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# **COSTS AND BENEFITS OF TWO ALTERNATIVE *SALMONELLA* CONTROL POLICIES IN FINNISH BROILER PRODUCTION**

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## **ABSTRACT**

In this study, costs and benefits of two *Salmonella* control options in broiler production were compared. The first option was to control *Salmonella* as set by Council Directive 92/117/EEC, so-called Zoonosis Directive. The second option was more intense control programme, the so-called Finnish *Salmonella* control programme. The costs of controlling *Salmonella* in primary and secondary production and the direct and indirect losses due to *Salmonella* infection in humans in both options were compared. The national control option was found to be economically feasible. One prevented loss of life covered all the control costs of the national programme.

**Keywords:** *Salmonella*, broiler, cost-benefit, control

**Abbreviations:** FSCP = Finnish *Salmonella* control programme  
BC ratio = benefit-cost ratio

## **INTRODUCTION**

Salmonellosis is one of the most reported zoonotic diseases in Europe. In order to prevent foodborne salmonellosis, various control strategies has been designed. In Finland, salmonellosis has been combated since 1995 by the Finnish *Salmonella* control programme (FSCP). Before instituting the FSCP, *Salmonella* in animals and feed had been controlled by other legislation for decades. Reason to institute the FSCP was relatively low *Salmonella* prevalence in domestic livestock production at the time Finland became a member of the European Union. In 1990-1994, the annual apparent prevalence in commercial broiler flocks was 1.5-2.9% (National Veterinary and Food Research Institute, personal communication).

The objective of the FSCP is to protect the consumers and maintain apparent *Salmonella* prevalence below 1% in swine, bovine and poultry and meat and eggs derived from these animals (MMM 2000). The FSCP was accepted by Commission Decision 94/968/EC. The FSCP constitutes of sampling for *Salmonella* in primary and secondary production and interventions after positive

detection. The FSCP forms a basis for the additional guarantees granted for Finland. Governmental compensations are not paid to compensate the interventions.

In 2000, slightly above 44 million broilers and broiler parents were slaughtered in Finland. 2,669 commercial broiler flocks were slaughtered. Domestic broiler meat production was 57.4 million kg. Broiler meat consumption was 60 million kg.

In this study, the FSCP for broilers was compared to controlling *Salmonella* only according to Council Directive 92/117/EEC, the so-called Zoonosis Directive. This Directive set the minimum for *Salmonella* control in poultry in the reference year 2000. In November 2003 new Directive and Regulation on zoonoses have been adopted.

## MATERIALS AND METHODS

The major components of the estimations of costs were direct control costs in primary and secondary production and direct and indirect public health losses. To compare the two control options we segmented the costs to official *Salmonella* control costs, public health losses, costs of additional control in primary and secondary production, feed control, additional control costs to society, losses due to premature death and market disturbances. The difference of the control options was regarded as benefit of the option that caused less costs.

In this study, the costs and benefits were studied by constructing a stochastic calculation model. In addition to point estimates, over twenty input parameters that included uncertainty or variability were fed in as distributions. The effect of the FSCP in infections in broilers and humans in Finland has been modelled in a risk assessment project (Ranta & Maijala 2002; Maijala & Ranta 2002). The probability distributions from this risk assessment model were used as input values in this study.

The output distributions were simulated by Monte Carlo method with 20,000 iterations. Before simulation the models of the two control options were synchronised: same variable in both options was associated with same random number during iteration. When this was difficult to achieve due to limitations of the software, a link was created of a rank order correlation function (value = 1) mimicing the true synchronisation. The Monte Carlo simulations were performed by @RISK 3.52 software (Palisade Inc., USA). Results presented in this paper are medians of the distributions.

To compare the costs and benefits of the control options, the benefit-cost ratios (BC ratio) were calculated. The BC ratio less than one, indicates that the losses exceed benefits, whereas the BC ratio greater than one suggests that benefits exceed losses. By combining probability density of the BC ratio and the distance of each BC ratio from one, a win lose-ratio was received.

Estimations of the control costs in primary and secondary production were based on information gathered from the broiler producing companies and FSCP statistics. Costs of the entire FSCP have been previously reported in Maijala 1998 and Maijala & Peltola 2002. Human *Salmonella* infections are compulsory notifiable in Finland, however, like in many other countries, there is believed to be a considerable underreporting of intestinal infections like salmonellosis (Persson & Jendte 1992; Roberts et al. 2003; Baird-Parker 1994; Frenzen et al. 1999). In 2000, 2,624 *Salmonella* cases in humans were reported. The incidence was 51 / 100 000 inhabitants. The origin of these cases was both foreign and domestic. Based on the reporting system, the proportion of domestic cases is approximately one third. In this study the proportion of reporting a salmonellosis case was estimated to vary between 10 % and 30% (Wheeler et al. 1999; Ruutu 2001). Human cases of *Salmonella* were classified into four categories: hospitalized patients, those visiting a physician without hospitalization, unreported cases and deaths. The public health losses were calculated to consist of human illness costs and productivity losses. Using information from the risk assessment, it was

estimated how number of human infections would rise in case the Salmonella control in primary production was reduced to the level of Council Directive 92/117/EEC.

The highest input value, the monetary value for a death (944,952 EUR – 1,760,739 EUR), was obtained from the economic assessments of alcohol induced deaths in Finland (Salomaa 1993). Number of deaths was assumed to be related to the number of reported broiler meat-borne Salmonella cases. A uniform distribution of reported cases (0.11-0.38%) was applied when estimating the number of cases expected to end in death. In 2000 there were no reported Salmonella induced deaths.

#### *Control option 1: Council Directive 92/117/EEC*

The old Council Directive 92/117/EEC stipulated a reporting system on the prevalence of zoonoses and monitoring, control and eradication of some invasive serotypes of Salmonella in poultry breeding flocks. According to this directive, in parent rearing houses stool specimens were analysed three times per flock. When *S. Typhimurium* or *S. Enteritidis* were suspected, also internal organs were examined for Salmonella. In hatcheries chickens were examined by sampling bottom papers from boxes or meconium. Sampling frequency in hatcheries was two weeks. Only *S. Typhimurium* and *S. Enteritidis* launched eradication measures. This directive has recently been repealed and replaced by new legislation.

#### *Control option 2: Finnish Salmonella Control Programme (FSCP)*

The FSCP for broilers encompasses breeding and commercial flocks, hatcheries and cutting plants. All Salmonella serotypes launch interventions. Sampling of breeding flocks according to Council Directive 92/117/EEC was included in the FSCP. Breeding flocks are investigated by box bottom paper or meconium sampling when the birds are one day old. At four weeks of age and two weeks prior to entering the laying phase, breeding flocks are investigated by faecal sampling. In the laying period, faecal samples are analysed every eighth weeks. At hatcheries, chickens from every breeding flock are investigated every two weeks. Since 2001, official sampling is conducted every eighth weeks in hatcheries. In 2000 the official sampling frequency was once in a year. Also surface swabs are analysed in hatcheries. The sampling scheme is approved by a municipal veterinarian.

In case of detecting Salmonella in a breeding flock, official restrictions are imposed on the farm. A positive result is confirmed by official sampling. The official restrictions include prohibition of egg and animal delivery. An epidemiological investigation is done to identify the source and possible spread of the infection. Hatching eggs originating from the flock are destroyed. The official restrictions result in the slaughter of positive breeding flocks. Restrictions are lifted after the premises have been disinfected and the surface swab samples have given negative results (MMM 2000).

Commercial broiler flocks are investigated for Salmonella once, one to two weeks prior to slaughter. Results of analyses must be available before slaughtering. Salmonella positive flocks are sanitary slaughtered. Meat is heat treated and delivered only to the domestic market. The slaughterhouse and premises in the farm are thoroughly disinfected. Cleaning and disinfection is a standard protocol in farms between the flocks.

FSCP stipulates Salmonella analyses of meat in cutting plants. In 2000 the sampling frequency was one sample per week. Since 2001 the corresponding frequency has been dependent on the production amount. Sampling frequency in large cutting plants is one sample per day. A positive detection launches compulsory disinfection and sampling of 59 samples within the following five working days. These additional samples are taken from meat and the structures of the establishment. A positive finding in one of these induces sampling of a further 59 samples (MMM 2000).

### *Salmonella control additional to the FSCP*

Salmonella control of feedstuffs is compulsory for feed manufacturers. Salmonella in feeds has been controlled over 40 years by legislation. Feed control is an important basis for FSCP to reach its targets.

Also voluntary control measures in primary and secondary production were calculated and included in as costs of control option 2 (the FSCP). We found that in 2000 over 53,000 EUR were spent in primary production on voluntary Salmonella investigations. In secondary production the costs of own-check sampling and other voluntary measures were more than 28,000 EUR. All these voluntary measures are also aiming to reduce the incidence of salmonellosis in humans. Considering Salmonella as a health risk for consumers, Salmonella detection in meat products could launch a withdrawal of products from market. These protecting measures are naturally unwanted in the industry. The losses due to the market disturbances after withdrawal were included in these calculations based on personal communication of industry.

## **RESULTS**

### *Control costs*

The total costs of the FSCP, including primary and secondary production of broilers, were 990,400 EUR. Out of the FSCP costs, 38% were derived from primary production, 60% from secondary production and 2% from society. Out of the 2,669 commercial broiler flocks slaughtered, 26 were detected positive. The apparent prevalence was 0.97 %. The costs of FSCP were low in primary production since there were no positive detections in breeding flocks or hatcheries.. Of the costs in secondary production, 97% constituted of freezing and heat treatment of meat from positive flocks. The costs of voluntary Salmonella control in secondary production were 39,000 EUR.

### *Public health losses*

The public health losses with FSCP were estimated to be 136,600 EUR. Public health losses due to domestic broiler meat-borne Salmonella infections would have been 735,000 EUR with Council Directive 92/117/EEC only in force. In the control option Council Directive 92/117/EEC alone, there were estimated to have been at least one loss of life in 2000. The total public health losses, deaths included, would thus have been 1,967,000 EUR.

### *Benefit-cost ratio*

The benefit-cost ratio for the FSCP was calculated to be 4.4 (95% CI 0.06-29.09). Benefit-cost ratio of the FSCP was found to be mainly dependent on the number and costs of recalls and loss incurred with loss of life.

## DISCUSSION

Based on these results, the FSCP for broilers can be seen as an economically feasible programme when compared to the control based on Zoonosis Directive 92/117/EEC alone. Losses due to human salmonellosis were estimated to be considerably lower with the FSCP. The cost per produced kilogram of broiler meat is relatively low. The FSCP can be seen profitable also from poultry meat producer's view as the FSCP prevents recalls of products from market and reduces market disturbances. The losses due to human infections were mostly dependent on the number of Salmonella-induced deaths and their monetary value. The conclusion is that one prevented death makes the FSCP profitable. Persson & Jendteg (1992) and Frenzen et al. (1999) have also shown that the importance of preventive efforts increases as the estimate for the cost of illness is extended to include a value for reducing the risk of death. The role of Salmonella as a cause of death may even have been underestimated in past. Helms et al (2003) reported in registry based study that people with gastrointestinal infections (Salmonella, Campylobacter, Yersinia enterocolitica and Shigella) had increased short term risk of death even after effects of pre-existing illnesses were taken into account. The one year relative mortality among Salmonella patients was 2.85 compared with matched controls.

Costs of Salmonella cases have been calculated in some studies. Roberts et al. (2003) calculated the average costs per Salmonella case to be 606 GBP (857 EUR) when mortality costs were not included. Persson & Jendteg (1992) estimated the cost per case to be 1200-1500 GBP (1,696 – 2,120 EUR) when mortality costs were included. The chronic effects of salmonellosis were not included in these calculations. Sequelae of a Salmonella infection may include endocarditis, polyarthritis, ankylosing spondylitis and osteomyelitis (Baird-Parker 1990). If the disability from chronic disease and loss of quality of life were also taken into account, the losses due to salmonellosis would increase.

Legislation in the European Union is renewed to improve the prevention and control of zoonoses. New Council Directive (2003/99/EC) and Regulation (2160/2003/EC) of the European Parliament and of the Council on the monitoring and controlling zoonoses and zoonotic agents have recently been adopted. Salmonella is identified as the priority target, especially in poultry products and eggs. The baseline for Salmonella monitoring will be increased closer to the level of the FSCP. Based on our study, this can be seen reasonable considering public health and economic aspects. However, the economic efficiency of the FSCP is also based on the Salmonella control measures used during many decades in Finland. Therefore, benefit-cost ratios would probably be different, if these measures were applied in the situation with higher prevalence of Salmonella in broiler production. Benefit-cost ratio would be affected by risen costs in primary production and prevented deaths.

Monitoring Salmonella itself does not decrease the public health risk of salmonellosis. Also control measures are needed. Salmonella can be controlled by many different measures. Heat treatment of meat from positive flocks is one effective intervention. Other effective measures are feed control, effective cleaning and disinfection after positive detection, destroying hatching eggs from positive breeding flocks and epidemiological investigations. This kind of calculations help to see, are the investments in control reasonable in economic sense. Economic calculations are useful tool for risk managers to evaluate their actions.

## REFERENCES:

Baird-Parker, A.C., 1990. Foodborne salmonellosis. *Lancet* 336:1231-1235.

Baird-Parker, A.C., 1994. Foods and microbiological risks. 1993 Fred Griffith Review Lecture, Delivered at the 126<sup>th</sup> Ordinary Meeting of the Society for General Microbiology, 8 September 1993. *Microbiology* (1994), 140, 687-695.

Commission Decision (94/968/EC). Approving the operational programme for the control of Salmonella in certain living animals and animal products presented by Finland. OJ of the European Communities L 371:36-37.

Council Directive (92/117/EEC). Concerning measures for protection against specified zoonoses and specific zoonotic agents in animals and products of animal origin in order to prevent outbreaks of food-borne infections and intoxications, as amended. OJ of the European Communities L 62:38-48.

Directive (2003/99/EC) of the European Parliament and of the Council. On the monitoring of zoonoses and zoonotic agents amending Council Decision 90/424/EEC and repealing Council Directive 92/117/EEC. OJ of the European Communities L 325:31-40.

Frenzen, P., Riggs, T.L., Buzby, J., Breuer, T., Roberts, T., Voetch, D., Reddy, S., and the FoodNet Working Group, 1999. Salmonella Cost Estimate Updated Using Food Net Data; FoodReview Vol 22, Issue 2.

Helms, M. Vastrup, P., Gerner-Smidt, P. and Mølbak, K 2003. Short and long term mortality associated with foodborne bacterial gastrointestinal infections: registry based study. British Medical Journal vol 326;357-360.

Maijala, R., 1998. The costs, benefits and effects of the Salmonella Control Programme in Finland. Abstract. Workshop on Analytical Methods in the Epidemiology of Zoonosis, 23-24<sup>th</sup> November 1998; Berlin.

Maijala, R. & Peltola, J. 2002. Finnish Salmonella Control Program – Efficiency and Viability in Food Safety Promotion. The 10th EAAE Congress; Zaragoga; Spain; August 28-31, 2002.

Maijala, R. & Ranta, J., 2002. Effect of the Finnish Salmonella Control Programme on Risk Caused by Salmonella in Broilers. International Symposium Salmonella and Salmonellosis i3S, 29-31 May 2002, St Briec, France, Proceedings, pp. 561-564.

MMM 2000. Zoonoses in Finland in 1995-1999. Ministry of Agriculture and forestry 2000. (<http://www.mmm.fi/el/julk/zoonen.htm> ).

MMM (23/EEO/2001). Salmonella control programme for broilers and turkeys. (In Finnish and Swedish) (<http://www.mmm.fi/el/laki/d/default.html>; D110).

Persson, U. & Jendteg, S., 1992. The economic impact of poultry-borne salmonellosis: how much should be spent on prophylaxis?. International Journal of Food Microbiology, 15 (1992) 207-213, Elsevier Science Publishers 1992.

Ranta, J. and Maijala, R., 2002. A Probabilistic Transmission Model of Salmonella in the Primary Broiler Production Chain. Risk Analysis, 22(1):47-58.

Regulation (EC) No 2160/2003 of the European Parliament and of the Council. On the control of salmonella and other specified food-borne zoonotic agents. OJ of the European Communities L 325:1-15.

Roberts, J.A., Cumberland, P., Socket P.N., Wheeler, J., Rodrigues L.C., Sethi, D., and Roderick, P.J. on behalf of the infectious intestinal study executive, 2003. The study of infectious intestinal disease in England: socio-Economic impact. Epidemiol. Infect. 2003, 130, 1-11.

Ruutu, P., 2001. Seminar on Zoonosis Strategy 2001. In helsinki 4 th September 2001, compendium.

Salomaa, J., 1993. Alkoholien käytön haittakustannukset ja verotaso Suomessa, Alko, Alkoholipoliittinen suunnittelu ja tiedotus. Tutkimuslause No 22.

Seminar on Zoonosis Strategy 2001. In Helsinki 4 th September 2001, compendium.

Wheeler, J., Sethi, D., Cowden, J., Wall, P., Rodrigues, L., Tompkins, D., Hudson, M., and Roderick, P., 1999. Study of infectious intestinal disease in England: rates in the community, presenting to general practice and reported to national surveillance. British Medical Journal 1999;318:1046-50.