Principles for integrated surveillance and control of salmonella in swine production

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In many countries an often dramatic increase in human outbreaks of salmonellosis originating from infections in animals has been seen during recent years. Great attention has therefore been focused on the prevention and control of salmonella infections in animals (WHO 1993-a). Primarily, attention was concentrated on the poultry production. The possibility and need to control salmonella in swine production is today increasingly also focused upon and in some countries control of salmonella in swine has been introduced as a part of the quality control programmes set up to secure animal and public health and consumer confidence in the pig meat produced. Because of the ever-increasing international trade, comparable epidemiological data from different countries is needed which, as in the EU Zoonosis Directive (92/117 EEC), emphasises the need for surveillance that gives a more precise knowledge of the prevalence of salmonella in different populations.

In contrast to the relatively uniform concept for surveillance and control of salmonella applied in poultry production, so far no specific guidelines for corresponding actions seem to have been formulated for swine production. As the system for the latter production varies, programmes for both surveillance and control have to be designed according to the individual situation. The following general principles can be formulated.

\textbf{DEFINITION AND BASIC CONDITIONS}

Surveillance is an organized epidemiological intelligence on a broad scale in order to obtain data on the occurrence of a disease or an agent, while control means those actions taken to reduce the frequency of a disease or agent already existing in the population (Schwabe et al, 1977). Salmonella infected animals may or may not develop disease but those salmonella strains causing disease in animals cannot strictly be limited to specific serovars. Moreover, most serovars of salmonella that infect animals constitute a potential hazard to human health as a source of food-borne salmonellosis (Old 1990). From the viewpoint of surveillance and control, these two consequences of salmonella infection, disease in animals and potential hazard to human health, cannot be separated. Consequently, both surveillance and control must cover the whole production line from feed to the meat produced and the surveillance should also cover all occurring serovars even though the control may be concentrated to those serovars considered to be of major importance. These general facts also apply to salmonella infection in swine which is described in detail by Wilock & Schwarz (1992).

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SURVEILLANCE

A surveillance programme should be designed to fulfil specified objects. The surveillance is usually an integrated part of a control programme and the epidemiological information obtained is used as a basis for adjusting the intervention strategies or to identify risks and risk reducing factors. As a minimum requirement for surveillance when the salmonella status is unknown it is suggested that each country or region regularly should undertake studies to estimate the prevalence of salmonella infections in the swine population and of the salmonella contamination of pork produced. To obtain these data an epidemiological type of surveillance system should be used. The principles for such a surveillance are described by Van De Giessen et al (1992), who also specified the major elements to be considered when designing such a surveillance (Van De Giessen et al, 1997).

In order to obtain data on the salmonella status of the swine population it has to be decided whether sampling should be performed at herd or animal level and whether the sampling should take place on the farm or at slaughter and which diagnostic methods should be used. If sampling is based on bacteriological examination of faecal samples at slaughter the possible influence on the transport should be considered. If no detailed data from previous studies are available on the salmonella status of the target population, it seems logical that the sampling should be based on herd level and performed so that the within-herd prevalence is also obtained. A primary and introductory study from randomized selected farms is likely to offer good information on whether further prevalence studies from different strata are needed, e.g. herds of different size or types as a base for subsequent control measures.

Due to the primary importance of food safety, surveillance of pork should be based on randomly and systematically selected carcasses. Studies comparing the contamination at different slaughterhouses is also a good base for control interventions.

DIAGNOSTIC METHODS

So far, bacteriological examination is needed for identification of the salmonella bacteria and subsequent subtyping for identifying the serovars and also phagetypes when appropriate. Specificity of the bacteriological test is 100% but the sensitivity is lower especially when bacteriological methods are used to identify salmonella-infected animals based on investigation of faeces or intestinal contents, from chronically infected animals being silent carriers or intermittent shedders of salmonella. The method is, thus, foremost, a herd or a pen test and not a test to identify single infected animals. However, repeated sampling and increased numbers of animals sampled per herd or pen increases the sensitivity in detecting salmonella infected herds and individual animals, and the vast majority of animals developing acute salmonellosis are likely to be detected by bacteriological examination of faeces.

Intestinal lymphnodes can also be used as a specimen for bacteriological examination. salmonella infections in the lymphnodes are likely to persist longer than salmonella is shedded in faeces, but exact knowledge from the pig are lacking. In a surveillance conducted in Sweden where a low prevalence of salmonella was known to exist five intestinal lymphnodes from the ileo-caecal region of approximately 3000 pigs were taken from all large slaughterhouses. At each slaughterhouse enough samples were collected to detect a prevalence of 1-3% with 95% confidence level (Wahlström et al 1993). A similar but more extensive type of surveillance is today an integrated part of the control of salmonella applied in Sweden (Wahlström et al 1997).
Swabs from the pharynx or tonsil area could also be tested at slaughter but isolation of salmonella from such swabs may be the result of a faecal contamination at slaughter. Consequently, the detection rate by this technique is likely to decrease when clean slaughter procedures are improved, thus giving false negative results when trying to detect salmonella infected pigs by this method (Baggesen et al 1997).

PCR-techniques are increasingly being developed and introduced in the diagnostics produced to identify the salmonella bacteria, but so far this technique is done from the same but preenriched samples as used for the conventional bacteriological examinations.

Indirect detection of salmonella infected animals by the use of serology with a salmonella mixed-ELISA technique has proved to be a valuable tool (Nielsen et al 1995) and is used in the salmonella control in pork in Denmark (Nielsen et al 1997). The fact that the test can be used on juice from meat, a specimen easily obtained from the slaughter line is of particular importance. However, in a surveillance study the technique needs the supplementary support of bacteriological studies in order not to lose the identification of serovars that may not be covered by the antigen used in the mixed-ELISA. In addition the serological technique does not separate previously from presently infected pigs but instead detects animals being exposed to salmonella. Valuable data on the evaluation of different isolation techniques were presented by Käsbohrer et al (1997) but more knowledge is needed in this area.

A currently ongoing multinational FAIR project in EU (FAIR 1995) offers an example of a surveillance study. One of the specific objects of the project is to determine and compare prevalence and type of salmonella infections in slaughter pig herds and pork from abattoirs in different EU-regions. In each participating country 60 fattening herds (farrow to finish or feeder to finish) are sampled in order to provide scientific evidence of the prevalence of salmonella infections in fattening pigs herds. In each herd, 50 blood samples from pigs close to delivery to slaughter are tested for antibodies against salmonella antigens. Subsequently, 20 faecal samplings (>25 grams each representing > 5 pigs) from close-to-slaughter or ready-to-ship breeding animals are taken from 20 of the seropositive randomly selected herds. Seropositive as well as seronegative herds are also studied to identify sources for the salmonella infections and to identify herd level risk factors by repeated serological and bacteriological studies.

In addition to the basic diagnostic tests to serovar or phagetype level, further subtyping is also needed, especially when a single or few strain types are dominating in a certain group of specimens. Tests of the antibiogram can be used as a supporting diagnostic tool. This test is also of special clinical importance and without that test the emerging of antibiotic resistant strains may continue undetected, as was demonstrated by the emerging of the multiresistant S. Typhimurium DT 104 in the UK and other countries (Ward and Thr elfall 1997).

For further subtyping, different forms of molecular typing are available and are being increasingly used, such as DNA-based methods based on analysis of plasmid DNA and chromosomal DNA. The use of the molecular methods was the topic of a recent workshop (COST action 1997) when their usefulness in epidemiological studies was described. It was emphasized that these methods, often very sensitive, have to be carefully evaluated before being used in outbreak investigations. The different methods also have to be standardized in order to obtain comparable data between different laboratories (Threlfall 1997).
CONTROL

Today it seems to be generally accepted that it is necessary to control salmonella in animal production in order to prevent foodborne infections in humans. This means that the control has to focus on the first of the three lines of defence, the food-producing animals, that were formulated by WHO already in 1980 (WHO 1980). The second line of defence, the slaughter process, also has to be improved, but we have abandoned the previously often supported strategy that it is possible to control salmonella only at consumer level, the third line of defence. This also means that the control has to cover all serovars of salmonella and not, as previously, only those causing diseases in animals.

Preharvest control

In a recent review submitted to OIE on current knowledge and experiences on the control and prevention of salmonellosis in livestock farms it was concluded that the control can follow those general rules that have been successfully applied to other infectious diseases (Wierup 1993). Fundamental for the control is that monitoring programmes are set up by which salmonella infected herds and animals are identified and efforts laid down to stop the spread of the infection.

The strategies for the surveillance described above have to be designed for a monitoring programme that fits the ambition and objective of the control to be run. The practical and economical feasibility of the monitoring is essential. In a high prevalence situation of salmonella the serological approach, when meat juice is tested against a pool of the dominating salmonella antigens as described above today, seems to be the method of choice. The method can be automated and designed to cover all herds and has a potential to be used also in the control of other microbes. However, from a control point of view, a special monitoring has to be directed at key-herds such as herds delivering breeding animals and other risk herds. This is the case for the salmonella control run in Sweden, which today also is run in Finland and Norway. In addition to the control at slaughter described above, all multiplying and breeding herds are bacteriologically tested at herd level annually, and the sow pools, which cover 15 per cent of the production are similarly tested twice a year (Wahlström et al 1997). It is also essential that the monitoring is combined and analyzed together with the result of monitoring of for example feed, clinical outbreaks in animals and especially with data from humans so that a total view of the salmonella situation is obtained and the monitoring and control can be adjusted when needed.

The challenge is to eliminate or control the salmonella infection at herd level. An initial bacteriological monitoring of faecal samples gives a good indication of the prevalence and location of infection in the herd. Animals or groups of animals repeatedly found to be salmonella infected should be eliminated by slaughter. From an economic point of view, it is therefore essential to find a model for slaughter of salmonella infected animals under special precautions that does not conflict with the consumer’s health. The object for the control should be to obtain zero prevalence, but no specific action can guarantee a good result. However, actions known to improve hygiene and good husbandry should be undertaken, as described by Wierup (1993). Surprisingly few scientific reports on these issues are available in contrast to the experience gained. In Sweden, where salmonella has been actively controlled for the last 40 years, it is found that in the vast majority of salmonella infected herds targeted, the prevalence of salmonella infection and contamination by the mentioned method decline often to an undetectable level. This emphasizes that salmonella is not a ubiquitous bacteria and therefore is starved out when its
primary source, the salmonella infected animals, is eliminated. However, occasionally on larger farms, especially those infected with S. derby, the bacteria have repeatedly reoccurred and have not disappeared until after depopulation. In the specialized fattening production, the control is usually easier because the stable can be emptied for necessary cleaning and disinfection procedures. The problems are often larger for integrated swine production, especially those with a continuous non-segregated production. Efforts should therefore be made to enforce and optimize the health supporting management routines. Age segregated batchwise production, the concept of the multi-site production, is found to be a good way of controlling the spread of infectious diseases within a production site. This effect is also obtained by FTS system where the pigs are raised in the same pen from birth to slaughter Olsson (1996).

Cleaning and disinfection, especially before restocking after salmonella-infected animals have been removed, must be carried out methodically and carefully. WHO has presented guidelines on this issue as well as on vector control (WHO 1993-b). Efforts also should be made to prevent reinfection from external sources, especially by feed. Implementation and tough control of the feed is necessary and strongly supported. The feed control must be an integrated part of the preharvest control of salmonella and can follow the procedure described by Häggblom et al (1994 a. b.) based upon 50 years of experience of salmonella control in feed. The control cannot rely upon control of the finished feed from which salmonella seldom is isolated unless it is heavily contaminated. Instead the concept of the control should be to detect salmonella as early as possible, starting with the raw material.

Antibiotics should not be used to control salmonella. Long experience from humans and different animal species including pigs, has demonstrated that prevalence, magnitude or duration of salmonella shedding by sick or recovered animals is not reduced by antibiotics (Wilcock & Schwarz 1992). Instead the use of antibiotics, especially on herd or flock basis, may act as a trigger for the spread of salmonella infection within the herd (Wierup 1993) and the emergence of antibiotic resistance is the basic reason why antibiotics should be used with great care.

Vaccines may be used to control certain serovars but in spite of a lot of research vaccines are at present of limited use in control of the serovars of concern for public but not for animal health (Meyer et al 1992).

Control at slaughter

The control of salmonella at slaughter should focus on strict slaughter hygiene. Special attention should be given to avoid faecal contamination of the carcasses as presented by Nielsen et al (1997). Monitoring of carcase contamination as a part of a quality assurance programme supports the improvement of the slaughter hygiene, thereby decreasing the possible contamination of the carcase by salmonella. A monitoring programme should also be carried out on the end-products. In Sweden for example, a regular control is done at all cutting plants where a specified number of samples are taken daily at the larger plants (Wahlström et al 1997).

Establishment of controls

The design and introduction of a salmonella control programme is a qualified challenge where basic epidemiological facts on the salmonella situation in the production to be controlled have to be combined with the structure of the animal production and other variables of concern not least the economy. Controls and experiences from other countries should be studied, but the
situation in a single country and also at farm level is unique, and the programme has to be formulated accordingly. The aspects to consider when starting a programme have been summarized by Wierup (1993). Cooperation between representatives of the animal and human sides together with the responsible authorities and the industry are essential.

Progressive limits have to be formulated and a control programme without limits and actions taken accordingly cannot constitute a control. Formulation of these limits is the duty of the responsible authorities and perhaps operates best when set up by the producers and the industry. These procedures should be undertaken before the consumer and the politician lose the confidence in swine production and ask for urgent actions, which often have to be enforced under pressure of time and guided by lack of knowledge.

Control can focus on certain serovars, and if necessary actions are taken, such a control is likely to improve the situation also concerning other serovars. However, a supporting surveillance is needed to prevent so-called exotic serovars becoming introduced in the production and, without interventions, perhaps later becoming spread and reaching epidemic proportions.

In summary, we know today that it is possible to prevent and control salmonella. We also know that the control is not solved by one or a few specific actions. Instead, we have to effectively apply all well-known concepts for control of infectious diseases. Long-term use of these actions has demonstrated that it is possible not only to prevent a further increase of the salmonella problem but also to reach a very favourable salmonella situation even though it can be hard to control the salmonella on individual farms.

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