

COST-BENEFIT ANALYSIS OF MEASURES TO REDUCE *SALMONELLA* IN DANISH PORK

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Abstract The Danish control program for *Salmonella* in pork was initiated in 1995, and since then the number of human cases of salmonellosis in Denmark has dropped significantly. The question is, how further reductions can be attained in a cost-effective way. To address this issue, four essentially different alternatives to the existing control strategy for *Salmonella* in pork were analyzed and compared: A) hot water decontamination of all pigs at slaughter combined with reduced surveillance, B) sanitary slaughter of pigs from herds with higher levels of *Salmonella*, C) use of home-mixed feed in herds with slaughter pigs and D) use of acidified feed for slaughter pigs.

The analysis was carried out as a traditional cost-benefit analysis (CBA). The results clearly indicated that only hot water decontamination combined with reduced surveillance was socio-economically profitable. Thorough sensitivity tests were carried out, and they indicated that the conclusions were robust.

Introduction The national Danish control program for *Salmonella* in pigs and pork was initiated in 1995. Since then, the number of human salmonellosis cases attributable to pork has dropped significantly. For example, in 1995 approx. 1,100 human cases were ascribed to Danish pork, whereas in 2003 the number of cases had declined to 202 (Anon., 2004). Since May 2002, the *Salmonella* control program has been administered by the Danish Bacon & Meat Council (DBMC). This implies that the costs of the program are now paid entirely by the pig industry, and efforts are ongoing to optimize the program economically without jeopardizing food safety.

The surveillance consists of two parts: a herd monitoring program based on serology and follow-up bacteriology (Alban *et al.* 2002); and post-chill monitoring of pig carcasses based on bacteriology (Nielsen *et al.* 2001). Farmers with high levels of *Salmonella* in the herds are financially penalized through deductions in the slaughter price.

The level of *Salmonella* in pigs and pork can be reduced by implementing control measures either pre-harvest or post-harvest. The purpose of the analysis presented here was to investigate the socio-economic profitability of four different control strategies along the entire production chain—from stable to table.

Materials and Methods Data were provided mainly by DBMC and the Danish Zoonosis Centre. Where no data were available, assumptions and parameter values were based on expert opinion.

The data included the most recent number of registered human cases, estimates on the level of un-registered human cases, the distribution of cases on different severity categories including number of days sick and lost work days, and death risks associated with sickness. With respect to the valuation of the costs of the human cases, the data included estimates on the value of "a statistical life," the costs of pain and suffering as well as the costs of consultation in general practice, culture of faecal samples, hospitalization and surgery.

Furthermore, the data material included assumptions on the future pig production and the *salmonella* prevalence in fresh pork, as well as estimates on the costs of the present *salmonella* control program to farmers, DBMC and slaughterhouses.

With respect to the four strategies analyzed, the data included the potential reduction in *Salmonella*, the investment costs of the different strategies as well as changes in production costs and maintenance costs either on farms or at slaughterhouses following the investment.

The strategy for controlling for *Salmonella* in pigs in Denmark is partly a political issue. Therefore, in our analysis we included not only the possible costs and benefits to the pig industry, but also the costs and benefits to society – i.e. public health. A systematic way to do this is by using a cost-benefit analysis (CBA), in which all costs and benefits to different groups in society that are directly or indirectly affected are described and assessed. In our case, the affected groups are the consumers, the pig industry (farmers, DBMC, and slaughterhouses) and the public budget (representing tax payers).

Results The following risk-mitigating measures were analyzed:

- A hot water decontamination of all pigs at slaughter combined with reduced surveillance pre-harvest and post-harvest.
- B sanitary slaughter of pigs from herds with high levels of *Salmonella*.
- C use of home-mixed feed in all herds with slaughter pigs.
- D use of acidified feed for all slaughter pigs.

In the analysis of the four alternatives, some important general assumptions were made. First, it was assumed that a given decrease (%) in the number of infected pigs would result in the same decrease (%) in *Salmonella*-infected pork, which again would lead to the same decrease (%) in the number of human salmonellosis cases.

Second, it was assumed that the registered cases of human salmonellosis represent only 12.5% of the total number of cases (mid-value of the interval 5% to 20% estimated by Nielsen & Korsgaard (2003)). Therefore, the "true" number of human cases was assumed to be 1,208 in 2003.

Finally, it was assumed that there is no productivity loss associated with sub clinical *Salmonella* in a pig herd (Schwartz, 1999).

By definition, all of the alternatives would imply fewer cases of human gastroenteritis attributable to fresh pork. The estimated effect on human cases is outlined in Table 1. Hence, consumers as a group would benefit from fewer days of sickness as well as fewer deaths seen over the years. National authorities would benefit from reduced health care expenses as well as decreases in lost production because of sickness. Furthermore, in alternative A the national authorities' existing annual expenses on *Salmonella* control would be reduced.

In the hot water decontamination alternative, the farmers would benefit from a reduction in the *Salmonella* surveillance costs as well as from a cancellation of the penalty system, and DBMC would reduce annual expenses on *Salmonella* control. Slaughterhouses, on the other hand, would incur the costs of hot water decontamination. Although their existing yearly expenses on *Salmonella* control would be reduced, they would at the same time lose income from penalties. Furthermore, hot water decontamination of all slaughter pigs would require major investments in facilities and buildings and would result in increased maintenance costs and production costs.

Sanitary slaughter would not affect the pig farmers or DBMC, but the slaughterhouses would suffer increased production costs because the number of sanitary slaughterings would increase significantly (from approximately 100,000 pigs to 700,000 pigs).

Using home-mixed feed would decrease the level of *Salmonella* in the stables and thus result in reduced slaughter price penalties paid by the farmers. However, the introduction of mandatory home-mixing of feed would necessitate major investments in home-mix feeding systems for a large number of farmers. Furthermore, there would be productivity effects (increased feed use, decreased mortality, reduced daily weight gain, decreased feed price, increased work time and increased energy use) associated with feeding home-mixed feed instead of ready-mixed feed (unpublished results, DBMC). These productivity effects were included in the analysis. Implementing home-mix feeding

Effect per year	Strategy regarding reduction of <i>Salmonella</i> in pork			
	Hot water decontamination	Sanitary slaughter	Home-mixed feed	Acidified feed
Salmonellosis:				
Decrease in salmonellosis	90%	7%	42%	50%
Decrease in # of dead persons	2.6	0.2	1.2	1.4
Decrease in salmonellosis cases	1087	85	511	604
Yersiniosis:				
Decrease in yersiniosis	70%	3%	-	-
Decrease in # of dead persons	0.4	0*	-	-
Decrease in yersiniosis cases	837	33	-	-

Table 1: The estimated yearly effect^a on "true"^b human incidences of salmonellosis and yersiniosis resulting from four different national strategies against *Salmonella* in Danish pork, 2004

a: A yearly decrease in number of dead of e.g. 0.2 means that one life is saved on average every 5 years. An * means that the figure is not zero but only rounded to zero. A "-" means that the strategy has no effect on Yersinia.

b: The registered number of cases is scaled up to account for the un-registered cases.

systems on all pig farms would not directly affect the DBMC, but the slaughterhouses would experience a decrease in income from penalties, which would be partly compensated by a decrease in annual production costs because of fewer sanitary slaughterings.

Feeding acidified feed would decrease the *Salmonella* occurrence in the herds, thereby resulting in reduced slaughter price penalties paid by the farmers. However, data were not available to obtain an estimate of these reductions, and therefore the penalties are not included in the analysis. This, however, does not influence the final result, as the benefit to the farmers of reduced penalties offsets the costs to the slaughterhouses. The increase in feed price combined with changes in productivity (decreased feed use, decreased mortality and increased daily weight gain, unpublished results, DBMC) would increase production costs. The alternative would not directly affect the DBMC, but the slaughterhouses would experience a decrease in income from penalties (not included), which would be partly offset by a decrease in production costs because of fewer sanitary slaughterings.

In the calculations of the net present value of each scenario, we used a real interest rate of 6% as recommended by The Danish Ministry of Finance (Anon., 1999). The time period was set to 15 years.

The calculations showed that only hot water decontamination of all slaughter pigs combined with significant reductions in the present *Salmonella* control program would be profitable from a socio-economic point of view as it had a positive net present value of EUR 14.6m (Table 2). Furthermore, it can be seen from Table 2 that, regardless of the alternative chosen, it is the pig industry (the sum of farmers, DBMC and slaughterhouses) that would have to pay for the benefits to the rest of society. The least profitable alternative – from a socioeconomic point of view – was use of home-mixed feed (EUR -343.9m), whereas sanitary slaughter (EUR -47.6m) and use of acidified feed (EUR -76.7m) were non-profitable but less expensive (Table 2).

A sensitivity analysis was carried out as a simultaneous analysis of the importance of uncertainties in parameter values. The sensitivity analysis showed that the decontamination alternative combined with reduced control was the most profitable alternative because the net present value was above zero in 90% of the simulations. By comparison, acidified feed showed a net present value greater than zero in only 2% of the simulations. For the last two alternatives, the net present value was below zero in all simulations.

Discussion Our analysis rested on the assumption of a linear relationship between the *Salmonella* prevalence in the primary production, the prevalence in fresh pork, and the number of human cases of salmonellosis. This is a simplification. There are indications that changes in the prevalence in pigs will result in smaller changes in the prevalence in pork. (Alban & Stärk, 2002). This would imply that the net present values of home-mixed feed and acidified feed would be even more negative.

The controversial issue of assigning a monetary value to life—albeit a statistical life—may be partly omitted by calculating a break-even value, i.e. the value that would balance the sum of costs and the sum of benefits. For hot water decontamination combined with reduced control, this value is EUR 0.3m, for sanitary slaughtering it is EUR 21m, for home-mixed feed it is EUR 31m, and for acidified feed it is EUR 6m. Such a break-even analysis does not exempt the decision maker completely from (at least indirectly) assigning some kind of monetary value to life, but

Discounted net benefits (million EUR) for 2005-2020	Hot water decontamination	Sanitary slaughter	Home-mixed feed	Acidified feed
Net benefits, consumers	23.5	1.9	8.9	11.6
Net benefits, national authorities	14.4	0.7	2.6	3.4
Sub total	37.9	2.5	11.5	15.0
Net benefits, farmers	21.5	-	-354.5	-95.0 ^a
Net benefits, DBMC ^b	8.5	-	-	-
Net benefits, slaughterhouses	-53.3	-50.1	-0.8	3.3 ^a
Sub total pig sector	-23.3	-50.1	-355.3	-91.7
Total net present value	14.6	-47.6	-343.9	-76.7

Table 2: Results of a cost-benefit analysis of four different national strategies against *Salmonella* in Danish pork, 2004. ^aNet benefits without penalties. ^bDanish Bacon & Meat Council.

it will serve to emphasize the relative profitability of the alternatives. Irrespective of a CBA being carried out, when decision makers choose an alternative, the choice will reveal some kind of relative valuation of the aspects of the alternatives – including an implicit relative valuation of money costs and saved lives.

Our analysis showed that hot water decontamination combined with reduced surveillance is the only socio-economically profitable alternative. There are, however, other aspects of this alternative that could not be included in the CBA but are still important when a decision needs to be made. These include the possible reduction in human campylobacteriosis, possible effects on demand, the intensive use of water and the question of whether the level of *Salmonella* in the herds would increase if the existing *Salmonella* control program were largely cancelled. Likewise, there are aspects of the other alternatives that were not included in the CBA and that have to be considered separately, e.g. the problem of the required legislation if the use of home-mixed feed were mandatory.

Conclusion In conclusion, the CBA has shown that hot water decontamination in combination with significant reductions in the existing *Salmonella* control program was the only socio-economically profitable alternative of those investigated. Moreover, the sensitivity analysis indicated that this conclusion was robust.

The results of the CBA should be seen as one part of the decision-making basis concerning alternatives to the existing *Salmonella* control program. For hot water decontamination there are other concerns that might influence the final decision. Also, it should be borne in mind that other decontamination procedures that require less space and water consumption are in the pipeline.

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