Assessing the effect of on-farm and abattoir interventions in reducing human salmonellosis from pig meat consumption in the EU

Andrew A. Hill[1,]*

Arno Swart[2], Robin R.L. Simons[1], Hakan Vigre[3], Ana R. Coutinho Calado Domingues[3], Tine Hald[3], Eric Evers[2], Emma L. Snary[1]

[1] *Veterinary Laboratories Agency, Woodham Lane, New Haw, Surrey, UK*
[2] *National Institute for Public Health and the Environment (RIVM), Bilthoven, The Netherlands.*
[3] *National Food Institute, Technical University of Denmark, Søborg, Denmark.*

* Veterinary Laboratories Agency, Woodham Lane, New Haw, Surrey, KT15 3NB, United Kingdom.
e-mail: a.hill@vla.defra.gsi.gov.uk; fax: +44 (0) 1932 357 445

Abstract

Pigs are commonly infected with Salmonella spp. at the slaughterhouse, and the consumption of pig meat is hypothesised to be an important contributor to human salmonellosis. The European Union (EU) will shortly set targets for the reduction of Salmonella in pigs at slaughter for each Member State (MS), and each MS is expected to put in place a National Control Plan (NCP) in order to achieve their targets. If MSs are to realise their targets then practical interventions that consistently work must be identified.

As part of the evidence base for the development of NCPs, a Quantitative Microbiological Risk Assessment (QMRA) was funded to support the scientific opinion required by the EC from the European Food Safety Authority, which was subsequently adopted by the BIOHAZ panel. Here we describe how the baseline model was modified to simulate the effect of both on-farm and abattoir interventions, and the resultant reductions on the predicted number of human Salmonella cases attributable to pig meat consumption in an EU MS. We present the results from two case study MSs with differing slaughter pig Salmonella prevalence and production systems to exemplify the differences that interventions have between MSs.

In the two MSs, both on-farm and abattoir interventions were predicted to be able to produce a significant reduction in salmonellosis attributable to pig meat consumption. Anal bunging of the carcass during processing was shown to be the most effective intervention mechanism in reducing human illness. Some intervention mechanisms were ineffective in reducing human illness, including increased cleaning and disinfection (C&D) at the farm and logistic slaughter.

Introduction

Pigs are commonly infected with Salmonella spp. upon entrance to the slaughterhouse and the consumption of pig meat is hypothesised to be an important contributor to human salmonellosis in the EU. The EU is predicted to set targets for the reduction of Salmonella in pigs at slaughter for each EU MS in 2013, and each MS is expected to put in place a NCP in order to achieve their targets. Control programs in several EU MSs are already underway (Blaha 2004; Mousing et al. 1997); however, the success of these programs is varied (Nielsen et al. 2001, BPEx 2009), In addition, it is not a easy task to attribute reductions in human cases to a control program due to the natural variation in foodborne cases that would occur regardless of any intervention.

If MSs are to meet their targets, and the EU is to realise its aim of reducing human salmonellosis attributable to pig meat consumption, then practical interventions (across the food chain) that work consistently and efficiently must be identified. The most effective interventions are likely to differ between MSs, due to factors such as differing management practices or production processes involved in producing a MS's commonly consumed pig meat products. Therefore, as part of the evidence base for the development of NCPs in individual MSs, a QMRA was funded to support the scientific opinion required by the EC from the European Food Safety Authority. As such, the main aim of this QMRA was to assess the effectiveness of interventions implemented on-farm and at the abattoir and how this may vary across EU MSs. Therefore the baseline model (EFSA 2010) was modified to describe the effect of both on-farm and abattoir interventions and the resultant reductions (if any) on the predicted number of human Salmonella cases in an EU MS attributable to the consumption of 3 pig meat products (pork chops, minced meat and fermented sausage). We present the results from two case

Proceedings - Posters

study MSs (one "low prevalence" MS (MS1) and one "high prevalence" MS (MS2)) to exemplify the differences that may occur in the effectiveness of interventions between MSs.

Material and Methods

In general, one of the main benefits of producing a QMRA is the ability to investigate the relative effect of interventions. These relative reductions can be investigated by comparing the baseline results (in this case, the number of human cases attributable to pork chop, minced meat and fermented sausage consumption) with the percentage reductions in the number of cases observed for each intervention. Not all farm and abattoir interventions investigated in the QMRA are presented here for reasons of space and clarity. The interventions discussed here, and a brief description of how the baseline model was modified for each intervention, are listed in Table 1.

Results

No effect in reducing human cases of Salmonella infection was seen for either MS1 or MS2 for increased C&D (both farm and transport) and logistic slaughter interventions.

The effect of reducing slaughter pig prevalence is shown in Figure 1. Reducing slaughter pig prevalence appears to be effective in reducing the number of human cases per year for each case study MS. Breeding herd prevalence was established as a significant factor within the farm model, via investigation of the main sources of infection (see accompanying conference paper on farm transmission model by Hill et al.). Broadly speaking, low breeding herd prevalence (low number of positive piglets) equates to low slaughter pig prevalence and vice versa. The intervention of reducing breeding herd prevalence produces a similar result as for reducing slaughter pig prevalence, where broadly speaking there is a proportional percentage reduction in human cases for a given percentage reduction in breeding herd prevalence (analysis not shown).

Modifying the resistance of the pig, such that a tenfold increase in dose is needed to cause the same probability of infection as for the baseline model, produced a large reduction (~90%) in the number of human cases in both MS1 and MS2. Increasing that resistance, to a 100-fold increase in dose to cause the same probability of infection, virtually eliminates human infection.

The effect of a 1, 2 or 3 log reduction in contamination of the carcass pre-chill was investigated and the results are also presented in Figure 1. A reduction of carcass contamination level of between 1 and 2 logs is sufficient to produce a large (>80%) percentage decrease in the number of human cases within both MS1 and MS2. The majority of contamination on the carcass post-singe originates from faecal leakage. Preventing this faecal leakage within the model resulted in an average reduction across all carcasses at pre-chill of roughly 1 log. This resulted in an 80-99% reduction in human cases in MS1 and MS2 (equivalent to a 1-log reduction as shown in Figure 1).

Discussion

The results of this analysis suggest that interventions (both on farm and at the abattoir) that can achieve the level assumed in the analysis could lead to large reductions (up to 99%) in the number of human cases per year in both MS1 and MS2. However, to produce these large reductions the slaughter pig prevalence and/or the level of contamination at pre-chill must be reduced by approximately ten-fold. It is unlikely that on-farm interventions, implemented on a nationwide scale, can consistently produce such large (~90%) reductions in slaughter pig prevalence (at least in the short to medium term). There is no evidence that interventions that can modify the resistance of the pig to infection

Table 1: List of interventions and the modifications made to the baseline model to assess their effect

Table 1: List of interventions and the modifications made to the baseline model to assess their effect

Stage	Intervention	Intervention analysis parameter estimate
Farm	Reduce breeding herd prevalence, p_{herd}, within farm model.	MS2 model ran with p_{herd}= {0,0.01,0.05,0.1,0.2,0.3,0.4,0.5}.
	Reduce slaughter pig prevalence	Reduce slaughter pig prevalence to 10, 20, 30, 50, 70, 90, 99% of baseline result.
	Increased effectiveness of cleaning and disinfection (C&D)	An extra 1 or 2-log reduction (over and above the reduction in the baseline model) in *Salmonella* numbers present in pen after C&D.
	Increased resistance of pigs to *Salmonella* infection by using e.g. wet feed, vaccination or organic acids	Dose response parameters modified such that it takes an extra 1 or 2-log increase in dose to produce baseline model dose-response curve.
	All farms use wet feed.	Dose-response curve set to wet feed parameter estimation for all farms.
Transport	Increased cleaning	Additional reduction over and above baseline C&D effect of 0.5, 1 or 2 logs.
Slaughterhouse	Reducing/preventing faecal leakage	Set CFUs in gut to zero.
	Logistic slaughter (process high-risk pigs at end of day)	Model randomly selected batches for one day's processing, and then sorts these batches in ascending order of within-batch prevalence.
	Decontamination step pre-chill	Reduce carcass contamination pre-chill by 1,2 and 3 logs.
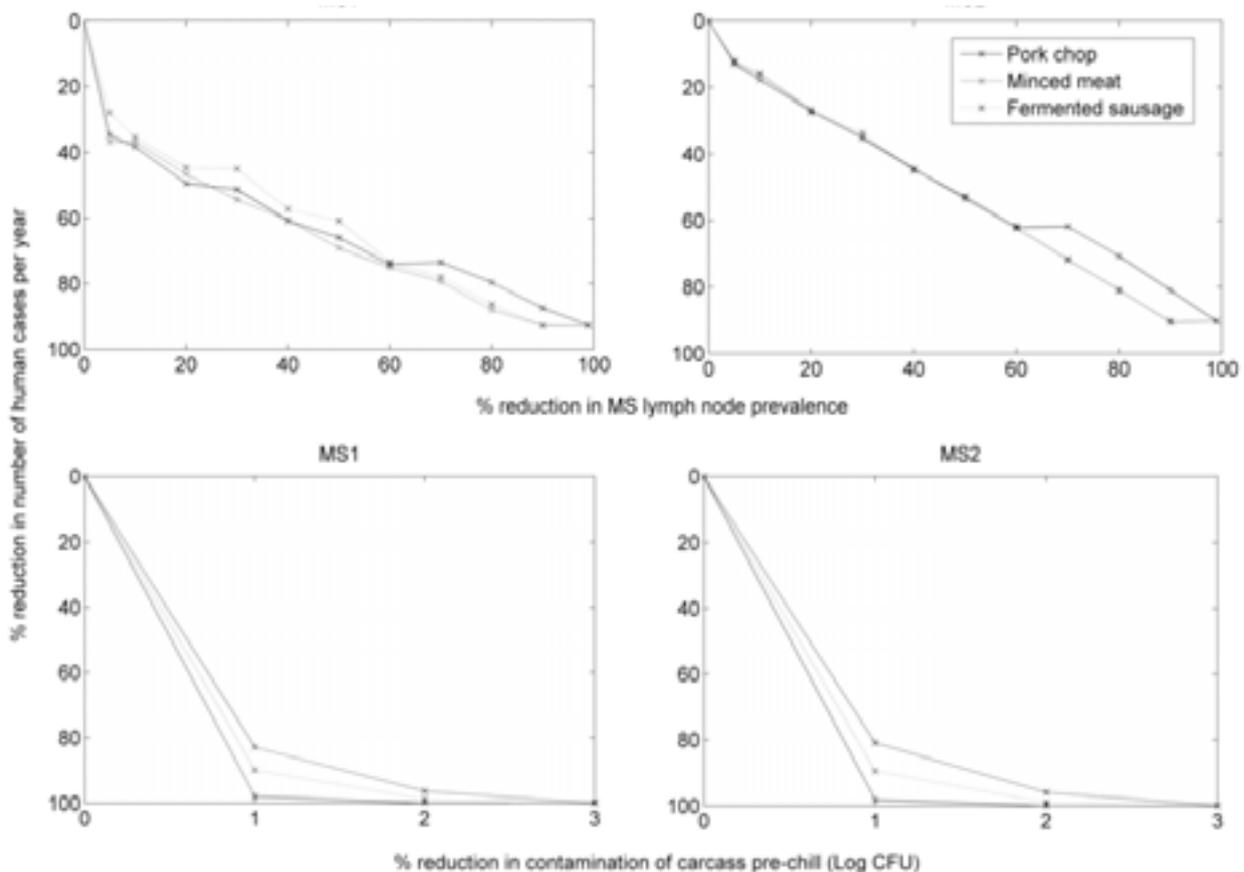
Figure 1: Percentage reduction in human Salmonella cases due to reductions in baseline slaughter pig prevalence (top) or contamination of carcass pre-chill (bottom), for MS1 and MS2.

(e.g. vaccination, organic acids, fermented feed) can induce a ten-fold increase in resistance. However, there are abattoir interventions such as anal bunging that have been shown to consistently reduce the average contamination level of pre-chill carcasses by a log or more (Christiansen et al. 2009; James 2009).

It is difficult to validate such intervention results as they are necessarily predictive. However, it is possible to validate the breeding herd prevalence reduction, by comparing the breeding herd prevalence and slaughter pig prevalence estimates for each MS from the two EFSA baseline surveys (EFSA 2008; 2009). While geographical, farm management and slaughterhouse differences are undoubtedly an issue, comparing the two studies there does seem to be a broadly linear relationship between breeding herd prevalence and slaughter pig prevalence, which is in agreement with the model result. This supports the conclusion that the sow is a major source of infection for slaughter-age pigs.

Conclusion

Theoretically, we predict that intervention at either the farm or abattoir can be effective in significantly reducing human cases. The reductions achieved are strongly dependent on the mechanism of the intervention. Decontamination of the carcass and prevention of carcass contamination are promising interventions that have evidence of consistent efficacy. The only farm mechanism investigated that was estimated to reduce human cases was modifying the resistance of the pig, through interventions such as vaccination and organic acids. However, there is no consistent evidence for the true efficacy of these resistance interventions. Increased C&D and logistic slaughter were predicted to have a negligible effect in reducing human cases.

Acknowledgements

References

Blaha T (2004) The present state of the German QS Salmonella monitoring and reduction programme. Deutsche Tierarztliche Wochenschrift 111, 324-326.

BPEx (2009) Annual report of the Zoonoses Action Plan Salmonella Programme July 2007-March 2008

Christiansen P, et al. (2009) Effect of hot water and lactic acid decontamination on Escherichia coli, Salmonella Typhimurium and Yersinia enterocolitica on pork. . In 'Safepork 2009'Quebec City, Canada).

EFSA (2008) Analysis of the baseline survey on the prevalence of Salmonella in slaughter pigs, in the EU, 2006-2007 - Part B: factors associated with Salmonella infection in lymph nodes, Salmonella surface contamination of carcasses, and the distribution of Salmonella serovars.

EFSA (2009) Analysis of the baseline survey on the prevalence of Salmonella in holdings with breeding pigs in the EU, 2008 - Part A: Salmonella prevalence estimates.

EFSA (2010). Quantitative Microbiological Risk Assessment on Salmonella in Slaughter and Breeder pigs. www.efsa.europa.eu/en/supporting/pub/46e.htm

James C, et al. (2009) Reduction of Salmonella contamination of pig meat (M01038). University of Bristol. Report to UK Food Standards Agency.

Mousing J, et al. (1997) Nation-wide Salmonella enterica surveillance and control in Danish slaughter swine herds. Preventive Veterinary Medicine 29, 247-261.

Nielsen B, et al. (2001) A new Salmonella surveillance and control programme in Danish pig herds and slaughterhouses. Berliner Und Munchener Tierarztliche Wochenschrift 114, 323-326.

384

Proceedings - Posters