SURVEILLANCE OF SALMONELLA IN LOW PREVALENCE SWINE HERDS IN DENMARK

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Abstract The nation-wide Danish Salmonella surveillance and control program in finisher herds is primarily based on the monitoring of the presence of specific antibodies against Salmonella enterica in meat juice from carcasses.

The pig industry is aiming at reducing the expense of the serological surveillance program, without jeopardizing food safety. This can be done through reduction of the number of meat juice samples taken at slaughter.

Simulation using surveillance data indicated that the number of meat juice samples from herds with a zero or low seroprevalence of Salmonella could be reduced to one per herd per month without a resulting decrease in the overall proportion of seropositive pigs slaughtered under special hygienic conditions. The estimated net reduction in expense was $293,355 per year.

Introduction In the nation-wide Danish Salmonella surveillance and control program (Mousing et al., 1997; Nielsen et al., 2001), the prevalence of Salmonella enterica in finisher herds is monitored serologically at slaughter, by use of a mix-ELISA for detection of antibodies in meat juice (Nielsen et al., 1998). The mix-ELISA includes several S. enterica lipopolysaccharide antigens (O-antigens; 1, 4, 5, 6, 7 and 12) (Nielsen et al., 1995). This combination of O-antigens theoretically covers at least 93% of the S. enterica serovars that have been isolated from Danish pigs (Baggesen et al., 1996).

The rationale behind the serological surveillance program is the assumption that the S. enterica infection level is a proxy measure of the risk of processing pigs infected with S. enterica from a given herd in the abattoir (Mousing et al., 1997). This assumption has been supported by a study that shows a clear association between herd serology and the risk of identifying Salmonella bacteria on the carcass (Sørensen et al., 2004).

To deal effectively with the risk of processing pigs carrying Salmonella, herds are assigned into 3 S. enterica infection levels each month: Level 1, herds in which the S. enterica seroprevalence is considered to be low and acceptable; Level 2, herds with a moderate seroprevalence of S. enterica; Level 3, herds with an unacceptably high seroprevalence of S. enterica (Mousing et al., 1997). Pigs from herds categorized in Level 3 are slaughtered under special hygienic precautions. The criteria for assigning herds into levels 1, 2 and 3 depend on the proportion of positive meat juice samples and the annual kill from the herds. For details on the original program, please refer to Mousing et al. (1997). The criteria for assigning the infection levels were modified in August 2001 (Nielsen et al., 2001; Alban et al., 2002). Currently, the proportions of S. enterica seroreactors in the previous 3 months are weighted by 0.2:0.2:0.6 and averaged. Herds are assigned to level 1, 2 or 3 when the weighted average is <40, 40-69 or >69, respectively (Nielsen et al., 2001; Alban et al., 2002). The weighted average is named the serological Salmonella index. The effect of weighting the Salmonella index is that herds may be assigned a higher or lower level one month earlier than in the previous classification system. The net result of this is a potentially better correlation between possible shedding of Salmonella and the special precautions taken at slaughter.

The number of carcasses that should be examined from each herd is determined each month based on the number of pigs slaughtered in the previous 13 weeks. The sampling scheme has been described in detail elsewhere (Mousing et al., 1997). The sampling scheme was revised in August 2001 (Nielsen et al., 2001). At present, 60 carcasses have to be examined from herds with an annual kill of 201-2,000 pigs, 75 carcasses from herds with an annual kill of 2,001-5,000 pigs and 100 carcasses from herds with an annual kill larger than 5,000 pigs (Nielsen et al., 2001; Alban et al., 2002). In 2002, a total of 563,733 meat juice samples were examined from 10,912 herds. Thus the average number of samples per herd per month was approximately 4.3.

The overall expenses in 2002 on the veterinary surveillance and control of Salmonella amounted to $7.5 million of which the major part was funded by the pig industry (Nielsen et al., 2003). Therefore, the industry is interested in a reduction of the cost of the serological surveil-lance through reduction of the number of samples, while at the same time maintaining the current high
level of food safety. We carried out a database study with the aim to investigate whether the cost of the serological surveillance program could be reduced, by cutting down on the number of samples in low prevalence herds in Level 1, without compromising the ability of the surveillance program to assign herds to Level 3.

**Materials and Methods** Meat juice test results and data from the routine meat inspection from September 2001 to December 2002 were used to calculate the proportion of seropositive samples and the number of slaughtered pigs each month for finisher herds.

Data were used to simulate the effect of reducing the monthly number of samples in herds where the proportion of positive meat juice samples had been zero in 3, 4 and 6 previous months, respectively (scenarios A, B and C). In addition, in the simulation the number of meat juice samples per herd was reduced whenever possible to 4, 3, 2 and 1 per month, respectively, by hyper-geometric sampling from the actual number that had been sampled in the current surveillance program.

Subsequently, the number of meat juice samples and pigs slaughtered under special hygienic precautions were simulated for each of 16 scenarios, expressed as the mean values of the estimated numbers from 100 iterations of the simulation model and compared with the current surveillance program.

A random sample of 1,962 herds (1998) with meat juice test results and results from bacteriological examination of caecal content was used to estimate the probability of a pig being culture positive, given that it was seropositive. From this, the number of culture positive pigs slaughtered under special hygienic precautions was simulated.

Finally, the net reduction in overall cost was estimated for each scenario using the following assumptions:

1. The approximate cost of ELISA analysis was estimated at $1.8 per meat juice sample.
2. The expenses associated with slaughter under special hygienic precautions were estimated at $26 per carcass.
3. In finisher herds assigned to level 2 or 3 pen faecal samples are examined for *Salmonella* including typing. The average cost per finisher herd was estimated at $492.5.
4. In sow herds supplying weaners to a finisher herd assigned to level 2 or 3, pen faecal samples are examined and typed. The average cost per sow herd was estimated at $470.8.
5. The risk of additional sampling in sow herds was calculated as the proportion of finisher herds assigned to level 2 or 3 in 2002, where additional sampling was necessary in a supplier sow herd ~ 0.3146.
6. The overall cost attributable to assignment of a finisher herd to level 2 or 3 was calculated as $492.5 + 0.3146 \times $470.8 = $640.6.

**Results** The scenario yielding the largest reduction in the overall cost of the surveillance program was A1 (i.e. herds with 0 positive meat juice samples during 3 months being sampled with 1 sample per month). The estimated net reduction in this scenario was $293,355 per year.

The estimated reduction of number of meat juice samples was 339,521 and the estimated increase in number of pigs slaughtered under special hygienic precautions was 4,970 per year.

There was an acceptable although not perfect agreement between the two surveillance programs; the simulated reduced program, and the current surveillance program: 585 herds were assigned to Level 3 by both programs, whereas 25 herds were categorized as Level 3 herds in the current program but not in the reduced program, and 48 herds were assigned to Level 3 in the reduced program but not in the current program.

The total number of pigs slaughtered under special hygienic conditions from Level 3 herds in the reduced program and in the current program were: 201,479 and 194,571 respectively.

The number of seropositive pigs slaughtered under special hygienic conditions in the reduced program and in the current program were very similar: 101,641 and 100,404, respectively.

The number of culture positive pigs slaughtered under special hygienic conditions in the reduced program and in the current program were also very similar: 61,728 and 61,259, respectively.

**Discussion/Conclusion** The results indicate that the cost of the Danish *Salmonella* surveillance and control program can be reduced significantly by cutting down on the number of samples in
low prevalence herds in Level 1. Although there appears to be some discordance in the classification of herds between the current and the reduced program, the number of seropositive pigs, with an increased risk of *Salmonella* infection, slaughtered under special hygienic conditions in the 2 programs is similar. This means that the effort to control *Salmonella* at the abattoir remains unchanged. The total number of pigs slaughtered under special hygienic conditions actually was higher (4,970) in the reduced than in the current program. Other things being equal, this will improve the food safety.

Assuming that the level of *Salmonella* contamination during the slaughter process attributable to a seropositive pig is independent of the *S. enterica* infection level (Level 1, 2 or 3) of the herd of origin, the reduction can be instigated without jeopardizing food safety with regard to *Salmonella* in pork. The risk-based surveillance program is currently being implemented.

**References**


