PRRS virus transfer between groups of pigs. The disinfectant solution should be changed at least every day to remain effective.
- **Farm workers.** Workers should not be allowed to raise pigs at home and should avoid visiting live animal markets and slaughterhouses. If visits to those facilities cannot be avoided, downtime and cleaning and disinfection should be strictly followed.
- **Signage.** Provide signs asking visitors to comply with the farm's biosecurity measures.



Figure 19 A basin with water and disinfectant can be used in place of a fixed foot bath.
The disinfectant should be changed daily to maintain effectiveness
Photo courtesy of Luc Ledoux

Pens

- **Pens with animals.** Regularly clean pens of faeces, urine and other dirt.
- **Pens without animals.** In all-in-all-out operations, pens can be thoroughly cleaned and disinfected before the introduction of new animals (see Annex 2).
- **Feed troughs.** Clean regularly to avoid faecal contamination. Excess feed will attract insects, birds and other animals that may transmit disease.



Figure 20 Regularly clean pig pens to remove waste materials
Photo courtesy of ITCPH, Philippines

Feed

- **Feed storage.** Keep feed in a clean, dry storage area. Ensure that insects and pests cannot access the feed.
- **Pig meat.** No fresh or frozen pig meat from outside should be brought into the farm.
- **Disposal of dead animals.** Properly dispose of dead animals by burying or incinerating. Never allow rendering trucks on the farm.



Figure 21 Feed should not be accessible to insects and other animals
Photo courtesy of PORTEC Veterinary Service

Cleaning and disinfection

- Disinfect contaminated vehicles and areas at feed factories and slaughterhouses.
- All vehicles transporting animals and animal products must be cleaned and disinfected before leaving contaminated areas.
- A cleaning and disinfection area may be established at checkpoints to ensure compliance.



Figure 22 Vehicles transporting animals and animal products must be disinfected before leaving contaminated areas
Photo courtesy of NFMDTF, Philippines

Airborne spread

The PRRS virus can be transmitted by air, especially during periods of low temperature, high humidity, and low wind speed. Ideally, farm facilities must not be within 1.5 km of another pig farm.

Spread by objects, instruments and people

Sharing needles between batches of pigs can spread the PRRS virus. Veterinarians should use new or disinfected needles at every farm. New or disinfected needles and syringes must be used between batches of pigs in the farm.

The hands, coveralls and boots of farm personnel can potentially transmit PRRS virus. The same is also true for tools and equipment borrowed from other farms. These practices should be avoided as much as possible. Coveralls, boots, gloves and equipment specific for the farm must be used and should not leave the farm and should be cleaned and disinfected regularly.

The practice of allowing traders to visit the pigs for sale in the pens is very risky and should be avoided as much as possible.

Visitors and farm personnel who have their own pig farms or have visited facilities such as live animal markets and slaughterhouses can spread the virus. Visitors should not be allowed on the farm and staff should change clothing, shower and clean and disinfect every time they enter the farm.

One night of downtime and shower-in-shower-out for persons exposed to pigs in other farms/facilities is recommended.

The use of effective foot baths can help reduce the risk of PRRS virus transfer between farms and between groups of pigs on a farm. The disinfectant in the foot baths should be changed at least daily to remain effective.

Insects and other animals (fomites)

The PRRS virus can be transmitted by houseflies and mosquitoes up to a distance of 2 km.

Eliminate insect breeding areas by cutting grass and removing stagnant water (Pitkin *et al.*, 2006).

Chickens and mallard ducks shed the PRRS virus in their faeces and so transmit the virus.

The pig fence should be inaccessible to chickens and ducks to prevent contact with their faeces.



Figure 23 Pig pens should be inaccessible to other animals like chickens and ducks which could transmit diseases and parasites to pigs and vice versa
Photo courtesy of DLF, Lao PDR

Swill feeding

Do not feed pigs with raw pig meat. Raw meat from sick pigs can transmit the PRRS virus when eaten by other pigs. The PRRS virus can remain virulent (infective) in meat or food and can infect pigs. Swill must be heated to a minimum temperature for a sufficient period (100°C for at least an hour) (FAO/OIE/WB, 2010).

Movement control

Backyard farmers, commercial fattening farms and dealers should stop selling and buying sick pigs.

Live animal movement between districts and provinces can be monitored and controlled by setting up checkpoints.

Pig meat and pig products can be moved, but should not come into contact with live animals

Swill should be cooked thoroughly before feeding to pigs.

PRRS vaccines

Vaccination is an effective tool to control PRRS if used correctly. The purpose of vaccination is to produce an immune response that will protect against clinical disease, but it does not prevent infection. Vaccinated animals may shed the vaccine virus and infect unvaccinated animals. When modified live virus vaccines are used in pregnant sows and gilts, the vaccine virus may infect the foetuses in the uterus resulting in stillbirths, mummies and weak piglets. Vaccinated boars may shed the virus in their semen and infect sows and gilts during natural mating or when artificial insemination is used. The vaccination protocol needs to be farm-specific and should be followed strictly.

Inform the public

Inform the public about PRRS outbreaks. Informing and ensuring the cooperation of pig owners can be facilitated through information dissemination at village level meetings. Annex 3 lists some key messages for pig owners.

PRRS control

Manage and treat sick animals

Advise the local veterinary services and farmers how to treat and manage sick pigs. There is no specific treatment for PRRS. Attempts to reduce fever using NSAID (aspirin) or appetite stimulants (B vitamins) appear to have minimal benefit. Antibiotic treatments are only for the prevention of secondary bacterial infections.

Separate healthy and sick pigs. Sick pigs must be immediately separated from healthy pigs. Ideally, the distance of the isolation pen for sick animals must be at least 100 m from healthy animals and located to prevent spread of disease through movement, wind and surface drainage systems.



Figure 24 Sick, isolated animals and their discharges should not have contact with the rest of the herd.
The separation of sick and healthy pigs shown in the picture will not prevent the spread of PRRS and other diseases
Photo courtesy of DLF, Lao PDR

Treatment of adult pigs

To prevent secondary bacterial infections in the acute disease phase, medicate with antibiotics (in the feed or water or by individual injections) for up to six weeks. Broad spectrum antibiotics: tetracyclines, trimethoprim/sulpha, or synthetic penicillins are the medicines of choice. Use 500 to 800 g of tetracycline or trimethoprim/sulpha 400g/tonne in the feed. If facilities are available, it would be advisable to identify the major bacteria involved and determine their antibiotic sensitivities.

Treatment of piglets

- Piglets should be injected with either long-acting oxytetracycline or amoxicillin on days 3, 7 and 14 after farrowing.
- Give artificial colostrum if needed.
- Give electrolytes to counteract dehydration.
- Provide extra bedding. Use shavings or other suitable materials to create the best environment for the piglet.
- Iron injection and teeth clipping should be delayed.
- If cold, provide an extra lamp for heat.
- Euthanize any piglets that do not respond to treatment. Do not put sick piglets with non-affected pigs.



Figure 25 Creep boxes help keep piglets dry and warm during the suckling period
Photo courtesy of CARD Project, Viet Nam

Vaccination

The purpose of vaccination is to produce an immune response that will protect against clinical disease. Vaccination will not stop infection. It is important to develop farm-specific vaccination programs, based on individual farm diagnostic data, rather than promote standardized protocols.

Due to the necessity of cell-mediated immunity to control PRRS, modified live virus (MLV) vaccines appear to be more efficacious than killed preparations. However, modified live vaccines should not be used in PRRS virus-negative herds, pregnant females, or breeding age boars.

Combination vaccine products have also been brought to the market recently, including PRRS virus and *Haemophilus parasuis*, PRRS virus, *Haemophilus parasuis*, and *Erysipelothrix rhusiopathiae*, and PRRS virus, parvovirus, and *Leptospira interrogans* spp.

Outbreak investigation and management (OIM)

Outbreaks are investigated to identify the cause and source of the outbreaks. Investigations may help to identify ways to prevent further transmission of diseases and eventually prevent future outbreaks. For purposes of this handbook, PRRS is used as the suspect disease.

Steps in the investigation of outbreaks

An investigation must be conducted systematically. The procedure for an outbreak investigation involves the following 10 steps (Sharma and Baldock, 1999). In practice, several steps will be undertaken simultaneously. Each step is thoroughly discussed in Annex 1.

Table 1. Steps in the investigation of outbreaks

1	Define a PRRS “case.”
2	Farm selection.
3	Prepare for field work.
4	The field investigation.
5	Analyse the data.
6	Undertake intensive follow-up investigations.
7	Implement control and preventive measures. Formulate working hypotheses to identify the possible sources of infection and modes of spread.
8	Report the findings of the investigation.

Biosecurity protocols for the team

It is important that investigators observe farm biosecurity measures when conducting outbreak investigations to avoid spreading the virus. As a rule, only one farm should be visited by a team in one day.

Arriving at the farm

- If available; use shower-in-shower-out facilities and change clothes and boots.
- If no showers are available, prepare a disinfection and cleaning station using effective disinfectants.
 - Brush, clean and disinfect boots.
 - Wear scrub suits and coveralls and disinfect.
 - Wash hands before going to the pens.

Leaving the farm

When leaving the farm:

- Wash boots again.
- Place boots in a plastic bag with the used coveralls.
- Wash and sanitize hands.

The vehicle used by the team should be cleaned and disinfected after each farm visit.



Figure 26 Clean scrub suits, coveralls and boots should be used during investigation
Photo courtesy of BAI, Philippines

Samples to be collected

During PRRS outbreak investigations, the following diagnostic specimens should be collected to confirm the field diagnosis:

Blood samples

- **For virus isolation and RT-PCR:** 30 whole blood samples (tubes with EDTA) or serum (tubes with no anticoagulant).
- **For antibody testing (serology):** Serum from up to 20 exposed animals with clinical signs in the herd or at least two animals per neighbouring pen or shed without clinical signs.
- **Dead and severely sick pigs (after euthanasia):** Dead and sick pigs should be taken to the laboratory. At the laboratory, necropsy should be done and all organs with lesions should be tested for PRRS, CSF, PCV2, Pasteurella, Salmonella, Erysipelas, Mycoplasma and Leptospira.
- **If reproductive problems are investigated and PRRS is suspected:** Submission of several whole affected litters is advisable to provide material for diagnosis of PRRS and other diseases causing reproductive problems. If available, fresh stillborn and weak piglets are more useful than decomposing aborted foetuses.

Advice to farmers

It may take several days before the results of the laboratory tests are available, thus the **initial diagnosis** done in the field will be the basis for the implementation of control measures.

Before leaving the farm, advise the farmer to:

- Provide animals with appropriate medications (see management and treat sick animal).
- Separate sick and healthy animals.
- Refrain from selling pigs and transporting equipment and other materials from the farm.
- Burn or bury dead animals.
- Practice strict biosecurity measures to avoid the spread of the disease within the farm and also to other farms.

ANNEXES

Annex 1 PRRS outbreak investigation and management

Define a “case”

To be able to identify cases of PRRS, the definition for a case must be established by the national veterinary services. This will be the only case definition to be used by all investigators.

Example: A *PRRS case* is defined as: “a pig showing clinical signs of PRRS infection and having a positive PRRS serology test”.

Farm selection

The farms to be investigated should be selected by the provincial/district veterinary or agriculture office. The records of pig deaths and reports on PRRS and PRRS-like diseases can be compared. The farm or village with the most number of dead or sick pigs and those that reported the disease for the first time should be prioritized.



Figure 27 Discuss with the province/district the selection of farms to be investigated
Photo courtesy of BAI, Philippines

Prepare for field work

Before leaving for the field, research the disease. It is important to know clinical signs.

- Incubation period: In field outbreaks, the time from the introduction of the PRRS virus to the first obvious clinical signs in the herd (range 3 to 37 days).
- Diseases to be considered in addition to PRRS (differential diagnosis).
- Know which and how many diagnostic specimens need to be collected.
- Gather the supplies and equipment needed:
 - Clean boots, scrub pants and shirts, coveralls
 - Disinfectants and sprayers
 - Buckets and scrubbers
 - Needles and syringes for blood collection
 - Materials for restraining pigs
 - Forms for recording the samples collected
 - Materials for labelling samples
 - Outbreak investigation forms
 - Communication equipment such as radios and mobile phones

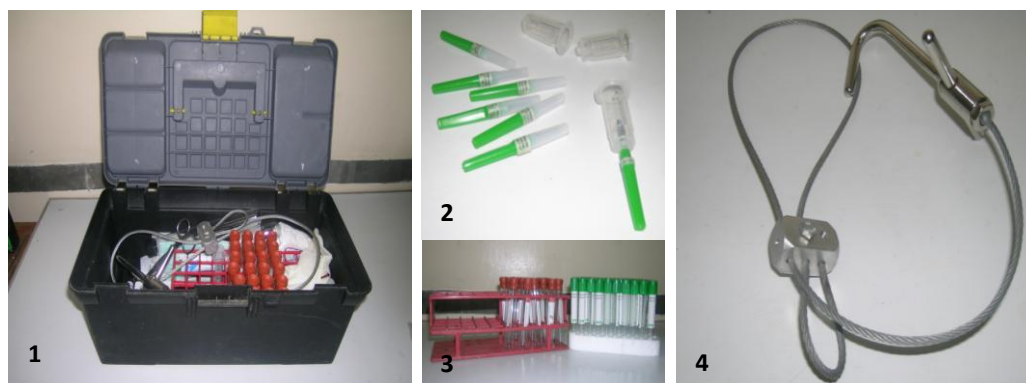


Figure 28

- 1: Tackle box with sample collection materials
- 2: Vacutainer needles and needle holder
- 3: Test tubes (red cap without anticoagulant, green cap with anticoagulant)
- 4: Snare for restraining older pigs

Photo courtesy of RADDL IV, Philippines

- Ensure that all the equipment is clean and disinfected.
- Make all necessary administrative, staffing and logistic arrangements for such things as travel.
- Inform counterparts in the province, district and municipality about the pending investigation.

Identify the roles of the different team members and discuss the plan for the investigation. If more than one farm is to be visited in a day, a different team should be assigned to each farm.

The field investigation

Conduct interview and record the cases

Based on the case definition, count the cases and gather the following information about the farm and the cases:

- **Farm information:** Name, address, owner, and telephone number of the affected farmer. If possible, collect the geospatial coordinates to plot the location of the farm using a global positioning system device.
- **Animal information:** Record the number of animals on the farm by age, sex, production system, barns and other useful information. Record the number of clinically sick animals also by age, sex, production system, barns, etc.
- **Clinical information:** The investigating team should examine the farm records for evidence of reproductive problems such as abortions and deaths in piglets. Record the clinical signs observed to verify the case definition.
- **Risk factor information:** Based on the farm records and farmer interview, look for:
 - History of PRRS and other diseases in the farm
 - Recent history of purchase of pigs
 - Sale of breeders or growers
 - Artificial insemination/natural mating
 - Swill feeding
 - Vaccination
 - Possible information on PRRS and other diseases in neighbouring farms

Collect samples for testing in the laboratory

- 30 blood samples from sick animals.
- Blood from at least two animals per neighbouring herd without clinical signs.
- Dead pigs and severely sick pigs (after euthanasia on the farm) should be taken to the laboratory.
- Fresh stillborn piglets.

Advise farmers before leaving the farm

The **initial diagnosis** done in the field will be the basis for the implementation of control measures at the affected farm. Before leaving the farm, advise the farmer to:

- Provide the sick animals with supportive medications.
- Refrain from selling pigs and transporting equipment and other materials from the farm.

- Burn or bury dead animals.
- Practice strict biosecurity measures.

Analyse the data: time, animal, and place

Once the data is collected, characterize the outbreak by time, place and animal. By doing this, assessment of the outbreak can be done as well as identification of the possible modes of transmission, sources, and duration of the outbreak.

Characterizing by time

A graph called an **epidemic curve** or "epicurve" showing the magnitude and trend of an outbreak through time can be created using the number of cases and their date of onset. An epicurve helps determine where you are in the course of the epidemic, and possibly to project its future course. Knowing the incubation period of PRRS, the possible time of introduction of the virus can be estimated.

Characterizing by place

Assessment of a PRRS outbreak by place (e.g. farm, village) provides information on the geographic extent of a problem and may also show clusters or patterns that provide clues to the source of the outbreak. A simple and useful technique for looking at geographic patterns is to plot the affected farms on a "spot map". A map can also be generated using geographic information systems.

A map of cases in an area (village/district/province) may show clusters or patterns that reflect proximity to a road, live animal market, or other possible source or mode of transmission.

Characterizing by animal

The pattern of PRRS can be described by measuring the disease frequency. The basic measurement used is called an "attack rate", which is the number of cases of the disease divided by the number of animals at risk at the beginning of the outbreak.

In a farrow-to-finish type of operation, the attack rate can be calculated using abortions in different stages of pregnancy. Below is an example of an attack rate for PRRS; the relative risk calculated using the attack rate:

Knowing this information, more effort can be directed at preventing the exposure of sows in their third trimester of gestation to prevent a massive abortion rate. The attack rates for different factors like management system, pen, etc. can be computed as well.

Third Trimester Gestation			First & Second Trimester Gestation			Attack Rate Difference	Relative Risk
Abortion Cases	Population	Attack Rate	Abortion Cases	Population	Attack Rate		
58	1208	3.3%	40	1207	4.8%	1.5%	*1.45

*Sows in the third trimester of gestation are 1.45 times more likely to experience abortion when exposed to PRRS than sows in the first and second trimester stage.

Undertake intensive follow-up investigations

Epidemiological follow-up should be done. This will include detailed analysis of the data as well as the search for additional cases on other farms and villages. It is particularly useful to trace back farms identified to be the source of animals at the infected farm. Other events can be also investigated like the recent visit of a trader or another pig farmer, or recent vaccination in neighbouring pig farms.

Implement control and preventive measures

Control and prevention measures should be implemented as soon as possible. Control measures undertaken even in the absence of conclusive findings should be aimed at controlling the PRRS virus and the source of the infection.

Report the findings of the investigation

The findings of the investigation should be communicated to stakeholders who need to know. This communication usually takes two forms: 1) an oral briefing for veterinary service authorities, and 2) a written report.

The oral briefing should be attended by the veterinary health authorities and people responsible for implementing control and prevention measures. The presentation will serve as an opportunity to describe the activities undertaken, findings, and recommendations.

A written report should follow the usual scientific format:

- Introduction
- Background
- Hypotheses
- Methods
- Results
- Financial impact (where appropriate)
- Recommendations

- Appendices (laboratory reports, pictures, etc.)

By formally presenting recommendations, the report provides a blueprint for action. It also serves as a record of performance, a document for potential legal issues, and a reference if the veterinary services encounter a similar situation in the future. Finally, a published report serves the broader purpose of contributing to the scientific knowledge base of epidemiology and animal health.

Annex 2 Steps in the cleaning and disinfection of animal facilities

It is important to carefully clean and disinfect the facilities before introducing new healthy animals.

All organic materials (faeces, urine, feed, bedding and body fluids) should be completely removed and the surface power-washed. Special attention should be paid to gratings, feeders, drinkers, floor slats and cracks or crevices.

Once clean, disinfect the pen area. The virus is easily inactivated by phenol, formaldehyde, and other common disinfectants.

After cleaning and disinfection, the facility must be allowed to dry. This is a very important step to complete the inactivation of viruses and bacteria.

A minimum 14-day period after cleaning and disinfection is required before restocking to avoid re-infection.



Figure 29 To ensure that organic materials are removed, the flooring and walls must be scrubbed
Photo courtesy of NFMDTF, Philippines



Figure 30 After thorough cleaning, the facility must be disinfected and allowed to dry
Photo courtesy of NFMDTF, Philippines

Annex 3 Key messages for farm owners

Immediately report pig diseases to the authorities

PRRS is a highly infectious disease with potential for rapid spread. Early detection of PRRS could mean early control of the disease. Immediately report the occurrence of disease on the farm or on neighbouring farms to the veterinary authorities. Consult the veterinary/agriculture office for advice on preventing PRRS.

Prevent entry of PRRS to your farm

- Practice strict biosecurity measures on the farm.
- Buy healthy animals from disease-free sources. Be careful buying animals sold for very low prices as it may mean that the animals are not healthy.
- Keep newly-purchased animals in a separate pen for 30 days before mixing with the existing animals on the farm.
- Prohibit or minimize contact of your pigs with visitors, especially traders.
- Avoid visiting other pig farms (especially when there is news of pig diseases in the community).
- Swill may bring the virus to the farm. Cook swill for at least 1 hour at 100°C before feeding to pigs.
- Use clean farm equipment only.
- Regularly clean the pens and disinfect empty facilities.

Do not spread PRRS

- Do not sell, buy or move sick pigs.
- Never sell dead animals. Burn or bury pigs that died from diseases.

Glossary

Acute: Having severe symptoms of a short duration.

Agalactia: Failure of the sow to produce milk.

All-in-all-out: A strategy to control infectious diseases. All animals are removed simultaneously from the farm, building, section or room. The area is then cleaned, disinfected and allowed to dry before new animals are introduced.

Atypical PRRS: PRRS caused by highly a virulent strain of the PRRS virus with more severe clinical signs and higher mortality in all age groups.

Biosecurity: Measures taken to keep disease agents out of populations, herds, or groups of animals where they do not exist. Biosecurity measures can be external (measures taken to prevent the entry of new diseases into a herd or production group), or internal (measures taken to prevent the spread of a disease already in the herd to other uninfected groups or sub-population within the herd).

Downtime: The period of time before a person can enter a pig farm, making sure that no contact with pigs occurs within that period. It also refers to the period when a farm, building, section or room is left empty before being repopulated.

Endemic disease: An infection is said to be endemic in a population when that infection is maintained in the population without the need for external inputs. A disease that occurs regularly and frequently in an area.

Herd: Group of pigs kept together for growing or breeding purposes.

Incidence: Number of new cases of a disease.

Incubation period: The time between the exposure to the virus (or other pathogenic organisms, chemicals, etc.) and the appearance of the clinical signs.

Mastitis: Inflammation and infection of the mammary glands. Sows with mastitis usually have raised temperatures and do not eat and produce little or f no milk.

Mummified pigs (mummies): Piglets that died in the uterus (from 30 to -115 days of age). Mummies are usually dry and dark brown and, enveloped in the placenta. If infected, it may be swollen and smell badly.

Edema: Abnormal accumulation of fluid.

Reproductive failure: Infertility; failure to produce healthy piglets that are capable to of surviving after farrowing.

Stillbirth: A piglet born dead.

Viraemic pigs: Pigs infected with a virus that is circulating and multiplying in the bloodstream of the pig. These pigs are normally highly contagious.

Virulent: Virus able to overcome the defensive mechanisms of the animal's body and multiple and be capable of causing severe disease.

References

- Animal Health Australia.** 2004. *Disease strategy: Porcine reproductive and respiratory syndrome (Version 3.0)*. Australian Veterinary Emergency Plan (AUSVETPLAN), Edition 3, Primary Industries Ministerial Council, Canberra, ACT.
- Beltran-Alcrudo D., Lubroth J., Depner K., DeLaRocque S., Martin V. and Amanfu W.** 2007. *Focus on porcine reproductive and respiratory syndrome (PRRS)*. FAO EMPRES 2:1-5.
- Benfield, D.A., Collins, J.E., Dee, S.A., Halbur, P.G., Joo, H.S., Lager, K.M., Mengeling, W.L., Murtaugh, M.P., Rossow, K.D., Stevenson, G.W. & Zimmerman, J.J.** 1999. *Porcine reproductive and respiratory syndrome. Diseases of Swine*, 18: 201–32.
- Blaha T.** 2008. *Report of a Mission to Viet Nam for Planning the Improvement of the Disease Surveillance and Control of PRRS*. A report prepared for the Food and Agriculture Organization, TCP/VIE/3104 (E).
- Centers for Disease Control and Prevention.** *Steps of an outbreak investigation*. At <http://www.cdc.gov/excite/classroom/outbreak/steps.htm>, accessed on 1 September 2011.
- Chanachai, K.** *Principles of outbreak investigation*. At vet.kku.ac.th/acad/FAO/outbreak_karoon1.ppt, accessed on 1 September 2011.
- Dietze, K., Pinto J., Wainwright, S. & Hamilton, C.** 2011. *Porcine reproductive and respiratory syndrome (PRRS): virulence jumps and persistent circulation in Southeast Asia*. In Focus on..., No. 5, p.8. Rome. Food and Agriculture Organization of the United Nations.
- Easichick.** *Security Involving Service Personnel*. At http://www.easichick.co.uk/bio_security.htm, accessed on 23 September 2011.
- Farm biosecurity.** *Secure your farm, secure your future*. At www.farmbiosecurity.com.au, accessed on 22 September 2011.

- FAO, OIE & WB.** 2010. *Good practices for biosecurity in the pig sector – Issues and options in developing and transition countries*. FAO Animal Production and Health Paper No. 169, Rome, FAO.
- FAO.** 2008. *Porcine Reproductive and Respiratory Syndrome (PRRS)*; EMPRES Bulletin (31).
- FAO.** 2008. *Ebola-Reston virus in pigs*. At <http://www.fao.org/ag/againfo/programmes/en/empres/ebola_111208.htm>, accessed on 6 September 2011.
- Genzow, M., Sungnak, P., Cho, B., Guo, Y., Maala, C.** *PRRS co-infections in Asia*. At <<http://www.prrspective.com.cn/upload/down/7a57a5a743894a0e/2009031916190553728.pdf>>, accessed on 6 September 2011.
- Hermann, J.R., Muñoz-Zanzi, C.A., Roof, M.B., Burkhart, K. & Zimmerman, J.J.** 2005. *Probability of porcine reproductive and respiratory syndrome (PRRS) virus infection as a function of exposure route and dose*. *Veterinary Microbiology* 110, 7-16.
- Hill H.** 1996. *PRRS: Practical strategies for prevention and management of a positive herd. Proceedings of the 1996 North Carolina Pork Producers Conference*, January, 1996, Fayetteville, Carolina, pp. 1–7, 9–10.
- Huang, Y.T., Teng, L.J., Ho, S.W. Hsueh P.R.** 2005. *Streptococcus suis* infection. *J Microbiol Immunol Infect* **38** (5): 306–13. PMID 16211137
- Iowa State University College of Veterinary Medicine.** *Porcine Reproductive and Respiratory Syndrome*. At <<http://vetmed.iastate.edu/vdpam/new-vdpam-employees/food-supply-veterinary-medicine/swine/swine-diseases/porcine-reproductive->>>, accessed on 6 October 2011.
- Lawhorn, B.** *Porcine Reproductive and Respiratory Syndrome*. At <<http://animalscience.tamu.edu/images/pdf/swine/L5137-prs.pdf>>, accessed on 6 September 2011.
- Magar R. & Laroche R.** *Evaluation of the presence of porcine reproductive and respiratory syndrome virus in pig meat and experimental transmission following oral exposure*, *Can. J. Vet. Res.* (2004) 68:259-266 [PubMed].
- Meredith, M.J.** 1995. *Porcine Reproductive and Respiratory Syndrome*. Pig Disease Information Centre, University of Cambridge.

- Neumann, E.J., Kliebenstein, J.B., Johnson, C.D., Mabry, J.W., Bush, E., Seitzinger, A.H., Green A. & Zimmerman J.J.** 2005. *Assessment of the economic impact of porcine reproductive and respiratory syndrome on swine production in the United States.* J Am Vet Med Assoc 227:385-392.
- OIE.** 2008. *PRRS: the disease, its diagnosis, prevention and control.* At <http://www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/PRRS_guide_web_bulletin.pdf >, accessed 22 July 2011.
- OIE.** 2010. *Porcine Reproductive and Respiratory Syndrome.* At <http://www.oie.int/fileadmin/Home/eng/Health_standards/tahm/2.08.07_PRRS.pdf>, accessed 22 July 2011.
- Pig333.com.** *PRRS: transmission via direct and indirect routes.* At <http://www.pig333.com/prrs/transmission-via-direct-and-indirect-routes-1-2_211/>, accessed on 15 September 2011.
- Pig333.com.** *What the experts say: Diagnosis of Porcine Reproductive and Respiratory Syndrome.* At <http://www.pig333.com/what_the_experts_say/diagnosis-of-porcine-reproductive-and-reproductive-syndrome_2255/ >, accessed on 16 September 2011.
- PigProgress.Net.** *Diseases: Mummified foetuses.* At <<http://www.pigprogress.net/diseases/mummified-foetuses-d57.html>>, accessed on 16 September 2011.
- PigProgress.Net.** *Diseases: Porcine reproductive and respiratory syndrome (PRRS)/Blue Ear.* At <<http://www.pigprogress.net/diseases/porcine-reproductive-and-respiratory-syndrome-prrs--blue-ear-d79.html>>, accessed on 15 September 2011.
- Pitkin, A., Otake, S., & Dee, S.** 2006. *Biosecurity Protocols for the Prevention of Spread of Porcine Reproductive and Respiratory Syndrome Virus.* University of Minnesota College of Veterinary Medicine, Swine Disease Eradication Center.
- Provincial Government of Western Cape, Department of Agriculture.** *Disease information: PRRS.* At <<http://www.elsenburg.com/vets/diseaseinfo/prrspic.html> >, accessed on 15 September 2011.
- Sharma, P. & Baldock, C. (ed.).** (1999). *Animal Health in Southeast Asia. Advances in the Collection, Management and Use of Animal Health Information.* ACIAR Monograph No. 58, xiv + 374 pp.

- Thanawongnuwech R.** 2011. *Current status and control measures of HP-PRRS in Myanmar*. A report prepared for the Food and Agriculture Organization, TCP/RAS/3215.
- The Merck Veterinary Manual.** *Porcine Reproductive and Respiratory Syndrome: Introduction*. At <<http://www.merckvetmanual.com/mvm/index.jsp?cfile=htm/bc/54100.htm>>, accessed on 6 September 2011.
- The PigSite.com.** *Group 5 Losses – Foetal Death and the Mummified Pig*. At <<http://www.thepigsite.com/pighealth/article/115/group-5-losses-foetal-death-and-the-mummified-pig>>, accessed on 16 September 2011.
- The PigSite.com.** *Porcine Reproductive & Respiratory Syndrome (PRRS)*. At <http://www.thepigsite.com/diseaseinfo/97/porcine-reproductive-respiratory-syndrome-prrs>>, accessed on 6 October 2011.
- The PigSite.com.** *The Stillborn Pig*. At <<http://www.thepigsite.com/pighealth/article/234/the-stillborn-pig>>, accessed on 15 September 2011.
- Tian, K., Yu, X., Zhao, T., Feng, Y. & Cao, Z.** 2007. *Emergence of Fatal PRRSV Variants: Unparalleled Outbreaks of Atypical PRRS in China and Molecular Dissection of the Unique Hallmark*. PLoS ONE, 2(6): e526. doi:10.1371/journal.pone.0000526
- Vashisht, K., Erlandson, K.R., Firkins, L.D., Zuckermann, F.A. & Goldberg, T.L.** 2008. *Evaluation of contact exposure as a method for acclimatizing growing pigs to porcine reproductive and respiratory syndrome virus*. *J Am Vet Med Assoc.* 2008 May 15;232 (10):1530-5.
- Zimmerman, J.J., Yoon, K.J. & Neumann, E.** 2003 *PRRS compendium: a reference for pork producers*. At <http://epicentre.massey.ac.nz/eric/PRRSCompendium/PRODUCER/PRRS_produceredition.pdf>, accessed 22 July 2011.