A REVIEW OF THE INDUSTRIALISATION OF PIG PRODUCTION WORLDWIDE WITH PARTICULAR REFERENCE TO THE ASIAN REGION

Focus is on clarifying the animal and human health risks

and

reviewing the Area Wide Integration concept of specialised crop and livestock activities

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1. INTRODUCTION

World pig meat production has nearly doubled over the last 20 years. Approximately 42.9 million tons of pork was produced in 1977. In 1998 production had grown to approximately 83.6 million tons the result of slaughtering approximately 1.15 billion pigs. Some 55% of all slaughter pigs come from the Asia/Pacific region. Between 1990 and 1998 the world's production of pig meat rose by an average 2.22% per year, this increase being mainly in Asia. The increase in pork production was due not only to the increase in pig numbers but also an increase in slaughter weights. In 1977 average slaughter weight was 67 kg and by 1997 the average was 77 kg. Because of the considerable differences in carcase weights between countries, the actual number of pigs slaughtered rather than tonnage of meat gives a better indication of overall pig numbers per country.

China is by far the largest producer of slaughtered pigs at 556 million in 1997, which was an increase of 29.6 million compared with the previous year. It has been estimated that China had a further increase of around 30 million pigs slaughtered in 1998. This huge increase in China compensated for a decline totalling 18 million in many other major pig producing countries. China accounted for approximately 84% of all on-farm pigs in Asia in 1997 with 467.8 million, followed by Vietnam with 18 million and India with 15.5 million. Japan and the Philippines account for around 10 million pigs on-farm each, and Indonesia and Taiwan have approximately 8 million each. The total number of on-farm pigs in Asia in 1997 was approximately 550 million. The Asia/Pacific region also had a massive increase in pork consumption between 1986 and 1998. This was due mainly to the contribution by China where 17.8 million tons (16.8 kg/person) in 1996 rose to 36.4 million tons (29.4 kg/person) in 1998.

Table 1. Estimated on-farm breeding sows and total pig numbers (x 1000) in the Asian region in 1998.

	On-farm pigs*	Breeding sows**
China	395,000	32,000
Vietnam	18,060	2,200
India	16,000	600
Philippines	10,912	1,100
Japan	9,915	900
Korea	6,710	900
Taiwan	6,539	800
Thailand	4,209	500
Indonesia	3,400	100
Malaysia	2,350	300
Laos	1,880	NA
Cambodia	1,410	NA

* Pig International (1999) **29:**6, p22 ** Pig International (1999) **29:**1, pp21-24

In west and central Europe approximately 110.8 million pigs were on-farm in 1997 and in east Europe approximately 75.2 million. In the USA in 1999 there were 60 million pigs on-farm and a total of 92 million for North and Central America. In 1997 South America had approximately 57.7 million pigs on-farm.

Accompanying the overall increase in pork production during the last 20 years has been a decrease in the actual number of pig farms with an increase in larger farms having 1000 or more animals. This trend has been particularly evident in eastern/western Europe, North and South America and Australia. In countries like the UK, Ireland and Italy for example, 70% of pigs are produced on farms with 1000 or more pigs, and in the case of the UK and Ireland 90-95% of their pigs are from units with 400 or more pigs. In the USA in 1993 the number of pigs on-farm was 56 million and in 1999 it had risen to 60 million, but in March 2000 there had been a slight fall to around 58 million. However the number of pig farms in 1993 was a little over 600,000 but this has fallen to around 100,000 in 1999. Large industrial operations with over 5000 pigs now make up 46.5% of all pig farms in the USA (USDA-NASS). In Australia nearly 50% of the 300,000 sows that make up the national herd are also found on larger industrialised units with over 400 sows places and 34.5% are in herds of 1000 or more sows. The number of pig farms in Australia has fallen from 19,297 in 1980 to 3522 in 1996.

In Asian countries there have been similar trends although not to the extent seen in Europe or North America and there is considerable difference between countries. In 1996 it was estimated that 20% of pork production in China was from large "high technique specialised" farms whereas it was only 5% of the output in 1980. In Thailand around 80% of pigs produced are from intensive farming systems and 56% of these are from farms with over 1000 pigs. The remainder are from small (50 – 200 pigs), to medium (201 – 1000 pigs) farms. Large intensive farms are either integrated company owned (8.5%) or private independent (47.5%) farms. Although modern intensive pig production in Thailand began in 1973 (Tisdell et al) large-scale or industrialised pig farming was slow to develop up until the 1980s after which it rapidly increased.

In the Philippines with around 9.7 million on-farm pigs, only 18% are reared on commercial enterprises the remaining 82% are backyard production. However the commercial sector produces most of the slaughtered pigs for the commercial market. In Vietnam large intensive pig holdings make up about 20% of the Vietnamese herds. The larger farms are usually State owned and have up to 3000 pigs whereas private farms typically have around 700 pigs (Gallacher et al). In 1998 it was estimated that 95% of sows in Vietnam were kept in the "extensive household sector where the pigs play a critical role as the family 'bank' as well as a source of valuable fertilizer for paddy and vegetable plots" (Pig International (1998) **28:** 25-27) and less than 5% of sows were housed in intensive conditions.

Hai and Nguyen (1997) described three main production systems in Vietnam. State-owned farms which account for only 4-5% of total production, private commercial farms producing15% and small-scale production accounting for 80% of all pigs produced. The same authors described the development of a new system involving breeding herds, fattening, feed supply, slaughter and processing. These systems have a capacity of 20,000-200,000 pigs.

2. THE EVOLUTION OF INDUSTRIALISATION OF THE PIG INDUSTRY

During the last 20 years industrialisation of pig production has been one of the major developments of the pig industry, particularly in east and western Europe, North America and Australia. Similar developments have taken place in a number of Asian countries in more recent years e.g. in Singapore, Malaysia, Thailand, Taiwan and the Philippines. Industrialisation is usually synonymous with increasing herd size. In eastern Europe nearly 20 years ago pig farms were developed to accommodate up to 3000 to 5000 breeding sows and their followers. In western Europe and the UK industrialised pig units were however relatively smaller accommodating 250-1000 sows. Similarly in North America the average size of large industrialised units was about 1000 sows.

2.1 The industrialised farrow to finisher system

Large industrialised units were usually the farrow-to-finish systems with breeding sows and boars through to finisher pigs all located on one site and often housed under the same roof. In the case of weaners and growers they were often kept in double or triple deck cage systems. Pregnant sows and boars were usually tethered or confined to individual stalls during their entire production life. Farrowing was and still is usually in farrowing crates. Weaners aged between three and four weeks were reared to 10 weeks of age in small groups of around 15 to 20 in cages providing about 0.36m^2/pig floor space. Growers (10-16 weeks) were kept in pens providing 0.5m^2/pig floor space and finishers (16-24 weeks) with 0.75m^2/pig floor space.

Flooring was usually slatted concrete for confined sows, solid concrete with or without metal mesh in farrowing crates, metal mesh in weaner cages and partial or fully slatted concrete pens for growers and finisher pigs. Effluent collection and storage was usually by channels built under the slatted or mesh flooring systems that were regularly hosed out and released every few weeks, or had flushing systems to allow daily flushing of the channel with water held in tanks situated at the end of each channel. Slatted floors and flushing systems reduced labour costs, eliminated the need for bedding and provided a more pleasant environment for both pigs and operators although they often contributed to noxious gasses rising up into the housing. Effluent disposal was usually carried out using a series of ponds designed for both evaporation and leaching or from which raw or treated waste could be pumped for irrigation. Treatments involved removal of gross solids, separation of liquids and solids by screens, centrifugation, and combinations of both aerobic and anaerobic ponds.

2.2 Modified intensive management

The early industrialised pig units although relatively profitable often presented with serious animal health, welfare and waste disposal problems. In the early 1980s there was a move towards less intensive systems although retaining the one site farrow to finish production system. Dry and pregnant sows were often moved into group pens after spending only the first four to six weeks in stalls, allowing mixing of sows with the advantage of promoting immunity to endemic organisms, improving muscular and skeletal strength as well as being more acceptable from a welfare point of view. This system was not without some problems however, such as fighting, vulva biting and sows low on the “peck order” getting less food. In some units this was overcome by providing feeding stalls (known as the cubicle system in the UK) allowing sows to separate themselves during feeding time.

The main modification of farrowing accommodation was smaller rooms holding between 25 and 50 farrowing crates only, often managed on an all-in-all-out (AIAO) basis. Farrowing crate flooring was usually fully meshed with specific creep accommodation for the piglets. Less intensive weaner accommodation was characterised by single deck cages with partial or fully meshed floors. In some units weaners were also managed on an AIAO basis with piglets moving from farrowing rooms to weaner rooms in batches, with an age difference of not more than one week. Grower and finisher accommodation changed little in the 1980s with the exception of maybe a greater use of partially slatted concrete floors and replacing floor feeding with feed hoppers.

Although AIAO management in conjunction with batch farrowing was used in some herds in the early 1970s its use did not gain momentum until the 1980s. AIAO involves rearing pigs of the same age, usually one week's production, in one room or building in which no other pigs are kept, and the room/building has been cleaned and disinfected before being populated. Pigs remain in the **same room or building** until moving to the next stage of production, e.g. in the case of sows and piglets usually two to four weeks, weaners six to seven weeks and growers to finishers approximately 12 to 15 weeks. When the room or building becomes vacant it is cleaned and disinfected again before repopulation with another week's production. If the stage of production is seven weeks then eight rooms/buildings will be required to allow one week for depopulation, cleaning and disinfecting before another batch is installed.

There is no doubt that the practice of batch farrowing in individual farrowing rooms managed on an AIAO basis, followed by AIAO movement of the weaned pigs into individual weaner rooms where they were reared separately, until moving into grower accommodation, was a major step forward in the control of many of the common diseases that affected production, in particular enteric and respiratory diseases. AIAO management greatly improved the efficacy of housing hygiene as well as avoiding the mixing of age groups, thus reducing vertical spread of disease. AIAO management of farrowing rooms also significantly reduced the incidence of mastitis/metritis/agalactia in sows while batch farrowing improved reproductive efficiency.

2.3 Minimal disease populations

In addition to changes in housing and management to reduce the impact and spread of disease in intensive systems there was a general acceptance of the value of establishing new or repopulated herds with minimal disease or specific pathogen free (SPF) pigs known as high health status herds. By producing nuclear stock (primary SPF pigs) by hysterectomy, hysterotomy or snatch farrowing, populations of pigs could be developed and maintained free of many of the common epizootic pathogens, in particular respiratory and enteric pathogens, as well as internal and external parasites. The establishment of commercial SPF herds (secondary SPF pigs) commenced as early as 1955 in the USA and extensive repopulation programs with SPF pigs were started in Europe between 1960 and 1970. At the same time with the advent of breeding companies producing specific genetic lines, the advantages of having high health status herds was promoted, with the result that there has been a huge increase in the numbers of high health status commercial herds particularly in Europe, USA, Australia and more recently in Asia.

2.4 Early weaning systems

In 1982 Alexander reported the establishment of high health status herds by a system known as medicated early weaning (MEW). This was based on the principle that older sows that have had several litters pass on strong protective immunity through colostrum and milk to their piglets, which greatly reduces the chances of piglets becoming infected with endemic pathogens carried by the sows or present in the environment, at least for the first four or five days of life. Medication of sows with antibacterial agents against the organisms that are to be eliminated, from 5 days before until 5 days after farrowing, and of the piglets from birth to 10-20 days of age provides added safeguard. Weaners at 5 to 10 weeks of age can then be moved on to isolated grow-out units, reared to puberty and become the basis of a new high health status herd. Early weaning of the piglets at around 5 days and rearing them in isolation was shown to eliminate pathogens such as Mycoplasma hyopneumoniae, M hyosynoviae, Pasteurella multocida, Bordetella bronchiseptica, Actinobacillus pleuropneumoniae, Haemophilus parasuis, Strep suis, Sepulina hyodysenteriae, TGE virus, porcine epidemic diarrhoea virus, pseudorabies virus and PRRS virus. Although this technique was first used by breeding companies in the United Kingdom to establish new nucleus herds or to eliminate pathogens in herds that had broken down with specific diseases, it soon became apparent that the method could be used as an on-going management procedure to produce commercial pigs free of the endemic diseases that affect production, without depopulation of the breeding herd.

Harris in 1988 developed a modification of MEW now known as modified medicated early weaning (MMEW), segregated early weaning (SEW) or isowean, where the sows are batch farrowed on the source farm after vaccination and medication against the organisms present in the herd. Piglets are weaned between 5 and 28 days depending on the specific diseases to be eliminated (Table 2), and reared in isolated nursery accommodation away from the source farm before moving to isolated grow-out units or to a new piggery.

Table 2. Infectious agents eliminated by modified medicated weaning and maximum weaning age and need for medication and vaccination.

Organism	Weaning Age (days)	Medication		Vaccination	
		Sows	Piglets	Sows	Piglets
H. parasuis	10	—	+	+	—
B. bronchiseptica	10	—	+	+	—
P. multocida	8-10	—	+	+	—
A. pleuropneumoniae	21-25	—	+	+	—
M. hyopneumoniae	14-16	—	—	+	—
Salmonella spp.	20	—	—	+	—
Leptospirosis	14-16	—	+	+	—
Pseudorabies virus	20	—	—	+	—
Swine Influenza virus	20	—	—	+	—
PRRS virus	14-16	—	—	+	—
TGE virus	20	—	—	+	—

(Harris and Alexander 1999)

2.5 Multi-site production

MEW and MMEW have shown that piglets remain free from most of the serious pathogens endemic in a herd until (early) weaning. Piglets subsequently get infected when mixed with older pigs. Therefore if piglets are removed from the source herd at weaning (age dependent on specific diseases) and reared in isolated cohorts away from any other pigs and other age groups they are likely to remain specific pathogen free (Harris and Alexander 1999). This is the basis on which multi-site systems have been developed combining early weaning and AIAO management of isolated cohorts of similar age. All-in-all-out may be by site, by building or by room, and populated at the same time by pigs of the same age and depopulated completely at the appropriate time (after 6-7 weeks for weaners in a nursery, or 14-15 weeks for finisher pigs), cleaned, disinfected, dried and left empty for up to a week before populating again.

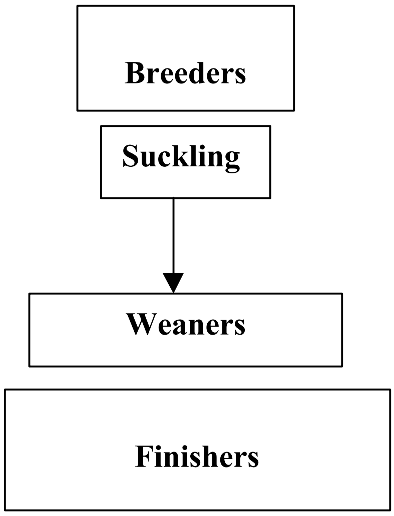
Various combinations of using the three stages of production (breeders, nursery and grow-out) with early weaning and AIAO management have evolved over the last 10 years, for example two, three or multi-site isowean production. In two-site situations breeders are on one site and weaners and finishers on another and AIAO may be by room or building. In three-site situations there are separate sites for breeders, weaners and finishers. Breeders are AIAO managed by room, whereas weaners and finishers are managed by room or building depending on the number of pigs in the batch. Multi-sites may have one or more breeder units at Site 1, providing weaners for up to eight weaner rooms or buildings (seven weeks production) at Site 2, and finishers for up to16 grow-out buildings (14 weeks production) at Site 3. Each weaner and finisher room or building will hold one week's production and where separate buildings are used they are separated by 12 metres (25 yards). (Figure 1)

Since the late 1980s multi-site isowean systems of pig production have been implemented increasingly by pig breeding companies, large-scale producers and integrators. These systems have been developed not only for the control of pathogens infectious to pigs, but also being aimed at reducing human disease via pork consumption or through contaminated waste products (Nielsen et al 1996 & Emborg et al 1996).

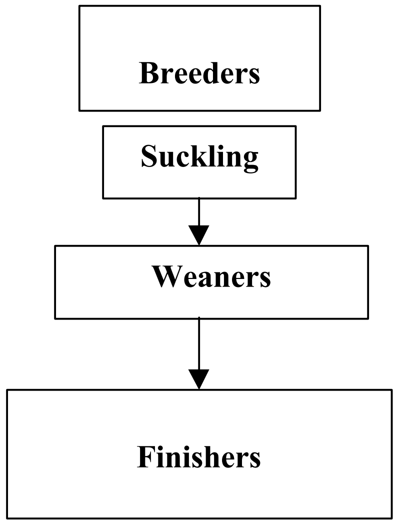
Although multi-site production as the name suggests involves separate geographical sites for the three different stages of production (breeders, nursery and grow-out) and separate buildings in the case of nursery and grow-out, the entire operation can be planned to cover a designated isolated pig production area integrated with some form of crop farming. It is also an advantage to have specific processing plants (abattoirs, feedmills etc.) near to the production system and isolated from other animal production systems.

Pigs produced in multi-site early wean systems using AIAO management have been shown to have improved efficiency of growth rates as a result of having less infectious agents to combat. When the pig's immune system is highly stimulated, energy and amino acids necessary for production of antibodies to the microbial agents are utilised and diverted from muscle protein accretion (Harris & Alexander 1999). Cytokines are also released when the pig is exposed to infections. Cytokines decrease food intake, body growth rates, efficiency of feed utilisation and protein synthesis (Williams et al 1997). Pigs reared in multi-site systems are exposed to less pathogens and less endotoxins in the environment so the immune system is less stimulated.

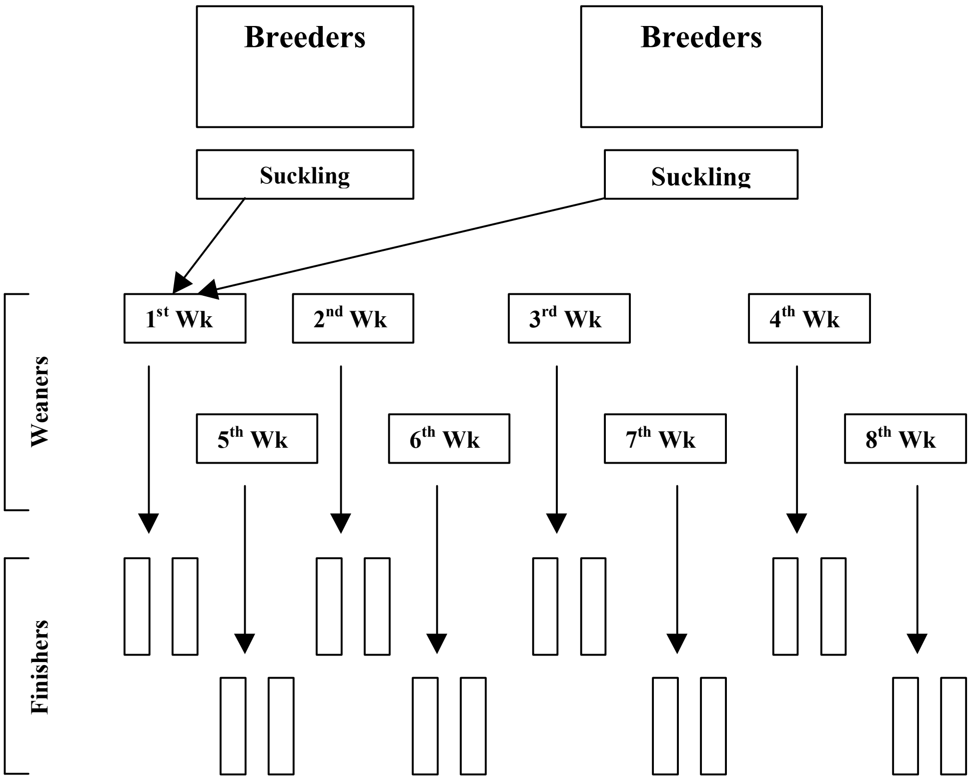
Figure 1. Multi-site systems (adapted from Harris and Alexander 1999)



Two-site production system using early weaning and AIAO farrowing (Site 1) and AIAO weaning and grow-out (Site 2).



Three site system with AIAO farrowing, weaning and grow-out on each separate site.



Multi-site early weaning production. AIAO farrowing, weaning and grow-out where each week's production populates a separate building.

3. BIOSECURITY

The evolution of industrialisation of the pig industry has resulted in specialised housing and management systems, however the success of these systems in maintaining animal and human health depends very much on the level of biosecurity of the herd or area in which the pigs are located. The levels of biosecurity required may differ slightly depending on the stage of production, for example a breeding site may over time develop a lower health status than a weaner site or finisher site. However every precaution should be taken to ensure maximum biosecurity to eliminate the risk of introducing disease.

- The **location** of the herd or area designated for pig production is critical. Proximity to other pigs, roads, railways, urban areas and the terrain must be taken into consideration. It is generally accepted that a distance of at least three to eight kilometres from other pigs is necessary. This will however depend on the density of the neighbouring pig farms, the disease status of these farms and the terrain. Large herds with a poor health status pose a greater risk than small herds. Herds with diseases that can be spread by prevailing winds e.g. Foot and Mouth disease and Enzootic Pneumonia present a serious risk if close by and in the line of the prevailing winds. Viral diseases appear to be carried long distances by wind, e.g. Foot and Mouth disease virus can be carried at least 20 km by wind, and Pseudorabies virus 9 km. Porcine Reproductive and Respiratory syndrome (PRRS) and Porcine Respiratory Coronavirus (PRCV) are two viral diseases now also believed to be windborne spread. Flies and rodents can travel from infected areas where pigs are kept for up to 3 to 4 km and carry infections such as salmonella, Strep. suis and Encephalomyocarditis virus (EMCV) and possibly Swine Dysentery. Public roads and railways may pose a risk if they carry livestock, although there is no clear evidence of pig herds being infected from passing vehicles.

- **Vehicles and the drivers transporting pigs** to the slaughter house or delivering feed, pose a major risk and require considerable supervision to ensure biosecurity. Vehicles need to be washed and disinfected after each slaughter plant delivery.
- **Loading ramps** need to be designed in such a way that the vehicles are as far as possible away from the pig buildings when loading pigs and the driver must not have to enter the piggery during the loading procedure.
- **Perimeter fencing** should surround the individual herd or site to ensure a clear demarcation and be constructed in such a way as to keep out other animals, vehicles and people.
- **All persons** entering the herd should not have been in contact with other pigs recently and must change boots and clothing and possibly shower before entering.
- **The down-time** of entering a high health status herd varies from 24 hours to 3 days depending on the health status of the herd and the health of the pigs previously in contact with.
- **Regular staff** working in the herd should have no contact with other pigs at any time and should be required to sign a declaration accordingly. If they do come in contact with other pigs they must observe the down time specified for casual visitors. In the case of multi-site systems staff working on one site must not move between and enter any of the other sites. In some situations the breeder site may have the lowest health status compared with the nursery site

and the grower/finisher sites, requiring special arrangements for moving iglets to the nursery site.

- **Visitors** should sign in and provide evidence of recent contact with pigs or other animals before entry to the farm.
- **A rodent and fly control program** should be implemented and buildings should be made bird-proof.
- **An isolation and acclimatisation (quarantine) area** should be used for incoming replacement stock and situated preferably 2 km away from the main herd. Incoming stock are usually held in quarantine for three to four weeks.

4. ANIMAL HEALTH AND INDUSTRIALISED PIG PRODUCTION.

Health problems in industrialised pig production systems can be classified as follows:

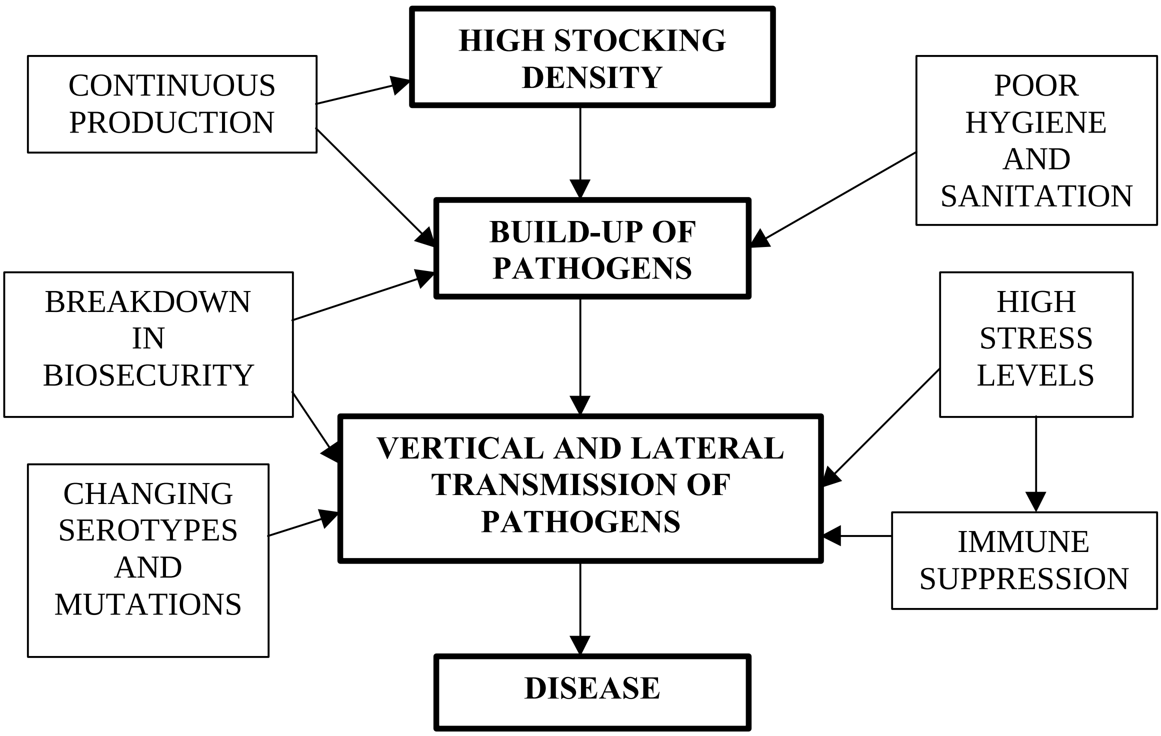
- **Endemic diseases** that become established in a population and are continually propagated from older animals, especially breeding sows and boars to younger animals. Once established they are transferred laterally between animals of similar age, especially where stocking densities are high.
- **Epizootic diseases** that cause sudden outbreaks due to the introduction of a pathogen from outside or when the herd immunity declines or is suppressed. Sudden disease outbreaks may also be associated with evolution of new strains or mutations of endemic pathogens developing in the population.
- **Stress induced diseases** often involve pathogens present in the population that cause disease when the animals are under stress e.g. due to transport, sudden changes in environmental conditions, overcrowding, changes in nutrition, excessive reproductive demands, and early weaning. Disease is a result of the sudden proliferation of pathogens and/or a decline in the animal's immunity due to the stress.

High concentrations of animals sharing a limited airspace and producing large quantities of effluent, and with the demands of intensive production (e.g. reproduction, lactation, early weaning, rapid growth rates) are extremely prone to disease due to:

- **the build-up of potential pathogens** in the environment and in carrier animals e.g. older breeding stock,
- **vertical and lateral spread** as a result of close contact especially when age groups are mixed together,

- **stress** associated with high stocking densities, inadequate ventilation and poor temperature control, handling and transport, changes in feed etc.,
- **emergence of new serotypes or mutations** of endemic organisms,
- **difficulty in maintaining adequate levels of hygiene** with effective cleaning and sanitation, due to the continual presence of animals — inability to de-populate,
- **multifactorial disease complex** due to the interaction and/or synergism of several organisms that become endemic in a population.

Figure 2. Factors influencing animal disease outbreaks in intensive production systems



Overt disease seen in intensively produced pigs is often associated with a particular stage of production or age group, e.g. breeding or lactating sows, weaners or finishers.

4.1 The breeding sows

Reproductive diseases in breeding sows become endemic in herds where large numbers of sows are kept together in all stages of pregnancy. Leptospirosis, Brucellosis and PRRS virus which cause infertility, abortions and stillborn piglets are typical examples. The close contact of sows at various stages of pregnancy and the intensive mating programs that are used in these large-scale production systems ensure the continual propagation of these diseases. Boars play a major role in venereal spread. Non-infectious diseases of the intensively managed breeding sow also can become a serious health and welfare problem e.g. lameness and skeletal problems, rectal prolapses, gastric ulcers and rapid loss of body condition associated with the stress of frequent pregnancies and lactation.

4.2 The lactating sow

The post-partum and lactation period can present major problems of health and welfare in intensively managed breeding sows. Post partum problems include uterine prolapses, lactation failure, mastitis, metritis and extreme loss of body condition. Metabolic disorders such as hypocalcaemia and hypomagnesemia may also be important sub-clinical problems in intensively bred sows.

4.3 Pre-weaned piglets

Intensive farrowing units can experience significant health problems in new-born piglets, e.g. colibacillosis, coccidiosis, TGE, HEV (vomiting and wasting disease) and salmonella and rotavirus in older suckling piglets. Colibacillosis, coccidiosis and salmonella are predisposed by poor sanitation, chilling and lack of colostrum intake. Continuous farrowing of large numbers of sows in the same building allows these diseases to become endemic. Polyarthritis caused by Strep. suis and Exudative Epidermitis caused by Staph. Hyicus are also common problems associated with poor hygiene in farrowing rooms. As piglets grow they become more susceptible to respiratory diseases especially from about three weeks of age. All-in-all-out batch farrowing greatly reduces the incidence of these diseases because better sanitation can be achieved and the age difference between piglets is less than one week.

4.4 Weaners

In the industrialised production system piglets are usually weaned at around three to four weeks of age and more recently as early as 14 days in some herds. Early weaning makes rearing of the piglets more difficult and they are more susceptible to disease if the housing, environment and nutrition are not optimal. Both enteric and respiratory diseases can be a major problem affecting weaners. The predisposing factors to many of these diseases include the stress of weaning, poor sanitation, poor ventilation and over-crowding. Weaner diseases are more prevalent when different age groups are mixed and where weaner housing cannot be spelled and cleaned regularly. Nutritional stress can be a problem in young early-weaned pigs. Piglets have difficulty in digesting solid feed before four weeks of age as their ability to produce a number of the digestive enzymes is limited. High quality weaner rations are essential for early-weaned pigs.

4.5 Growers and finishers

Large populations of grower and finisher pigs (12 weeks to 24 weeks of age) especially when age groups are mixed in the same buildings are very susceptible to respiratory and enteric diseases. Many large industrialised pig production units have had major problems with respiratory complex syndromes which not only cause high morbidity and high mortality but greatly affect efficiency of food conversion and thus growth rates and age at slaughter.

The major enteric diseases in these age groups include Swine dysentery, Salmonellosis and Proliferative Enteropathy. A number of internal parasites associated with the gastrointestinal tract become endemic in this age group. Both respiratory and enteric diseases in growing pigs have been the main reason for establishing AIAO multi-site production systems.

Other problems frequently encountered in intensively reared grower pigs are vices such as tail biting and flank biting associated with boredom, lack of stimulation and high stocking densities. These can be a serious welfare issue. Rectal prolapses and gastric ulcers also appear to be more common in large intensive grower systems.

5. DISEASES ASSOCIATED WITH INDUSTRIALISED PIG PRODUCTION IN ASIA

A wide range of diseases in pigs have been reported in Asian countries and it is also likely that outbreaks of disease in the past may not have been accurately diagnosed. New diseases also appear to be emerging. Diseases and pathogens that have been reported in pigs in Asia (Table 3) are most likely to become a greater health risk where large populations of pigs are kept under intensive conditions especially if adequate biosecurity precautions are not taken.

Many large industrialised pig production systems that have been established in Asia have been mainly the traditional farrow-to-finish systems often with very close mixing of age groups and no opportunity to manage even the farrowing sows and litters on an AIAO basis. These units are more often than not established with pigs from a variety of sources that can be carrying a large number of potential pathogens. Only a few units recently have been established with high health status stock. Replacement stock also often comes from a variety of sources and of unknown health status with no adequate quarantine before entry. Biosecurity has usually been very poor or non-existent with staff regularly in contact with outside pigs, unauthorised vehicles entering and in some cases no adequate perimeter fencing to stop other animals or people coming in contact with the pigs.

Effluent disposal is usually into large ponds in close proximity to the buildings and often subject to overflowing in the wet season into local rivers and waterways. Effluent treatment systems to remove pathogens are virtually non-existent. Consequently these herds are infected with a multitude of pathogens, bacterial, viral and parasitic, many of which find their way into the effluent becoming a human health hazard. Disease control is based on vaccination where possible and continuous ad hoc use of high levels of combinations of antibiotics and anti-bacterial agents without adequate supervision or veterinary advice.

Table 3. The important diseases and pathogens that could become a health risk to animals and humans in industrialised pig production systems in Asia.

DISEASE AND PATHOGEN	CLINICAL FEATURES	EPIDEMIOLOGY	AGE GROUP AFFECTED
Enzootic Pneumonia (Mycoplasma hyopneumoniae)	• Pneumonia • Coughing • Reduced growth	• Introduced by carrier pigs, people, semen? • Windborne • Rapidly becomes endemic • **ZOONOTIC**	• Weaners • Growers • Finishers
Pasteurellosis (P.multocida Type A, D, B_2)	• Pneumonia, • Septicaemia	• Carrier pigs • **Epizootic** outbreaks becomes **endemic**	• All ages
Porcine Pleuropneumonia (Actinobacillus pleuropneumoniae)	• Acute and chronic pneumonia • Weight loss • High mortalities	• Carrier pigs • **Epizootic** rapidly becoming **endemic**	• Weaners • Growers • Finishers
Bordatella Infections (Bordatella bronchiseptica)	• Rhinitis • Pneumonia	• Carrier pigs • Becomes endemic	• Weaners
Atrophic Rhinitis (Toxogenic P. multocida Type D)	• Sneezing • Turbinate atrophy	• Carrier pigs • Rapidly becomes **endemic**	• Weaners • Growers • Finishers
Porcine Respiratory Coronavirus (PRC virus)	• Bronchopneumonia	• **Epizootic**	• All ages
Swine influenza (Influenza A virus)	• Respiratory signs • Coughing • Sneezing • Fever • Low mortality	• Carrier pigs • Aerosol or droplet spread • May be carried by birds and dogs • **ZOONOTIC**	• All ages
Glassers Disease (Haemophilius parasuis)	• Polyseriositis • Pneumonia • Polyarthritis	• Carrier pigs • Stress induced • **Epizootic** outbreaks, becomes **endemic**	• Weaners • Growers • Finishers
Streptococcus meningitis (Strep. suis Type II)	• Nervous signs • Respiratory signs • Polyarthritis • High mortality	• Carrier non-clinical pigs • Stress induced • Poor ventilation • Over-crowding • **ZOONOTIC**	• Weaners

Continued over

DISEASE AND PATHOGEN	CLINICAL FEATURES	EPIDEMIOLOGY	AGE GROUP AFFECTED
Lungworm (Metastrongylus elongartus	• Pneumonia • Coughing • Emphysema	• **Epizootic** becomes **endemic**	• Weaners • Growers
Colibacillosis (Eschericia coli)	• Diarrhoea • Septicaemia	• Endemic in most herds • **ZOONOTIC**	• Piglets • Weaners
Oedema Disease (Specific E. coli serotypes)	• Sudden death • Nervous signs	• Stress induced • **Epizootic**	• Weaners
Salmonellosis (Salmonella spp.)	• Diarrhoea • Pneumonia • Septicaemia • Emaciation	• Oral/faecal infection • Contaminated effluent • **Endemic** • **ZOONOTIC**	• Weaners • Growers
Rotavirus (Rotavirus)	• Diarrhoea • Vomiting	• Oral/faecal contamination • **Endemic**	• Piglets • Weaners
Coccidiosis (Isospora suis)	• Diarrhoea	• Carrier pigs • Sows to piglets • Piglet faeces • **Endemic**	• Piglets
Swine Dysentery (Serpulina hyodysenteriae)	• Dysentery • High mortalities	• Carrier pigs • Faeces • Rodents • Dogs • **Epizootic**, becoming **endemic**	• Weaners • Growers • Finishers
Spirochaetal diarrhoea (Serpulina pilosicoli)	• Mild diarrhoea	• Carrier pigs • Faeces • **ZOONOTIC**	• Growers • Finishers
Proliferative Enteropathy (Lawsonia intracellularis)	• Dysentery • Weight loss	• Carrier pigs • Faeces • Becomes **endemic**	• Growers • Finishers • Young adults
Epidemic Diarrhoea (Coronavirus)	• Vomiting • Diarrhoea	• Carrier pigs • Stress induced • **Epizootic** outbreaks • Can become **endemic**	• Weaners • Growers • Finishers
Transmissible gastroenteritis (TGE virus, corona virus)	• Diarrhoea • Vomiting • High mortality in young	• Carrier pigs • Faeces • Air-born • Sows milk • Footwear • Vehicles • Effluent • Dogs and birds can be passive carriers	• All ages Most severe in young
Round Worm Infection (Ascaris suis)	• Coughing • Diarrhoea • Emaciation	• Carrier pigs • Footwear • Vehicles • Faeces • Becomes **endemic**	• Weaners • Growers • Finishers
Oesophagostomiasis (Oesophagostomum dentatum)	• Diarrhoea	• Faecal contamination • Becomes **endemic**	• All ages

Continued over

DISEASE AND PATHOGEN	CLINICAL FEATURES	EPIDEMIOLOGY	AGE GROUP AFFECTED
Leptospirosis (Leptospira spp.)	• Reproductive failure • Abortions • Infertility	• Carrier pigs • Rodents • Cattle • Contaminated water supply • Becomes **endemic** • **ZOONOTIC**	• All ages
Brucellosis (Brucella suis)	• Abortion • Stillborn piglets • Infertility in boars	• **Epizootic** becoming **endemic** • Transmitted in semen, aborted foetuses and placenta • Humans in contact with pigs • **ZOONOTIC**	• All ages especially breeding sows and boars
Parvovirus (Porcine parvovirus)	• Reproductive failure • Infertility • Mummified foetuses • Small litters	• Carrier pigs • Virus shed in faeces • Oral/nasal infection • Becomes **endemic**	• Sows • Piglets
Porcine Reproductive and Respiratory Syndrome (PRRS virus)	• Reproductive failure • Pneumonia • Immuno-suppressent	• Carrier pigs • Semen • Windborne • Becomes **endemic**	• All ages
Erysipelas (Erysipelothrix rhusiopathiae)	• Septicaemia • Skin lesions • Polyarthritis	• Carrier pigs • Faeces • Flies • **Epizootic**	• All ages
Tuberculosis (Micobacterium tuberculosis, avian and bovine)	• Chronic pneumonia • Weight loss • Lesions detected at slaughter	• Avian — infected poultry, bird faeces • Bovine — contact with infected cattle, milk, • Pig to pig • **ZOONOTIC**	• All ages
Exudative Epidermitis (Staphlococcus hyicus)	• Skin lesions • Toxaemia	• Carrier pigs • Poor hygiene • High humidity	• Piglets • Weaners
Mange (Sarcoptes scabiei)	• Skin lesions • Pruritis	• Carrier pigs • Sows to piglets • Egg contaminated housing • Becomes **endemic**	• All ages
Encephalomyocarditis (Picornavirus)	• Sudden death in young grower pigs • Foetal death in pregnant sows • Stillborn piglets	• **Epizootic** • Carried by rats and mice • Contaminated feed and water by rats • Pig to pig contact • Other hosts include monkeys, squirrels, lions • **ZOONOTIC**	• Piglets • Growers • Sows

Continued over

DISEASE AND PATHOGEN	CLINICAL FEATURES	EPIDEMIOLOGY	AGE GROUP AFFECTED
Japanese encephalitis (Japanese encephalitis virus —	Clinical signs in piglets • Weak • Stillborn • Mummified foetuses • Reduced libido in boars	• Transmitted by mosquitoes, birds, horses, • Airborne transmission • Seasonal epidemics • Pigs are the amplifying host • **ZOONOTIC**	• Piglets • Sows • Boars
Classical Swine Fever — Hog cholera (Pestivirus)	• Huddling • Erythema • Nervous signs • Abortion • Chronic fever • High mortalities	• Carrier pigs • Virus contaminated feed • Semen • Vehicles • Clothing • Footwear • Infected pork	• All ages
Pseudorabies (Herpes virus)	• Nervous signs • Fever • High mortality in young • Respiratory signs in growers • Abortion • Mummified foetuses	• Pigs are main reservoir • Other mammals can be infected • Seasonal incidence • Spread pig to pig by nasal/oral route • Airborne • Semen • Possibly other mammals	• All ages Most severe in young
Foot and mouth disease (Aphthovirus)	• Vesicles on lips, snout, tongue, coronet in the interdigital space	• Pigs major carriers • Aerosol transmission • Infected meat, milk, carcases • Cattle • Sheep • Goats • Buffaloes	• All ages
Swine Vesicular Disease (Picornavirus)	• Vesicles/erosions on the snout, lips, tongue and feet • Severe lameness	• Carrier pigs • Faeces • Vehicles • Clothing • Footwear • Pork • **ZOONOTIC**	• All ages
Nipah Encephalitis (Megamyxovirus)	• Fever • Severe coughing • Laboured breath • Nasal discharge • Nervous signs • Abortion • Stillbirths • High morbidity • Moderate mortality	• **Epizootic** • Carried by fruit bats, dogs, goats, cats, horses • Transmitted from pig to pig • Airborne • **ZOONOTIC**	• All ages

Table 4 lists the important zoonoses that could become a human health risk associated with industrialised pig production systems in Asia if allowed to become endemic in these herds. As indicated in the table the most common methods of transmission are:

- by contact, handling or consumption of contaminated pork carcases, or pork products, or
- through direct contact with infected pigs where the pathogens are being shed or excreted in the piggery environment e.g. by faeces, urine or airborne.

The most effective means of reducing the risk to human health therefore is by producing pigs free of these pathogens, or in the case of the more ubiquitous organisms, reducing their incidence.

By considering the epidemiology of these diseases pig herds can be established free of many zoonoses or managed in such a way as to reduce their incidence in the population, therefore reducing the risk of contamination of pork products produced for human consumption. Reducing the risk associated with zoonoses involves:

- establishing herds free of the specific pathogens where possible,
- implementing vaccination programs and using maximum hygiene in the herds,
- strict biosecurity,
- treating effluent to eliminate potential pathogens,
- ensuring effluent does not contaminate soils, waterways or domestic water supplies,
- avoiding cross contamination with pigs in lairage and between carcases at the abattoir and at meat processing plants.

Table 4. Important Zoonoses that could become a human health risk associated with industrialised pig production systems in Asia.

Zoonoses involving intensively reared pigs	Method of transmission to humans	Nature of the disease in humans
Balantidium coli	• Contact with infected faeces	• Dysentery
Brucellosis	• Direct contact with pigs and pig carcases, • Occupational risk for farmers, abattoir workers and veterinarians	• Fever • Arthritis • Lesions in spleen, liver, bone marrow.
Clostridium perfringens Type A	• Consumption of infected pork	• Food poisioning
Encephalomyocarditis virus	• Exposure to infected pigs, contaminated housing, feed and water, —a result of contamination by rats and mice	• Antibodies detected in humans • Myocarditis?
Erysipelas	• Contact with infected pigs, pig carcases. • Occupational risk for abattoir workers, veterinarians, farmers.	• Local skin reactions • Rarely endocarditis • Acute septicaemia
Japanese B. Encephalitis	• Transmitted by mosquitoes	• Fatal encephalitis in children • Abortion in women • Subclinical in adults
Leptospirosis	• Direct contact with pigs especially urine • Handling of infected carcases.	• Fever • Meningitis • Haemorrhagic jaundice • Glomerulonephritis • Weil's disease
<u>Pasteurella multocida</u> (Toxagenic strains)	• Airborne • Occupational risk to farmers and veterinarians	• Tonsillitis • Rhinitis • Sinusitis • Pleuritis • Septicaemia
Salmonellosis	• Consumption of infected pork products • Contact with live infected pigs • Contact with contaminated effluent	• Food poisoning • Fever • Dysentery
Serpulina pilosicoli	• Contact with infected faeces	• Diarrhoea

Continued over

Streptococcus suis	• Close contact with infected pigs • Airborne • Handling infected pork products • Transmission through skin abrasions and cuts	• Meningitis • Septicaemia • Endocarditis
Staphylococcus spp.	• Infected carcases • Piggery environment	• Food poisoning
Swine Influenza	• Direct contact with infected pigs	• Mild to severe influenza • Severe fatal pneumonia
Toxoplasmosis	• Ingestion of cysts in infected pork • Contaminated food and water via the cat • Pig is the intermediate host	• Mild lymphadenitis • Infections of the brain, liver and lungs • Transplacental causes foetal damage and stillbirth
Yersinia spp.	• Pig faeces • Pig carcases • Pork products	• Food poisoning • Enteritis • Appendicitis
E. coli	• Direct contact with infected pig faeces	• Food poisoning • Gastroenteritis with dysentery
Nipah virus	• Direct contact with infected pigs	• Fatal encephalitis

6. EMERGING DISEASE PROBLEMS AS A RESULT OF INDUSTRIALISATION OF PIG PRODUCTION IN THE LAST DECADE

Although the discovery of emerging diseases may be due to increasing vigilance and improved diagnostic methods, industrialisation of animal production such as for pigs and poultry will produce factors that may increase the risk of new diseases outbreaks. Increased risks include:

- changes in the ecology of the pig,
- housing environment,
- increasing population (stocking) density, and
- demographic factors such as:
  - close proximity to human populations (urban spread) and/or wildlife habitat
  - introduction of animals from other geographical regions,
  - a greater opportunity for evolution of viral and microbial variants, and drug resistance.

Industrialisation of pig production has resulted in the emergence of a number of disease syndromes or disease complexes that have had a major influence on housing, management, gene transfer techniques and the importance of biosecurity. By far the most spectacular example is the Porcine Respiratory Complex, a product of a combination of pathogens including Mycoplasma spp, Actinobacillis pleuropneumoniae, Pasteurella spp and in Asia viruses such as the PRRS virus and coronavirus. The complex is due to the mixing of large numbers of animals often from different sources, carrying a variety of pathogens which on their own may not be highly pathogenic, but together can create a major disease problem. These together with continuous flow production, high stocking densities and poor ventilation in industrialised systems reduce efficiency of food conversion, growth rates and significantly increase mortalities, and require continuous medication that adds greatly to the cost of production.

Similarly enteric organisms have been a major problem in large industrialised systems. For example, E. coli, Coccidiosis species, Salmonella spp, rotavirus and the TGE virus to name a few, in varying combinations can cause major disease outbreaks in young pigs. A number of these organisms are important zoonotics and therefore a risk to human health, e.g. E. coli 0157 and other verocytogenic (VTEC) infections. Infection in humans is the result of direct contact with large numbers of infected pigs, contact with pig effluent and consumption of contaminated pork products.

Diseases associated with reproduction have also become prominent with the industrialisation of the breeding sow and boar where several hundreds or thousands of sows are kept in close contact, producing at least 2 or 2.5 litters per year and with a sow to boar ratio of around 15:1. Diseases that have become endemic in these situations include Leptospirosis, Brucellosis, Porcine parvovirus and the Vulval Discharge syndrome. Further, diseases associated with poor hygiene in the breeding herd that have significantly increased in prevalence in industrialised systems include cystitis/pyelonephritis, mastitis and endometritis.

The emergence of a number of relatively new diseases in pigs appears to have been associated with industrialisation, e.g. Swine Vesicular disease, PRRS virus, the Type II Porcine Circovirus causing Post-weaning Multisystemic Wasting Syndrome

(PWMS) and the Porcine Dermatitis and Nephropathy Syndrome (PDNS) of unknown aetiology. More recently the pig industry has seen the emergence of several new viral diseases such as the Nipah virus in Malaysia and the Menangle virus (a paramyxovirus) in Australia, both of which are zoonotics and have a host other than the pig — the fruit bat.

Industrialisation predisposes to a number of stress induced diseases that can reach epidemic proportions in some herds e.g. Streptococcus suis meningitis (a zoonotic) and Haemophilus para suis (Glassers Disease). Some viral diseases may also result in immuno-suppression resulting in a higher incidence of endemic diseases present in the population, e.g. PRRS infection in weaner and grower pigs has been associated with a higher incidence of septicaemic Salmonellosis, Glassers disease, Streptococcal meningitis, Swine dysentery and a variety of bacterial pneumonias. This PRRSV-associated enhancement of endemic disease is most significant in herds with poor health status and poor housing and management (Benfield et al 1999).

Pig health has also been adversely affected by contact with building materials, flooring systems etc. causing injury and traumatic changes leading to skeletal problems such as arthritis and lameness. Similarly high stocking numbers have lead to vices such as tail biting, vulva biting and fighting generally causing injury and sometimes death, especially following the mixing of pigs.

In summary animal and human health factors associated with industrialised pig production include:

- **the development of disease complexes** targeted at specific systems e.g. respiratory, gastro-intestinal and reproductive, associated with the mixing of large numbers of animals,
- **epidemic outbreaks** caused by common ubiquitous organisms brought on by stress, high stocking densities, poor ventilation, poor sanitation and the presence of immuno-suppressing viral infections,
- **emerging disease,** a result of changes in the ecology of the pig, pathogen or both, or introduced from other animal species in close contact, or increased opportunity for changes in pathogenicity of ubiquitous organisms,
- **disease in humans** as a result of close contact with high-density animal populations in confined airspace and/or contact with high concentrations of effluent or effluent polluted water and soil, and also the consumption and handling of contaminated pork and pork by-products.

Disease was controlled traditionally by using a combination of vaccination programs (often of doubtful efficacy) and continuous use of high levels of antibiotics in feed or water. This approach has usually been unsuccessful in eradication of disease with the result of continuing high costs to production and the evolution of antibiotic resistant organisms becoming endemic.

Table 5 lists the major animal health risk factors associated with industrialised pig production, and management options that can be used to reduce the level of risk, as an alternative approach to disease control. In many cases the management options may eradicate disease.

Table 5. Animal and human health risk factors and management options in industrialised pig production systems in Asia

Major risk factors	Risk management options
• Establishing herds with pigs carrying endemic pathogens	• Establish herds with minimal disease/SPF stock
• One site farrow-to-finish continuous production systems	• Pig production confined to specific isolated areas
• Inability to de-populate for cleaning and disinfection	• Multi-site production systems
• Close contact and mixing of different age groups	• All-in-all-out management of farrowing sows, weaners, growers and finishers
• High stocking densities	• Early weaning
• Poor ventilation, high dust and gas levels	• Strict biosecurity
• Ineffective disposal and treatment of effluent	• Efficient disposal and treatment of effluent
• Inadequate biosecurity	• Regular independent veterinary consulting and diagnostic services
• Lack of effective veterinary services for diagnosis and control of disease outbreaks	• Use of high technology e.g. artificial insemination, vaccinations, abattoir health monitoring and disease surveillance
• Inappropriate and excessive use of antimicrobials especially in feed.	

7. AREA WIDE (CROP-LIVESTOCK) INTEGRATION (AWI) AND ITS IMPLICATIONS FOR ANIMAL AND HUMAN HEALTH

Area wide integration (AWI) is a concept whereby a particular livestock activity is integrated with some form of crop farming in a specific area not used for other livestock production and away from urban development. This concept could be extremely compatible with the latest principles on development of industrialised pig production. AWI offers the major advantage of having a disease-free zone and with strict biosecurity large populations of pigs can be established and maintained free of most of the production debilitating and zoonotic diseases. Further, by establishing AWI of pig production with some form of cropping the opportunity for using multi-site production systems is feasible and an effective means of controlling both animal and human health. Multi-site production would also provide the opportunity for some staff to be involved in both the pig production and cropping.

Within a specific area designated for AWI, associated facilities such as abattoirs, pork processing plants and feed mills could be established. Properly planned this could greatly enhance biosecurity by securing the area as a "pig-zone" only, "from birth to the final pork product".

Models proposed so far for projects in Thailand, Southern Vietnam, Malaysia and China have focussed mainly on policy options and guidelines on effluent collection, storage and treatment, including distribution on cropping land and possible techniques for other methods of utilisation of manure such as bio-gas, composting etc. Little or no policy details have been established in relation to the essential considerations for designating AWI sites, housing and management methods to ensure the health of the pigs and reduce the risk to human health.

When considering the animal and human health risks associated with AWI and industrialised pig production the following criteria are essential.

- The site must be entirely free of other livestock production, including household and village animals especially pigs.
- The nucleus animals used to establish the production system must be specific pathogen free (SPF).
- A strict biosecurity policy must be developed and strictly maintained. This will require a major education program for all persons involved in both the pig and crop production, and any other related facilities — abattoirs, feed mills, transport services etc.
- Provision of a highly qualified and independent specialist pig veterinary service with on-site facilities for diagnostic backup is essential.

7.1 The site

Selection of the site in relation to disease control will have to take into consideration the distance from densely populated urban development, local terrain, proximity to other livestock production, wildlife habitats, water supply and the method used to dispose of waste materials. The site ideally should be in a rural area, surrounded by high terrain or woodlands to protect from prevailing winds that pass over other livestock farms. Although the site needs to have access to main roads and/or rail for transport it should not be located directly in their pathway. The nature of the site will be determined to some extent by the method of collection, storage and distribution of effluent, taking into account impact on the land usage, smell, leakage to streams and rivers, and also water supply used for human consumption and washing. The site should be large enough in area to be able to establish multi-site production systems, that is, allow for adequate distance between the different stages of production (breeder site, nursery sites and grow-out sites) and also accommodate abattoir, feed processing facilities and possibly accommodation for staff to live within the site area. Separate AWI sites could be used to separate production sites, i.e. one AWI site may be for breeder units only supplying weaners for nursery production to an AWI site at a different location, or one AWI site could accommodate both breeder units and nursery units to supply growers for contract growing at several smaller AWI sites.

7.2 Housing

Ideally the housing system should be based on a multi-site complex either a two site system or preferably a three site system (Figure 1). Each production site should be managed on a batch AIAO basis. The breeder and farrowing site would have AIAO farrowing rooms designed for weekly batch farrowing. The nursery accommodation should be rooms or buildings depending on the number of animals per batch. The grow-out units should be AIAO buildings. Contract growing whereby small AWI sites can be managed by one family combining growing pigs and cropping, similar to broiler production in the poultry industry, is another alternative.

The actual size and design of the housing will depend on the weekly pig throughput. The minimum size considered practical in most western countries is about 1200 sows producing approximately 500 pigs per week. However smaller units could considered especially breeder units that supply weaners for co-mingling at the nursery stage of production.

7.3 Disease control management

AWI should ensure isolation of the pig production from other forms of livestock production, and strict biosecurity for the area is essential for maintenance of the health status where the original nucleus stock commenced with is pathogen free. All-in-all-out management allows some degree of control over a specific breakdown as the affected batch is isolated and can be treated appropriately. Biosecurity combined with a sound vaccination program and strategic medication will ensure disease control if strictly adhered to. All-in-all-out production also eliminates the problems associated with mixing of age groups and vertical spread of disease.

Further disease control can be achieved by early weaning. Weaning at 14 days is ideal and is likely to eliminate most pathogens in the weaner pigs (Table 2), however weaning at this age does require a great deal of expertise and optimum housing and nutrition to be successful. The age at weaning however, is determined to some extent by the disease status of the breeder herd. If the breeders are SPF then weaning at 21 days may be adequate. If some specific pathogens are in the breeder herds earlier weaning may be necessary. Vaccination and strategic medications can also be used to adjust the weaning age.

Introduction of new genetic material on an ongoing basis is necessary to avoid inbreeding and to continually improve production. This can be done by artificial insemination (AI), embryo transfer or through a quarantine program. The most common way disease breakdown takes place is via the introduction of live pigs of a lower health status. AI can also be used as a routine management procedure in the breeding herds to further reduce the spread of ubiquitous organisms within the herd with the added advantage of reducing the number of boars that have to be kept for natural mating.

Multi-site production systems cater for different levels of disease status in the breeding herds which can be managed without total depopulation if a pathogen is introduced. Multi-site AIAO also allows disease outbreaks to be contained within a given room or building without compromising the health status of the entire site or AWI program.

Multi-site production systems also have the advantage of having specialised staff for each production site. These staff can be trained to develop expertise in particular areas of production e.g.

- mating management and AI,
- farrowing and care of the newborn,
- weaner management in the nursery,
- grow-out and finisher management.

Specific in-house programs can be designed for training staff in these management skills. This has been shown to stimulate motivation and develop confidence and lead to higher levels of production.

7.4 Veterinary services

It is essential to have a sound veterinary service carried out by veterinarians who have had experience and specialised training in pig health and production, as well as experience in the management and biosecurity aspects of multi-site minimal disease production systems. An on-site veterinary diagnostic laboratory and autopsy facility would be an advantage for routine disease monitoring and diagnostic procedures. Abattoir facilities within the AWI site would be a major advantage for routine inspections of viscera for the detection of both animal and zoonotic diseases.

8. PRIORITY AREAS FOR POLICY ON THE ESTABLISHMENT OF AREA-WIDE-INTEGRATION (AWI) OF PIG PRODUCTION AND CROPPING

Area Wide Integration provides a major opportunity to reduce the risk of both animal and human disease by means of establishing a population of one animal species kept in isolation. By using industrialisation of production and incorporating a number of the recently developed management and housing techniques to control disease, large numbers of pigs can be produced free of specific pathogens and ubiquitous pathogens can be kept to a low incidence.

By considering the epidemiology of the major pig diseases their incidence can be significantly reduced by a combination of the following management and housing techniques:

- establishing herds in isolation with **specific pathogen-free pigs**,
- maintaining the health status by **strict biosecurity**,
- using a **batch production** system with **all-in-all-out** accommodation from birth to slaughter,
- **early weaning** at 14 to 21 days,
- **separating production stages** by site.

The establishment of AWI needs to be undertaken with a sound knowledge of the epidemiology and methods of prevention and control of pig diseases. **Health management policy should be established by experienced veterinarians that have a sound knowledge of the specific disease problems known to occur in Asia, as well as a thorough working knowledge of all aspects of the biosecurity required to control these diseases in the Asian environment.** Further ongoing veterinary consultancy backed up by veterinary diagnostic pathology and microbiology services must be provided to monitor ongoing health status of each and every production batch as well as quickly and accurately diagnosing overt disease outbreaks if and when they occur.

Multi-site early wean systems are generally easier to manage than one-site or traditional two-site systems. A higher standard of specialised management can be achieved. The nursery (Site 2) and finisher (Site 3) can provide the opportunity for staff to also be involved in cropping as these sections do not necessarily involve a fulltime work commitment. Production can be planned months ahead based on when the site will be filled and emptied. Managed properly with strict biosecurity multi-site systems provide pigs for slaughter of a very high health status. High health status pigs grow more efficiently and economically than conventional pigs (Harris & Alexander 1999). For example high health animals have been shown to have the advantage of a reduced cost of production in the order of US$16.00 per pig (Table 6 Moore 1995).

Table 6. Comparison of factors affecting profitability in high health and conventional health status herds.

FACTORS	HIGH HEALTH	CONVENTIONAL	$$ ADVANTAGE
Piglets weaned per sow	21	18	1.60
Weaning age (days)	21	28	1.16
Nursery FE	1.4	1.7	0.90
Nursery mortality (%)	1.5	3.0	
Nursery ADG (lb/day)	0.8	0.65	
Grow-finish FE (gain)	2.65	3.0	5.25
Grow-finish mortality (%)	1.5	3.0	1.20
Drug cost ($)	1.25	4.00	2.75
Grow-finish ADG (lb/day)	1.80	1.45	
Age to slaughter (days)	150/165	190/205	3.20
TOTAL			**16.06**

FE = Feed efficiency ADG = Average daily gain

Other disciplines that are essential to be involved in policy include experts in:

- **environmental housing design** for multi-site, AIAO early weaning systems,
- **effluent disposal**, storage and treatment in conjunction with the land utilisation and specific cropping activities,
- **nutrition** of pigs especially in industrialised production and early weaning systems,
- **genetics and animal breeding** with specific knowledge of the Asian environment and marketing requirements,
- **animal reproduction** control techniques e.g. AI, embryo transfer, synchronised farrowing etc.

High priority for policy must also include **staff education and training** in all disciplines and in particular in disease control. Courses involving the basics of pig diseases, especially epidemiology, methods of treatment and control, biosecurity and disease monitoring methods must be taught. Staff can also have specialised training in specific areas of production e.g. the breeding herd including AI, farrowing management, early weaning and nursery management, growers and finisher management, and then work in their area of expertise. **Management manuals** can be developed to clearly define the day-to-day management procedures that have to be carried out in the specific areas of production. Education should involve **inservice training as well as regular courses** provided by international experts in conjunction with local University Veterinary Schools. **Certificates for appropriate qualifications should be awarded** and employment based on levels of experience and qualification.

9. GENERAL CONCLUSION

Because of the complexity of establishing and managing intensive industrialised pig production units with minimal risk to animal and human health and welfare as outlined in this report, priority should be given to establishing at least one pilot AWI project based on the following:

- 1200 breeding sows,
- 90 – 100 boars,
- approximately 500 piglets weaned per week,
- preferably three site production (breeders and farrowing, nursery, growers/finishers),
- weaning at 21 days,
- use of artificial insemination for replacement genes,
- The original breeding stock must be specific pathogen free, purchased from a reputable breeding company**.**

Such a pilot project could be used to demonstrate the concept of AWI involving low risk factors for both animal and human health and at the same time be an educational and training facility for producing managers for additional AWI systems using industrialised pig production.

The long-term success of such a project will depend on the quality of the housing and management, level of staff training and education, and especially the maintenance of strict biosecurity. Failure could result in major risk to both animal and human health as well as enormous economic loss.

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- Factors in the emergence of diseases in man and animals.
- Area-Wide Integration (AWI) of Specialised Crop and Livestock Activities: Identification of policy options for four provinces in Southern Vietnam.
- Area-Wide Integration (AWI) in Jiangsu Province (China)
- Designing models for Area-Wide Integration (AWI) in Region 2, Thailand.
- A Blueprint for FAO's Livestock Production Programme (Discussion paper) by J. Slingenbergh and H. Steinfeld.
- Gallacher et al. 'Survey of large pig holdings in South Vietnam.
- Singh et al. 'Nutrition and Performance of small pig holdings in selected Vietnamese provinces.
- Gallacher et al. 'Development of pig production to reduce poverty in South Vietnam.
- Area-Wide Integration (AWI) of Specialised Crop and Livestock Activities: Identification of policy options in Jiangsu Province, China.
- Area-Wide Integration (AWI) of Specialised Crop and Livestock Activities. Identification of policy options in Eastern Thailand.
- Devendra, C. 'Mixed farming and intensification of animal production systems in Asia.' www.fao.org/wairdocs/ilri/x5462e/x5462eOi.htm
- Tisdell et al 'Characteristics of Thailand's commercial pig and poultry industries, with international comparisons.' www.fao.org/docrep/w6437/w6437t02.htm

11. Appendix — Copies of all Tables (1 to 5) and all Figures (1 & 2).

Table 1. Estimated on-farm breeding sows and total pig numbers (x 1000) in the Asian region in 1998.

	On-farm pigs*	Breeding sows**
China	395,000	32,000
Vietnam	18,060	2,200
India	16,000	600
Philippines	10,912	1,100
Japan	9,915	900
Korea	6,710	900
Taiwan	6,539	800
Thailand	4,209	500
Indonesia	3,400	100
Malaysia	2,350	300
Laos	1,880	NA
Cambodia	1,410	NA

* Pig International **29:**22 ** Pig International **29:**1

Table 2. Infectious agents eliminated by modified medicated weaning and maximum weaning age and need for medication and vaccination.

Organism	Weaning Age (days)	Medication		Vaccination	
		Sows	Piglets	Sows	Piglets
H. parasuis	10	—	+	+	—
B. bronchiseptica	10	—	+	+	—
P. multocida	8-10	—	+	+	—
A. pleuropneumoniae	21-25	—	+	+	—
M. hyopneumoniae	14-16	—	—	+	—
Salmonella spp.	20	—	—	+	—
Leptospirosis	14-16	—	+	+	—
Pseudorabies virus	20	—	—	+	—
Swine Influenza virus	20	—	—	+	—
PRRS virus	14-16	—	—	+	—
TGE virus	20	—	—	+	—

(Harris and Alexander 1999)

Table 3. The important diseases and pathogens that could become a health risk to animals and humans in industrialised pig production systems in Asia.

DISEASE AND PATHOGEN	CLINICAL FEATURES	EPIDEMIOLOGY	AGE GROUP AFFECTED
Enzootic Pneumonia (Mycoplasma hyopneumoniae)	• Pneumonia • Coughing • Reduced growth	• Introduced by carrier pigs, people, semen? • Windborne • Rapidly becomes endemic • **ZOONOTIC**	• Weaners • Growers • Finishers
Pasteurellosis (P.multocida Type A, D, B$_2$)	• Pneumonia, • Septicaemia	• Carrier pigs • **Epizootic** outbreaks becomes **endemic**	• All ages
Porcine Pleuropneumonia (Actinobacillus pleuropneumoniae)	• Acute and chronic pneumonia • Weight loss • High mortalities	• Carrier pigs • **Epizootic** rapidly becoming **endemic**	• Weaners • Growers • Finishers
Bordatella Infections (Bordatella bronchiseptica)	• Rhinitis • Pneumonia	• Carrier pigs • Becomes endemic	• Weaners
Atrophic Rhinitis (Toxogenic P. multocida Type D)	• Sneezing • Turbinate atrophy	• Carrier pigs • Rapidly becomes **endemic**	• Weaners • Growers • Finishers
Porcine Respiratory Coronavirus (PRC virus)	• Bronchopneumonia	• **Epizootic**	• All ages
Swine influenza (Influenza A virus)	• Respiratory signs • Coughing • Sneezing • Fever • Low mortality	• Carrier pigs • Aerosol or droplet spread • May be carried by birds and dogs • **ZOONOTIC**	• All ages
Glassers Disease (Haemophilius parasuis)	• Polyseriositis • Pneumonia • Polyarthritis	• Carrier pigs • Stress induced • **Epizootic** outbreaks, becomes **endemic**	• Weaners • Growers • Finishers
Streptococcus meningitis (<u>Strep. suis</u> Type II)	• Nervous signs • Respiratory signs • Polyarthritis • High mortality	• Carrier non-clinical pigs • Stress induced • Poor ventilation • Over-crowding • **ZOONOTIC**	• Weaners
Lungworm (Metastrongylus elongartus	• Pneumonia • Coughing • Emphysema	• **Epizootic** becomes **endemic**	• Weaners • Growers
Colibacillosis (Eschericia coli)	• Diarrhoea • Septicaemia	• Endemic in most herds • **ZOONOTIC**	• Piglets • Weaners
Oedema Disease (Specific E. coli serotypes)	• Sudden death • Nervous signs	• Stress induced • **Epizootic**	• Weaners
Salmonellosis (Salmonella spp.)	• Diarrhoea • Pneumonia • Septicaemia • Emaciation	• Oral/faecal infection • Contaminated effluent • **Endemic** • **ZOONOTIC**	• Weaners • Growers

Continued over

DISEASE AND PATHOGEN	CLINICAL FEATURES	EPIDEMIOLOGY	AGE GROUP AFFECTED
Rotavirus (Rotavirus)	• Diarrhoea • Vomiting	• Oral/faecal contamination • **Endemic**	• Piglets • Weaners
Coccidiosis (Isospora suis)	• Diarrhoea	• Carrier pigs • Sows to piglets • Piglet faeces • **Endemic**	• Piglets
Swine Dysentery (Serpulina hyodysenteriae)	• Dysentery • High mortalities	• Carrier pigs • Faeces • Rodents • Dogs • **Epizootic**, becoming **endemic**	• Weaners • Growers • Finishers
Spirochaetal diarrhoea (Serpulina pilosicoli)	• Mild diarrhoea	• Carrier pigs • Faeces	• Growers • Finishers
Proliferative Enteropathy (Lawsonia intracellularis)	• Dysentery • Weight loss	• Carrier pigs • Faeces • Becomes **endemic**	• Growers • Finishers • Young adults
Epidemic Diarrhoea (Coronavirus)	• Vomiting • Diarrhoea	• Carrier pigs • Stress induced • **Epizootic** outbreaks • Can become **endemic**	• Weaners • Growers • Finishers
Transmissible gastroenteritis (TGE virus, corona virus)	• Diarrhoea • Vomiting • High mortality in young	• Carrier pigs • Faeces • Air-born • Sows milk • Footwear • Vehicles • Effluent • Dogs and birds can be passive carriers	• All ages Most severe in young
Round Worm Infection (Ascaris suis)	• Coughing • Diarrhoea • Emaciation	• Carrier pigs • Footwear • Vehicles • Faeces • Becomes **endemic**	• Weaners • Growers • Finishers
Oesophagostomiasis (Oesophagostomum dentatum)	• Diarrhoea	• Faecal contamination • Becomes **endemic**	• All ages
Leptospirosis (Leptospira spp.)	• Reproductive failure • Abortions • Infertility	• Carrier pigs • Rodents • Cattle • Contaminated water supply • Becomes **endemic** • **ZOONOTIC**	• All ages

Continued over

DISEASE AND PATHOGEN	CLINICAL FEATURES	EPIDEMIOLOGY	AGE GROUP AFFECTED
Brucellosis (Brucella suis)	• Abortion • Stillborn piglets • Infertility in boars	• **Epizootic** becoming **endemic** • Transmitted in semen, aborted foetuses and placenta • Humans in contact with pigs • **ZOONOTIC**	• All ages especially breeding sows and boars
Parvovirus (Porcine parvovirus)	• Reproductive failure • Infertility • Mummified foetuses • Small litters	• Carrier pigs • Virus shed in faeces • Oral/nasal infection • Becomes **endemic**	• Sows • Piglets
Porcine Reproductive and Respiratory Syndrome (PRRS virus)	• Reproductive failure • Pneumonia • Immuno-suppressent	• Carrier pigs • Semen • Windborne • Becomes **endemic**	• All ages
Erysipelas (Erysipelothrix rhusiopathiae)	• Septicaemia • Skin lesions • Polyarthritis	• Carrier pigs • Faeces • Flies • **Epizootic**	• All ages
Tuberculosis (Micobacterium tuberculosis, avian and bovine)	• Chronic pneumonia • Weight loss • Lesions detected at slaughter	• Avian — infected poultry, bird faeces • Bovine — contact with infected cattle, milk, • Pig to pig • **ZOONOTIC**	• All ages
Greasy pig disease (Staphlococcus hyicus)	• Skin lesions • Toxaemia	• Carrier pigs • Poor hygiene • High humidity	• Piglets • Weaners
Mange (Sarcoptes scabiei)	• Skin lesions • Pruritis	• Carrier pigs • Sows to piglets • Egg contaminated housing • Becomes **endemic**	• All ages
Encephalomyocarditis (Picornavirus)	• Sudden death in young grower pigs • Foetal death in pregnant sows • Stillborn piglets	• **Epizootic** • Carried by rats and mice • Contaminated feed and water by rats • Pig to pig contact • Other hosts include monkeys, squirrels, lions • **ZOONOTIC**	• Piglets • Growers • Sows
Japanese encephalitis (Japanese encephalitis virus — flavivirus)	Clinical signs in piglets • Weak • Stillborn • Mummified foetuses • Reduced libido in boars	• Transmitted by mosquitoes, birds, horses, • Airborne transmission • Seasonal epidemics • Pigs are the amplifying host • **ZOONOTIC**	• Piglets • Sows • Boars

Continued over

DISEASE AND PATHOGEN	CLINICAL FEATURES	EPIDEMIOLOGY	AGE GROUP AFFECTED
Classical Swine Fever — Hog cholera (Pestivirus)	• Huddling • Erythema • Nervous signs • Abortion • Chronic fever • High mortalities	• Carrier pigs • Virus contaminated feed • Semen • Vehicles • Clothing • Footwear • Infected pork	• All ages
Pseudorabies (Herpes virus)	• Nervous signs • Fever • High mortality in young • Respiratory signs in growers • Abortion • Mummified foetuses	• Pigs are main reservoir • Other mammals can be infected • Seasonal incidence • Spread pig to pig by nasal/oral route • Airborne • Semen • Possibly other mammals	• All ages Most severe in young
Foot and mouth disease (Aphthovirus)	• Vesicles on lips, snout, tongue, coronet interdigital space	• Pigs major carriers • Aerosol transmission • Infected meat, milk, carcases • Cattle • Sheep • Goats • Buffaloes	• All ages
Swine Vesicular Disease (Picornavirus)	• Vesicles/erosions on the snout, lips, tongue and feet • Severe lameness	• Carrier pigs • Faeces • Vehicles • Clothing • Footwear • Pork • **ZOONOTIC**	• All ages
Nipah Encephalitis (Megamyxovirus)	• Fever • Severe coughing • Laboured breath • Nasal discharge • Nervous signs • Abortion • Stillbirths • High morbidity • Moderate mortality	• **Epizootic** • Carried by fruit bats, dogs, goats, cats, horses • Transmitted from pig to pig • Airborne • Humans infected • **ZOONOTIC**	• All ages

Table 4. Important Zoonoses that could become a human health risk associated with industrialised pig production systems in Asia.

Zoonoses involving intensively reared pigs	Method of transmission to humans	Nature of the disease in humans
Balantidium coli	• Contact with infected faeces	• Dysentery
Brucellosis	• Direct contact with pigs and pig carcases, • Occupational risk for farmers, abattoir workers and veterinarians	• Fever • Arthritis • Lesions in spleen, liver, bone marrow.
Clostridium perfringens Type A	• Consumption of infected pork	• Food poisioning
Encephalomyocarditis virus	• Exposure to infected pigs, contaminated housing, feed and water, —a result of contamination by rats and mice	• Antibodies detected in humans • Myocarditis?
Erysipelas	• Contact with infected pigs, pig carcases. • Occupational risk for abattoir workers, veterinarians, farmers.	• Local skin reactions • Rarely endocarditis • Acute septicaemia
Japanese B. Encephalitis	• Transmitted by mosquitoes	• Fatal encephalitis in children • Abortion in women • Subclinical in adults
Leptospirosis	• Direct contact with pigs especially urine • Handling of infected carcases.	• Fever • Meningitis • Haemorrhagic jaundice • Glomerulonephritis • Weil's disease
Pasteurella multocida (Toxagenic strains)	• Airborne • Occupational risk to farmers and veterinarians	• Tonsillitis • Rhinitis • Sinusitis • Pleuritis • Septicaemia
Salmonellosis	• Consumption of infected pork products • Contact with live infected pigs • Contact with contaminated effluent	• Food poisoning • Fever • Dysentery
Serpulina pilosicoli	• Contact with infected faeces	• Diarrhoea

Continued over

Streptococcus suis	• Close contact with infected pigs • Airborne • Handling infected pork products • Transmission through skin abrasions and cuts	• Meningitis • Septicaemia • Endocarditis
Staphlococcus spp.	• Infected carcases • Piggery environment	• Food poisoning
Swine Influenza	• Direct contact with infected pigs	• Mild to severe influenza • Severe fatal pneumonia
Toxoplasmosis	• Ingestion of cysts in infected pork • Contaminated food and water via the cat • Pig is the intermediate host	• Mild lymphadenitis • Infections of the brain, liver and lungs • Transplacental causes foetal damage and stillbirth
Yersinias spp.	• Pig faeces • Pig carcases • Pork products	• Food poisoning
E. coli	• Direct contact with infected pig faeces	• Food poisoning • Gastroenteritis with dysentery
Nipah virus	• Direct contact with infected pigs	• Encephalitis

Table 5. Animal and human health risk factors and management options in industrialised pig production systems in Asia

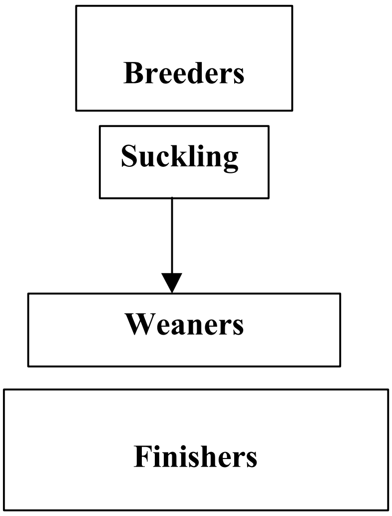
Major risk factors	Risk management options
• Establishing herds with pigs carrying endemic pathogens • One site farrow-to-finish continuous production systems • Inability to de-populate for cleaning and disinfection • Close contact and mixing of different age groups • High stocking densities • Poor ventilation, high dust and gas levels • Ineffective disposal and treatment of effluent • Inadequate biosecurity • Lack of effective veterinary services for diagnosis and control of disease outbreaks • Inappropriate and excessive use of antimicrobials especially in feed.	• Establish herds with minimal disease/SPF stock • Pig production confined to specific isolated areas • Multi-site production systems • All-in-all-out management of farrowing sows, weaners, growers and finishers • Early weaning • Strict biosecurity • Efficient disposal and treatment of effluent • Regular independent veterinary consulting services • Use of high technology e.g. artificial insemination, vaccinations, abattoir health monitoring and disease surveillance

Table 6. Comparison of factors affecting profitability in high health and conventional health status herds.

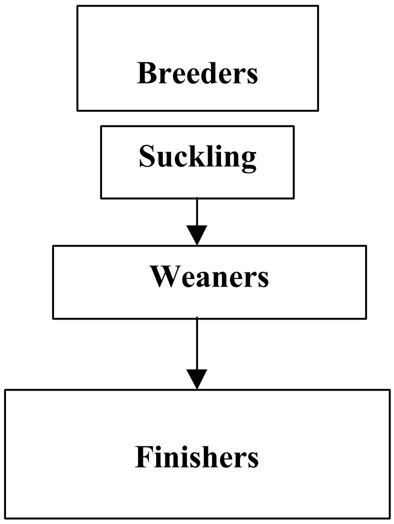
FACTORS	HIGH HEALTH	CONVENTIONAL	$$ ADVANTAGE
Piglets weaned per sow	21	18	1.60
Weaning age (days)	21	28	1.16
Nursery FE	1.4	1.7	0.90
Nursery mortality (%)	1.5	3.0	
Nursery ADG (lb/day)	0.8	0.65	
Grow-finish FE (gain)	2.65	3.0	5.25
Grow-finish mortality (%)	1.5	3.0	1.20
Drug cost ($)	1.25	4.00	2.75
Grow-finish ADG (lb/day)	1.80	1.45	
Age to slaughter (days)	150/165	190/205	3.20
TOTAL			**16.06**

FE = Feed efficiency   ADG = Average daily gain

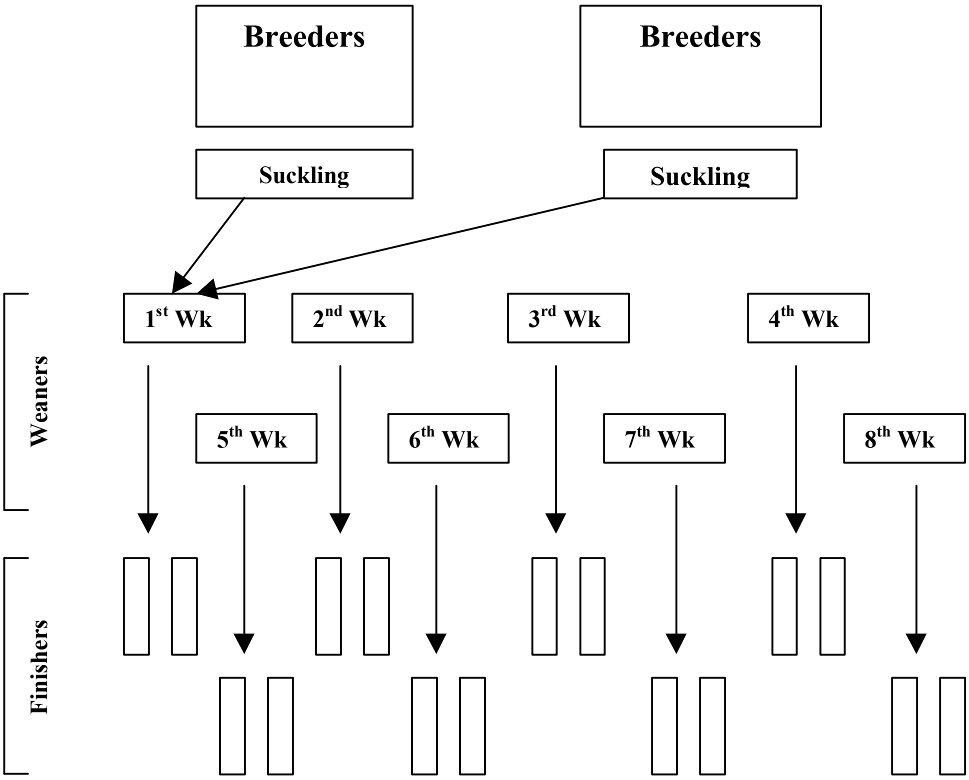
Figure 1. Multi-site systems (adapted from Harris and Alexander 1999)



Two-site production system using early weaning and AIAO farrowing (Site 1) and AIAO weaning and grow-out (Site 2).



Three site system with AIAO farrowing, weaning and grow-out on each separate site.



Multi-site early weaning production. AIAO farrowing, weaning and grow-out where each week's production populates a separate building.

Figure 2. Factors influencing animal disease outbreaks in intensive production systems