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Report of the Task Force on Zoonoses Data Collection on the analysis of the baseline survey on the prevalence of *Salmonella* in slaughter pigs, in the EU, 2006-2007[1]

Part A: *Salmonella* prevalence estimates

(Question N° EFSA-Q-2006-042A)

Adopted by
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Summary

Salmonella is an important cause of food-borne illness in humans. Farm animals and foods of animal origin form an important source of human *Salmonella* infections. Therefore, in order to reduce the incidence of human salmonellosis in the European Union, Community legislation foresees the setting of *Salmonella* reduction targets for food-animal populations including slaughter pigs. To underpin such a target, a European Union-wide baseline survey was carried out to determine, at the point of slaughter, the prevalence of pigs infected with *Salmonella*. The pigs were randomly selected from those slaughterhouses that together accounted for 80% of pigs slaughtered within each Member State. This slaughterhouse survey was the fourth baseline survey to be conducted in the European Community.

The sampling of slaughter pigs took place between October 2006 and September 2007. All participating Member States and Norway sampled ileo-caecal lymph nodes from the selected slaughtered pigs. In total 19,159 slaughter pigs were sampled and 19,071 lymph node samples collected.

Twenty-four of the 25 participating Member States isolated *Salmonella* spp. from the lymph node samples, which resulted in a Community observed prevalence of *Salmonella*-positive slaughter pigs of 10.3%. This means that in the European Union at the point of slaughter one in ten slaughter pigs were estimated to be infected with *Salmonella* in the lymph nodes. The *Salmonella* prevalence in these slaughter pigs varied widely amongst the Member States, from 0.0% to 29.0%. All 24 Member States reporting *Salmonella* positive findings isolated *Salmonella* Typhimurium and 20 Member States detected *Salmonella* Derby, which are two common serovars found in *Salmonella* infection cases in humans. This resulted in an estimated Community observed prevalence of 4.7% for *S.* Typhimurium, varying from 0.0% to 16.1% within the Member States, and of 2.1% for *S.* Derby, varying from 0.0% to 6.5%.

From the pigs that had already been selected for sampling of lymph nodes, 13 Member States collected carcass swabs to determine the prevalence of external contamination with *Salmonella*. Data from this group of Member States showed that the observed prevalence of carcasses contaminated with *Salmonella* spp. was 8.3% overall, meaning that one in twelve carcasses were contaminated with *Salmonella* for this group of Member States. At the Member States' level, the prevalence of contaminated carcasses ranged from 0.0% to 20.0%.

In addition, 9 Member States additionally collected either meat juice or blood samples with the aim of investigating the prevalence of slaughter pigs with antibodies against *Salmonella*, indicating past exposure of the pig to *Salmonella*. These Member States used different laboratory antibody detection test kits and a comparison study done by the Community Reference Laboratory for *Salmonella* showed that the results of these different test methods were not comparable between the Member States. Therefore no overall prevalence of slaughter pigs with antibodies against *Salmonella* could be estimated for this group of Member States. At the Member States' level the prevalence of slaughter pigs with antibodies against *Salmonella* ranged from 3.5% to 33.3%.

The diversity of isolated *Salmonella* serovars in slaughter pig lymph nodes was big and in total 87 different serovars were isolated in the European Union. The five most frequently isolated *Salmonella* serovars from lymph nodes in the European Union were respectively in decreasing order *S.* Typhimurium, *S.* Derby, S. Rissen, *S.* 4,[5],12:i:- and *S.* Enteritidis. All these serovars, with the exception of *S*. Rissen, are frequent causes of *Salmonella* infections in humans within the European Union. *S.* Typhimurium and *S.* Derby serovars were highly predominant in lymph nodes; *S*. Typhimurium being the most common serovar, detected in 40.0% of the *Salmonella*-positive slaughter pigs and reported by all 24 *Salmonella*-positive Member States. *S*. Derby accounted also for an important proportion of positive lymph nodes (14.6%) and was reported by 20 *Salmonella*-positive Member States.

Together 30 different serovars were reported from the surface of the slaughter pig carcasses by the 13 Member States that carried out the test. The five most frequently isolated serovars from carcasses were respectively in decreasing order *S.* Typhimurium, *S.* Derby, *S.* Infantis, *S.* Bredeney and *S.* Brandenburg. The former three serovars are frequent causes of *Salmonella* infections in humans within the European Union. *S.* Typhimurium was the most common serovar isolated on the surface of the slaughter pig carcasses and detected in 49.4% of the *Salmonella* positive carcasses. The second most common serovar was *S.* Derby (24.3% of the positive carcasses). *S.* Typhimurium and *S.* Derby were also the most commonly reported ones in terms of the number of Member States, in total 10 of the 13 participating Member States.

Salmonella infection in slaughter pigs has the potential to translate into *Salmonella* contamination of pig meat and lead to human disease. Intervention to reduce the prevalence of infection in pigs may reduce the number of human salmonellosis cases. Safe handing of raw meat and thorough cooking are important measures to minimise human health risks from *Salmonella* contaminated pig meat.

The results of this baseline survey are suitable to be used for setting of targets for reduction of *Salmonella* in pigs. The Community legislation foresees setting of target for slaughter pigs regarding all *Salmonella* serovars with public health significance supported by a cost benefit analysis.

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1. Introduction

This report describes the results of a baseline survey carried out in the European Union (EU) to estimate the prevalence of *Salmonella* spp. in slaughter pigs. This survey was the fourth in a series of baseline surveys of *Salmonella* carried out within the EU. The objective of the surveys has been to obtain comparable data for all Member States (MSs) through harmonised sampling schemes. According to Regulation (EC) No 2160/2003 on the control of *Salmonella* spp. and other zoonotic agents[1], which aims to reduce the incidence of food-borne diseases in the EU, results of such a survey will inform the setting of the Community target for reduction of the prevalence of the infection in slaughter pigs.

The survey was carried out over a one year period, starting 1 October 2006 and finishing 30 September 2007. Tested slaughter pigs were selected in slaughterhouses that together accounted for 80% of pigs slaughtered within each Member State (MS), which constituted the survey target population. Twenty-five EU MSs participated in the survey. Norway participated on a voluntary basis.

The objectives, the sampling frame, the diagnostic testing methods, as well as the collection and reporting of data, and the timelines of this baseline survey were specified in the Commission Decisions 2006/668/EC and 2007/219/EC [2, 3].

[1] Regulation (EC) No 2160/2003 of the European Parliament and of the Council of 17 November 2003 on the control of *Salmonella* and other specified food-borne zoonotic agents. OJ L 325, 12.12.2003, p. 1.

[2] Commission Decision of 29 September 2006 concerning a financial contribution from the Community towards a baseline survey on the prevalence of *Salmonella* in slaughter pigs to be carried out in the Member States. OJ L 275, 6.10.2006, p. 51.

[3] Commission Decision of 30 March 2007 concerning a financial contribution from the Community towards a baseline survey on the prevalence of *Salmonella* in slaughter pigs to be carried out in Bulgaria and Romania. OJ L 95, 5.4.2007, p. 41.

2. Objectives

The aim of the survey was to estimate, at the point of slaughter, the prevalence of pigs infected with *Salmonella* in those slaughterhouses that together accounted for 80% of pigs slaughtered in the country, at the European Community level as well as for each MS.

The specific respective primary objectives were:

- to estimate the prevalence of slaughter pigs infected with *Salmonella* in the lymph nodes, at the EU level and for each MS individually, at slaughter,
- to investigate the *Salmonella* serovar distribution and determine the most frequently occurring serovars in slaughter pigs across the EU,
- to investigate the effect of potential risk factors, such as the month of sampling, and the sampling time during the day, which may be associated with the occurrence of *Salmonella*,
- to investigate the impact of test misclassification bias (false-negative and false-positive tested pigs) on the prevalence estimates.

A secondary aim of this survey was to collect additional data regarding the surface contamination of the slaughter pig carcasses with *Salmonella* and regarding the prevalence of slaughter pigs with antibodies against *Salmonella*. Respectively 13 and 9 MSs collected these data, from those pigs that had already been selected for sampling of lymph nodes.

The specific secondary objectives were:

- to estimate the prevalence of *Salmonella*–contaminated slaughter pig carcasses at the level of a group of MSs and for each MS individually,
- to estimate the prevalence of slaughter pigs with antibodies against *Salmonella* at the level of a group of MSs and for each MS individually, at slaughter,
- to analyse the concordance and discordance between the MS-specific results of slaughter pigs infected with *Salmonella* in the lymph nodes as compared to their status regarding *Salmonella* antibodies,
- to investigate the association between the three used survey tests: lymph node bacteriological test, antibody detection test (both on samples taken at the beginning of the slaughter line) and carcass swab bacteriological test (on samples taken at the end of the slaughter line), with respect to *Salmonella* spp..

MSs were also invited to submit additional information on *S.* Enteritidis and *S.* Typhimurium phage types and antimicrobial susceptibility of the *Salmonella* isolates, but this testing was not a compulsory requirement of the survey.

This part A report includes the estimation of the prevalence of *Salmonella*, the analysis of the most frequent reported serovars, the investigation of the test misclassification bias and a preliminary concordance-discordance analysis between the results of the lymph node and antibody detection tests. The analyses of potential risk factors, of the association between the three used survey tests including the concordance-discordance analysis, the comparison between the overall prevalence estimates in groups of MSs as well as more in depth analyses of serovar and phage type distribution will be provided in the part B report. The analyses of the antimicrobial susceptibility of *Salmonella* isolates will be specifically addressed in a separate report to be published by EFSA.

3. Materials and methods

A detailed description of the design of the baseline survey, the sampling design, sample size, and the bacteriological and antibody detection testing is found in Annex I of Commission Decision 2006/668/EC[1] of 29 September 2006 concerning a financial contribution from the Community towards a baseline survey on the prevalence of *Salmonella* in slaughter pigs to be carried out in the MSs.

Slaughtered pigs with a live weight between 50 kg and 170 kg and their carcasses were randomly sampled in slaughterhouses representing at least 80% of MSs' total production of slaughtered pigs. The samples to take were stratified by the slaughterhouses' capacity (throughput) in the year 2005 and by the month. The day on which the samples were taken was also randomly chosen from all days of the month of sampling as was the slaughtered pig or its carcass from all scheduled pigs to slaughter on the selected slaughter day. A detailed description of the 2005 pig population and production in the EU is given in Annex II.

From a selected slaughter pig at least 5 ileo-caecal lymph nodes weighing at least 15 grams were collected on a mandatory basis. This sampling was used to estimate the prevalence of slaughter pigs infected with *Salmonella* in the lymph nodes. The number of pigs to sample was 384 minimum and 2,400 maximum and was calculated for each MS based on a priori criteria, which can be found in the above mentioned Commission Decision.

In addition, in order to assess the contamination of slaughter pig carcasses, 13 MSs (Austria, Belgium, Cyprus, Czech Republic, Denmark, France, Ireland, Latvia, Lithuania, Poland, Slovenia, Sweden and The United Kingdom) voluntarily sampled each at least 384 carcasses belonging to the slaughtered pigs of which lymph nodes were taken. This additional sampling was done by swabbing the surface of the carcass in a standardized way, after evisceration and before chilling.

Moreover, 9 MSs (Cyprus, Denmark, France, Ireland, Lithuania, Slovenia, Sweden, The Netherlands and The United Kingdom) voluntarily collected a muscle sample (to extract meat juice) or a blood sample from all pigs selected for lymph node sampling for antibody detection examination. These samples are referred to as serological samples in the report. Germany also carried out antibody detection tests, but the submitted data had to be rejected due to important mistakes in the dataset.

The three types of samples were collected by eight MSs; Cyprus, Denmark, France, Ireland, Lithuania, Slovenia, Sweden and The United Kingdom.

Samples were taken by the competent authority in each MS or under its supervision. Bacteriological samples were tested by the National Reference Laboratory (NRL) (or an authorised laboratory) using the ISO 6579 Annex D method. All *Salmonella* isolates were serotyped according to the Kaufmann-White scheme. For quality assurance of the serotyping, a selection of typable and non-typable isolates from each MS was sent to Community Reference

[1] OJ L 275, 6.10.2006, p. 51 - notified under document number C(2006) 4306.

Laboratory (CRL) for *Salmonella* for duplicated analysis. Phage typing and anti-microbial susceptibility testing of isolates were both optional.

As no standard method existed for the antibody detection test, the NRLs-*Salmonella* (or an authorised laboratory) used the test and the cut-off value of their choice.

3.1. Data description

3.1.1. Data validation and cleaning

The EFSA received the final dataset of the survey from the European Commission (COM) on 4 February 2008. This dataset contained data from 19,300 slaughter pigs in 25 MSs and in Norway. No data was submitted by Malta and Romania.

A set of data exclusion criteria (Annex III) was used by EFSA to identify non-valid and non-plausible information in the dataset received. Only those slaughter pigs were excluded from which all the sample types (lymph nodes, serological sample, or carcass swab) had this non-valid information. This resulted in a cleaned, validated dataset comprising 19,159 slaughter pigs from 25 MSs and Norway (final dataset), which formed the basis for all subsequent analyses. An overview of the number of excluded slaughter pigs per MS is given in Table 1. Altogether, 0.7% of the pigs (141 out of 19,300) were excluded from the full dataset. The reasons for exclusion of slaughter pigs in accordance with the exclusion criteria are summarized in Annex IV. The criterion that caused the highest number of pigs to be excluded was a total weight of the lymph nodes below 15 grams. The second most common cause of excluding pigs was samples containing less than 5 lymph nodes.

3.2. Statistical analysis

3.2.1. Descriptive analysis

A comparison between the survey protocol and the collected sample in terms of sample size, stratification by month, by slaughterhouse, time of sampling during the working day, and in terms of other important variables was done using frequency tables and graphs.

3.2.2. Estimates of prevalence of infection and of contamination

Data on lymph nodes and carcass swabs were separately analysed and the following four outcomes were considered for the lymph nodes and carcass swab samples:

- Positivity for *Salmonella* spp.,
- Positivity for *S*. Typhimurium,
- Positivity for *S*. Derby,
- Positivity for serovars other than *S*. Typhimurium and *S*. Derby.

The prevalence of infection and of contamination with *S*. Typhimurium and *S*. Derby were estimated separately as these two serovars were predominant (see section 4.6. of the report). For

each outcome the prevalence with 95% confidence intervals (CI) was estimated. No 95% CI was estimated for countries that reported not to have isolated *Salmonella*. Only the observed prevalence was investigated and no correction was made for imperfect test sensitivity or specificity.

Prevalence was estimated for each MS, at the EU-level and at the level of groups of MSs, by Generalized Estimating Equations (GEE) taking into account that outcomes (presence or absence of infection/contamination) in pigs/carcasses from the same slaughterhouse are expected to be more alike than in pigs/carcasses from different slaughterhouse (aspect of clustering) (PROC GENMOD, SAS, 1999). Standardised weights (WY) were used in the GEE models to account for a disproportionate stratified sampling design (aspect of weighting). In fact, MSs and slaughterhouses were considered as strata, and the proportion of sampled slaughterhouses was not constant across MSs. Similarly, the proportion of sampled pigs was not constant across slaughterhouses. The reciprocal of the sampling proportion for throughput (eighty percent of the total number of pigs slaughtered in a MS divided by the sum of the annual numbers of pigs slaughtered in the sampled slaughterhouses in the same MS) was used as the MS-level weight (WY1), whereas the reciprocal of the sampling proportion for pigs (the total number of pigs slaughtered in a slaughterhouse during a year divided by the number of sampled pigs in the same slaughterhouse) was used as the slaughterhouse-level weight (WY2). Only WY2 was used to estimate individual MSs' prevalence, whereas the product between WY1 and WY2 was used to estimate the EU- and MS-group-level prevalence. More details on statistical models and weighting are given in Annex I.

The prevalence of slaughter pigs with antibodies against *Salmonella* was only estimated for each MS separately, not at the level of the group of MSs. The reason was that the results of the different antibody detection tests were not comparable between the MSs, as reported by a comparison study done by the Community Reference Laboratory of *Salmonella*[1]. The NRLs used different serological test kits (ELISAs) and different cut-off values for the same kit. The results of the serological analysis could have been reported as negative, positive or inconclusive. Weighted MS-specific seroprevalence was estimated in a similar way as for the bacteriological prevalence estimations. Different prevalence estimates were done classifying the inconclusive results firstly as positive, secondly as negative and thirdly as missing.

In this report,

- the observed prevalence means the prevalence estimate that accounts for the aspects of clustering and of weighting but not for imperfect test sensitivity or specificity,
- the unweighted prevalence means the prevalence estimate that accounts for the aspects of clustering only, and
- the raw proportion (%) of positive slaughter pigs means the number of positive pigs out of the sampled pigs and does not account for any design aspect.

[1] P.A. Berk, H.M.J.F. van der Heijden and K.A. Mooijman. 2008. Comparability of different ELISA's on the detection of *Salmonella* spp. antibodies in meat juice and serum. RIVM report 330604007, Bilthoven, the Netherlands. *To be published on; www.rivm.nl/crlsalmonella.*

3.2.3. Investigation of the impact of test misclassification bias

Diagnostic tests are not completely accurate and due to a lower than 100% sensitivity and specificity test characteristics they misclassify some subjects respectively as false negative or false positive. To initially investigate the impact of this test misclassification bias on the observed prevalence estimates at the EU-level and the MS-group level, a range of plausible sensitivity and specificity values of the three used survey test were considered. Next correcting the bias according to the Rogan-Gladen (Rogan and Gladen, 1978[1]) estimator (π) estimated the true prevalence.

$$\pi = (\hat{y} + \mathrm{Sp} - 1)/(\mathrm{Se} + \mathrm{Sp} - 1)$$

Where:

π is the true prevalence,
$\hat{y}$ stands for the observed prevalence,
Se is the diagnostic sensitivity,
Sp is the diagnostic specificity.

3.2.4. Concordance-discordance between the MS-specific results of the lymph nodes bacteriological test and of the antibody detection test

Agreement at the carcass level between lymph nodes and antibody test results was investigated by Cohen's kappa coefficient (κ)[2]. The κ was calculated focusing only on the positive and negative results for the serological samples, ignoring the inconclusive outcomes. The κ equals zero when there is no agreement. The stronger the positive agreement, the higher is the value of the κ. The κ reaches its maximum possible value of 1 in case of perfect positive agreement[3]. Care must be taken when using κ, as it is dependant both on true prevalence and sensitivity and specificity of the applied tests[4].

[1] Rogan, W. J. and Gladen, B. (1978) Estimating prevalence from the results of a screening test. *American Journal of Epidemiology* 107, 71-76.
[2] Cohen, J. (1960). A Coefficient of Agreement for Nominal Scales. *Educ. Psychol. Meas.* 20, 37-46.
[3] Agresti, A. (2002). *Categorical Data Analysis*. Hoboken, New Jersey: Wiley.
[4] Thompson, W.D. and Walter S.D. (1988). A reappraisal of the kappa coefficient. *J. Clin. Epid.* 41, 949-958.

Table 1. Overview of the data validation[1] at pig-level, *Salmonella* in slaughter pig baseline survey in the EU, 2006-2007

	Full dataset received from the EC			EFSA final validated dataset			Exclusion by EFSA		
	Number of slaughter pigs	Number of lymph nodes	Number of carcass swabs	Number of slaughter pigs	Number of lymph nodes	Number of carcass swabs	Number of slaughter pigs	Number of lymph nodes	Number of carcass swabs
Austria	617	617	617	617	617	617			
Belgium	647	633	381	634	601	381	13	32	
Bulgaria	176	177		176	176			1	
Cyprus	359	359	359	359	359	359			
Czech Republic	659	654	417	659	654	417			
Denmark	998	998	344	998	998	344			
Estonia	420	420		420	420				
Finland	419	419		419	419				
France	1,165	1,164	413	1,164	1,163	413	1	1	
Germany	2,568	2,568		2,568	2,567			1	
Greece	427	427		345	345		82	82	
Hungary	662	662		658	658		4	4	
Ireland	422	422	422	422	422	422			
Italy	709	709		709	709				
Latvia	392	392	391	392	392	391			
Lithuania	465	462	462	462	461	461	3	1	1
Luxembourg	343	343		313	313		30	30	
Poland	1,183	1,177	449	1,177	1,176	447	6	1	2
Portugal	660	660		658	658		2	2	
Slovakia	385	385		385	385				
Slovenia	443	443	441	443	431	441		12	
Spain	2,619	2,619		2,619	2,619				
Sweden	402	394	402	402	394	402			
The Netherlands	1,111	1,111		1,111	1,087			24	
The United Kingdom	641	639	641	641	639	641			
EU	18,892	18,854	5,739	18,751	18,663	5,736	141	191	3
Norway	408	408		408	408				

[1] Of the 5,972 meat juice and sera samples submitted by 9 MSs, none was excluded. More information is provided in Annex V.

4. Results

4.1. Features of the Community slaughter pig population and production

An overview of the pig population and production in the EU is presented in Annex II. The EU live pig population totalled 160 million heads in 2005. The largest population was in Germany, 17% of the EU live pig population. Seven MSs (Germany, Spain, Poland, France, Denmark, The Netherlands and Italy) accounted for 74% of the total EU population. Conversely, several MSs had very small live pig populations. The EU slaughtered pig population totalled 240 million heads in 2005. The largest population was in Germany, 20% of the EU slaughtered pig population. Eight MSs, being the seven aforementioned ones plus Belgium, accounted for 81% of the total EU slaughtered pig population. Conversely, several MSs had very small slaughtered pig populations.

4.2. Sample summary statistics and protocol-sample comparison

The cleaned validated dataset comprised data on 19,159 slaughter pigs. On the sample-level the dataset contained 18,663 samples of lymph nodes, 5,736 carcass swabs and 5,972 serological samples originating from 25, 13 and 9 MSs, respectively. The dataset also included data on 408 lymph node samples from Norway. The numbers of sampled slaughter pigs and of lymph node samples does not match at the EU level and for certain MSs, because of exclusion of some invalid lymph node test results. A total of 934 slaughterhouses in the EU and nine in Norway were sampled, varying from three in Cyprus and Luxembourg to up to 400 in Poland. The detailed numbers of samples collected and slaughterhouses involved are presented in Annex V.

The results of the descriptive analysis are presented in Annex VI. A summary of these results is presented thereafter.

The distribution of the number of sampled slaughterhouses by the number of lymph node samples, at the MS- and the EU-level, shows that, for a majority of the slaughterhouses (90%), less than 50 lymph node samples were collected during the survey.

The distribution of the number of samples by the month of sampling was represented for lymph nodes, for carcass swabs as well as for the meat juices and sera. The sampling appears to be evenly distributed over the year by most participating countries. Bulgaria, Latvia, Lithuania and Portugal started the sampling a few months later than the other countries. Hungary has obtained almost 40% of its samples during the last two months of the survey.

The distributions of the number of lymph node samples, carcass swabs, and meat juices and sera by the time of sampling during the working day show that the majority of the samples was taken between 5 a.m. and 6 p.m.

The distribution of the weights of the sampled carcasses shows that the sampled carcasses weighed between 40 and 136 kg. The average EU carcass weight in this survey was 87 kg.

In addition, in Annex VI, also the number and the raw proportions (%) of positive samples, meaning the number of positive samples out of the total number of samples, for each of the outcomes in lymph nodes and carcass swabs are displayed, as well as the number and the raw proportions (%) of slaughter pigs with antibodies against *Salmonella*.

4.3. Observed prevalence of *Salmonella*

A total of 0.7% of the sampled pigs was excluded from the final dataset in the data validation process. No pigs were excluded from 17 MSs and Norway, whereas five MSs lost less than 1% of the sample pigs in the validation, and three MSs more than 1%; Greece, Luxembourg and Belgium, respectively 19.2%, 8.7% and 2.0%.

In this report the observed prevalence means the prevalence estimate that accounts for the aspects of clustering and of weighting but not for imperfect test sensitivity or specificity, whereas the unweighted prevalence means the prevalence estimate that accounts for the aspects of clustering only.

4.3.1. Observed prevalence of slaughter pigs infected with *Salmonella* in lymph nodes

The observed *Salmonella* prevalences in lymph nodes of slaughter pigs in each MS and at EU level as well as in Norway are presented Table 2. The unweighted prevalence estimates are reported in Annex VII.

Observed prevalence of slaughter pigs infected with *Salmonella* spp. in lymph nodes

Salmonella spp. was found in 24 out of the 25 MSs providing data on lymph node samples of slaughter pigs (Figure 1). No lymph node tested positive in Finland, whereas one pig tested positive in Norway. The observed EU-level prevalence was 10.3% (95% CI: 9.2; 11.5). The unweighted prevalence (10.8%) was included in the CI 95%. At the MS-level, the observed prevalence was highest in Spain (29.0%).

Observed prevalence of slaughter pigs infected with *S.* Typhimurium in lymph nodes

S. Typhimurium was isolated in all the 24 MSs reporting positive results for *Salmonella* in lymph nodes. One pig tested positive in Norway. The observed EU-level prevalence was 4.7% (95% CI: 4.1; 5.3). The unweighted prevalence (4.2%) was included in the CI 95% CI. At the MS-level, the observed prevalence was highest in Luxembourg (16.1%) (Figure 2).

Observed prevalence of slaughter pigs infected with *S.* Derby in lymph nodes

S. Derby was isolated in 20 MSs. No lymph node tested positive for *S.* Derby in Cyprus, Estonia, Finland, Lithuania, Sweden and in Norway. The observed EU-level prevalence was 2.1% (95% CI: 1.8; 2.6). The unweighted prevalence (1.8%) was included in the CI 95% CI. At the MS-level, the observed prevalence was highest in France (6.5%) (Figure 3).

Observed prevalence of slaughter pigs infected with serovars other than *S.* Typhimurium or *S.* Derby in lymph nodes

Serovars of *Salmonella* other than *S.* Typhimurium and *S.* Derby were found in lymph nodes of slaughter pigs from 24 MSs (Figure 4). The observed EU-level prevalence was 5.0% (95% CI: 4.4; 5.7). The unweighted prevalence (5.6%) was included in the CI 95%. At the MS-level, the observed prevalence was highest in Greece (17.2%) (Figure 4).

Table 2. Observed prevalence of slaughter pigs infected with *Salmonella* in lymph nodes, in the EU and Norway, 2006-2007

		Salmonella spp.		*S.* Typhimurium		*S.* Derby		Serovars other than *S.* Typhimurium and *S.* Derby	
Member State	**N**	**% prev.**	**CI**	**% prev.**	**CI**	**% prev.**	**CI**	**% prev.**	**IC**
Austria	617	2.0	1.1 - 3.6	0.7	0.2 - 2	0.3	0.1 - 1.1	1.1	0.5 – 2.3
Belgium	601	13.9	9.8 - 19.3	7.8	5.3 - 11.5	1.3	0.4 - 3.6	4.9	3.0 – 7.9
Bulgaria	176	16.7	8.1 - 31.4	1.8	0.6 - 4.9	4.9	1.3 - 16.4	10.1	4.9 – 19.7
Cyprus	359	12.4	10.1 - 15.2	1.0	0.8 - 1.3	0		11.5	9.1 – 14.5
Czech Republic	654	5.8	3.8 - 8.9	1.6	0.8 - 3.3	1.4	0.5 - 4.1	2.7	1.6 – 4.5
Denmark	998	7.7	5.5 - 10.7	4.5	3.4 - 5.9	1.3	0.8 - 2.2	2.0	1.4 – 3.0
Estonia	420	4.7	2.3 - 9.4	1.1	0.6 - 2.1	0		3.8	1.7 – 8.3
Finland	419	0		0		0		0	
France	1,163	18.1	16 - 20.5	7.1	5.4 - 9.5	6.5	5.6 - 7.4	4.5	3.2 – 6.3
Germany	2,567	10.9	8.8 - 13.5	6.1	4.7 - 7.8	1.2	0.8 - 1.8	4.3	3.4 – 5.5
Greece	345	24.8	18 - 33.2	3.4	1.6 - 7.1	3.8	1.6 - 8.8	17.2	11.7 – 24.6
Hungary	658	9.3	5.3 - 15.8	2.9	1.4 - 5.9	1.5	0.4 - 5.2	4.7	2.9 – 7.6
Ireland	422	16.1	15.6 - 16.7	9.1	9 - 9.2	2.4	2.3 - 2.5	3.6	2.0 – 6.4
Italy	709	16.5	14.1 - 19.1	1.6	0.9 - 2.6	5.4	3.8 - 7.7	9.6	7.7 – 12.1
Latvia	392	5.6	3.3 - 9.1	0.3	0.1 - 2	1.9	0.6 - 6	3.4	1.7 – 6.6
Lithuania	461	1.8	0.8 - 3.9	1.3	0.5 - 3.8	0		0.5	0.2 – 1.5
Luxembourg	313	22.4	12.7 - 36.4	16.1	8.8 - 27.6	1.5	0.7 - 2.8	4.0	1.6 – 9.6
Poland	1,176	5.1	3.7 - 6.9	1.4	0.8 - 2.5	0.1	0 - 0.2	3.5	2.5 – 4.9
Portugal	658	23.4	19.4 - 28	8.4	6.1 - 11.5	2.5	1.3 - 4.7	12.1	10.3 – 14.2
Slovakia	385	4.8	2.6 - 8.9	0.8	0.3 - 2.1	1.1	0.4 - 2.7	3.6	1.8 – 6.8
Slovenia	431	6.2	4.2 - 9.1	0.7	0.2 - 2	0.6	0.1 - 2.6	5.1	3.4 – 7.5
Spain	2,619	29.0	24.9 - 33.5	10.6	8.6 - 13.1	2.8	1.8 - 4.3	16.1	13.5 – 19.1
Sweden	394	1.3	1.2 - 1.5	1.2	0.5 - 2.7	0		0.5	0.3 – 0.5
The Netherlands	1,087	8.5	7.3 - 9.8	4.9	4.7 - 5	1.3	0.8 - 2.1	2.1	1.4 – 3.2
The United Kingdom	639	21.2	17.8 - 25	13.8	11.9 - 15.8	4.8	3.6 - 6.3	3.8	2.5 – 5.5
EU	18,663	10.3	9.2 - 11.5	4.7	4.1 - 5.3	2.1	1.8 - 2.6	5.0	4.4 – 5.7
Norway	408	0.3	0.04 – 1.6	0.3	0.04 – 1.6	0		0	

The observed prevalence accounts for the aspects of clustering and of weighting. N = number of tested carcasses (surface swabbing); % prev. = observed prevalence estimate; CI = 95% confidence interval

The '*S.* Typhimurium', '*S.* Derby' and '*Salmonella* serovars other than *S.* Typhimurium and *S.* Derby' prevalence estimates do not add up to the '*Salmonella* spp.' prevalence estimates due to some rounding errors in the estimation process.

Figure 1. Observed prevalence of slaughter pigs infected with *Salmonella* spp. in lymph nodes, with 95% confidence intervals, in the EU and Norway, 2006-2007

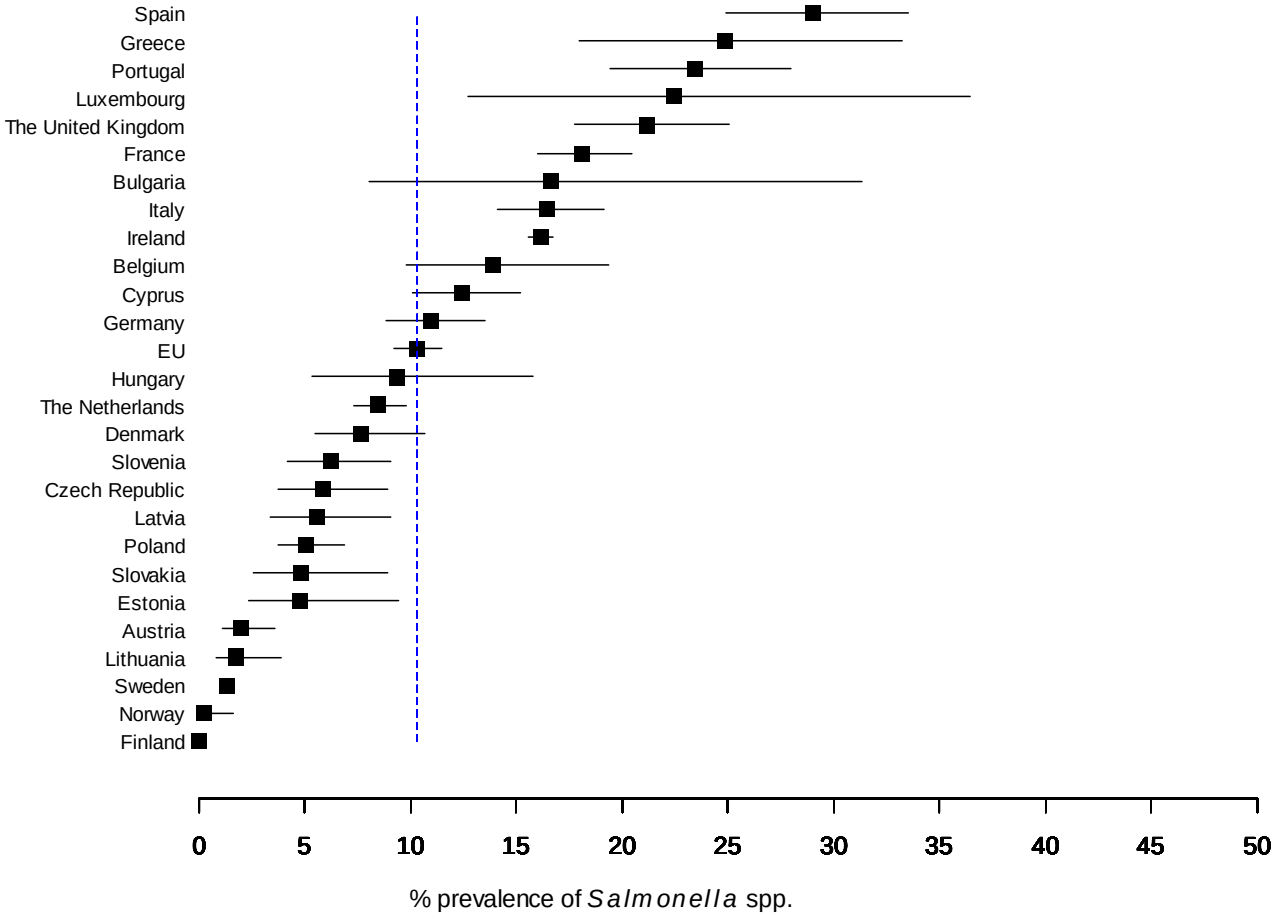


Figure 2. Observed prevalence of slaughter pigs infected with *S.* Typhimurium in lymph nodes, with 95% confidence intervals, in the EU and Norway, 2006-2007

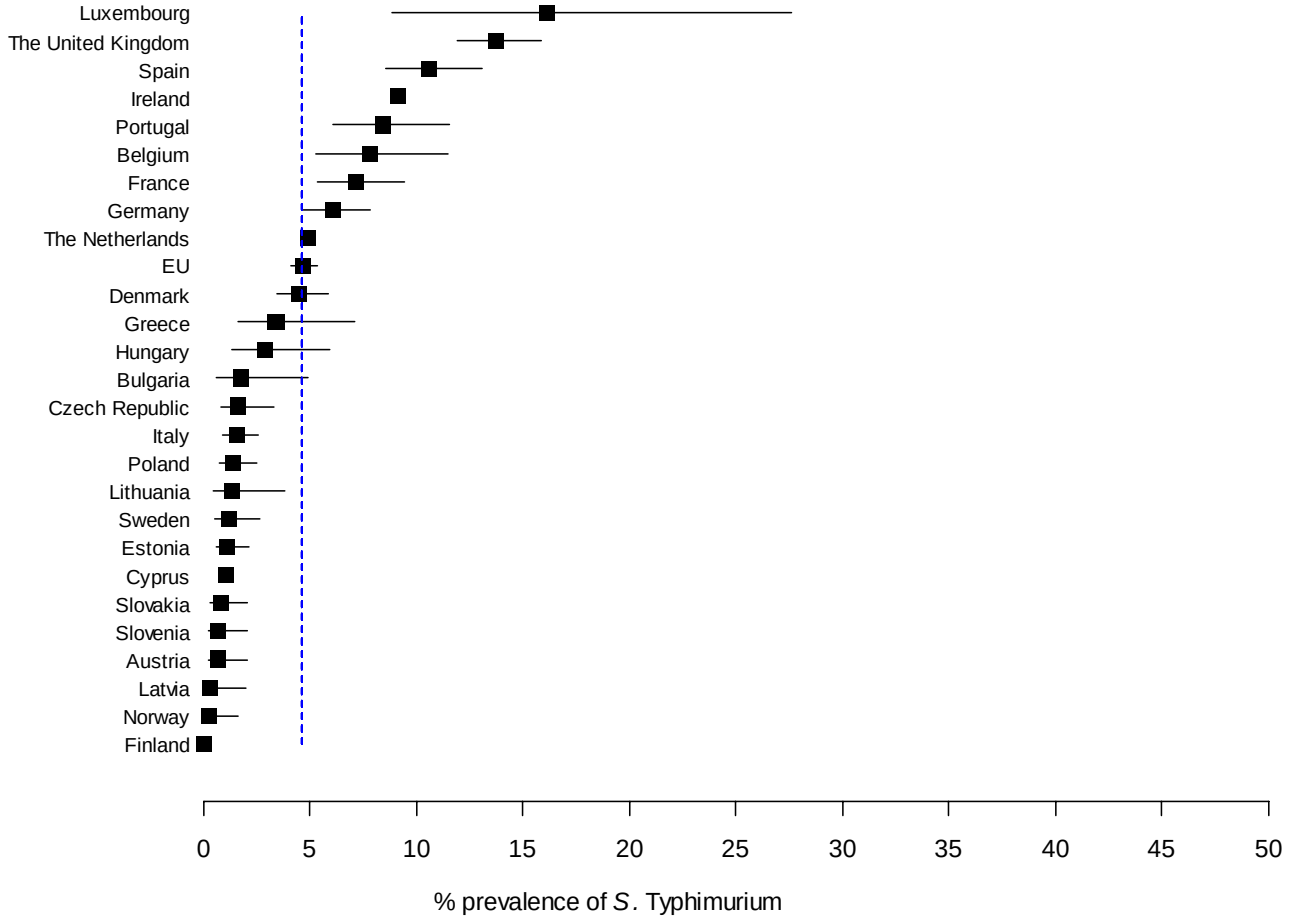


Figure 3. Observed prevalence of slaughter pigs infected with *S.* Derby in lymph nodes, with 95% confidence intervals, in the EU and Norway, 2006-2007

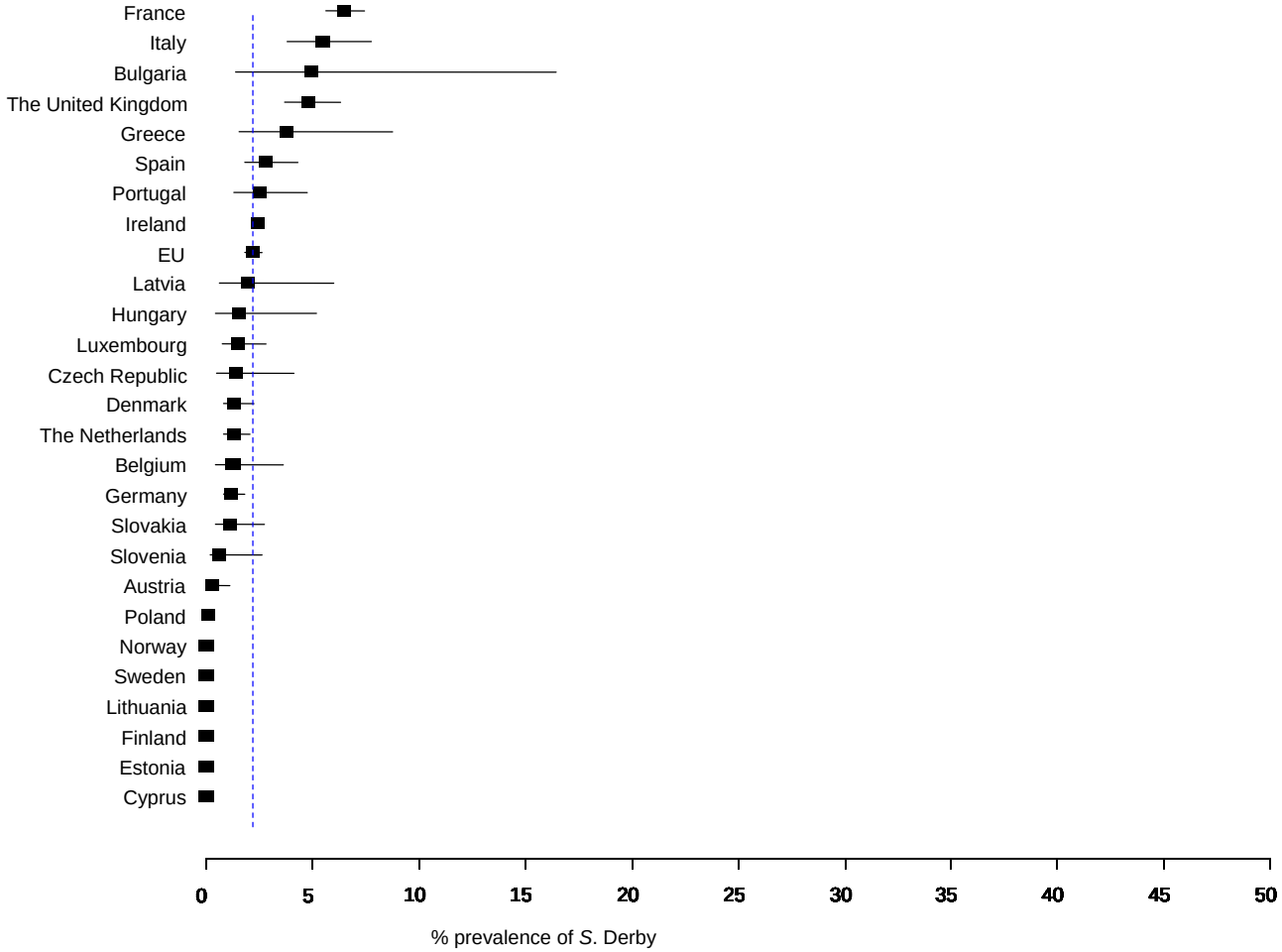
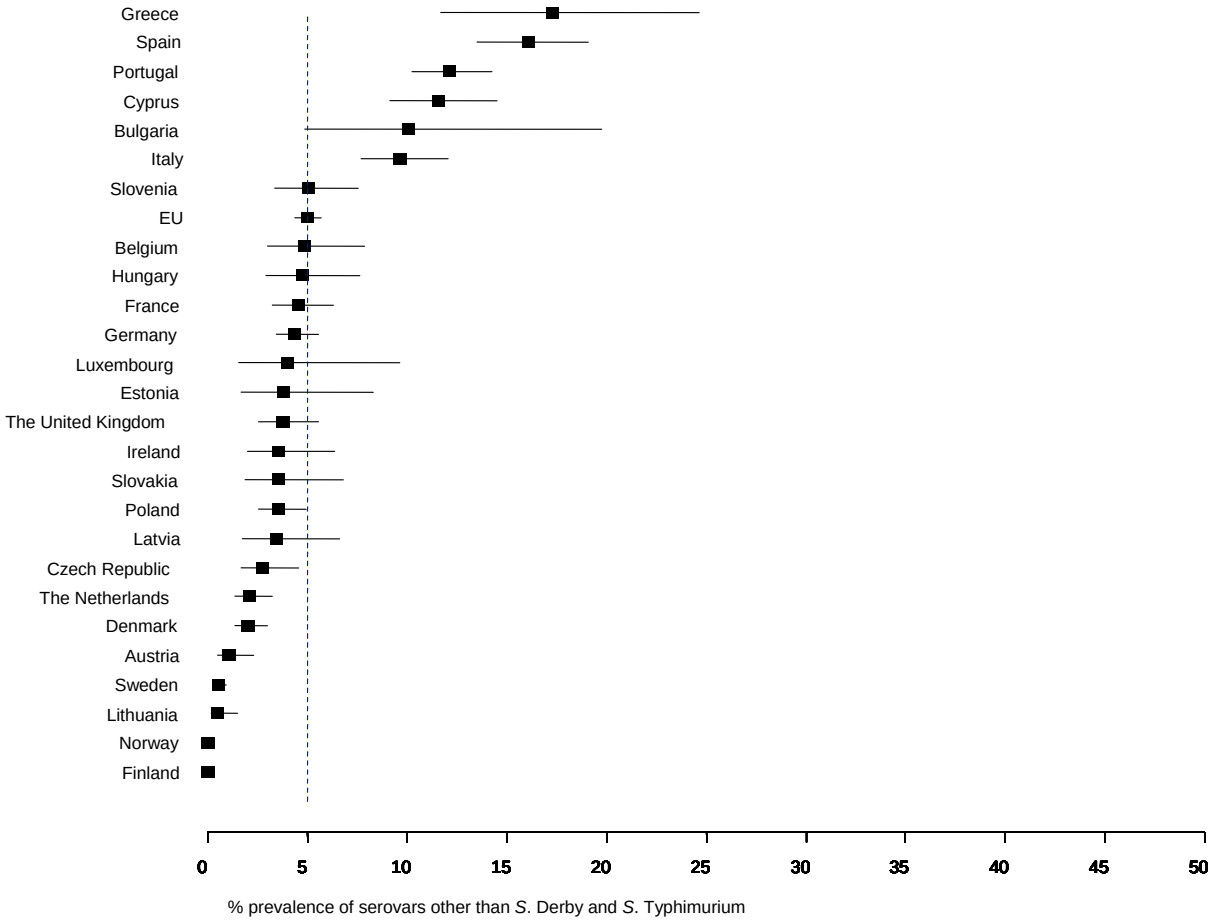


Figure 4. Observed prevalence of slaughter pigs infected with serovars other than *S.* Typhimurium or *S.* Derby in lymph nodes, with 95% confidence intervals, in the EU and Norway, 2006-2007



4.3.2. Observed prevalence of carcasses contaminated with *Salmonella*

The observed *Salmonella* prevalence in carcass swabs of slaughter pigs in each of the 13 reporting MS and at 13 MS-group level are presented Table 3.

Observed prevalence of carcasses contaminated with *Salmonella* spp.

Salmonella spp. was found in 11 out of the 13 MSs providing data on surface swabs-sampling of carcasses (Figure 5). No carcass swabs tested positive in Slovenia and Sweden. The observed 13 MS-group level prevalence was 8.3% (95% CI: 6.3; 11.0). At the MS-level, the observed prevalence was highest in Ireland (20.0%).
For this 13 MS-group the observed prevalence of slaughter pigs infected with *Salmonella* spp. in lymph nodes was estimated as 9.6% (95% CI: 8.2%; 11.1%).

Observed prevalence of carcasses contaminated with *S.* Typhimurium

S. Typhimurium was isolated in 10 MSs reporting positive results for *Salmonella* in carcass swabs. No carcass swabs tested positive in Latvia, Slovenia and Sweden. The observed 13 group-level prevalence was 3.9% (95% CI: 2.8; 5.5). At the MS-level, the observed prevalence was highest in Ireland (11.7%) (Figure 6).

Observed prevalence of carcasses contaminated with *S.* Derby

S. Derby was isolated in 10 MSs. No carcass swabs tested positive in Cyprus, Slovenia and Sweden. The observed 13 MSs group-level prevalence was 2.6% (95% CI: 1.7; 3.9). At the MS-level, the observed prevalence was highest in France (5.9%) (Figure 7).

Observed prevalence of carcasses contaminated with serovars other than *S.* Typhimurium or *S.* Derby

Serovars of *Salmonella* other than *S.* Typhimurium and *S.* Derby were found on carcass swabs from 11 MSs. No carcass swabs tested positive in Slovenia and Sweden. The observed 13 group-level prevalence was 2.3% (95% CI: 1.6; 2.5). At the MS-level, the observed prevalence was highest in France (4.8%) (Figure 8).

Table 3. Observed prevalence of carcasses contaminated with *Salmonella*, with 95% confidence intervals, in 13 MSs, 2006-2007

		Salmonella spp.		*S.* Typhimurium		*S.* Derby		Serovars other than *S.* Typhimurium and *S.* Derby	
Member State	**N**	**% prev.**	**CI**	**% prev.**	**CI**	**% prev.**	**CI**	**% prev.**	**CI**
Austria	617	1.2	0.4 - 3.7	0.4	0.1 - 1.4	0.7	0.1 - 4.6	0.2	0.0 – 1.4
Belgium	381	18.8	14.1 - 24.6	10.9	6.9 - 16.8	3.8	2.1 - 6.7	3.1	1.9 – 4.9
Cyprus	359	3.3	3.2 - 3.4	0.5	0.5 - 0.5	0		2.8	2.6 – 3.0
Czech Republic	417	3.7	2.2 - 6.3	1.3	0.5 - 3.5	0.9	0.3 - 2.6	1.3	0.5 – 3.2
Denmark	344	3.3	1.3 - 8.5	1.6	0.6 - 4.2	0.5	0.2 - 1.5	1.3	0.4 – 4.8
France	413	17.6	11.8 - 25.4	7.0	3.9 - 12.1	5.9	3.3 - 10.5	4.8	2.6 – 8.7
Ireland	422	20.0	10.8 - 34	11.7	6.4 - 20.5	3.5	1.4 - 8.8	4.6	2.4 – 8.7
Latvia	391	3.3	1.2 - 8.9	0		0.5	0.1 - 3.2	2.9	0.9 – 9.1
Lithuania	461	1.6	0.6 - 4	0.6	0.2 - 2.3	0.5	0.1 - 1.4	0.7	0.3 – 1.6
Poland	447	1.3	0.5 - 3.2	0.5	0.1 - 1.7	0.6	0.2 - 2.5	0.1	0.0 – 0.8
Slovenia	441	0		0		0		0	
Sweden	402	0		0		0		0	
The United Kingdom	641	13.5	9.9 - 18.1	7.2	5.3 - 9.7	3.1	1.8 - 5.2	3.8	2.2 – 6.6
13 MS-group	5,736	8.3	6.3 – 11.0	3.9	2.8 - 5.5	2.6	1.7 - 3.9	2.3	1.6 – 3.5

The observed prevalence accounts for the aspects of clustering and of weighting.

N = number of tested carcasses (surface swabbing); % prev. = observed prevalence estimate; CI = 95% confidence interval

The '*S.* Typhimurium', '*S.* Derby' and '*Salmonella* serovars other than *S.* Typhimurium and *S.* Derby' prevalence estimates do not add up to the '*Salmonella* spp.' prevalence estimates due to some rounding errors in the estimation process.

Figure 5. Observed prevalence of carcasses contaminated with *Salmonella* spp., with 95% confidence intervals, in 13 MSs, 2006-2007

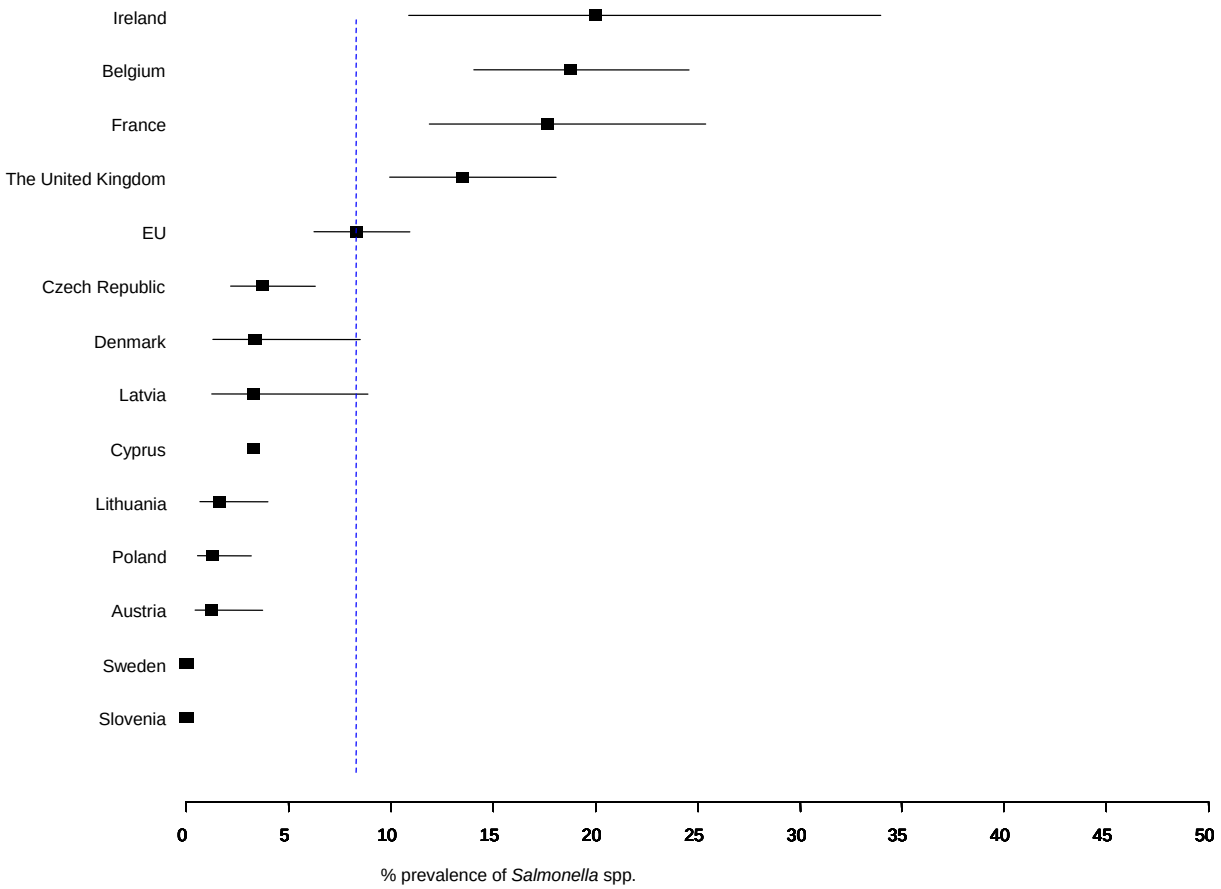


Figure 6. Observed prevalence of carcasses contaminated with *S.* Typhimurium, with 95% confidence intervals, in 13 MSs, 2006-2007

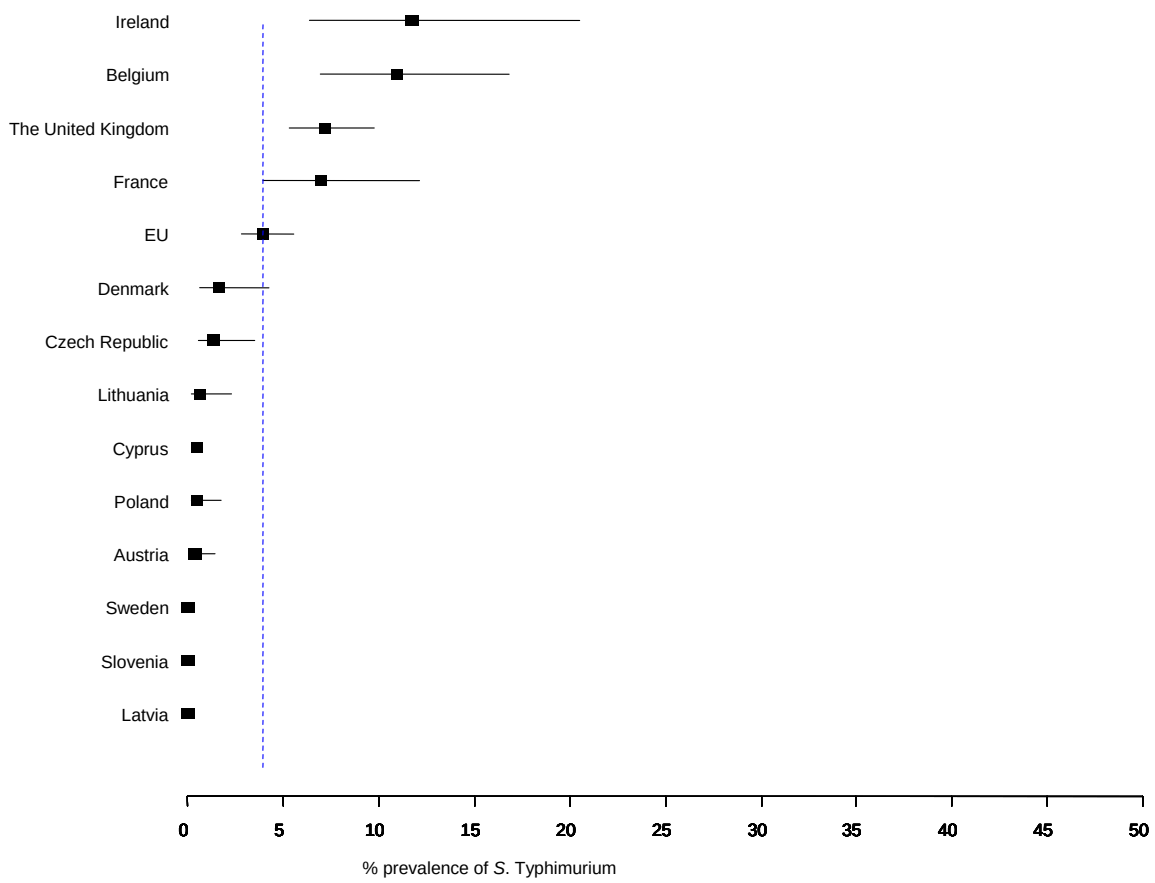


Figure 7. Observed prevalence of carcasses contaminated with *S.* Derby, with 95% confidence intervals, in 13 MSs, 2006-2007

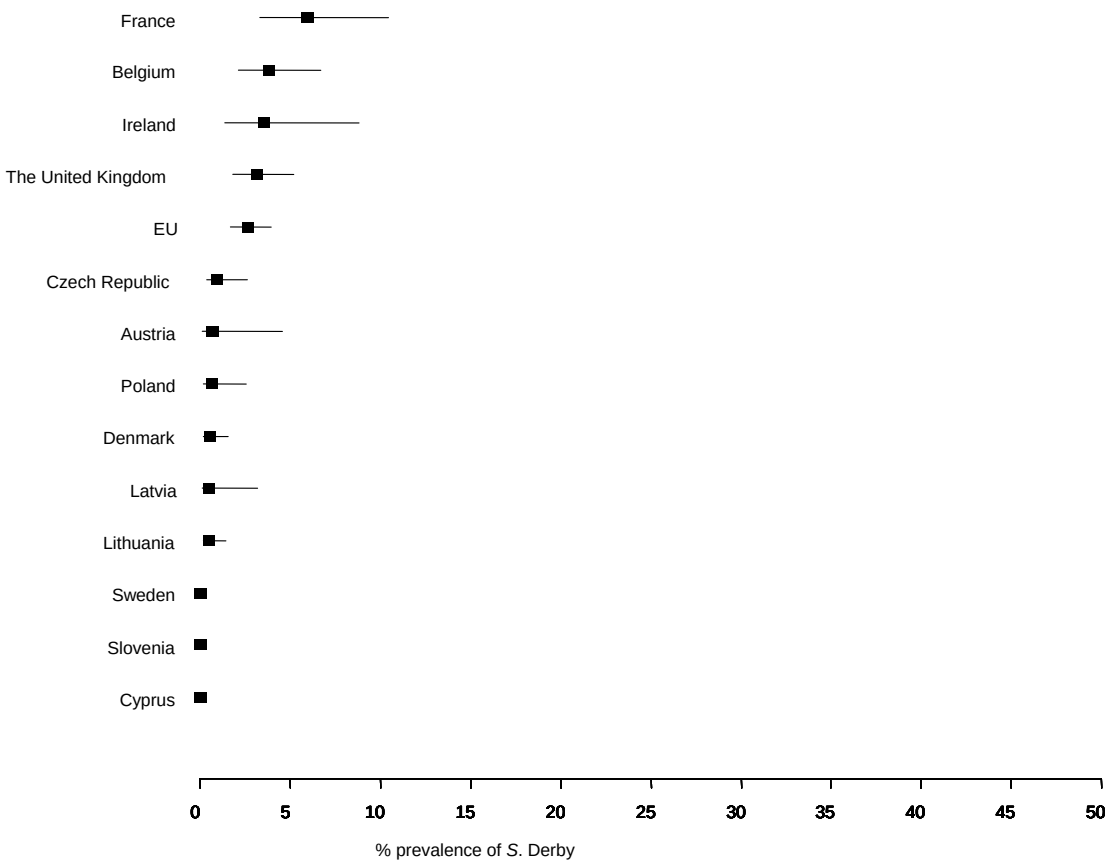
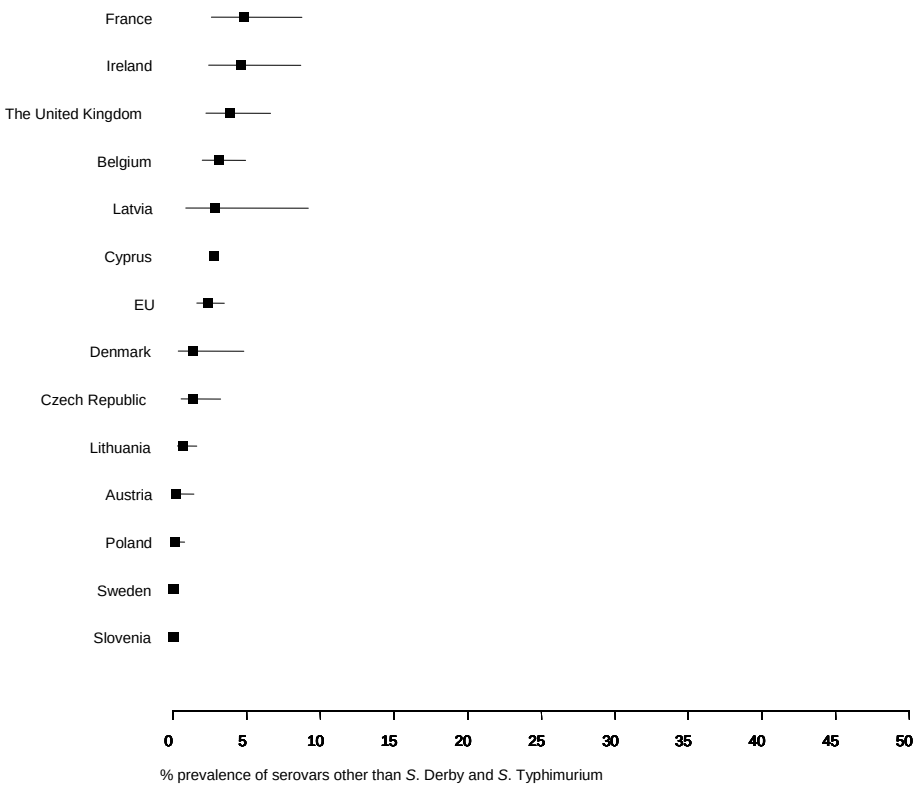


Figure 8. Observed prevalence of carcasses contaminated with serovars other than *S.* Typhimurium or *S.* Derby, with 95% confidence intervals, in 13 MSs, 2006-2007



4.3.3. Observed prevalence of slaughter pigs with antibodies against *Salmonella*

Amongst the 9 participating MSs, two used the Salmotype Pig Screen® ELISA by Labor Diagnostik Leipzig, three MSs used the HerdCheck Swine *Salmonella*® ELISA by IDEXX, two MSs used an in house ELISA, one MS used the VetSign Porcine *Salmonella*® ELISA by Guildhay, and one MS used both the Salmotype Pig Screen® ELISA and the HerdCheck Swine *Salmonella*® ELISA. The NRLs used the cut-off of their choice. Eight MSs reported their results as relative optical densities (OD%) and one MS reported his results in S/P ratio (sample value related to positive control value).

Four participating MSs reported inconclusive results. A total of 2.4% of the serological test results in the participating MSs were classified as inconclusive.

The observed prevalence of slaughter pigs with antibodies against *Salmonella* is presented in Table 4, per MS. When no inconclusive outcomes were reported by a MS, only one prevalence estimate is reported. Conversely, for MSs reporting inconclusive results a conservative CI was constructed, which's lower bound corresponds to the lower bound obtained from viewing the inconclusive results as negative and the upper bound corresponds to the upper bound obtained from viewing the inconclusive results as positive.

In Figure 9 the prevalence estimates when considering inconclusive outcomes alternatively as positive or negative are displayed together with the corresponding conservative CI.

It should be emphasised that these prevalence estimates of slaughter pigs with antibodies against *Salmonella* are not comparable between MSs, because of different assays and different thresholds used within participating MSs. No overall prevalence was therefore estimated at the MS-group level.

Table 4. Observed prevalence of slaughter pigs with antibodies to *Salmonella*, with conservative 95% confidence intervals, in 9 MSs, 2006-2007

Member State	Seroprevalence (%)	CI
Cyprus	16.7[a] – 33.3[b]	13.3[d] - 41.6[e]
	20.5[c]	15.6 - 26.6[f]
Denmark	7.1	5.3 - 9.5[g]
France	9.9	7.2[d] - 13.5[e]
Ireland	10.1	7.8 - 13.0[g]
Lithuania	12.7[a] – 16.5[b]	8.8[d] - 23.2[e]
	13.3[c]	9.1 - 19.0[f]
Slovenia	9.1	4.8 - 16.7[g]
Sweden[h]	3.5[a] – 18.2[b]	2.2[d] - 19.0[e]
	4.0[c]	2.6 - 6.2[f]
The Netherlands	6.5[a] – 7.9[b]	5.2[d] - 9.5[e]
	6.6[c]	5.3 - 8.2[f]
The United Kingdom	23.2	18.4 - 28.8[g]

The observed prevalence accounts for the aspects of clustering and of weighting, but not for imperfect test sensitivity or specificity.

[a] Seroprevalence estimate obtained whenever inconclusive results were treated as negative

[b] Seroprevalence estimate obtained whenever inconclusive results were treated as positive

[c] Seroprevalence estimate obtained whenever inconclusive results were treated as missing

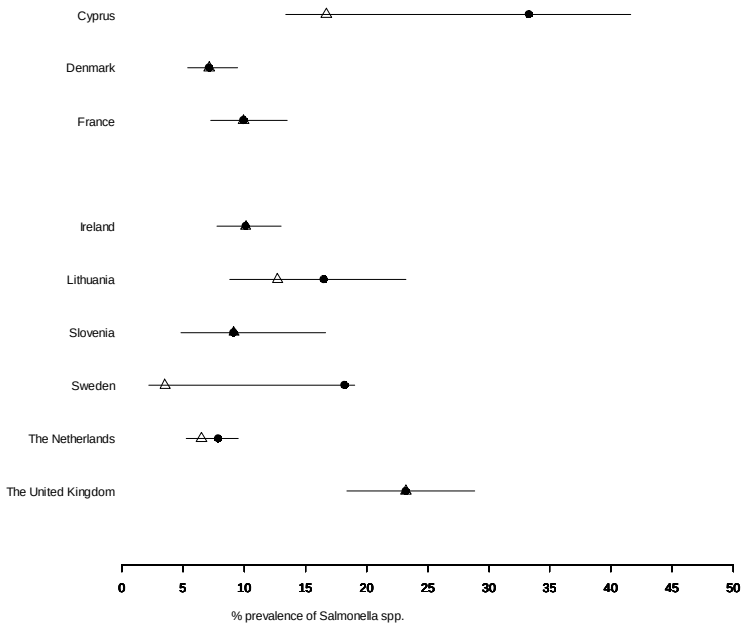
[d] Lower bound of the conservative 95% CI whenever inconclusive results were treated as negative

[e] Upper bound of the conservative 95% CI whenever inconclusive results were treated as positive

[f] 95% CI whenever inconclusive results were treated as missing

[g/h] 95% CI results obtained assuming independent covariance structure

Figure 9. Observed prevalence of slaughter pigs with antibodies to *Salmonella*, with conservative 95% confidence intervals, in 9 MSs, 2006-2007 (△: prevalence estimate obtained when inconclusive results were treated as negative; •: prevalence estimate obtained when inconclusive results were treated as positive)



4.4. Investigation of the impact of test misclassification bias

The impact of test misclassification bias was investigated at the MS-group level for the lymph node and carcass swab survey test. A true prevalence was calculated for a given range of values of the sensitivity and specificity of each bacteriological test using Rogan and Gladen's formula.

The *Salmonella* prevalences in lymph node samples at the EU-level and in the carcass swabs at the 13 MS-group level were estimated as 10.3% and 8.3%, respectively, considering the bacteriological test as completely accurate (sensitivity and specificity equal to 100%). The impact of the different sensitivity and specificity values on these prevalence estimates is displayed in Figure 10 and Figure 11. For example, in Figure 10, considering a specificity of the lymph node test of 97.5% and a sensitivity of 80% yields a true prevalence of 10.1% of slaughter pigs infected with *Salmonella* in lymph nodes, in the EU. Analogous diagnostic test characteristics for the carcass swab test yields a true prevalence of *Salmonella*-contaminated carcasses of 7.5% in the 13 MS-group (Figure 11).

Figure 10. Estimated EU true prevalence of slaughter pigs infected with *Salmonella* in lymph nodes, accounting for test misclassification bias

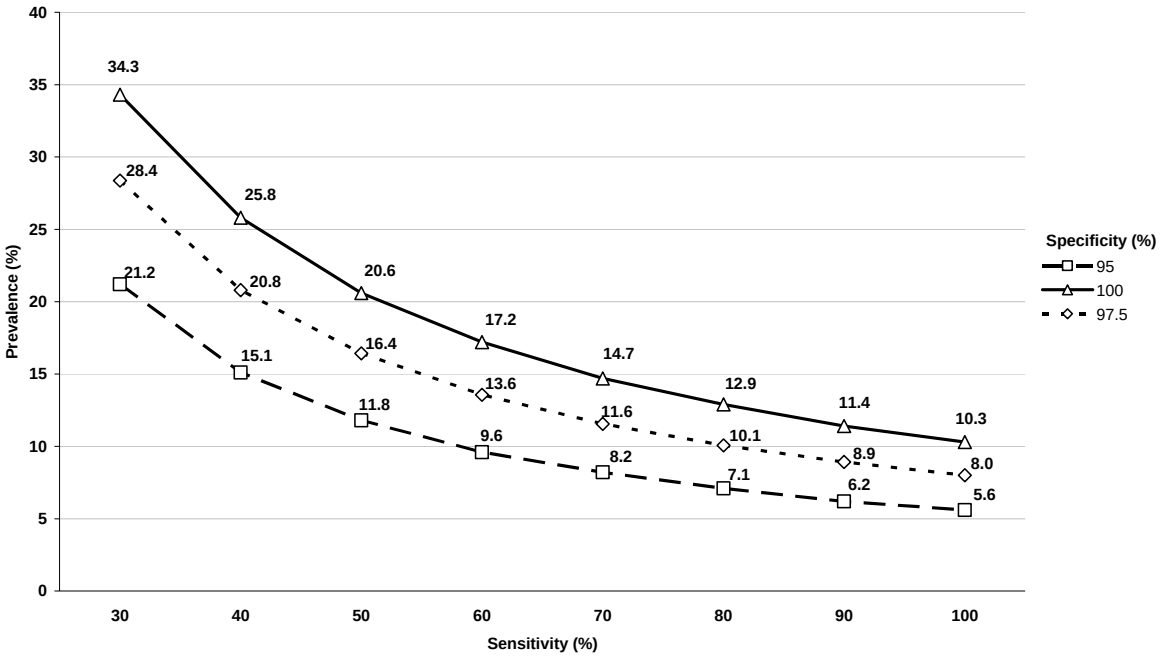
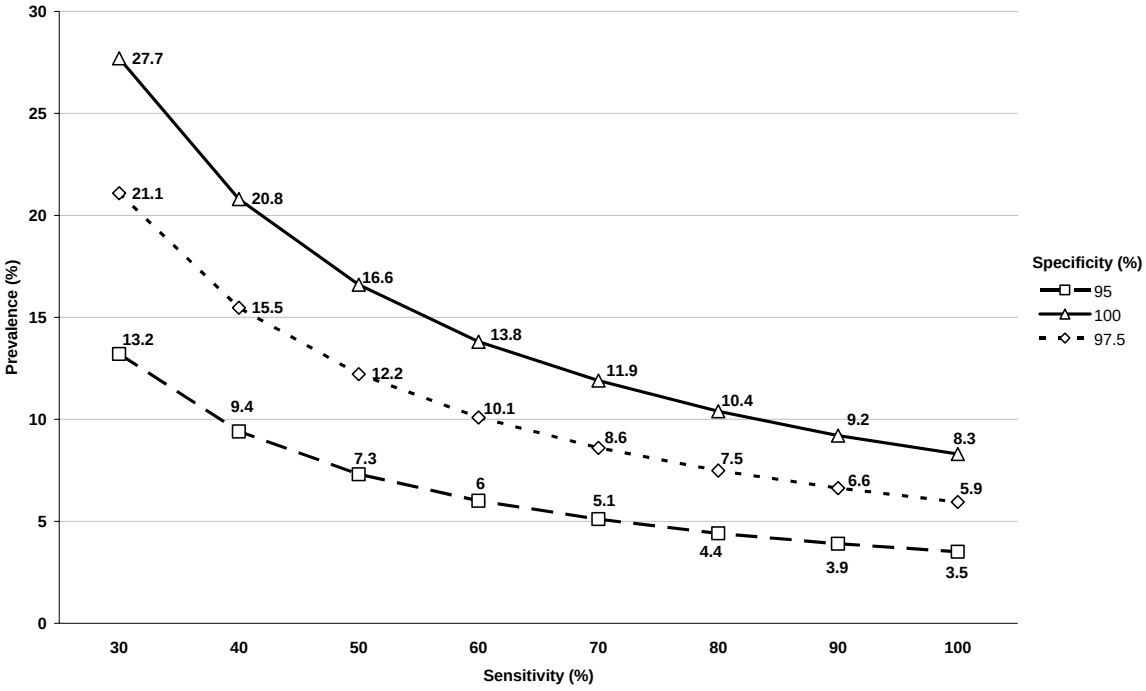


Figure 11. Estimated true prevalence of carcasses contaminated with *Salmonella* in the 13 MS-group, accounting for test misclassification bias



4.5. Concordance-discordance between the MS-specific results of the lymph nodes bacteriological test and of the antibody detection test

The results of the analysis of the concordance-discordance between the test results for *Salmonella* spp. using lymph nodes and meat juice and sera samples at the MS-level are presented in Annex VIII. The values of the κ ranged between -0.01 and 0.31. Further taking account of the CIs for each reporting MS, these measures reveal no to low agreement between the results of the two tests.

4.6. Frequency distribution of *Salmonella* serovars

The serotyping of *Salmonella* isolates was mandatory according to the technical specifications of the survey. At least one isolate from each positive sample was to be typed according to the Kaufmann-White Scheme. Results from any sample where the serovar information was not available for any isolate were excluded from the final dataset.

4.6.1. Lymph node samples

In total there were 2,600 *Salmonella*-positive lymph node samples. Two different *Salmonella* serovars were isolated from three *Salmonella*-positive lymph nodes. The frequency distribution of isolated *Salmonella* serovars in the EU and Norway is listed in Table 5. Eighty-seven different serovars were isolated from the lymph nodes of slaughter pigs across the EU. MS-specific overviews of the frequency distribution of serovars are shown in Annex IX.

S. Typhimurium and *S.* Derby were highly predominant. *S.* Typhimurium was the most frequently reported serovar from the slaughter pigs' lymph nodes in EU and Norway, isolated in 40.0% of the *Salmonella* positive slaughter pigs, and reported by all (24) MSs having found *Salmonella*-positive slaughter pigs and by Norway. The next common reported serovar was *S.* Derby, isolated from 14.6% of the positive slaughter pigs. *S.* Derby was also the second serovar most commonly isolated in terms of number of reporting MSs (20). *S.* Rissen and *S.* 4,[5],12:i:- were the third and the fourth most frequently recovered serovars, with an isolation rate in lymph nodes of 5.8% and 4.9%, respectively. *S.* Rissen was isolated in five MSs, notably in Spain and Portugal where it was the second most frequently recovered serovars, and *S.* 4,[5],12:i:- in eight MSs. *S.* Enteritidis was the fifth most common reported serovar and recovered in 19 MSs, in particular in Cyprus, Estonia, Poland and Slovenia where it was the most frequently isolated serovars in lymph nodes.

The distribution of the reported serovars varied amongst the MSs. From 2 to 29 different serovars were identified in the MSs having reported positive slaughter pigs.

Table 5. Frequency distribution of isolated *Salmonella* serovars from lymph nodes in the slaughter pigs baseline survey, in the EU and Norway, 2006-2007

Lymph node samples with serovars (N=2,600)	N	%	Nb. of countries with serovars
S. Typhimurium	1,040	40.00	25
S. Derby	380	14.62	20
S. Rissen	151	5.81	5
S. 4,[5],12:i:-	128	4.92	8
S. Enteritidis	126	4.85	19
S. Anatum	63	2.42	10
S. Bredeney	51	1.96	9
S. Infantis	49	1.88	16
S. London	33	1.27	9
S. Brandenburg	31	1.19	7
S. Agona	28	1.08	12
S. Newport	24	0.92	7
S. Montevideo	19	0.73	9
S. Bovismorbificans	15	0.58	8
S. Goldcoast	14	0.54	7
S. Give	11	0.42	5
S. Livingstone	9	0.35	5
S. Thompson	9	0.35	5
S. Hadar	8	0.31	3
S. Kedougou	8	0.31	4
S. Senftenberg	8	0.31	4
S. Kottbus	7	0.27	2
S. Mbandaka	7	0.27	4
S. Ohio	7	0.27	6
S. Virchow	7	0.27	5
S. Istanbul	6	0.23	1
S. Lexington	6	0.23	2
S. Choleraesuis	5	0.19	3
S. Choleraesuis var. Kunzendorf	5	0.19	2
S. Eboko	5	0.19	4
S. Mikawasima	5	0.19	1
S. Muenchen	5	0.19	2
S. Panama	5	0.19	4
S. Reading	5	0.19	1
S. Braenderup	4	0.15	3
S. Coeln	4	0.15	4
S. Essen	4	0.15	2
S. Schwarzengrund	4	0.15	1
S. Abony	3	0.12	1
S. Bardo	3	0.12	1
S. Bonariensis	3	0.12	1
S. Brikama	3	0.12	1
S. Havana	3	0.12	3
S. IIIa 48:z4,z23:-	3	0.12	1
S. Oranienburg	3	0.12	2
S. Saintpaul	3	0.12	2
S. Umbilo	3	0.12	1
S. 6,7:-:1,5	2	0.08	1

S. Agama	2	0.08	2
S. Blockley	2	0.08	1
S. Colindale	2	0.08	1
S. Dublin	2	0.08	2
S. Indiana	2	0.08	2
S. Muenster	2	0.08	1
S. Paratyphi B var. Java	2	0.08	2
S. 3,10:-:1,7	1	0.04	1
S. 6,7:-:l,w	1	0.04	1
S. 9,12:l,v:-	1	0.04	1
S. Adelaide	1	0.04	1
S. Amersfoort	1	0.04	1
S. Augustenborg	1	0.04	1
S. Bareilly	1	0.04	1
S. Bradford	1	0.04	1
S. Carno	1	0.04	1
S. Cerro	1	0.04	1
S. Freetown	1	0.04	1
S. Fyris	1	0.04	1
S. Gaminara	1	0.04	1
S. Goettingen	1	0.04	1
S. Grumpensis	1	0.04	1
S. Heidelberg	1	0.04	1
S. Hermannswerder	1	0.04	1
S. Hillingdon	1	0.04	1
S. II 18:-:-	1	0.04	1
S. Isangi	1	0.04	1
S. Lomita	1	0.04	1
S. Manhattan	1	0.04	1
S. Meleagridis	1	0.04	1
S. Menden	1	0.04	1
S. Mishmarhaemek	1	0.04	1
S. O 6,7:Z29	1	0.04	1
S. Offa	1	0.04	1
S. Stourbridge	1	0.04	1
S. Szentes	1	0.04	1
S. Teddington	1	0.04	1
S. Tennessee	1	0.04	1
S. Veneziana	1	0.04	1
Salmonella untypeable	130	5.00	11
Salmonella Group B	69	2.65	5
S. enterica subsp. *enterica*	27	1.04	6
S. enterica subsp. *houtenae*	2	0.08	2
S. enterica	1	0.04	1

4.6.2. Carcass swabs

There were a total of 387 carcasses testing positive for *Salmonella* by surface swab-sampling. The frequency distribution of isolated *Salmonella* serovars in the 13 MSs-group is listed in Table 6. Thirty different serovars were isolated on the surface of the slaughter pig carcasses in this MSs-group. MS-specific overview of the frequency distribution of serovars is shown in Annex X.

S. Typhimurium was the most frequently recovered serovar from the surface of the slaughter pig carcasses in EU, representing 49.4% of the *Salmonella* positive carcasses. The second most frequent serovar was *S.* Derby (24.3% of the positive carcasses). *S.* Typhimurium and *S.* Derby were also the most commonly isolated in terms of the number of MS, in total 10. The three next most frequent serovars were *S.* Infantis, *S.* Bredeney, and *S.* Brandenburg (3.4%, 2.1% and 1.8% of the positive carcasses, respectively).

S. Typhimurium was the dominant serovar in 10 MSs. In Austria and in Poland, *S.* Derby is isolated as frequently as *S.* Typhimurium. *S.* Brandenburg was the leading serovar in one MS only; Latvia. *S.* Derby is the second most frequent isolated serovar in seven MSs; Belgium, Czech Republic, Denmark, France, Ireland, Latvia, and the United Kingdom.

Table 6. Frequency distribution of isolated *Salmonella* serovars from carcass swabs in the slaughter pigs baseline survey, in 13 MSs, 2006-2007

Carcass swabs with serovars (N=387)	N	%	Nb. of countries with serovars
S. Typhimurium	191	49.35	10
S. Derby	94	24.29	10
S. Infantis	13	3.36	5
S. Bredeney	8	2.07	4
S. Brandenburg	7	1.81	3
S. Reading	6	1.55	1
S. Enteritidis	5	1.29	3
S. Kedougou	5	1.29	2
S. 4,[5],12:i:-	5	1.29	1
S. Agona	4	1.03	3
S. Livingstone	4	1.03	2
S. Panama	3	0.78	1
S. London	2	0.52	2
S. Rissen	2	0.52	2
S. Schwarzengrund	2	0.52	2
S. 4,5,12:-:1,2	1	0.26	1
S. 9:I,v:-	1	0.26	1
S. Anatum	1	0.26	1
S. Bovismorbificans	1	0.26	1
S. Bradford	1	0.26	1
S. Chartres	1	0.26	1
S. Give	1	0.26	1
S. Goldcoast	1	0.26	1
S. Hadar	1	0.26	1
S. Kentucky	1	0.26	1
S. Manhattan	1	0.26	1
S. O 6,7:Z29	1	0.26	1
S. Ohio	1	0.26	1
S. Senegal	1	0.26	1
S. Virchow	1	0.26	1
Salmonella untypeable	16	4.13	4
S. enterica subsp. *arizonae*	2	0.52	1
S. enterica subsp. *diarizonae*	1	0.26	1
Salmonella Group B	1	0.26	1
S. enterica subsp. *enterica*	1	0.26	1

4.7. Overview of the quality of the bacteriological testing

In the technical specifications of the baseline survey it was indicated that all strains isolated and confirmed as *Salmonella* spp. should be serotyped according to the Kaufmann-White scheme. For quality assurance of the serotyping, a maximum of 16 typeable strains and 16 non-typeable isolates of the survey had to be sent to the Community Reference Laboratory for *Salmonella* (CRL-*Salmonella*). If fewer strains had been isolated, all should have been sent.

The CRL-*Salmonella* reported on the quality of the serotyping of typeable strains and non-typeable isolates of *Salmonella* from the baseline survey in slaughter pigs.

Twenty-three NRLs-*Salmonella* (of the 25 participation MSs) sent in some typeable strains to the CRL; one NRL indicated that it did not isolate any *Salmonella* during the baseline survey and a second NRL mentioned it was not able to send strains. A total of 340 typeable strains were received by the CRL-*Salmonella*. Thirty-two strains (9.4%) were serotyped differently by the CRL.

Twelve NRLs-*Salmonella* sent in some non-typeable isolates to the CRL. A total of 84 non-typeable isolates were received by the CRL-*Salmonella*. Of these strains, CRL-*Salmonella* was able to further identify 17 strains to serovar names. The unavailability of a complete set of specific antisera in certain MSs may explain the difficulty experienced by these NRLs in identifying a number of strains at the level of the serovar.

5. Discussion

5.1. Introduction

Salmonella infection in pigs is often sub-clinical, although some animals may show a range of clinical signs varying from mild diarrhoea through to acute septicaemia and death. Thus, the greatest importance of *Salmonella* infection in pigs is the potential for transmission through the food chain resulting in human infection and disease. There is convincing evidence that some human cases of salmonellosis are attributable to infection derived from *Salmonella* infected pigs or products of pig origin but the population attributable fraction for the EU has not been estimated[1].

This baseline survey was conducted by 25 MSs and Norway with the aim of estimating the prevalence of *Salmonella* infection amongst pigs raised for slaughter. All MSs were obliged to collect lymph node samples. Lymph nodes were collected and tested in all MSs from slaughtered pigs immediately after slaughtering in the slaughterhouse.

An additional objective of this slaughterhouse survey was to collect information on the external contamination of the carcasses with *Salmonella* and on the prevalence of slaughter pigs with antibodies against *Salmonella*. Nine MSs collected either meat juice or blood samples from the pigs that had already been selected for sampling of lymph nodes, approximately at the same point in the slaughter line where the lymph nodes were taken, which was at the beginning of the slaughter line, and 13 MSs additionally sampled the pigs' carcasses by swabbing, at the end of the slaughter line, after evisceration and before chilling.

Overall, there was very good compliance with the survey and very few samples were rejected.

5.1.1. Interpretation of the results from each of the three used survey tests

Each of the three tests used in the survey assessed a different outcome, as described in the following paragraphs. Obligatory sampling of the ileo-caecal lymph nodes was conducted by all MSs and Norway. This test detects *Salmonella* infection of slaughter pigs at the level of the primary production and is a sensitive test at the individual animal level.

Salmonella infection results from ingestion or occasionally inhalation of viable bacteria. In pigs, infection within the intestinal tract may be followed by invasion of the cells of the gut and thence, infection is established in the intestinal lymph nodes. It is possible for pigs to ingest material containing *Salmonella* and for this to be in passive transit through the gut without actively establishing infection. Infected pigs may become carriers and excrete *Salmonella* in their faeces intermittently. Therefore, the presence of *Salmonella* within the lymph node is incontrovertible

[1] Opinion of the Scientific Panel on Biological Hazards on "Risk assessment and mitigation options of *Salmonella* in pig production", *The EFSA Journal (2006),* 341, 1-131.

evidence that a pig is infected, as it is very unlikely that *Salmonella* can be isolated from lymph nodes of uninfected pigs and false positive results are rare. However, the test sensitivity is not 100% and there may therefore be false negative results. *Salmonella* excretion by carrier pigs is thought to be provoked by stress and may occur as the pigs are loaded and transported to the slaughterhouse. It is possible for pigs to become infected and for that infection to be transferred to the intestinal lymph nodes in a matter of hours. Therefore, a positive lymph node result may reflect infection on the farm of origin or during transport or lairage[1]. The longer the duration of the transport and lairage phases, the more contaminated the environment during those phases, and the more stressful the conditions that are experienced, the greater the risk of infection occurring after departure from the farm.

Presence of *Salmonella* on carcass swabs reflects the surface contamination of the carcass. Although this may occur during transport or in the lairage, normal slaughterhouse practices including passing pigs thorough a scald tank and singeing to remove bristles act to reduce *Salmonella* contamination. Presence of *Salmonella* infection in the pig need not result in carcass contamination unless e.g. there is faecal leakage from the anus or the gut is accidentally nicked during processing. *Salmonella* may also survive in slaughterhouse environments, especially in equipment that is difficult to clean thoroughly. Poor hygiene in a slaughterhouse or amongst staff may also result in contamination of carcasses and one contaminated carcass may touch others, resulting in cross-contamination. Thus, the prevalence of positive carcass swabs is a product of the risk of infection within a pig, the risk that the infection is released to the exterior and the risk of cross-contamination from other carcasses or the slaughterhouse environment. It is predictable that presence of *Salmonella* in the gut is not completely associated with carcass contamination. It is also important to consider that the presence of *Salmonella* infection in the intestinal lymph nodes, which are removed from the carcass and are not consumed, may only represent a limited public health threat whilst a contaminated carcass is likely to be a greater risk to public health as the carcass is the start of the food chain.

Salmonella infection[2] stimulates an immune response and circulating antibodies can be detected in blood, serum or meat juice. Some countries, e.g. Denmark, France, Ireland, The Netherlands, and The United Kingdom, used in this survey a mix-ELISA system that detects antibodies against a range of common serovars in the Group B and C_1 *Salmonella.* As antibodies persist beyond the time of infection, unsurprisingly a positive serological result is a poor indicator of current infection. Infection during transport to a slaughterhouse or in lairage does not result in a seropositive reaction, as there is insufficient time for a detectable immune response to occur before death. However, the prevalence of seropositive pigs does give a good estimate of the lifetime exposure to *Salmonella*. Therefore, it may be a valuable tool for surveillance of *Salmonella* infection on farms as part of a control programme.

[1] With a lairage is meant the animal handling facilities at sale yards or slaughterhouses; this includes; loading ramps, laneways, branding and injection chutes, weigh-scales, and holding.

[2] Also vaccination against *Salmonella* stimulates immune response. Although it is not a standard practice to vaccinate fattening pigs against *Salmonella*, the possible use of vaccines in some MSs must be taken into consideration. Antibodies induced by *Salmonella* vaccination can not been distinguished from those originating from natural infection. During this survey no data were collected regarding the vaccination status of slaughter pigs.

5.2. Survey design, and data analysis

Three issues were taken into consideration in the statistical analysis, in order to obtain valid prevalence estimates for pigs infected with *Salmonella* in lymph nodes, at slaughter. First is the potential correlation between outcomes (presence or absence of infection/contamination) for pigs/carcasses sampled in the same slaughterhouse. Whilst pigs were selected at random within each slaughterhouse, there remains a possibility of a slaughterhouse-level effect. Thus, pigs slaughtered at one slaughterhouse may be more alike than pigs slaughtered at other slaughterhouses. For example, they may come from the same region within a country or may be derived from a large integrated company and thus have been raised in similar systems. Second is the sampling of different proportions of slaughterhouses in the participating MSs, and third is the sampling of different proportions of slaughtered pigs in the sampled slaughterhouses. Indeed, for the latter issue the number of samples collected from each slaughterhouse was related to the reported throughput of the slaughterhouse in a previous calendar year. Therefore, the estimated prevalence accounts for the varying sampling fraction within each slaughterhouse.

The statistical techniques that were implemented in the analysis (GEE) are specific for correlated observations (issue 1). Moreover, disproportionate sampling at the country (issue 2), and at the slaughterhouse level (issue 3) were considered through weighting of the results. In this way, an effort was made to apply the most appropriate analysis to such a complex survey design. The resulting, weighted (observed) prevalence estimates are therefore valid and representative indices of the presence of *Salmonella* spp. in slaughter pigs. These adjustments are particularly important in the estimation of the likely range within which lies the true population prevalence that the baseline survey was designed to estimate. Therefore, such estimates are most suitable to be used in target setting for the control of *Salmonella* infection in the EU, and as references for further studies at the EU level and within MSs.

The results are intended to be extrapolated to the EU-level and to the national (slaughter pig) herd of each MS; they are not intended to estimate the prevalence of infection either within individual pig herds or within slaughterhouses. Those slaughterhouses which together represented 80% of pigs slaughtered, apart from cull sows and boars, in each MS were selected for sampling. Restriction criteria were applied in order to ensure comparability of pigs samples amongst MSs as well as of the biological samples submitted for testing. In the latter case, a minimum weight of 15g of lymph node material and a minimum of 5 lymph nodes were required from each pig. Isolation of *Salmonella* organisms from a tissue matrix depends upon the actual number of *Salmonella* present in bacterial clusters and the cluster distribution through the tissue. The presence of other material (lymphoid cells, other organisms, antibodies etc) within the tissue matrix may also affect the ability of the culture system to grow any *Salmonella* that are present.

The dataset analysed was not the complete dataset submitted by MSs, due to exclusion of some samples with implausible data values. In total, 0.7% of the sampled pigs were excluded from the final EU dataset. No pigs were excluded from 17 MSs and Norway. This proportion of excluded data can be considered to be extremely small at the EU-level. Therefore the exclusion is unlikely to have a significant impact on the results at the Community-level. On the other hand, in certain MSs, the proportion of excluded data was relatively high and reached 19.2% in Greece. Two MSs, Malta and Romania, did not submit any data. Since the Romanian slaughter pig population

appears to be small (although entirely constituted by relatively small holdings), the impact of this MS to the EU prevalence of *Salmonella* could likely have been small, but it remains unknown.

The survey was designed to account for any seasonal variation by ensuring that sampling was conducted over a 12 month period, with roughly equal numbers of pigs being selected and sampled each month. As shown in Annex VI, most MSs followed this direction, although there was a delay before the survey was begun in Bulgaria (begun in month 8), Latvia (begun in month 5), Lithuania (begun in Month 4) and Portugal (begun in Month 5). These discrepancies did not have an important impact at EU level, although the possibility that the within-country prevalence in these four MSs was biased should there be an important seasonal effect cannot be completely discounted.

Annex VI shows the frequency distribution of sample collection by time. Most sampling occurred between 5 a.m. and 6 p.m., reflecting slaughterhouse operating practices.

It is also noteworthy that slaughter facilities varied importantly between the MSs. Some Eastern EU MSs sampled hundreds of slaughterhouses while some Western EU MSs sampled only some. This indicates that the scale of the slaughter pig production is structured quite differently between the MSs and could partly explain the variation observed in the prevalence.

5.3. Observed *Salmonella* prevalence

5.3.1. Observed prevalence of slaughter pigs infected with *Salmonella* in lymph nodes

Positive lymph node samples were obtained from 24 of 25 MSs and from Norway. It is important to note that the absence of any *Salmonella* from the tested samples does not imply that a MS is *Salmonella* - free, as firstly the detection method has a sensitivity of less than 100%, so false negative results are plausible. Secondly, the prevalence within the MS may be too low for even one positive animal to be detected with the sample size that was used. The EU wide, observed prevalence of *Salmonella* infection in lymph nodes was 10.3%, with a 95% confidence interval of 9.2% - 11.5%. Within MSs, the prevalence varied between 0.0% and 29.0%. This can be interpreted as showing that one in ten pigs slaughtered in the EU was infected with *Salmonella* when slaughtered. This infection may have arisen on the farm of origin or at any time during transport to slaughter or lairage. About half of the MSs had a *Salmonella* prevalence in lymph nodes above the EU average, while the other half had prevalence below the EU mean. This was also the case for *S.* Typhimurium, but less true for *S.* Derby and for serovars other than these latter two, for which fewer MSs had figures above the EU mean. Finland did not report any *Salmonella* isolate from lymph nodes, whereas one pig was reported positive to *S.* Typhimurium in the lymph nodes in Norway.

It is noteworthy that although there was a large variation in the slaughter pig *Salmonella* prevalence, the serovar distribution was not remarkably varying between the MSs, because two specific *Salmonella* serovars, *S.* Typhimurium and *S. D*erby, accounted for a major part of the

positive findings at the EU-level and for most *Salmonella*-positive MSs. Indeed, all 24 *Salmonella*-positive MSs isolated *Salmonella* Typhimurium (Community observed prevalence of 4.7%) and 20 detected *Salmonella* Derby (Community observed prevalence of 2.1%). These two serovars are common serovars found in *Salmonella* infection cases in humans, and are both amongst the ten most frequently reported serovars in humans[1]. They have also been isolated from other species of domestic livestock, including poultry.

5.3.2. Observed prevalence of carcasses contaminated with *Salmonella*

Salmonella was isolated from carcass swabs from 11 of 13 MSs that elected to collect these samples. No positive test results were observed in Sweden or Slovenia. The observed prevalence of infected carcass swabs in this group of 13 MSs was 8.3% (95% CI 6.3% - 11.0%). Thus, one in 12 pig carcasses produced in this group of 13 MSs was contaminated with *Salmonella*. This estimation cannot as such be extrapolated to the level of the EU, because this group of MSs may not be representative for all MSs. One group of participating MSs had a prevalence above the weighted average (Belgium, France, Ireland and the United Kingdom), and the other one below the average (Austria, Cyprus, Czech Republic, Denmark, Latvia, Lithuania, Poland). This was the case for *Salmonella* spp., for *S*. Typhimurium, and to a lesser extend for *S.* Derby. It was not the case for serovars other than the two latter ones.

It is again noteworthy that although there was a large variation in the prevalence of *Salmonella* contaminated carcasses, the serovar distribution was not remarkably varying between these MSs, because two specific *Salmonella* serovars, *S.* Typhimurium and *S. D*erby, accounted for a major part of the positive findings at the EU-level and for most *Salmonella*-positive MSs. Indeed, 10 of the 13 participating MSs isolated *S.* Typhimurium (MS-group observed prevalence of 3.9%) and also 10 isolated *S.* Derby (MS-group observed prevalence 2.6%).

The contamination of the carcasses occurred in the slaughterhouse and may have been due to infection within the pigs or from the slaughterhouse environment. For this 13-MS group the carcass swab *Salmonella* spp. prevalence appears to be similar to the lymph node prevalence. At the MS-level, the prevalence of contaminated carcass swabs tended to be similar or lower than the prevalence of slaughter pigs infected with *Salmonella* spp. in lymph nodes in 11 of the 13 MSs. Conversely, in two MSs (Belgium and Ireland) the prevalence of contaminated carcass swabs seemed higher than the prevalence of infected lymph nodes. However, sample size calculations have not been predicated for such comparison; indeed fewer carcasses were sampled compared to the number of lymph node samples, resulting in a wider CI around the prevalence estimate of carcasses contaminated with *Salmonella*.

In this survey the carcass swab represents the closest sampled point to the exposure of the consumer, at the beginning of the food chain. Thus, since the imperative for control of *Salmonella* in pigs is the protection of public health, there is an argument that the carcass swab is the most appropriate measure of those utilised in this survey. Further, individual MSs might choose whether intervention at the farm, the slaughterhouse or some combined strategy afforded the best option for their particular circumstances.

[1] The Community Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents, Antimicrobial Resistance and Foodborne Outbreaks in the European Union in 2006, *The EFSA Journal* (2007) 130.

5.3.3. Observed prevalence of slaughter pigs with antibodies against *Salmonella*

Seroprevalence (presence of *Salmonella* antibodies in meat juice or in sera) is a measure of the prior exposure of the pig to *Salmonella* infection. Due to the diversity of tests and cut-off points employed by the 9 MSs that chose to collect these samples, no group level prevalence can be estimated. The sensitivity and specificity of these tests is not precisely known and in most MSs, some inconclusive results were reported. The seroprevalence amongst these 9 MSs was estimated to have been as low as 2.2% (lower boundary of 95% CI, classifying inconclusive results as negative) in Sweden to as high as 41.6% (upper boundary of 95% CI, classifying inconclusive results as positive) in Cyprus.

The future value of testing of serological samples probably lies in their application within a MSs for surveillance purposes and identification of positive herds, since these tests are relatively cheap, sample collection is straightforward and can be done by a slaughterhouse technician and in the case of meat samples, can be frozen for transport and batch testing. However, it should be recalled that these samples are poor predictors of the *Salmonella* status of the individual pig or carcass. This was further underpinned by the survey concordance-discordance results, at the MS-level, between the test for *Salmonella* spp. using lymph nodes and meat juice and sera samples. These analyses results revealed no to low agreement.

5.4. Investigation of the impact of test misclassification bias

From the investigation of the impact of misclassification bias of the used bacteriological tests it resulted that due to the nature of these tests (highly specific but likely missing some sensitivity) the true prevalence of slaughter pigs infected with *Salmonella* and of carcasses contaminated with *Salmonella* would be underestimated when only considering the observed test results. For a perfectly specific test the underestimation of those prevalence at the EU-level would be 2.1% to 2.6% when considering a sensitivity of 80%, and 3.6% to 4.4% when considering a sensitivity of 70%. The investigation of the impact of the test misclassification bias was performed considering that the sensitivity and the specificity of the test are uniform across the EU. However, the sensitivity and specificity of the test may not be the same within the countries, in particular for a given serovar of *Salmonella.* The samples analysed (mass of the lymph nodes) and the quality of the bacteriological testing may have an effect on the sensitivity and the specificity of the test.

5.5. Frequency of isolated *Salmonella* serovars

A greater diversity of *Salmonella* serovars were isolated from lymph nodes than from carcass swabs, although there were five serovars that were only isolated from carcass swabs. Firstly, carcass swabs were collected from fewer MSs and secondly, the overall prevalence of *Salmonella* positive swabs was lower than that of lymph node samples within those MSs that tested both. The number of bacteria that may be collected from a carcass is also likely to be lower than the number

found in the lymph node of an infected pig except in case of extreme contamination. Finally, the presence of *Salmonella* on a carcass swab may reflect post-slaughter contamination with serovars that exist in the slaughterhouse environment as well as infection originating from within the slaughtered pigs.

S. Typhimurium was isolated in all of the 24 MSs that found *Salmonella* in lymph node samples and in Norway. It was the most frequent isolate in all MSs except Bulgaria (*S.* Derby), Cyprus (*S.* Enteritidis), Estonia (*S.* Enteritidis), Italy (*S.* Derby), Latvia (*S.* Brandenburg), Poland (*S.* Enteritidis), Slovenia (*S.* Enteritidis) and Slovakia (*S.* Derby). In six of these 8 MSs, *S.* Typhimurium was the second most common serovar to be isolated whilst in Bulgaria, *S.* Infantis was the second most prevalent serovar and in Latvia, where *S.* Derby came second. *S.* Typhimurium has long been recognised in many European countries as a common serovar amongst pigs although it has a wide host range and has also been isolated from domesticated mammals and poultry species[1]. Overall, *S.* Typhimurium accounted for 40% of the serovars isolated in the survey.

In 18 of 24 MSs that isolated *Salmonella* from lymph nodes, *S.* Derby was amongst the top three serovars to be isolated. In Spain and Portugal, *S.* Derby was ranked fourth whilst it was not detected in Cyprus, Estonia, Lithuania or Sweden. *S.* Derby is widely recognised as a common serovar in pigs although it does occur in other livestock species. *S.* Derby accounted for 14.6% of the S*almonella* isolated in this survey.

A wide range of other serovars were also detected, many in very low numbers. *S.* Enteritidis, which is usually associated with poultry, was found in 19 MSs and from 4.9% of all lymph node samples. It was as noted above, the most common isolate in Cyprus, Estonia, Poland, and Slovenia and the second most frequent isolate from Austria, Czech Republic, and Hungary. *S.* Enteritidis is the most frequent cause of human salmonellosis in the EU. *S.* Rissen was particularly prevalent in Portugal and Spain.

It can further be mentioned that *S.* Typhimurium and *S.* Derby were the most frequent serovars both in lymph nodes and on the surface of carcasses, suggesting that the serovars that exist in the slaughterhouse environment come mainly from the infected pigs that are slaughtered there.

Overall, this survey demonstrates a wide variation in the distribution of *Salmonella* serovars in slaughter pigs and the presence of two dominant serovar in this species. These results contrast with those found in breeding and fattening turkeys, where no particular serovar seemed dominant. On the contrary, in *Gallus gallus* (fowl), *S.* Enteritidis predominated in both laying hens and broilers in many MSs. A risk factor analysis, as well as a more in depth analysis of the *Salmonella* serovars including the phage types will be presented in the Part B report.

[1] The Community Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents, Antimicrobial Resistance and Foodborne Outbreaks in the European Union in 2006, *The EFSA Journal* (2007) 130.

5.6. Relevance of findings to human health

This survey estimated the prevalence of *Salmonella* infection in lymph nodes of pigs at slaughter and therefore, at the point where primary production ends. Infection may have occurred on the farm or at any point during transport to the slaughterhouse or in the lairage. The intestinal lymph nodes are removed from the carcass with the guts and therefore, should not enter the food chain. However, presence of infection in the lymph node may be associated with infection elsewhere in the carcass or in the gut content. During the slaughter process, contamination may be spread from inedible material to edible meat or slaughterhouse environment by poor hygiene or after accidental rupture of the guts or anal leakage.

EFSA's Scientific Panel on Biological Hazards concluded in its opinion[1] on *Salmonella* in pigs that all *Salmonella* serovars isolated from pigs or pig meat are to be regarded as a hazard for public health. The presence of *S.* Typhimurium is of particular note, as this is the second most frequent isolate from reported human cases of salmonellosis in the EU. However, *S.* Typhimurium also occurs in other domesticated animal species. There is a body of scientific evidence[1] that shows that *S.* Typhimurium from pigs may infect people but it is not clear what proportion of human *S.* Typhimurium cases can be attributed to an origin in EU pigs. According to the opinion of BIOHAZ Panel, pig meat is a significant source of human foodborne salmonellosis in the EU. Many foodborne *Salmonella* outbreaks are attributed to consumption of pig meat or products thereof[2].

Risk of *Salmonella* contamination on food products may be increased or decreased by processing beyond the slaughterhouse. For example, mixing with raw ingredients, cutting and handling may increase risk whilst cooking, curing, fermentation or drying may reduce risk. There is also a risk that contaminated food may lead to cross-contamination to other food or surfaces in a domestic home environment or in catering establishments and thus lead to indirect human infection. Thorough cooking will kill *Salmonella* and reduce risk to a negligible level. In some MSs there is a tradition of consuming raw pig meat products, which may constitute a special risk for *Salmonella* infection.

5.7. The *Salmonella* reduction targets

The findings of this survey are expected to inform the setting of targets for reducing the prevalence of *Salmonella* in pigs at slaughter, in order to safeguard human health. Pursuant to the Regulation EC No 2160/2003[3], the *Salmonella* reduction target is to be established at the level of the primary production for herds of slaughter pigs, and should cover all *Salmonella* serovars with public health significance. The criteria determining the *Salmonella* serovars with public health significance are specified in the Regulation as:

[1] Opinion of the Scientific Panel on Biological Hazards on "Risk assessment and mitigation options of *Salmonella* in pig production", *The EFSA Journal (2006),* 341, 1-131.
[2] The Community Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents, Antimicrobial Resistance and Foodborne Outbreaks in the European Union in 2006, *The EFSA Journal* (2007) 130.
[3] Regulation (EC) No 2160/2003 of the European Parliament and of the Council of 17 November 2003 on the control of *salmonella* and other specified food-borne zoonotic agents. *Official Journal of the European Union* 2003; L 325/1: 12.12.2003.

- the most frequent *Salmonella* serovars in human salmonellosis on the basis of data collected through EC monitoring systems,
- the route of infection (that is, the presence of the serovar in relevant animal populations and feed),
- whether any serovar shows a rapid and recent ability to spread and to cause disease in humans and animals, and
- whether any serovar show increased virulence, for instance as regards invasiveness, or resistance to relevant therapies for human infections.

When defining the Community target, the Commission will provide an analysis of its expected costs and benefits. This analysis will, in particular, take account of the above mentioned criteria for *Salmonella* serovars with public health significance. Crucially, it will be important to estimate the proportion of human cases of salmonellosis that can be attributed to *Salmonella* in pigs. This population attributable fraction represents the maximum benefit that could be derived from elimination of *Salmonella* in the pig meat food chain.

There have been discussions whether interventions to reduce *Salmonella* in pig meat would be more cost effective at the level of the primary production or at slaughtering or at processing. A combined strategy may afford an economically optimum solution for some MSs. Given the importance of factors beyond the farm gate, carcass swabs could have presented a viable alternative or complement to lymph node samples for setting targets. Antibody detection tests are unlikely to be useful for target setting, as they are poor indicators of public health risk. However, serological tests may have a valuable role within MSs for surveillance purposes.

An EU baseline survey for *Salmonella* in breeding pigs is currently underway. Once these results are also available, it will be possible to judge how any target set at this higher level of the industry pyramid may impact upon the slaughter pig generation. There is also a developing body of scientific literature based on observational studies and quantitative risk assessments that can be used to model the predicted public health benefits from control and thus offer further evidence to decision-makers. Amongst these is an EU quantitative risk assessment being carried out by EFSA's Scientific Panel on Biological Hazards and the results from this work should be especially useful.

6. Conclusions

This baseline survey has established a baseline observed prevalence of slaughter pigs infected with *Salmonella* in ileo-caecal lymph nodes in the EU. These baseline prevalence figures may be used later to compare future trends and follow the impact of future control programmes. The other variables studied, such as the observed *Salmonella* prevalence on carcasses in 13 participating MSs, the observed seroprevalences of *Salmonella* in 9 participating MSs and the serovar distribution in lymph nodes and carcasses, will also contribute to understanding and managing the *Salmonella* infections.

- The survey provides valuable data for risk managers on the prevalence and distribution of *Salmonella* in EU MSs, and results are suitable to be used for setting targets for the reduction of the frequency of the *Salmonella* infection in slaughter pigs in the EU.
- Three tests were used in the survey: bacteriological tests of lymph nodes and of carcass swabs and a test for antibodies. *Salmonella* prevalence in lymph nodes reflects the infection of the pigs at the level of the primary production (i.e. on the farm and during subsequent transport and lairage). *Salmonella* contamination of the carcass may derive from the infection within the pig or from the slaughterhouse environment, whereas the presence of antibodies reflects past exposure of the pigs to *Salmonella*.
- The observed prevalence of slaughter pigs infected with *Salmonella* spp. in ileo-caecal lymph nodes varied widely amongst MSs.
- The observed prevalence of slaughter pigs infected with *Salmonella* spp. in ileo-caecal lymph nodes within the EU was estimated to be 10.3% whereas the observed prevalence of *S.* Typhimurium was 4.7%.
- A large variety of serovars of *Salmonella* were isolated from ileo-caecal lymph nodes of slaughter pigs in the EU. However, *S*. Typhimurium was the most frequently isolated serovar (40.0% of isolates), at the EU-level. It was found in all the 24 MSs having reported positive results. Of the two next frequent serovars, *S*. Derby (24.3% of isolates) was found in 20 MSs, and *S.* Rissen in 5 MSs. The fourth and fifth most commonly reported serovars at the EU-level were *S.* 4,[5],12:i:- and *S.* Enteritidis.
- Within the group of 13 MSs that voluntarily carried out the survey in pig carcasses, the observed prevalence of carcasses contaminated on the surface with *Salmonella* spp. was estimated to be 8.3% whereas the observed prevalence of *S.* Typhimurium was 3.9%.
- A more limited range of serovars was identified on the surface of carcasses but the two most frequently isolated *Salmonella* serovars remained *S.* Typhimurium (49.4% of the isolates) and *S.* Derby (24.3%) both recovered from 10 MSs amongst the 13 MSs.
- With regard to seroprevalence, the observed estimates in slaughter pigs varied among the 9 participating MSs. However, these seroprevalence estimates are not directly comparable because of different tests and different thresholds used within participating MSs. No prevalence was therefore estimated at the MS-group level. Credible estimate of prevalence amongst these MSs varied from as low as 2% to as high as 42%.

7. Recommendations

- These results inform the setting of EU targets for the reduction of *Salmonella* infection in slaughter pigs in order to improve public health. Cost benefit analysis and quantitative risk assessment should be used to ensure that those targets are commensurate with risk.
- Whilst *S*. Typhimurium and *S*. Derby were the most frequent serovars isolated in this survey, the diversity of serovars encountered and the scientific opinion that all *Salmonella* serovars isolated from pigs and pig meat are to be regarded as a hazard for public health implies that targets may be most usefully set at the level of all serovars.
- *Salmonella* infected slaughter pigs contribute to consequent contamination of fresh pig meat. *Salmonella* infection in humans may result from undercooking of the meat, eating products made from raw pig meat or cross-contamination to other foods. Thorough cooking of the pig meat and strict kitchen hygiene would prevent or reduce the risk posed by *Salmonella* contaminated pig meat at the consumer level.
- Analysis of some recorded risk factors for *Salmonella* infection in lymph nodes at slaughter should be a focus for the Part B report, in order to enhance knowledge of the epidemiology of *Salmonella* infection on pigs and to inform control strategies.
- The Part B report should also consider the relationship between carcass swab and lymph node infection for the group of MSs that tested both sample types. The Part B report should as well investigate the relationship between serological tests and culture for the group of MSs that performed both of these tests, although it is recognised that the range in methods used precluded estimation of a group-level effect.
- Since carcass swabs indicate carcass contamination at a point closer to consumption in the food chain, these may offer a valid complementary target in addition to the lymph node target. This would encourage MSs to consider whether on farm intervention, slaughterhouse intervention or a combination of both offer the optimum control strategy for their individual production systems.

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Abbreviations

CI	Confidence Interval
CRL-*Salmonella*	Community Reference Laboratory for *Salmonella*
EEA	European Economic Area
EFSA	European Food Safety Authority
ELISA	Enzyme-linked Immunosorbent Assay
EU	European Union
GEE	Generalized Estimating Equations
MS(s)	Member State(s)
NRL-*Salmonella*	National Reference Laboratory for *Salmonella*
OD%	Optical Density
S/P ratio	Sample value related to positive control value
WY	Weight

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