

PORK SAFETY

Title: Analysis of Salmonella Pre-Harvest Control Strategies – NPB #11-082

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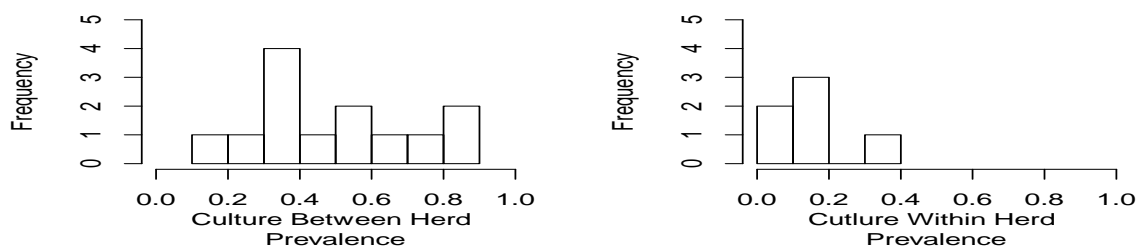
Institution: Iowa State University

Date Submitted: July 5, 2012

Industry Summary. The purpose of this project was to provide a comprehensive description of the efficacy of mandated control programs for pre-harvest *Salmonella* spp. used by major pork exporting/importing nations. Such information enables the industry to be aware of the approaches used that may affect trade and food safety.

The 1st and 2nd aspects of the project were to describe mandated *Salmonella* spp. specific pre-harvest control approaches in major pork exporting/importing countries. We searched grey and peer reviewed literature for reported programs and contacted individuals in these countries. The information was difficult to find and verify. Our conclusion is that no major pork producing countries have mandatory *Salmonella* spp. specific pre-harvest control programs except Denmark. Denmark requires mandatory declaration of *Salmonella* spp. status prior to sale and testing of purchased feeds for *Salmonella*.

The 3rd aspect of the project was to collate estimates of the prevalence of *Salmonella* spp. pre-harvest in the United States. We used data from two prior reviews and an updated review of the literature. We collated estimates of the prevalence of *Salmonella* positive herds and the within herd prevalence(Figure 1.)



The 4th aspect of the project was to summarize the efficacy of mandated programs. The Danes suggests their combined pre-harvest and post-harvest approach is effective but the importance of the pre-harvest component is not clear¹⁻⁴. An assessment of the Belgium voluntary program which focused unilaterally on primary production concluded “*The evaluation of this Salmonella action plan demonstrated that it had only little effect on the level of Salmonella infection in pigs.*”⁵ The European Food Safety Commission has published two cost benefit assessments of pre-harvest control of *Salmonella* spp. in finishers⁶ and breeding’s⁷ and concluded “*On the basis of current scientific advice and the experience of Member States, it is not possible at this time to*

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demonstrate cost-beneficial interventions to reduce *Salmonella* infections at EU level in either breeding pigs or slaughter pigs, or in combinations of both herds. Sensitivity analyses indicate that positive cost-benefits can be found only in extreme scenarios.⁷

The 5th aspect of the project was to summarize the findings about the effect of pre-harvest interventions and assess the GRADE system for making recommendations. We used published reviews of *Salmonella* pre-harvest interventions and the GRADE process to assess the efficacy⁸. The GRADE process uses 4 factors to reach a conclusion for adoption of an intervention- the quality of the evidence, the cost benefit, the balance of benefits and harms and the balance of values and preferences. The panel concluded it was unlikely that any intervention assessed would be strongly recommended to swine production entities for adoption based either on lack of evidence for an effect, or very low cost versus benefit (i.e. would cost much more than the benefit).

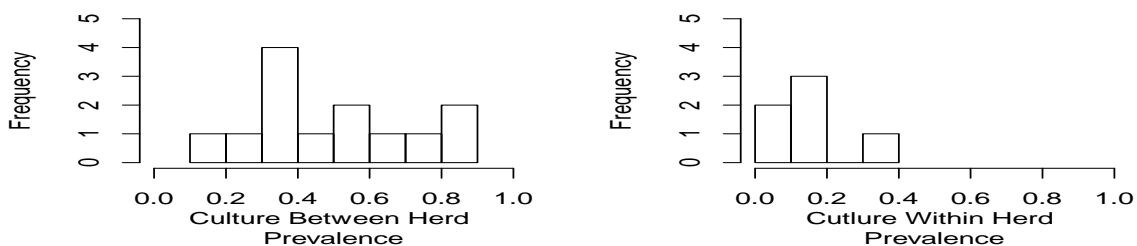
Keywords: *Salmonella*, pre-harvest, interventions, food safety,

Scientific Abstract:

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or slaughter pigs, or in combinations of both herds. Sensitivity analyses indicate that positive cost-benefits can be found only in extreme scenarios.⁷

The 5th aspect of the project was to summarize the findings about the effect of pre-harvest interventions-antibiotics, commercially available *S. choleraesuis* vaccines and feed management. We used previously published reviews of Salmonella pre-harvest interventions and the GRADE process to assess the efficacy⁸. The GRADE process uses 4 factors to reach a conclusion for adoption of an intervention- the quality of the evidence, the cost benefit, the balance of benefits and harms and the balance of values and preferences. The panel concluded it was unlikely that any intervention assessed would be strongly recommended for adoption based either on lack of evidence for an effect, or very low cost versus benefit (i.e. would cost much more than the benefit)

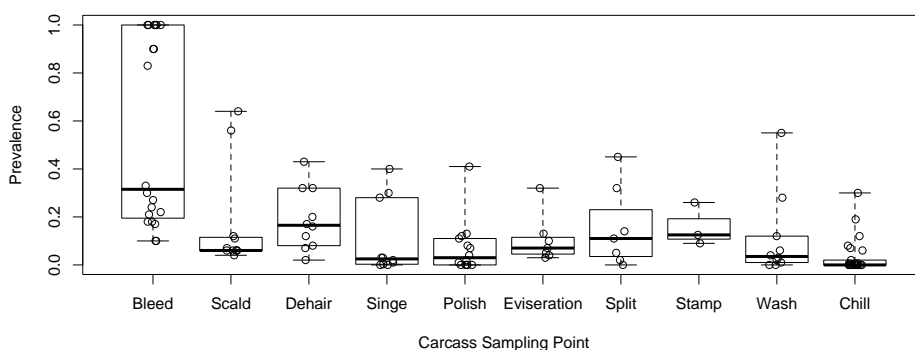
Introduction:

The control of food borne pathogens at all sectors of the production system is desirable, however dependent upon the organism-food combination involved, the mechanism by which food is contaminated it may or may not be feasible or economic to mandate widespread adoption of pre-harvest control measures. For example, for products that are not processed after harvest such as eggs and leafy greens, opportunities for effective post-harvest mitigations strategies are few. For such organism–food combinations pre-harvest control is critical. For other organism-food combinations pre-harvest controls may be ineffective or cost-prohibitive given the potential efficacy of post-harvest approaches.

In a recent review of the effect of post-harvest control of Salmonella we were able to document, using a meta-analysis derived process mapping, strong evidence that post-harvest practices substantially reduce the prevalence of Salmonella spp. on pork carcasses (Figure 1). Further in prior conducted systematic reviews we concluded there is little evidence that pre-harvest control approaches to Salmonella are effective. Given, little evidence of effect there can be no expectation of a cost benefit to implementing pre-harvest Salmonella control.

Despite this knowledge, there is still a need to be aware of what other countries are doing with respect to pre-harvest control of Salmonella spp. as such practices may indicate changing attitudes and potential barriers. Therefore, although the US has no industry backed or legislatively mandated Salmonella specific pre-harvest control programs for pork, the aim here was to determine what other major pork producers or importers were doing with respect to Salmonella spp. in pork.

Figure 1: Process map of Salmonella spp. prevalence on carcasses at processing points during post-harvest.



Objectives:

Deliverable 1: A description of the components of nationally mandated approaches to *Salmonella spp.* control pre-harvest in major pork-exporting countries.

Deliverable 2: A description of the components of the nationally mandated approaches to *Salmonella spp.* control pre-harvest for major importers of US pork products.

Deliverable 3: A description of estimates of the prevalence of *Salmonella spp.* pre-harvest in the United States, including estimates of the proportion of positive *Salmonella* positive farms and estimates of the distribution of the prevalence of *Salmonella* within farms.

Deliverable 4: A summary of estimates of efficacy of national control measures designed to reduce *Salmonella* pre-harvest.

Deliverable 5: A summary of evidence for the efficacy of components of on-farm *Salmonella* control programs.

Materials & Methods:

Deliverables 1, 2 and 4

This information was gathered using a combination of literature search and personal contacts. The literature search was conducted by an ISU librarian under guidance of the investigator. Because of the nature of the information sought searching for control programs and *Salmonella*, the majority of the search was a self described “creative Google search”. Articles identified by the principle investigator such as EFSA scientific opinions⁹ served as a basis for these searches. Finally, the principle investigator contacted colleagues in numerous countries to directly to ask for information or guidance. If none of these contacts were useful, the primary investigator contacted the contact author on peer-reviewed publications that were relevant to the topic. When none of these methods worked, the primary investigator used a Google search to identify either the equivalent of the National Pork Board or the USDA in the country of interest and using the contact information sent an email to the agency outlining the request about programs and assessments of the efficacy of programs. When documents were obtained in foreign languages, Google translate was used to translate the documents and look for the key elements of the document.t

Deliverable 3.

Data was obtained from three sources. Two previous reviews of *Salmonella* prevalence had been conducted by Sanchez et al¹⁰ and Fosse et al¹¹ through to March of 2008, therefore these reviews were used to identify papers that reported *Salmonella* prevalence pre-2008. To update the review to include estimates from 2008 and beyond, a search of electronic citation databases was conducted. The final search was conducted on May 15th, 2012. The literature search was conducted in the databases of MEDLINE using the PubMed interface and CAB Abstracts. The following keyword combination was used in MEDLINE: (((prevalence) AND (salmonella) AND ((pigs) OR (pig) OR (swine))). This search string reflected that used by Sanchez et al¹⁰ and Fosse et al¹¹. In CAB abstracts the terms “pigs, salmonella, and prevalence” were used as descriptors. References were then combined into the program EndNote to further carry out the data extraction.

In End Note ⑧, a rapid screening exercise was conducted with the retained references limited to studies reported in English and conducted in the United States. If a study was conducted in multiple locations worldwide and the authors specifically reported their data by location such as U.S not North America, the data for the U.S. were extracted.

Once the references were narrowed down to the United States and English, two authors separately screened the remaining references for relevance based on the following criteria:

- The study described the prevalence of Salmonella in swine on-farm. This was interpreted as meaning that fecal samples must have been taken at the farm, however serological samples could have been taken at farm or slaughter.
- The study reported prevalence of indoor-reared fattening pigs. Prevalence estimates in piglets, sows, out-door reared pigs, carcasses, and retail pork was not considered relevant and therefore excluded.
- Estimates of Salmonella had to be derived from faecal shedding or serological prevalence. Samples taken from feed, trucks, holding pens, interventional or experimental studies were also excluded.

Once the two authors agreed on final references to be included, the original papers were obtained and data was extracted into a database containing the desired data from the two previous reviews. For relevant articles from the previous two reviews, the papers were obtained and the data verified. Data extracted were estimates of positive herds, estimates of positive samples and estimates of within-herd prevalence. One author extracted all of the data and then the second author verified all data entered for the updated literature. Prevalence distribution histograms were used to summarize the available data. Estimates were computed using between farm, within farm, overcall sample for serological and culture based measures of Salmonella prevalence.

Deliverable 5:

The original aim was the assess mandated interventions, however, the only mandated interventions were sale of pigs with Salmonella status declared, and there was no data available on this intervention as it is included only as part of a larger program. Therefore the project placed greater emphasis on the GRADE project and its utility for making recommendations. The pre-harvest interventions assessed by the panel GRADE were decided upon by the principle investigator (lead author) based on the availability of the reviews. Because of the time associated with the project, the choose was limited to topics where the lead author had already been involved in a systematic review of the topic¹²⁻²¹. Within this set of topics, the aim was to capture increasing complexity in assessing control options or disease risk factors. Complexity was identified but the number of outcomes, number of interventions and number of study designs included in the evidence base. Although numerous other scenarios are possible, these represented a gamut of realistic options.

The topics chosen were

- 1) The assessment of commercial available *Salmonella cholerasuis* vaccines for the prevention of Salmonella in pork. This topic presented one clearly defined intervention with two options (Argus SC vaccine and SC-54 vaccines) with a single study design, (controlled trial) and multiple defined outcomes.
- 2) The assessment of antibodies for the prevention of Salmonella in pork. This topic presented multiple intervention with a single study design, (challenge trials) and multiple outcomes.
- 3) The assessment of feed management strategies for the prevention of Salmonella in pork. This topic presented multiple intervention with multiple designs and multiple outcomes.

This approach differed from the GRADE process as normally it would be expected that the panel would identify the topic, and then commission systematic reviews, then that review would then be passed to the panel to use for recommendation making.

For each topic, the lead author prepared all the materials for the panel meeting. These materials include the

published review and the papers used in the review. These materials were provided to the panel members prior to the meeting. Instructions to the panel members were to read each systematic review prior to the meeting and to refer to the original papers for additional clarifications.

Panel recruitment.

Consistent with GRADE recommendations, panel members were recruited with as wide expertise as 6 members panel would allow. Six panel members were chosen based on the budget available. The panel consisted of 6 invited panel members, and the chair (lead authors). The invited experts had expertise in food safety, five were PhD level epidemiologists, 1 a PhD level food safety microbiologist. All panel members had extensive experience with industry groups. Four panel members had extensive experience with pathogens associated with pork, one had extensive experience with pathogens associated with poultry, three experts had extensive experience with pathogens associated with pork. None had any familiarity with GRADE prior to the project.

The panel review meeting:

The panel meeting was held in January 2012 over 1.5 days in Ames, Iowa and/or a teleconference in June 2012. At the meeting the panel members were provided with hard copies of the systematic reviews and the original research publications for each of the four topics. Forest plots, incomplete summary of findings tables and evidence grade tables were also provided to the panel members. For each scenario the aim was to 1) understand the evidence based using the prior reviews, the original papers, forest plots and meta-analyses from REVMAN when relevant and discussion, 2) complete the recommendation tables for each scenario. Further, the panel captures concerns and issues associated with each scenario and particularly the application of GRADE and assessing the utility of the GRADE process and identifying caveats and limitations

Results: Report your research results by objective.

Deliverable 1

Although surveillance for Salmonella is mandatory in the EU, specific pre-slaughter Salmonella approaches such as vaccination, biosecurity, changes in feed texture, depopulation etc are generally not. In the European Union (EU), Regulation (EC) No 2160/2003 on the control of *Salmonella* and other specified food-borne zoonotic agents states that the protection of human health against zoonotic diseases is of paramount importance. This regulation also specifies that countries must have Salmonella spp. surveillance programs, and it had been proposed since 2003 that EU countries should have Salmonella specific pre-harvest control programs. However, prior to adoption of control programs it was necessary to determine the targets. To establish these targets several studies were conducted: a baseline study of Salmonella prevalence across all EU member states, risk factors for Salmonella, and cost-benefit analysis for Salmonella spp. control in breeding and fattening pigs. Based on the findings of these projects it seems unlikely that Salmonella specific pre-harvest control programs will be adopted as the conclusion of the two cost-benefit analysis, one for fattening pigs and another for breeding's pigs was that pre-harvest control would not be cost effective.

From the breeding pig analysis (2011) “ *On the basis of current scientific advice and the experience of Member States, it is not possible at this time to demonstrate cost-beneficial interventions to reduce Salmonella infections at EU level in either breeding pigs or slaughter pigs, or in combinations of both herds. Sensitivity analyses indicate that positive cost-benefits can be found only in extreme scenarios.* ”⁷

From the fattening pigs analysis (2010) *“On the basis of the available data and the assumptions made, the cost-benefit analysis did not show an economic benefit from any of the intervention scenarios. Sensitivity analyses did not change the results markedly, although did offer some possible direction for the development of Salmonella control at producer level.”*⁶

Although, the European Commission currently does not compel EU member states to have pre-harvest *Salmonella* spp. control programs in swine, some counties have control programs in place.

Counties that legislate control programs:

Some countries do legislate that high risk producers must take action to reduce pre-harvest *Salmonella* spp. when detected as part of the *Salmonella* surveillance programs. However, **the specific actions that must be taken to control pre-harvest *Salmonella* spp. are rarely mandated. No major swine producing countries appears to regulate the control options such as requiring vaccination or particular feed types. Denmark appears to regulate aspects of pig sale between farms and feed testing.** It should be noted that it is difficult to ensure that no meaning is lost in the translation and its is somewhat difficult to ensure that the terms mandated, legislated and required have been correctly understood in all communications. The Scandinavian countries, Finland, Norway and Sweden have a very unique *Salmonella* programs with the aim being to almost eradicate *Salmonella* but these are not major swine producing countries.

Denmark: Denmark has a long running program for *Salmonella* spp. control. The structure of the Danish program has been very flexible and has evolved over the years. The program currently focuses on surveillance and the Danish Industry continues to monitor the serological status of herds and the practice of assigning herds to Category I, II and III based on serology. Category III herds are required by law to work to reduce *Salmonella* spp, and penalties apply for these herds when marketing swine by law. Interestingly it was concluded that this approach did not reduce spread of *Salmonella* between herds and therefore new regulations were adopted to reduced transmission between herds.

“The Danish pig industry chose to focus on herds with a high Salmonella index (measured by use of blood samples) and imposed restrictions on these herds. Unfortunately, this strategy turned out to be insufficient to mitigate the spreading of Salmonella to the finisher herds. According to an EU baseline study conducted in 2008, the prevalence of Salmonella-positive breeding holdings in Denmark was 41%...”

In 2010 to reduce Spread between herds the Danes introduce an additional classification system The herds are now allocated to one of three categories: negative for *Salmonella* (Status A), positive for *Salmonella* Typhimurium, *Salmonella* Derby or *Salmonella* Infantis (Status C), positive for other types of *Salmonella* (Status B). Herds are legally required to declare their status when selling animals between herds.¹

Apart from regulating sale of pigs as a means of pre-harvest control, the Danish system also imposes restrictions of feed sales. In Denmark, all purchased, compound feed has to be produced in compliance with the rules for *Salmonella*-free production of feed. It has to be heat-treated to 81 °C, or produced using methods that are equivalent to heat treatment. However home-produced feed does not have to follow these rules. The Danish system does not appear to mandate any other pre-harvest practices such as vaccination, other than the need to have a *Salmonella* action plan in accordance with regulation number 1329/2010.

Netherlands: Information about the Netherlands Salmonella programs in swine can be found at <http://www.pve.nl/pve?waxtrapp=fytFsHsuOpbPREcBRNqB&context=gfMsHsuOpbPRED>. In the Netherlands surveillance for Salmonella in pork is mandated, as is an action plan for control in herds with high infection status. No particular pre-harvest Salmonella control practices appear to be mandated. It is not clear if the Dutch legislation imposes trade restrictions and penalties on the highly infected herds as Denmark does.

Germany: Information about the German programs can be found at <http://www.q-s.info/>. In Germany surveillance for Salmonella in pork is mandated, as is an action plan for control in herds with high infection status. No particular practices appear to be mandated. It is not clear if the German legislation imposes trade restrictions and penalties on the highly infected herds as Denmark does.

Ireland: In Ireland, the Irish National Pig *Salmonella* Control Programme is mandated in the legislature under S.I. No. 522/2009 — Diseases of Animals Act 1966 (Control of Salmonella In Swine) Order 2009 (<http://www.irishstatutebook.ie/2009/en/si/0522.html>) . The program is very similar to the Danish programme except that there is no requirement to categorize farms. All herds must have an on-farm *Salmonella* control programme and must have a % *Salmonella* spp. prevalence established. Farms must also have an action plan to reduce Salmonella, that must minimally include the following

- (a) *bio security measures including staff, equipment, visitor access, pest control and control of animals and their products,*
- (b) *managerial practices including work flows, outputs, disinfection procedures, standard operating procedures and bacteriological sampling,*
- (c) *restocking, including sourcing from herds or stock that have a low incidence of salmonella serovars,*
- (d) *transport, including segregation and disinfection of vehicles and equipment, and*
- (e) *the identity of the record keeper and maintenance of all relevant documentation.*

Belgium: In Belgium, an on-farm Salmonella control program was mandated by Royal Decree in 2007²², requiring development of and execution of a farm specific action plan to control Salmonella on farms. Particular pre-harvest Salmonella control actions were not specified. However, an advice from the Belgian Federal Agency for the Safety of the Food Chain recently published a recommendation against continuing the program. The advice concluded that

*“ The current Salmonella action plan, that was introduced in 2007, is aimed unilaterally on primary production. The evaluation of this Salmonella action plan demonstrated that it had only little effect on the level of Salmonella infection in pigs.”*⁵

Finland: The Finnish control programme aims to maintain the annual prevalence of *Salmonella* below 1% and has been jointly organised through voluntary measures and mandatory regulations since the 1960s. The programme is based on random bacteriological testing of 3000 sows, 3000 fattening pigs and 3000 meat samples per annum. If *Salmonella* is detected, legislative measures are taken including, epidemiological identification of serovar, restrictions on sales or purchases of pigs and products, disinfection procedures and special arrangements for slaughter²³. The Finnish programme also implements a number of other control measures including, *Salmonella* testing of feedstuffs, removal of positive pigs from the production chain, avoiding cross-contamination from positive slurry to feed, fields and housing and the use of all in/all out production systems. Detection of Salmonellae on a farm, abattoir or in a cutting plant in Finland always leads

to legislative measures, including epidemiological investigations, restrictions on the sale or purchase of animals and on the use of products contaminated by *Salmonella*, disinfection procedures as well as special arrangements for slaughtering. These restrictions are revoked only after it has been established that there are no longer any *Salmonellae* on the farm. Overall, the control programme is very effective with *Salmonella* prevalence at less than 1% although the scheme is expensive. Eradication is Finland's goals rather than control¹.

Sweden and Norway: Like the Finnish programme, the Swedish and Norwegian control programmes have been in operation for over 30 years and *Salmonella* is present at very low levels. There is *Salmonella* testing of feed and bacteriological sampling of faeces from breeding/multiplier and finishing herds. If *Salmonella* is isolated, the herd is placed under restrictions and compensation is paid to producers. Both countries aim for eradication of *Salmonella* rather than control¹

Countries that have no legislative programs but producer or industry based programs

In some countries, *Salmonella* control programs are voluntary and producers are provided with general recommendations to reduce *Salmonella* without any quantification of the expected magnitude of effects. The scale of these programs seems to be decreasing.

United Kingdom: In the UK, the current program is called UK Zoonoses National Control Programme for *Salmonella* in pigs (ZNCPP). This program appears to provide producers with generic information about *Salmonella* control but there is no mandated *Salmonella* control actions required (<http://www.bpex-zncpp.org.uk/zncpp1/home.eb>). The site provides producers with a risk assessment tool, that can then be used to develop an action plan. The original UK *Salmonella* Control programme was introduced in 2002 and was based on the Danish ELISA testing system. The programme. The initially named Zoonoses Action Plan (ZAP) differed from the Danish control programme in that there was no requirement for testing of feeds, testing of breeding/multiplier herds and no requirement for follow-up microbiological testing. There also appear to be no penalties implemented against units with high ZAP status. On the 1 July 2012 BPEX suspended the use of meat juice testing methods and replaced it with a new on-farm risk assessment tool, designed to help farmers identify the best *salmonella* control methods for their particular farm.

Canada. Quebec has a producer initiated and voluntary *Salmonella* control program based on surveillance at the abattoir. The program has veterinarians recommend an action plan to farms identified by the system as needing assistance. (<http://www.leporcduquebec.com/les-producteurs-fr/programmes/surveillance-des-salmonelles.php>). In Ontario, Canada producers are provided with only generic information about *Salmonella* control but there is no mandated or voluntary *Salmonella* control programs http://www.omafra.gov.on.ca/english/livestock/swine/facts/info_qs_salmonella.htm. The other Canadian provinces do not have *Salmonella* control programs and provide similar advice to that provided by Ontario.

Counties that appear to have no legislative or voluntary programs

France: Using searches of the web and peer reviewer literature it was not possible to identify a *Salmonella* specific pre-harvest control program in France. Personal communications reported there are none.

Italy: Using searches of the web and peer reviewer literature it was not possible to identify a *Salmonella* specific pre-harvest control program in Italy. Personal communications reported there are none.

Spain: Using searches of the web and peer reviewer literature it was not possible to identify a *Salmonella* specific pre-harvest control programs in Spain. Personal communications reported there are none. The website of the Spanish Food Safety and Nutrition Agency provided only information of legislation for *Salmonella* but

no producer oriented control options.

(http://www.aesan.msc.es/en/AESAN/web/cadena_alimentaria/detalle/salmonella.shtml) . Another site provides general information on Salmonella control options but no program exist.

<http://www.magrama.gob.es/es/ganaderia/temas/sanidad-animal-e-higiene-ganadera/programas-nacionales-de-control-de-salmonella/Aplicacion-pnc.aspx#para11>

Poland: Using searches of the web and peer reviewer literature it was not possible to identify a Salmonella specific pre-harvest control program in Poland. Personal communications reported there are none.

Portugal: Using searches of the web and peer reviewer literature it was not possible to identify a Salmonella specific pre-harvest control program in Portugal. Personal communications reported there are none.

Australia: Using searches of the web and peer reviewer literature it was not possible to identify a Salmonella specific pre-harvest control program in Australia. Personal communications reported there are none.

New Zealand: Using searches of the web and peer reviewer literature it was not possible to identify a Salmonella specific pre-harvest control program in New Zealand. Personal communications reported there are none.

Deliverable 2.

Using searches of the web and peer reviewer literature it was not possible to identify a Salmonella specific pre-harvest control programs in Russia, Japan, China or Brazil. Personal communications were not available and emails to government offices were not returned. For South Korea, staff at the Standard Division, Animal, Plant and Fisheries Quarantine and Inspection Agency indicated that there are no pre-harvest Salmonella control programs for swine in Korea.

Deliverable 3.

The PUBMED search identified results in 794 citations and the CAB search identified 332. Of the 1,126 references retrieved from the PubMed and CAB abstracts, 5 articles were kept for analysis after relevance screening. Many of the papers reported multiple sets of results (faecal, serological, different OD % cut-offs etc) and all were accounted separately in the analysis resulting in 49 data points. There were a total of 21 between herd level prevalence estimates, 9 within herd level prevalence estimates and 19 sample level prevalence estimates included in the analysis. 31 of the 49 estimates derived from studies included in the previous two published reviews and 18 of the estimates came from the 5 post 2008 publications. Table 1 contains the specific information extracted from the 49 data points. Figures 1-6 provide the breakdowns between serum and culture diagnostic procedures and the sample, within herd and between herd levels.

Footnotes:

^o<http://cran.r-project.org/doc/manuals/R-intro.html>

Deliverable 4:

As few countries have Salmonella specific pre-harvest control programs it is difficult to assess their efficacy . The Finish program is considered successful but not cost efficient, but the uniquely low prevalence of Salmonella in Scandinavian countries and the duration of their programs makes it difficult to extrapolate the results of those programs to other settings^{1,23}. The Danes suggests their combined pre-harvest and post-harvest approach is effective but the relative importance and impact of the pre-harvest component is not clear¹⁻⁴. An assessment of the Belgium voluntary program which focused unilaterally on primary production concluded *“The evaluation of this Salmonella action plan demonstrated that it had only little effect on the level of Salmonella infection in pigs.”*⁵ The European Food Safety Commission has published 2 cost benefit assessments of pre-harvest control of *Salmonella spp.* in finishers⁶ and breeding’s⁷ and concluded *“On the basis of current scientific advice and the experience of Member States, it is not possible at this time to demonstrate cost-beneficial interventions to reduce Salmonella infections at EU level in either breeding pigs or slaughter pigs, or in combinations of both herds. Sensitivity analyses indicate that positive cost-benefits can be found only in extreme scenarios.”*⁷

Deliverable 5:

This aspect of the project is still being drafted into a final publication and some conclusions, interpretations and recommendations have not been finalized.

The grading process was conducted in two stages in an onsite meeting in January 2012 and a teleconference in June 2012. The conclusions reached by the panel where that the Grade process has some value in providing clear recommendations although modification may be needed for food and feed safety. The preliminary recommendations made are presented in Table 3 to Table 7.

The panel noted that the major limitation of the GRADE process were as follows 1) absence of a cost-benefit analysis conducted in the US, 2) the need for updated reviews and 3) the need for a large panel. Because this was missing the panel was required to guess as to estimated cost-benefit analysis. This increased uncertainty. Further, because GRADE includes questions about values and preferences, the absence of stakeholders such as producers and consumers was a serious error. Also the analysis of evidence was based on previously conducted reviews. It would have been preferable to have updated reviews but this would have added greatly to the cost. However it was also noted that generally the quality of the work was very poor and unless well executed studies were added since the reviews, the conclusions about the quality of the work would likely not have changed.

Finally it was difficult to know who was the target of the recommendations and this was an important issue. For example, if the recommendation was for industry wide adoption different conclusions might be reached. The panel suggested that individual entities i.e., companies were the target. Therefore when weak recommendations were made , the implication as that there might be situations where some companies wanted or needed to address particular Salmonella problems. The recommendation was directed at those companies, not at the industry as a whole. This meant that issues of values and preferences were variable at the entity level but without stakeholders those differences could only be inferred. This approach is consistent with GRADE, where recommendations are directed for individual patient decisions not nationally mandated or legislative decisions.

Figure 2: Estimates of Salmonella prevalence based on serum/meat juice or culture.

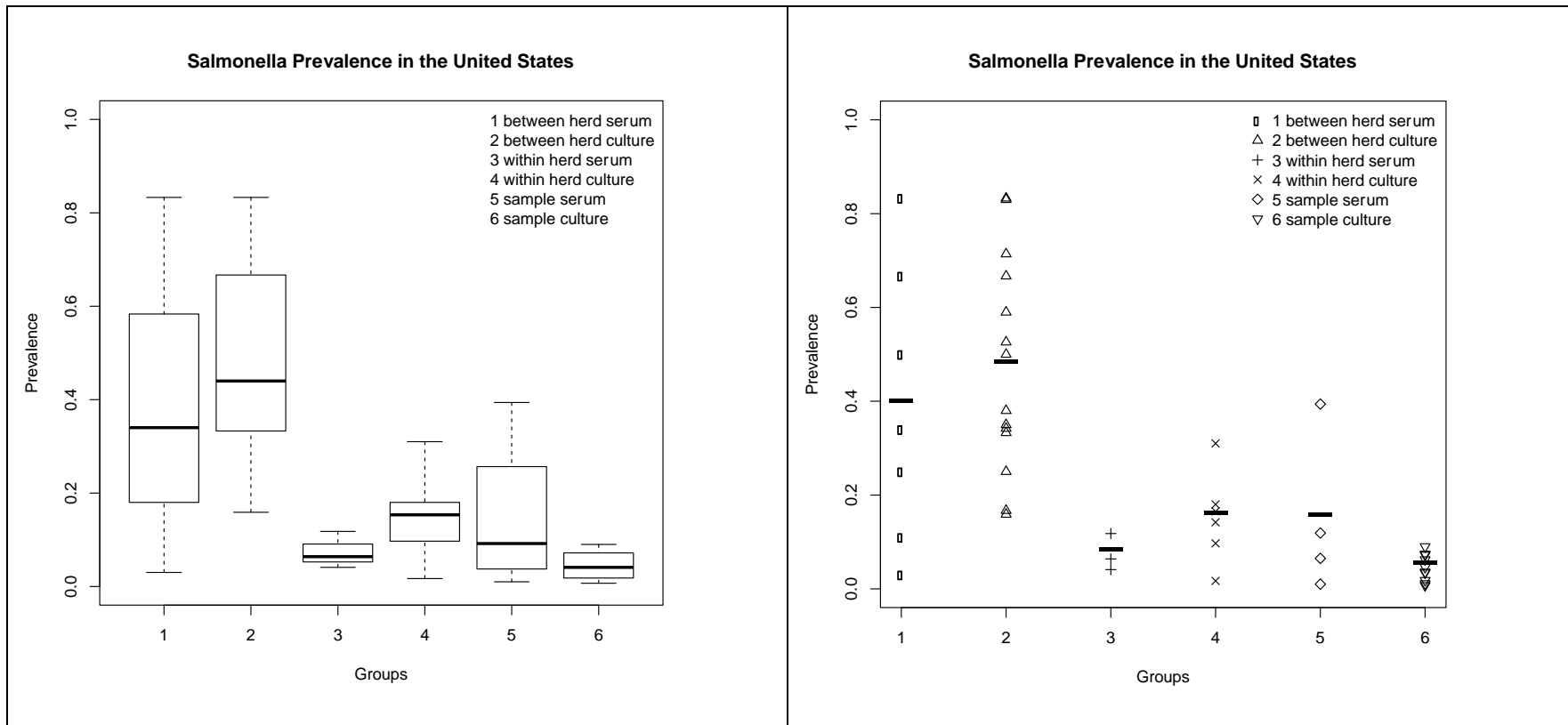


Figure 3: Frequency distribution histograms for 6 different measures of Salmonella spp. prevalence in the US.

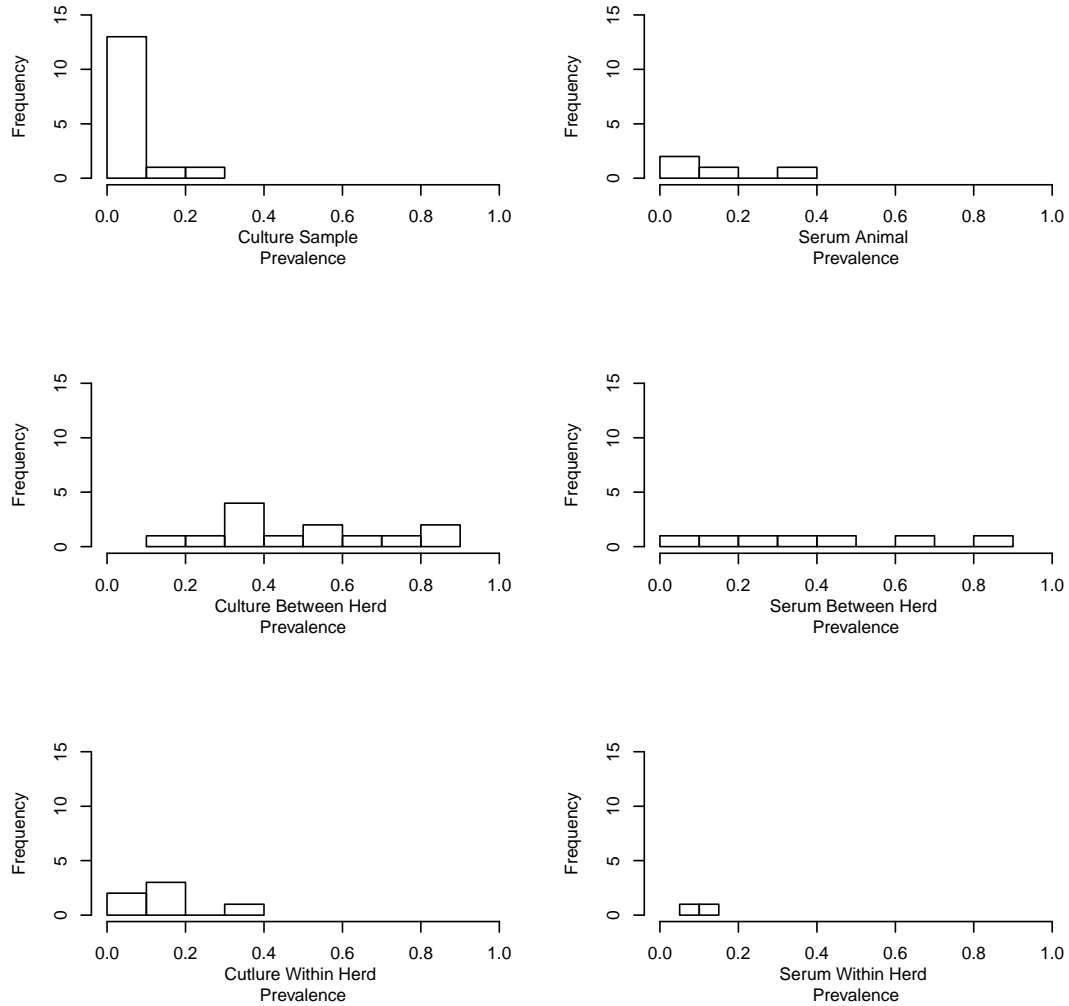


Table 1. Prevalence of Salmonella in finishing pigs reported in 15 studies in the Unites States

Reference	Sample Prevalence		Between Herd Prevalence		Within Herd Prevalence		Diagnostic Procedure
	p	Pigs tested	p	Herds tested	p	Herds tested*	
Bahnson et al., 2006 ²⁴	0.049	934	0.159	63	-	-	Individual/culture/faeces
Bahnson et al, 1997 ²⁵	0.05	1057	-	-	0.18	68	Individual/culture/faeces
Barber et al., 2002 ²⁶	0.01	720	0.25	12	-	-	Individual/culture/faeces
Bush et al., 2003 ²⁷	-	-	0.38	152	-	-	Pool/culture/faeces
	-	-	0.35	124	-	-	Pool/culture/faeces
Davies et al., 1997a ²⁸	0.135	288	-	-	-	-	Individual/culture/faeces
Davies et al, 1997b ²⁹	0.25	2288	0.83	29	0.31	24	Individual/culture/faeces
Erdman et al., 2001 ³⁰	-	-	0.59	37	-	-	Pool/culture/faeces
Funk et al., 2001 ³¹	0.09	1445	-	-	-	-	Individual/culture/faeces
Gebreyes et al., 2008 ³²	0.394	292	-	-	-	-	Individual/serum/blood
Haley et al., 2012 ³³	0.062	5470	0.342	123	0.165	42	Individual/culture/faeces
	0.072	7788	0.526	135	0.142	71	Individual/culture/faeces
Hurd et al., 2004 ³⁴	0.018	281	0.333	6	-	-	Individual/culture/caecal
	0.036	281	0.833	6	-	-	Individual/culture/lymph nodes
	0.011	280	0.667	6	-	-	Individual/culture/faeces
	0.007	281	0.167	6	-	-	Individual/culture/faeces (necropsy)
	-	-	0.833	6	-	-	Individual/serum/meat juice
	-	-	0.667	6	-	-	Individual/serum/meat juice
McKean et al., 2009 ³⁵	0.065	934	0.5	502	0.064	251	Individual/serum/meat juice
	0.119	1639	0.34	502	0.118	171	Individual/serum/meat juice
	-	-	0.11	45	-	-	Individual/serum/meat juice
	-	-	0.03	87	-	-	Individual/serum/meat juice
Molla et al., 2010 ³⁶	0.074	5231	-	-	-	-	Individual/culture/faeces
Proescholdt et al., 1999 ³⁷	0.01	389	0.25	8	0.041	2	Individual/serum/blood
	0.046	395	0.5	8	0.097	4	Individual/culture/faeces
Wang et al., 2010 ³⁸	0.034	1490	0.714	21	0.017	15	Individual/culture/faeces

*The within herd numbers were calculated according to the between herd prevalence if not stated in the study

Table 2: Grade recommendation for the use of antibiotics to control Salmonella in pork. Note the target for recommendations was individual entities not national or regional entities. It was proposed that entities with particular concerns would use the recommendations as guidance for deciding between candidate interventions.*

GRADE	Strong	Weak	No strength	Weak	Strong
Assessors view of the balance of desirable and undesirable consequences of the intervention	Desirable consequences clearly outweigh undesirable consequences	Desirable consequences probably outweigh undesirable consequences	Consequences equally balanced or uncertain	Undesirable consequences probably outweigh desirable consequences	Undesirable consequences clearly outweigh desirable consequences
Recommendation	We recommend to use antibiotics in commercial swine to reduce Salmonella on carcasses or in ground pork	We suggest to use antibiotics in commercial swine to reduce Salmonella on carcasses or in ground pork	No specific recommendation	We recommend to not use antibiotics in commercial swine to reduce Salmonella on carcasses or in ground pork	We recommend to not use antibiotics in commercial swine to reduce Salmonella on carcasses or in ground pork
	0	0	0	2	4

* *The aspect of the project is still being drafted into a final publication and some conclusions, interpretations and recommendations have not been finalized. End users should refer to the final peer-reviewed publication for final conclusion

Table 3 Grade recommendation for the use of Enterisol SC-54 vaccine to control Salmonella in pork. Note the target for recommendations was individual entities not national or regional entities. It was proposed that entities with particular concerns would use the recommendations as guidance for deciding between candidate interventions.*

GRADE	Strong	Weak	No strength	Weak	Strong
Assessors view of the balance of desirable and undesirable consequences of the intervention	Desirable consequences clearly outweigh undesirable consequences	Desirable consequences probably outweigh undesirable consequences	Consequences equally balanced or uncertain	Undesirable consequences probably outweigh desirable consequences	Undesirable consequences clearly outweigh desirable consequences
Recommendation	We recommend to use Enterisol SC-54 vaccine in commercial swine to reduce Salmonella on carcasses or in ground pork	We suggest to use of Enterisol SC-54 vaccine in commercial swine to reduce Salmonella on carcasses or in ground pork	No specific recommendation	We recommend to not use Enterisol SC-54 vaccine in commercial swine to reduce Salmonella on carcasses or in ground pork	We recommend to not use of Enterisol SC-54 vaccine in commercial swine to reduce Salmonella on carcasses or in ground pork
	0	0	0	6	0

*The aspect of the project is still being drafted into a final publication and some conclusions, interpretations and recommendations have not been finalized. End users should refer to the final peer-reviewed publication for final conclusions.

Table 4: Grade recommendation for the use of Argus SC vaccine to control Salmonella in pork. Note the target for recommendations was individual entities not national or regional entities. It was proposed that entities with particular concerns would use the recommendations as guidance for deciding between candidate interventions. *

GRADE	Strong	Weak	No strength	Weak	Strong
Assessors view of the balance of desirable and undesirable consequences of the intervention	Desirable consequences clearly outweigh undesirable consequences	Desirable consequences probably outweigh undesirable consequences	Consequences equally balanced or uncertain	Undesirable consequences probably outweigh desirable consequences	Undesirable consequences clearly outweigh desirable consequences
Recommendation	We recommend to use Argus SC vaccine in commercial swine to reduce Salmonella on carcasses or in ground pork	We suggest to use of Argus SC vaccine in commercial swine to reduce Salmonella on carcasses or in ground pork	No specific recommendation on Argus SC vaccine in commercial swine to reduce Salmonella on carcasses or in ground pork	We recommend to not use Argus SC vaccine in commercial swine to reduce Salmonella on carcasses or in ground pork	We recommend to not use of Argus SC vaccine in commercial swine to reduce Salmonella on carcasses or in ground pork
	0	0	0	6	0

*The aspect of the project is still being drafted into a final publication and some conclusions, interpretations and recommendations have not been finalized. End users should refer to the final peer-reviewed publication for final conclusions

Table 5: Recommendation for using dry feed for finisher pigs over wet feed for finisher pigs to control Salmonella on pork carcasses. Note the target for recommendations was individual entities not national or regional entities. It was proposed that entities with particular concerns would use the recommendations as guidance for deciding between candidate interventions. *

GRADE	Strong	Weak	No strength	Weak	Strong
Assessors view of the balance of desirable and undesirable consequences of the intervention	Desirable consequences clearly outweigh undesirable consequences	Desirable consequences probably outweigh undesirable consequences	Consequences equally balanced or uncertain	Undesirable consequences probably outweigh desirable consequences	Undesirable consequences clearly outweigh desirable consequences
Recommendation	We do recommend using dry feed compared to wet feed to reduce Salmonella on carcasses or in ground pork	We do recommend using dry feed compared to wet feed to reduce Salmonella on carcasses or in ground pork	No specific recommendation	We do not recommend using dry feed compared to wet feed to reduce Salmonella on carcasses or in ground pork	We do not recommend using dry feed compared to wet feed to reduce Salmonella on carcasses or in ground pork
We suggest/recommend dry feed for finisher pigs over wet feed for finisher pigs				3	2

*The aspect of the project is still being drafted into a final publication and some conclusions, interpretations and recommendations have not been finalized. End users should refer to the final peer-reviewed publication for final conclusions

Table 6: Recommendation pelleted feed for finisher pigs over non-pelleted feed for finisher pigs to control Salmonella on pork carcasses. Note the target for recommendations was individual entities not national or regional entities. It was proposed that entities with particular concerns would use the recommendations as guidance for deciding between candidate interventions. *

GRADE	Strong	Weak	No strength	Weak	Strong
Assessors view of the balance of desirable and undesirable consequences of the intervention	Desirable consequences clearly outweigh undesirable consequences	Desirable consequences probably outweigh undesirable consequences	Consequences equally balanced or uncertain	Undesirable consequences probably outweigh desirable consequences	Undesirable consequences clearly outweigh desirable consequences
Recommendation	We recommend using pelleted feed for finisher pigs over non-pelleted feed for finisher pigs to reduce Salmonella on carcasses or in ground pork	We recommend using pelleted feed for finisher pigs over non-pelleted feed for finisher pigs to reduce Salmonella on carcasses or in ground pork	No specific recommendation	We do not recommend using pelleted feed for finisher pigs over non-pelleted feed for finisher pigs to reduce Salmonella on carcasses or in ground pork	We do not recommend using pelleted feed for finisher pigs over non-pelleted feed for finisher pigs to reduce Salmonella on carcasses or in ground pork
We suggest/recommend pelleted feed for finisher pigs over non-pelleted feed for finisher pigs	0	5	0	0	0

*The aspect of the project is still being drafted into a final publication and some conclusions, interpretations and recommendations have not been finalized. End users should refer to the final peer-reviewed publication for final conclusions

Table 7: Recommendation for acidified feed for finisher pigs over non-acidified feed for finisher pigs to control Salmonella on pork carcasses. Note the target for recommendations was individual entities not national or regional entities. It was proposed that entities with particular concerns would use the recommendations as guidance for deciding between candidate interventions. *

GRADE	Strong	Weak	No strength	Weak	Strong
Assessors view of the balance of desirable and undesirable consequences of the intervention	Desirable consequences clearly outweigh undesirable consequences	Desirable consequences probably outweigh undesirable consequences	Consequences equally balanced or uncertain	Undesirable consequences probably outweigh desirable consequences	Undesirable consequences clearly outweigh desirable consequences
Recommendation	We recommend using acidified feed for finisher pigs over non-acidified feed for finisher pigs to reduce Salmonella on carcasses or in ground pork	We recommend using acidified feed for finisher pigs over non-acidified feed for finisher pigs to reduce Salmonella on carcasses or in ground pork	No specific recommendation	We do not recommend using acidified feed for finisher pigs over non-acidified feed for finisher pigs to reduce Salmonella on carcasses or in ground pork	We do not recommend using acidified feed for finisher pigs over non-acidified feed for finisher pigs to reduce Salmonella on carcasses or in ground pork
We suggest/recommend acidified feed for finisher pigs over non-acidified feed for finisher pigs	0	1	0	1	3

*This aspect of the project is still being drafted into a final publication and some conclusions, interpretations and recommendations have not been finalized.

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