Biosecurity - Part 1:

Biosecurity in pig production

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Introduction

Pigs are susceptible to a wide range of endemic and epidemic diseases, including zoonotic infections, which can affect health, welfare and productivity, resulting in a major economic impact. The implementation of biosecurity measures along the production chain presents itself as one of the major solutions to minimize the risk of introduction of these diseases into a farm (external biosecurity), as well as their spread within the farm (internal biosecurity). Probably as a consequence of its role in disease prevention and control, biosecurity is known to have a positive impact on reducing the amount of antimicrobials used in pig production (Laanen et al., 2013; Postma et al., 2016; Collineau et al., 2017). This is a promising finding considering that antimicrobial use in pig production has been identified as one of the highest among all livestock sectors (Filippitzi et al., 2014; Carmo et al., 2017).

Recently, several studies demonstrated a positive association between biosecurity and production parameters (Laanen et al., 2013; Postma et al., 2016) and between biosecurity and farm profitability (Corrégé et al., 2012; Siekkinen et al., 2012; Rojo Jimeno et al., 2016; Collineau et al., 2017). Despite these documented associations and the recognized importance of biosecurity measures, there are still major shortcomings in the implementation of these measures in pig farms (Laanen et al., 2013; Backhans et al., 2015, Filippitzi et al., 2017). There are several examples of disease spread due to insufficient implementation of biosecurity measures, such as porcine epidemic diarrhea (PED) (Scott et al., 2016), highly pathogenic strain of porcine reproductive and respiratory syndrome (HP-PRRS) (Brookes et al., 2015) and foot-and-mouth disease (FMD) epidemic in the United Kingdom in 2001 (Ellis-Iversen et al., 2011). Thus, the importance of biosecurity in disease prevention requires continued emphasis. The following paper summarizes critical factors to be considered with respect to Biosecurity in farms.

Transmission routes of pig diseases

To identify biosecurity measures, one needs to have a good understanding of the major transmission routes of pig diseases. Recently Fillipitzi et al., 2017 made an overview of the different transmission routes of the major pig diseases. In this, a distinction is made between transmission through direct animal to animal contact and transmission trough different intermediate steps such as persons, semen, manure, rodents, aerosols, fomites, etc. When reviewing the epidemiology of all these infectious agents, it becomes clear that most of the pathogens have unique biological properties and life cycles. However, while these differences need to be taken into account, it is often more practical to focus on commonalities, as opposed to differences when developing and ranking biosecurity measures.

Ranking of biosecurity measures

Given the variation in occurrence of different transmission routes it is easy to understand that also biosecurity measures may have different levels of priority. Measures that are oriented towards avoiding risky direct animal contacts (e.g. implementing good quarantine) are more important than measures that try to prevent less likely transmission routes such as for instance introduction trough remaining pathogens in the nose of humans. A second important characteristic when biosecurity measures are ranked is the frequency of occurrence of the risk. When addressing a risk which occurs once very frequently (e.g. transport of feed to the farm) one needs to take more precautions in comparison to a risk which occurs only very rarely.

Another principle that needs to be taken into account when evaluating biosecurity, Is that the larger the farms are, the stricter one needs to be in the implementation of biosecurity measures. The reason is that in larger farms there are more susceptible animals present that more easily can sustain the continuous circulation of pathogens, whereas in smaller farms this might run dead at a certain stage. Often it is observed that farms have grown substantially whereas the biosecurity awareness has not evolved equally.

Assessing biosecurity

The biocheck.ugent biosecurity scoring tool (www.biocheck.ugent.be) is a very easy and free of charge tool that allows one to assess the biosecurity level at a pig farm. The tool is based on a questionnaire of all biosecurity measures in the farm and translates the answers into a risk based scoring (higher risks receive a higher weight). The outcome of the evaluation is a biosecurity score ranging from 0 (total absence of any biosecurity measure) to 100 (perfect biosecurity). This score is then further subdivided into a score for each external and internal biosecurity that are further subdivided in 6 different subcategories. These individual scores allow evaluation of the strong and weak points of the farm biosecurity and form the basis for improvements.

Biosecurity measures in pig production

When developing biosecurity measures one needs to consider two distinct risks. The first is the risk of introduction of pathogens into a herd, the second is the spread of the pathogens within the herd, e.g. between age categories, compartments, etc. Therefore we generally divide biosecurity measures into measures for external biosecurity, aiming at prevention of disease introduction, and measures for internal biosecurity, aiming at prevention of within herd disease spread.

External Biosecurity:

1 Purchasing policy

The introduction of non-proprietary animals or genetic material (e.g. semen) might lead to the introduction of pathogens against which no farm immunity exists. Pathogen transmission occurs very effectively via direct contact between infected and susceptible animals (Filippitzi et al., 2017). Therefore, the importance of biosecurity in purchasing policy is high in protecting a farm from many pathogens as listed in Filippitzi et al. (2017). As a consequence, the primary aim should be to avoid the purchase of animals or genetic material as much as possible (Dewulf, 2014; Filippitzi et al., 2017). A fully closed herd has a substantially lower risk of disease introduction. Moreover, besides the risk of disease introduction, the frequent introduction of "naïve" animals may also favor the continued circulation of herd specific pathogens. This may hamper the control and eradication of certain pathogens in a herd. Yet, in modern pig production, avoiding introduction of new animals or semen is often very difficult. Therefore, whenever new animals are introduced a number of precautionary measures should be taken.

A. Limit the frequency of introduction

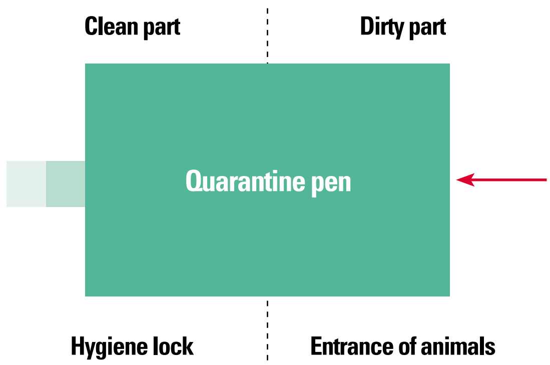
Both the frequency of introduction and the number of animals bought will influence the risk of disease introduction (Fèvre et al., 2006; Laanen et al., 2013). In both, the adagio is "the lesser, the better". However, sometimes it is advisable to increase the size of the group of purchased animals (e.g. new gilts) as this may reduce the buying frequency. For example, it is believed to be less risky to buy twenty gilts 5 times a year rather than 10 gilts 10 times a year.

B. Limit the number of sources

Limiting the number of source herds, both for animals and semen, is also important (Dewulf, 2014). Several studies confirm that introducing animals from different source herds increases the risk of disease introduction (Hege et al., 2002; Lo Fo Wong, 2004). Moreover, the source herds preferably have a documented high health status (Pritchard et al., 2005; Kirwan, 2008; Dewulf, 2014). This status may include the certified absence of a number of infectious diseases (e.g. specific pathogen free status) and avoids the unintended introduction of new diseases in the acceptor herd (Laanen et al., 2010; Filippitzi et al., 2017).

C. Respect a good quarantine

Newly accepted animals should always be introduced first in a quarantine stable. A good quarantine stable is fully separated from the other animal facilities and should be entered through a separate entry with a separate hygiene lock. During the quarantine period animals should be clinically inspected to assure that no signs of any new diseases are present. Additionally animals can be sampled for the detection of infections. Moreover, newly introduced animals should also be vaccinated during the quarantine period to assure a sufficient level of immunity when brought into contact with the resident animals (Barceló et al., 1998; Correge, 2002; Pritchard et al., 2005; Calvar et al., 2012; Dewulf, 2014). A quarantine period should last at least 4 weeks however for some diseases longer periods are required (PRRSV and PCV2 – 6 to 8 weeks; *M. hyopneumoniae* – 8 to 10 weeks) (Pritchard et al., 2005).



2 Transport of animals, removal of manure and carcasses

Disease can spread through the transport of live animals and the removal of cadavers and manure, directly (*i.e.* via se- and excreta of diseased animals or cadavers) or indirectly (*i.e.* from cadavers via fomites, the rendering truck, people and their material, rodents, domestic animals and from manure).

A. Use clean animal transport vehicles

Epidemiological field studies have pointed out contaminated livestock lorries as the focus of infection for many disease-causing agents, including Classical swine fever (CSF) (Fritzemeier et al., 2000), *Mycoplasma hyopneumoniae* (Hege et al., 2002), *Acti-*

nobacillus pleuropneumoniae (Fussing et al., 1998 and Hege et al., 2002), *Brachyspira hyodysenteriae* (Windsor and Simmons, 1981) and salmonella (Rajkowski et al., 1998). Therefore, they should at all times be empty, cleaned and disinfected before entering the premises (Pritchard et al., 2005; Dewulf, 2014). Although this is a well-known principle, this is not always sufficiently respected. This might be the result of whether conditions (e.g. cold) that interfere with a thorough cleaning and disinfection. Also the trucks that are collecting cull sows often are not empty upon arrival on the farm. It is sometimes stated that a lorry for the transport of livestock should have been empty for at least a couple of hours or days before it can enter the company. This might provide an additional risk reduction; however it is clear that a thorough cleaning, disinfection and drying are the principal measures that cannot be replaced by a certain "downtime". Pigs that have been in contact with the lorry during loading may not be returned to the farm in order to minimize the chance of introducing pathogens through an insufficiently cleaned lorry. For the same reason, the lorry-driver is not allowed to enter the farms. Also the loading bay should be cleaned and disinfected after every animal load (Pritchard et al., 2005; Backhans et al., 2015).

B. Make a separation between the clean and the dirty area

The principle of the clean and dirty road on a pig farm means that there is a clear separation between clean and dirty sections of the premises (Hémonic et al., 2010; Neumann, 2012; Filippitzi et al., 2017). All inbound and outbound traffic that serves multiple companies (feed, liquid manure, external transportation of animals and other) are always guided via the dirty road. The clean road is preserved for possible supply of animals, but only in fully cleaned and disinfected lorries, and supply of harmless products.

Only the 'dirty road' is relatively easily accessible for visitors, suppliers and consumers. The cadaver collecting is obviously part of the dirty section (cadaver storage box, loading point). Barrels, wheelbarrows and other tools used for this, may only be returned to the clean section after they have been thoroughly cleaned and disinfected.

Liquid manure is always transported via the dirty road. Furthermore, it is advisable to use your own discharge pipes in order to prevent that pipes, which recently were in contact with manure in other farms, are also used in your farm.

Recent studies have indicated that the clean-dirty area principle is not thoroughly respected by the manure removal and supplying companies in most countries (Filipitzi et al., 2017). This indicates that the farmers should be ensuring that the clean-dirty areas are clearly defined and signs illustrate how to adhere to these.

C. Management of cadavers

Cadavers are almost always a major source of infectious material. The animals often died due to an infection and therefore potentially spread a lot of infectious material. It is therefore strongly advised to remove cadavers as soon as possible from the stables and to store them in a well-insulated place (Meroz et al., 1995; Pritchard et al., 2005). Ensure that no vermin can reach the cadavers (as they could spread infectious material).

After cadaver collection, it is advisable to thoroughly clean and disinfect the cadaver storage room. The person manipulating the cadavers should always wear disposable gloves for their own safety as well as to avoid further spread of pathogens (Pritchard et al., 2005; Filippitzi et al., 2017).

The cadaver storage room should be located so that the rendering company can collect the cadavers without entering the farm to avoid disease introduction through these potentially risky transports (Evans et al., 2000; McQuiston et al., 2005; Pritchard et al., 2005; Maes, 2016). It is also advisable that the cadaver storage room is cooled both to avoid smell and to achieve a higher storage capacity which again can reduce the frequency of visits by the rendering company. Moreover these cooled systems are generally also fully closed and therefore effectively prevent contact with vermin.

3 Supply of feed, water and equipment & access check (personnel and visitors)

Transmission of pathogens is possible by materials or vehicles related to feed delivery, via water and also by people entering the farm.

A. Feed, water and equipment

Feed itself should generally not pose a risk due to the strict hygienic conditions of its production, however swill feeding (banned for decades under EU law) is a practice which has previously been associated with large outbreaks of infectious diseases, among others classical swine fever (Horst et al., 1997; Fritzemeier et al., 2000; Filippitzi et al., 2017). The pigs' drinking-water quality often leaves much to be desired. The water, which may originate from different sources (surface, wells, other), is stored in a tank and supplied to the animals. Both at the source, in the reservoir and the pipes, the water can be contaminated and biofilms may be created. Regular (at least once a year) examination of the drinking-water quality both at the entrance and at the nipples, and regular cleaning of the pipes is therefore definitely advisable. The introduction of all sorts of equipment, which comes into contact with the animals, may also introduce pathogens. Therefore it is preferred to avoid introduction of new equipment as much as possible and, if introduced, to first perform a disinfection step.

B. Personnel and visitors

People act as a mechanical vector if they have been in contact with infected animals and subsequently switch to susceptible animals without taking any precautions. This type of transmission has been proven through experiments for several germs, among which Transmissible Gastroenteritis Virus (Alvarez et al., 2001), *Escherichia coli* (Amass et al., 2003) and Classical Swine Fever (Ribbens et al., 2007) and happens mainly through leftovers of excreta from infected animals on footwear and clothing. The chance of biological transmission between people and pigs exists for germs that can infect them as well as pigs, such as the H1N1 influenza virus (Wentworth et al., 1997) or methicillin-resistant *Staphylococcus aureus* (MRSA) ST398 (Huijsdens et al., 2006). Therefore, the first measure is to limit the number of people that can access the barns. To do so, provide clear markings that prevent visitors to enter by coincidence.

When visitors and personnel are entering the stables they should always wear clean and herd specific clothing and footwear and at least wash their hands thoroughly (Pritchard et al., 2005; Hémonic et al., 2010; Dewulf, 2014; Maes, 2016). The latter is a simple and very useful measure, which is often forgotten. The hands of animal care takers are an efficient way to transfer germs through direct contact with the animals (Vangroenweghe et al., 2009; Hémonic et al., 2010; Backhans et al., 2015). A study by Lo Fo Wong et al. (2004) supported that the chance of testing positive for Salmonella is reduced when consistently washing hands before entering a section with pigs.

To assure effective change of clothing and allow washing of hands, a good hygiene lock should be available (Vangroenweghe et al., 2009). The hygiene lock needs to have a clear physical separation (e.g. bench) between dirty and clean area. When entering the hygiene lock the following steps should be respected (Maes, 2016):

1. Take off your jacket and shoes when entering the lock
2. Wash your hands with disinfecting soap
3. Step over the bench and put on a clean coverall and boots
4. Disinfect the boots with the boot washer before entering the barn
5. When returning to the hygiene lock, clean and disinfect the boots with the boot washer
6. Put the boots on the appropriate shelf
7. Take off the dirty coverall and put it in the laundry basket
8. Step over the bench and wash your hands before you put on your own jacket and shoes again

In companies with high health standards, visitors and personnel are often obliged to shower before entering the farm. The main benefit of this requirement is the certainty that all possibly contaminated clothing will be exchanged for farm-specific clothing and that the hands are washed thoroughly. In addition, it discourages less urgent visits (Moore, 1992; Amass and Clark, 1999).

Often, visitors are required a 24 or even 48 hours pig free downtime before access to the farm is granted. This is based on the argumentation that germs excreted by pigs could survive on people for a specific period. During this period the person could passively excrete germs and transfer them to susceptible animals. Yet, in scientific literature there is very little proof of the true risk related to this transmission route. As far as we are aware of there is only one study from 1970, in which it was noted that the foot-and-mouth disease could be isolated from the nose and mouth of people who had been in contact with animals infected with the FMD-virus. On one person, the virus was isolated 28 hours after contact with infected pigs and no longer after 48 hours (Sellers et al. 1970). If all required precautionary measures are taken as described above, the downtime probably has little additional value.

4 Vermin and bird control

A number of pathogens can be transmitted directly or indirectly by rodents, birds, dogs and cats, from outside the farm or between different compartments of it. They may also act as reservoirs for herd specific pathogens that may continue to circulate in the farm (Andres et al., 2015). Rodents and birds can also damage the equipment.

An efficient vermin control program is also required and is often developed in collaboration with specialized companies (Lister, 2008; Hémonic et al., 2010; Dewulf, 2014; Backhans et al., 2015; Filippitzi et al., 2017). Such programs need to prevent that vermin can house in the barn surroundings, which can be achieved by removing various hiding places in the vicinity of the barns (e.g. plants, piles of dirt, etc). Also, feed should be stored in well closed rooms where there is no access for vermin (Lister, 2008).

The entrance of birds in barns can be achieved by covering all air inlets with netting that prevent entry. Also pets should be kept out as they can also act as mechanical vector of pathogens. Therefore, cats or dogs are not a good approach to control rats and mice (Vangroenweghe et al., 2009).

5 Location and environment

Farm location and farm density are important factors for airborne and vector-borne disease transmission. Moreover, wild boars may act as a reservoir for swine diseases.

A. Airborne transmission of diseases

Usually, transmission through the air is particularly important within short distances (< 2 km), hence the importance of the distance to the nearest neighbor. Rose and Madec (2002) concluded that the number of farms within a range of 2 kilometers had a significant influence on the frequency of respiratory disorders in a farm. Distance to neighboring farms is also considered to be the most determining factor for *Mycoplasma hyopneumoniae* transmission through the air (Goodwin, 1985, Dee et al., 2009). Minitiens et al. (2003) confirmed that a combination of distance to a neighboring farm and concentration of farms per unit area are a major risk factor for the spread of Classical Swine Fever. When planning construction of a new pig farm, the distance to the nearest neighbor could be a determining factor in selecting a location. Additionally, the predominant direction of the wind needs to be considered. Knowledge of the presence of diseases in neighboring farms is important as well. Also the spread of liquid manure from other farms in the immediate farm vicinity should be avoided. High performing airfiltration systems can reduce pathogen entry and may be a worthy consideration in densely populated livestock areas.

B. Wild animals

Especially direct or indirect contact with wild boars may cause disease transmission (e.g. Classical Swine Fever (Fritzemeier et al., 2000), Aujeszky's disease (Artois et al., 2002). Therefore, it is important to keep wild animals out of the farm with a fence (Amass and Clark, 1999), with a depth of 30 to 40 cm (Hartung, 2005). Even if the pigs are kept indoors, wild boars should have no access to the farm, in order to avoid indirect transmission (e.g. airborne, through vectors, trough contact with stored feed) of infections.

Internal Biosecurity

1 Disease Management

Disease management concerns all actions related to the correct handling and treatment of diseased animals, including proper diagnostics, isolation and disease registration as well as improvement of the immune status of susceptible animals, in particular through vaccination. Correct disease management should result in a good insight into the specific health situation of the herd and application of the required preventative treatments to avoid disease and their subsequent losses.

A. Returning pigs to younger age group

Slower growing piglets in a batch should not be held back and added to the next batch of younger piglets as these piglets may be carriers of one or more infectious diseases and a source of infection to a younger susceptible age group (Vangroenweghe et al., 2009; Dewulf, 2014; Filippitzi et al., 2017). When it is expected that the piglet has a low probability of becoming a profitable fattening pig, euthanasia is a better choice than letting it run around among its litter as a permanent infection source. If euthanasia is not believed to be the right option then these animals should be moved into the sickbay.

B. Sickbay

Diseased animals should be isolated, in order to prevent other animals from pathogen exposure through infected excretions and secretions. A good sickbay is fully separated from the rest of the animals (separated house) (Hémonic et al., 2010; Dewulf, 2014). Once an animal has been in the sick bay, it should not return to the regular stables as it is highly likely that it will introduce any remaining pathogens to the healthy animals. Therefore the sick bay should also be approached separately by the farm workers and the necessary hygienic measures (e.g. changing of coverall, footwear, washing hands, etc.) should be implemented when entering and leaving the sick bay. The sick bay is preferably also visited at the end of the working round (Vangroenweghe et al., 2009; Backhans et al., 2015).

C. Use of needles and medicines

There is extensive literature on the spread of germs via injection equipment (needles and syringes) (Hémonic et al., 2010; Filippitzi et al., 2017). In pig farms, needles are often reused and are only replaced when they become blunt! However these needles may get contaminated through use and storage by numerous environmental germs. In addition, needles (and consequently the bottle) can become contaminated by injecting sick animals. Injecting multiple animals with the same needle carries the risk of spreading germs. Although single use needles are preferred (Hémonic et al., 2010), one needle per group (pen) is recommended if this is not feasible. Avoid the use of the same needles for different age groups and do not wait to replace needles until they become blunt, both for hygienic reasons and for animal welfare. Opened bottles should be stored in a hygienic environment at the right temperature.

2 Farrowing and lactation period; Nursery and Finisher phase

Pathogens can be transmitted from sows to piglets vertically, via the placenta or contaminated colostrum or milk. They can also be transmitted horizontally, *e.g.* through the skin, the nipples and the udder. Cross-fostering in particular increases the risk of transmission from infected or carrier sows to susceptible piglets without maternal antibodies (*e.g.* of PRRSv as indicated by Zimmerman et al., 2012). Returning piglets to younger age groups is another risky practice, since it can bring pathogens to a susceptible population. Nursery pigs are a vulnerable age group, due to their temporary lower immune status, a higher presence of diverse pathogens (Johnson et al., 2012) and fighting and biting when pigs are mixed (Cameron et al., 2012). Another route of pathogen transmission in the farrowing unit is the use of materials (*e.g.* castration blade, elastrator for tail docking, ear-tagger, iron injection needles) between piglets without intermediate cleaning and disinfection.

A. Washing the sows

Before the sows are placed in the farrowing pen, they should be dewormed and washed in order to prevent germ transmission from the sow barn to the farrowing pen. Sows need to be washed before they enter the farrowing pen to avoid contamination of these pens though the washing process.

B. Cross-fostering

Mixing litters in the farrowing pen is an efficient way to spread infection to different animal groups. Sows that carry *Streptococcus suis* can already infect their piglets during parturition (Amass et al., 1996) and *S. suis* may spread further if piglets are moved to other litters. This principle applies to other germs as well. If 5 % of the piglets are moved in the farrowing pen more than 48 hours after birth, there is an increased chance for problems with PRRS (Duinhof et al., 2006). Therefore it is advised to avoid cross-fostering as much as possible. If it cannot be avoided, cross-fostering should be limited to one occasion in the first 48 day after birth.

C. Equipment for treatment of the piglets

Equipment, such as the pliers for cutting the teeth and castration blades, are exposed to secretions and excretions of piglets and could therefore be a source of infection for other piglets. This equipment needs to be cleaned and disinfected prior to using them for a different piglet (immerse in disinfectant) to limit the chance of disease transmission (Vangroenweghe et al., 2009; Filippitzi et al., 2017).

3 Nursery and fattening unit

A. All in / all-out

The AI/AO principle helps to prevent cross-contamination between consecutive production batches and makes it possible to clean and disinfect the barns between different production batches. Applying the all-in/all-out principle strictly is a very important measure to break the infection cycle between subsequent production batches (Clark et al., 1991). In AI/AO, it is of primary importance that especially the AO part is fully respected as sometimes this is only done at a 95% level when a few (light weight) animals are kept in the barns and mixed with the next batch. These animals, even if they are only few, are very likely sources of infection for the next groups (see above on returning to younger age groups). When moving the animals from one production stage to the next (eg from farrowing to nursery pen) it is advisable to keep the groups together as much as possible rather than sorting all animals in terms of their size as this will result in a lot of mixing which substantially increases the likelihood of spread of infections (Maes et al., 2008; Hémonic et al., 2010).

B. Stocking density

A high stocking density induces stress which results in an increased sensitivity to infections and an increased excretion of germs. Many infected pigs in a small area means a sharp increase in infectious pressure. Various studies have shown that a higher stocking density in different production phases increases the occurrence of respiratory illnesses as well as digestive tract disorders (Pointon et al., 1985; Maes et al., 2000a; Maes et al., 2000b; Stärk, 2000; Laanen, 2011). In addition, there is a positive connection between available space per animal and daily growth (Dewulf et al., 2007). In many cases the norms, as they are prescribed in the legislation, are based on outdated research and insights and have not evolved with the recent evolutions in the industry. Therefore, these norms need to be considered as absolute minimum requirements rather than ideal values (Dewulf et al., 2007) as optimal values are on average 24 % above the legal requirements (Laanen et al., 2011).

4 Compartmentalizing, working lines and equipment

Animals of different age may have different levels of sensitivity to certain pathogens and therefore it is crucial to keep different age groups separate and to work in a well-defined sequence. Equipment and materials (*e.g.* bedding material, feeders, drinking troughs, boots, spades, syringes and needles) may also play an important role in the transmission of a large number of diseases (Filippitzi et al., 2017).

A. Working lines and separate hygiene locks

An important basic rule to prevent the spread of diseases between different age groups is determining and upholding working lines within a farm. The same flow is followed for visits and work in the barn and goes from youngest animals, to pregnant sows, older age groups, quarantine and sick animals and finally the cadaver storage.

For each age category and especially for risk-bearing groups (e.g. quarantine stables, sickbay), an additional hygiene lock for changing of clothing, footwear and washing of hands is recommended to avoid pathogen spread between different age groups.

B. Equipment in the various compartments

Considering that brooms, shovels or floating panels can easily be contaminated with feces that can contain a great number of germs, each compartment should have designated equipment that is clearly recognizable (different colors) to avoid moving equipment from one section to another (Vangroenweghe et al., 2009; Laanen, 2011; Gelaude et al., 2014). The same rule applies to clothing and footwear, for exactly the same reason.

C. Boot washers and disinfection baths

To avoid dragging germs on footwear, boot washers and disinfection baths can be placed between production units. Disinfection is efficient after dirt and feces are removed first from the boots with water (preferably with adding a detergent). After, the boots have to be placed in a visually clean disinfectant solution at a proper concentration and for a recommended duration per the disinfectant manual (Amass et al., 2000). Disinfection baths that are not used properly will inadvertently increase the number of germs on the boots, resulting in a lot of wasted time and money, and increased risk that diseases are spread. However, as it is not practical to stand for many minutes in a disinfection bath before going to another section, a pair of extra boots can be provided at each disinfection bath to ensure that there's always a pair of boots waiting at each bath while the other boots are soaking in the disinfection solution. Additionally, the presence of foot baths reminds staff and visitors of the importance of biosecurity on farm grounds (Amass et al., 2000; Pritchard et al., 2005).

5 Cleaning and disinfection

Pens, feeding troughs and equipment infected with feces can maintain an infectious cycle because new animals keep getting infected, and will consequently secrete the germ and re-infect their environment. To break the infectious cycle between consecutive litters, a thorough cleaning and disinfection (C&D) of pens is required.

A thorough C&D protocol consists of seven steps:

1. Dry cleaning to remove all organic material
2. Soaking of all surfaces to loosen all remaining organic material
3. High pressure cleaning with water to remove all dirt. This step will go much easier, faster and effective if a good soaking step is performed before
4. Drying of the stable to avoid dilution of the disinfectant applied in the next step
5. Disinfection of the stable to achieve a further reduction of the concentration of germs
6. Drying of the stable to assure that animals afterwards cannot come into contact with pools of remaining disinfectant
7. Testing of the efficiency of the procedure through sampling of the surface

(Vangroenweghe et al., 2009; Hémonic et al., 2010; Laanen, 2011; Dewulf, 2014).

With the aid of pressure plates, all surfaces can be simply and quickly checked for microbial contamination. These plates measure and quantify the presence of bacterial contamination (mostly: the presence of small parts of germs after cleaning and disinfection). The results are expressed in colony-forming units (CFU) per plate. The norms used for hygienograms in pig stables are:

Score	CFU per plate
0	0
1	1-40
2	41-120
3	121-400
4	> 400
5	countless

CFU= colony-forming unit

When all these steps are performed correctly it is not required to foresee an additional empty period to further reduce the infectious load (Luycks et al., 2016).

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