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## SCIENTIFIC REPORT OF EFSA

# Analysis of the baseline survey on the prevalence of *Salmonella* in holdings with breeding pigs, in the EU, 2008[1]

## Part B: factors associated with *Salmonella* pen positivity

### European Food Safety Authority[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

**ABSTRACT**

A European Union-wide *Salmonella* baseline survey was conducted in 2008 in holdings with breeding pigs. A total of 1,609 randomly selected holdings housing and selling mainly breeding pigs (breeding holdings) and 3,508 holdings housing commercial breeding pigs and mainly selling pigs for fattening or slaughter (production holdings) were sampled. In each selected holding, pooled fresh faecal samples were collected from 10 randomly chosen pens of breeding pigs over six months of age, representing the different stages of the breeding herd, and examined for the presence of *Salmonella*. Analyses at country-level demonstrated a strong positive association between the prevalence of *Salmonella*-positive breeding holdings and the prevalence of *Salmonella*-positive production holdings, suggesting a vertical dissemination of *Salmonella* between the holdings. Based on the combined results from breeding and production holdings, multivariable regression analysis showed that the odds of *Salmonella*-positive pens with pigs increased with the number of breeding pigs in the holding and with the following pen-level factors: flooring systems other than slatted floors or solid floors with straw, presence of maiden gilts, number of pigs per pen, feed of commercial compound origin or pelleted feed. A tendency towards some Member State group-specific *Salmonella* serovars was identified, but spatial distribution of other serovars was heterogeneous. *S*. Typhimurium and *S*. Derby were widespread and dominant in the EU, in both breeding and production holdings. However, many other serovars were relatively prevalent in Western EU Member States. A complementary within-holding prevalence study indicated that, due to a non-perfect diagnostic test sensitivity, the observed EU-level prevalence of *Salmonella*-positive holdings with breeding pigs was roughly 80% of the estimated true EU-level prevalence. But this proportion varied between Member States.

**KEY WORDS**

*Salmonella*, pigs, breeding pigs, baseline survey, risk factors, EU

## SUMMARY

A European Union-wide baseline survey on *Salmonella* in holdings with breeding pigs was carried out in 2008. In the context of this survey, breeding pigs were defined as sows and boars of at least six months of age kept for breeding purposes. The survey distinguished between breeding holdings (holdings housing breeding pigs and delivering replacement breeding pigs to breeding holdings and production holdings) and production holdings with breeding pigs (holdings housing breeding pigs and producing mainly pigs for fattening or slaughter). Breeding and production holdings were randomly sampled from holdings harbouring at least 80% of the breeding pig population in each Member State. In each selected holding, pooled faecal samples for *Salmonella* detection were collected from 10 randomly selected pens of breeding pigs representing the different stages of production of the breeding herd (maiden gilts, pregnant pigs, farrowing and lactating pigs, pigs in the service area, or mixed). A total of 5,117 holdings with breeding pigs with validated results from 24 European Union Member States, plus Norway and Switzerland, were included in the survey analyses, corresponding to information on 1,609 breeding holdings and 3,508 production holdings. Samples were taken from a total of 48,951 pens selected in both breeding and production holdings. The results of the analysis of *Salmonella* prevalence have already been published by the European Food Safety Authority on 17 December 2009 in the Part A report. The present Part B report provides the results from analyses of the associations of 19 pen- or holding- level factors and *Salmonella* positivity of pens in holdings with breeding pigs. The investigated prevalence was the observed prevalence, meaning that the prevalence estimates did not account for imperfect test characteristics. Also the results from correlation analyses between *Salmonella* prevalence in breeding and in production holdings, from analyses of the *Salmonella* serovar distribution across the European Union, and from analyses of an additional within-holding prevalence study carried out by five Member States are also presented in this part B report.

Correlation analyses at country-level demonstrated a strong and significant positive association between the prevalence of *Salmonella*-positive breeding holdings and *Salmonella*-positive production holdings, suggesting the likelihood of vertical dissemination of *Salmonella* between the holdings. This hypothesis was further underpinned by the significant positive association between the prevalence of *Salmonella*-positive holdings with breeding pigs of the present survey and the 2006 to 2007 baseline survey prevalence of *Salmonella*-positive slaughter pigs.

Multivariable regression analysis of the combined dataset for breeding and production holdings showed that at European Union[4] level the odds of pens being positive to *Salmonella* increased as the holding size increased. Also the holding gilt replacement policy (way in which gilts are replaced in the holding) was associated with *Salmonella* pen positivity in breeding holdings, but not in production holdings. The odds of pens being positive to *Salmonella* increased with the number of pigs in the pen, with a 3% increase in odds per 10 additional pigs. The production stage of the pigs was also found to be significantly associated with *Salmonella* positivity with pens containing maiden gilts having higher odds than pens with pregnant or farrowing and lactating pigs. In breeding holdings, pens with fully slatted floors were associated with lower *Salmonella*-positivity than the category of pens with 'other' floor type. In production holdings, fully slatted pen floors had lower odds of being positive than outdoors in fields or paddocks as well as the other types of floor, except 'solid floor with straw' and pens where the floor type was classified as 'other'. Pens where pigs were fed with feed of commercial origin had higher odds of *Salmonella* positivity compared to those in which either home-mill mixed feed or feed from some other sources were used. Also, pens where pigs received pelleted feed as type of diet were associated with a higher *Salmonella*-positivity when compared to pens where pigs were fed with meal or wet feed.

In addition, the odds of pens being positive with *Salmonella* varied significantly between countries and between holdings within a country, even when other associated factors were accounted for.

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[4]  Two non-MSs, Norway and Switzerland, were included in the overall EU level dataset.

Moreover, swab samples (swab passed through accumulated mixed faeces in the pen) were more likely to be *Salmonella*-positive than composite samples (comprising individual pinches from faeces), suggesting that sampling using swabs was a more sensitive method for detecting *Salmonella* in the pen than the composite sample.

Holding level factors that were included in the analysis but which were not significantly associated with *Salmonella*-positive pens were season of sampling, delay between sampling and testing, type of breeding or production holding, and boar replacement policy. Non-significant pen-level factors were age category of the pigs, gender of the pigs, indoor/outdoor production, individual housing, all–in/all-out production and cleaned, feed/water supplement and the use of antibiotics in the pig pens. However, for some of the factors the power of the analyses was low due to too few samples in some specific categories. Moreover, the analyses showed that 56% of the unexplained variance in the *Salmonella*-positive pen results might have been attributable to holding-specific factors for which no data were gathered during the survey and/or to the clustering of *Salmonella* linked to its infectious character.

The highest estimated theoretical reduction of *Salmonella*-positive pens would be observed if specific control measures were put in place that focus on the reduction of the exposure to feed of commercial compound origin and pelleted feed diet.

A notable variation in the number of different *Salmonella* serovars was observed across the European Union Member States indicating a heterogeneous serovar distribution between participating countries. *S*. Typhimurium and *S*. Derby were widespread and dominant in most Member States, while other serovars, such as *S*. London, *S*. Infantis or *S*. Rissen were frequently isolated in some specific countries and their relevance cannot be generalised to the European Union as a whole. Many serovars isolated in the breeding pigs' survey are also common in slaughter pigs as well as in other food producing animal species and food thereof, indicating that the potential for contribution of these serovars to human infections may be shared between different sources.

The analysis of a complementary within-holding prevalence study allowed estimating the sensitivity of the pooled faecal sampling method, as well as the EU and MS level true prevalence of *Salmonella*-positive holdings with breeding pigs. The sensitivity of the pooled faecal sample was estimated to be 92% and it was shown to increase with the prevalence of positive pigs within the pen. Moreover, the results indicated that the EU level true prevalence of *Salmonella*-positive holdings with breeding pigs, as reported in the Part A report, and based on the sampling of 10 pens per holding, could be underestimated by 20%, although this percentage would vary between the Member States. It is recommended that Member States consider the factors found to be associated with *Salmonella*-positive pens at the European level in this survey, when they are designing and implementing national *Salmonella* control programmes for breeding pigs. Further national studies identifying more closely the factors that put pens with breeding pigs at risk of becoming infected with *Salmonella* in a country are recommended, taking into account the national *Salmonella* prevalence and the characteristics of the national breeding pig population. Also national investigations on prevention and intervention measures to contain *Salmonella* and achieve *Salmonella* reduction in holdings with breeding pigs are recommended. Since risk factors may vary between Member States and/or serovars, Member States are also encouraged to conduct serovar-specific analysis using their country specific data in order to identify risk factors for relevant serovars within their own country. Member States are encouraged to develop and enhance *Salmonella* controls in breeding holdings because these holdings have a unique potential role in the dissemination of *Salmonella* contamination throughout the whole production chain, as well as in contamination of the environment. Pooled faecal samples proved to be a robust and economic sampling method for surveys and should be used in future studies, as well as for monitoring the *Salmonella* status of breeding herds. Sampling procedures require standardisation to enhance sensitivity and comparability of monitoring results. Those Member States that did not participate in the within-holding prevalence study may wish to conduct their own research to validate pooling in their own situations.

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BACKGROUND

The Regulation (EC) No 2160/2003[5] on the control of *Salmonella* spp. and other specified zoonotic agents provides for the setting of Community targets for reducing the prevalence of *Salmonella* serovars with public health significance in food/animal populations. Furthermore, these targets are to be set for breeding herds of pigs. For the purpose of target setting, several European Union (EU) wide baseline surveys have been carried out.

Upon a request of the European Commission, the European Food Safety Authority (EFSA) adopted a "Report of the Task Force on Zoonoses Data Collection on a proposal for technical specifications for a baseline survey on the prevalence of *Salmonella* in breeding pigs (EFSA, 2007d)".

Based on the EFSA proposal, the Commission adopted the Decision 2008/55/EC[6] of 20 December 2007 concerning a financial contribution from the Community towards a survey on the prevalence of *Salmonella* spp. and Methicillin-resistant *Staphylococcus aureus* in herds of breeding pigs to be carried out in the Member States (MSs). The survey started on 1 January 2008 for a period of 12 months. The present report deals only with the survey regarding *Salmonella* spp.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

The Commission requested EFSA, on 19 April 2006, to analyse the results of the baseline survey on *Salmonella* spp. in herds of breeding pigs, in particular:

- to estimate the prevalence of *Salmonella* spp. in herds of breeding pigs in Member States and at level of the European Union,

- to assess quantitatively the risk factors for *Salmonella* spp. in herds of breeding pigs based on the information collected.

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[5] 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, pp. 1–15.

[6] Commission Decision 2008/55/EC of 20 December 2007 concerning a financial contribution from the Community towards a survey on the prevalence of *Salmonella* spp. and methicillin-resistant *Staphylococcus aureus* in herds of breeding pigs to be carried out in the Member States (notified under document number C(2007) 6579), OJ L 14, 17.1.2008, pp. 10–25.

ANALYSIS

## 1. Introduction

A baseline survey (BS) was carried out in the EU to estimate the prevalence of *Salmonella* in holdings with breeding pigs. This survey was the fifth in a series of baseline surveys carried out within the EU. The objective of the survey has been to obtain comparable data for all MSs through harmonised sampling schemes. According to Regulation (EC) No 2160/2003[7] on the control of *Salmonella* and other zoonotic agents, which aims to reduce the incidence of food-borne diseases in the EU, the results of such a survey will inform the setting of the Community target for the reduction of the prevalence of *Salmonella* in holdings with breeding pigs.

A scientific report by EFSA on the "Analysis of the baseline survey on the prevalence of *Salmonella* in holdings with breeding pigs, in the EU, 2008, part A: *Salmonella* prevalence estimates" (EFSA, 2009b) was published on 17 December 2009. This Part A report included the estimation of the prevalence of *Salmonella* spp., *S*. Typhimurium*, S*. Derby and serovars other than *S*. Typhimurium and *S*. Derby positive breeding holdings and production holdings at EU level and for each MS as well as the analyses of the most frequently identified *Salmonella* serovars in holdings with breeding pigs across the EU MSs, Norway and Switzerland.

The present Part B report presents the analyses of the correlation between the prevalence of *Salmonella*-positive breeding holdings and the prevalence of *Salmonella*-positive production holdings; the analyses of factors associated with *Salmonella*–positive pens in holdings with breeding pigs, as well as more in-depth analyses of the identified *Salmonella* serovar distributions. The Part B report also describes the results from the additional within-holding prevalence study, in which five Member States (the Czech Republic, Denmark, Slovenia, Sweden, and the United Kingdom) participated.

The objectives, sampling frame and methods of bacteriological analysis, as well as the collection and reporting of data, and the timelines of this *Salmonella* baseline survey in breeding pigs were specified in the Commission Decision 2008/55/EC[8].

Twenty-four EU MSs carried out the survey but Greece, Malta and Romania did not participate. In addition, two countries not belonging to the EU, Norway and Switzerland, (hereafter referred to as non-MSs) participated in the survey.

## 2. Definitions

In the scope of this baseline survey and report the following definitions were considered:

**Breeding pig**: pig (sow or boar) of at least six months of age kept for breeding purposes

**Breeding holding**: holding housing breeding pigs and selling gilts and/or boars for breeding purposes. Typically, a breeding holding sells 40% or more of the reared gilts for breeding whilst the remainder are sold for slaughter. It covers both nucleus holdings and multiplier holdings. The nucleus holdings generate genetic improvement of pure-bred pigs to render them better adapted to the requirements of farmers, processors and consumers, and deliver future pure-bred breeding pigs to multiplier holdings. Multiplier holdings produce future hybrid breeding pigs and deliver them to the production holdings with a breeding herd.

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[7] 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, pp. 1–15.

[8] Commission Decision 2008/55/EC of 20 December 2007 concerning a financial contribution from the Community towards a survey on the prevalence of *Salmonella* spp. and methicillin-resistant *Staphylococcus aureus* in herds of breeding pigs to be carried out in the Member States (notified under document number C(2007) 6579), OJ L 14, 17.1.2008, pp. 10–25.

**Farrow-to-finish holding**: a pig holding consisting of a herd of sows and their piglets, which are born, reared, weaned, grown and fattened in the one holding.

**Farrow-to-grower holding**: a pig holding including a sow herd and its progeny in which piglets are born, reared, weaned and grown for several weeks and then moved to the care of specialist fatteners.

**Farrow-to-weaner holding**: a pig holding consisting of a herd of sows and their piglets, which are born and reared up to weaning in the one holding, and then moved to the care of specialist growers and fatteners.

**Gilt**: a female breeding pig that has not yet had a litter of piglets.

**Maiden gilt**: a female breeding pig that has not yet had a litter of piglets.

**Multiplier holding or supplier holding**: a holding of pure-bred pigs that usually produce cross-bred future breeding pigs for production holdings.

**Nucleus holding**: a holding of pure-bred pigs that produces pure-bred breeding pigs (pure-bred gilts and boars) for multiplier and production holdings.

**Pen**: group of breeding pigs over six months of age kept in the same enclosure/yard.

**Population attributable fraction**: is the proportion of disease in the whole population that is attributable to the exposure, and would be avoided if the exposure were removed from the population. In this report, the term Population attributable fraction (PAF) was used to indicate the proportional reduction in *Salmonella*-positive pens that would occur if exposure to a risk factor was reduced to an alternative ideal exposure scenario (reduced exposure to the risk factor). Therefore, in this context PAF can be interpreted like a "partial impact fraction". In the present report, PAF calculation is used as a theoretical approach as no specific assumption of causal relationships can be made based on a cross sectional study.

**Prevalence:** the observed (apparent) prevalence estimate that accounts for the aspects of clustering and of weighting but not for imperfect test sensitivity or specificity.

**True prevalence**: represents the actual prevalence of the infection in the population in question. The true prevalence can be estimated from the apparent/observed prevalence by correcting for test misclassification bias due to the imperfect diagnostic tests used. The discrepancy between the apparent and the true prevalence is a function of the sensitivity and the specificity of the diagnostic test used.

**Prevalence definitions used in the within-holding prevalence study**

- **Within-pen prevalence**: proportion of individual samples positive to *Salmonella*, within a pen in a holding.

- **Within-holding prevalence**: proportion of pigs in a holding infected with *Salmonella*. The within-holding prevalence could not be directly observed from the survey results because pooled faecal samples were used. Instead, the within-holding prevalence was estimated using a Bayesian model in which the following factors were considered: the sensitivity of individual faecal samples, the sensitivity of pooled faecal samples (taking into account how it varies according to the proportion of positive samples in the pool), the clustering of infection within pens, and the relationship between the within-holding prevalence and the proportion of pens infected. Therefore, the result of this analysis is an estimate of the number of pigs that would have been positive for *Salmonella* if individual samples had been taken at random, accounting for the imperfect test sensitivity.

- **True MS-level prevalence of *Salmonella*-positive holdings**: proportion of *Salmonella*-positive holdings out of the total number of holdings in a country. This is the true prevalence estimated using a Bayesian model in which data on the observed number of positive pens from each holding sampled in each MS were combined with the following information: the sensitivity of a pooled faecal sample, the clustering of infection within pens and the relationship between the within-holding prevalence and the proportion of pens infected (further details in the Material and Methods section).

- **True EU-level prevalence:** EU-level prevalence estimated by weighting each MS's true prevalence with the fraction of its total number of holdings housing at least 50 breeding pigs out of the total number of holdings housing at least 50 breeding pigs in the EU. This EU true prevalence was calculated using the formula illustrated in Annex C of the Report Part A (EFSA, 2009b).

**Production holding**: a holding housing breeding pigs and selling mainly pigs for fattening to other specialised holdings or for slaughter. It covers farrow-to-weaner holdings or farrow-to-grower holdings or farrow-to-finish holdings.

**Proportion of positive units:** the number of positive units out of the sampled units, not accounting for any design aspect.

***Salmonella*:** all *Salmonella* spp. which can be isolated by the prescribed culture technique.

***Salmonella*-positive pen:** a pen from where *Salmonella* spp. has been isolated in the pooled faecal sample.

**Samples tested in the context of this baseline survey:**

- **Routine sample**: pooled sample of freshly voided faeces collected in each of the ten pens selected in a holding. *Salmonella* bacteriological positive results from routine samples are used to calculate the number of *Salmonella* contaminated holdings (used for estimating the MS and EU level prevalence of positive holdings) and the number of *Salmonella* contaminated pens (used as outcome for the risk factor analysis). This sample may be taken with a fabric swab which is passed through accumulated naturally pooled faeces or by combining separate faecal samples into a composite pool during collection.

- **Individual sample**: sample of freshly voided faeces collected in the framework of the within-holding prevalence study. Ten original individual samples of at least 30g are taken in each of the 10 pens selected in a holding. In the laboratory, the original individual sample is divided in two parts. One part weighting at least 25g is mixed and then tested individually: this is considered to be the 'individual sample'. The remaining second part is used to prepare the artificially pooled sample.

- **Artificially pooled sample**: pooled sample of 25g freshly voided faeces prepared in the laboratory pooling 2.5g from each of the 10 original individual samples collected in the framework of the within-holding prevalence study.

**(Diagnostic) sensitivity:** the conditional probability that a pooled faecal sample containing *Salmonella* will be positive using the prescribed survey culture technique.

**(Diagnostic) specificity:** the conditional probability that a pooled faecal sample not containing *Salmonella* will be negative using the prescribed survey culture technique.

Additional definitions can be found in Report part A (EFSA, 2009b).

## 3. Objectives

The specific objectives related to this Part B report were:

- to investigate the association between Salmonella prevalence in breeding and production holdings

- to investigate the effect of factors, which may be associated with Salmonella pen positivity, at the EU level

- to investigate the geographical distribution of Salmonella serovars across the EU

- to analyse the within-holding prevalence study results, more precisely:

  - to quantify the sensitivity of pooled faecal sampling to detect *Salmonella* infection in pigs,

  - to estimate the true EU-level and MS-specific prevalence of *Salmonella*-positive holdings with breeding pigs

## 4. Materials and methods

A detailed description of the design of the baseline survey, sampling scheme, sample size and bacteriological analyses is found in Commission Decision 2008/55/EC[9] (Annex I) and in the Part A report (EFSA, 2009b). Aspects of the survey design, laboratory analysis, and data of particular relevance to data analysis and interpretation are described here.

### 4.1. Survey design

The survey took place in the EU between January and December 2008 and targeted a population of holdings that together harboured at least 80% of the breeding pig population in a MS. In each MS, holdings to be sampled were randomly selected from the breeding holdings and production holdings group. In each selected breeding and production holding, pooled freshly voided faeces, originating from at least 10 individual breeding pigs, were collected from 10 randomly chosen pens, yards or groups of breeding pigs over six months of age. The number of pens, yards or groups to be sampled was proportionally allocated according to the number of breeding pigs over six months of age, representing the different stages of production of the breeding herd (maiden gilts, pregnant pigs, farrowing and lactating pigs, pigs in the service area, or mixed).

Sampling management, laboratory analysis and data submission were carried out by the competent authority of the MS or under its supervision. Samples were tested by the National Reference Laboratory (or an authorised laboratory) using the latest ISO 6579 Annex D method (ISO, 2007).

### 4.2. Data description

A detailed description of the validation and cleaning of the dataset carried out is provided in the Part A report. The final cleaned dataset contained data from 5,117 holdings with breeding pigs in 24 MSs and in two non-MSs (Norway and Switzerland), including 1,609 breeding holdings and 3,508 production holdings, which formed the basis for all subsequent analyses. Greece, Malta and Romania did not carry out the survey. An overview of the validated dataset at holding level is given in Table 1.

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[9] Commission Decision 2008/55/EC of 20 December 2007 concerning a financial contribution from the Community towards a survey on the prevalence of *Salmonella* spp. and methicillin-resistant *Staphylococcus aureus* in herds of breeding pigs to be carried out in the Member States (notified under document number C(2007) 6579), OJ L 14, 17.1.2008, pp. 10–25.

In the analysis for this Part B report, Norway and Switzerland are included in the EU-level analysis dataset.

**Table 1:** Overview of the validated data set at holding level by type of breeding and production holdings, *Salmonella* EU baseline survey, 2008[a]

| Country | Number of holdings | Number of breeding holdings | | | Number of production holdings | | | | Number of pens |
|---|---|---|---|---|---|---|---|---|---|
| | | Nucleus | Multiplier or Supplier | Total | Farrow to finish | Farrow to grower | Farrow to weaner | Total | |
| Austria | 252 | 18 | 61 | 79 | 94 | 61 | 18 | 173 | 2,520 |
| Belgium | 225 | 5 | 11 | 16 | 134 | 66 | 9 | 209 | 1,657 |
| Bulgaria | 72 | 4 | 43 | 47 | 19 | 1 | 5 | 25 | 720 |
| Cyprus | 64 | | 4 | 4 | 60 | | | 60 | 640 |
| Czech Republic | 267 | 2 | 104 | 106 | 27 | 124 | 10 | 161 | 2,670 |
| Denmark | 293 | 13 | 82 | 95 | 71 | 52 | 75 | 198 | 2,930 |
| Estonia | 34 | 3 | 3 | 6 | 25 | 1 | 2 | 28 | 340 |
| Finland | 207 | 16 | 34 | 50 | 56 | 101 | | 157 | 1,629 |
| France | 343 | 27 | 130 | 157 | 161 | 6 | 19 | 186 | 3,430 |
| Germany | 201 | 11 | 35 | 46 | 59 | 54 | 42 | 155 | 2,010 |
| Hungary | 181 | 12 | 28 | 40 | 131 | 7 | 3 | 141 | 1,809 |
| Ireland | 189 | 6 | 34 | 40 | 132 | 7 | 10 | 149 | 1,890 |
| Italy | 214 | 12 | 31 | 43 | 78 | 67 | 26 | 171 | 2,140 |
| Latvia | 33 | | 5 | 5 | 28 | | | 28 | 330 |
| Lithuania | 82 | 7 | 3 | 10 | 39 | 30 | 3 | 72 | 820 |
| Luxembourg | 44 | 1 | 2 | 3 | 21 | 6 | 14 | 41 | 440 |
| Netherlands | 321 | 42 | 67 | 109 | 15 | 193 | 4 | 212 | 3,210 |
| Poland | 322 | 19 | 125 | 144 | 64 | 102 | 12 | 178 | 3,220 |
| Portugal | 167 | 1 | 32 | 33 | 86 | 29 | 19 | 134 | 1,592 |
| Slovakia | 192 | 33 | 63 | 96 | 89 | | 7 | 96 | 1,920 |
| Slovenia | 114 | 14 | 13 | 27 | 61 | 26 | | 87 | 625 |
| Spain | 359 | 37 | 113 | 150 | 131 | 78 | | 209 | 3,590 |
| Sweden | 207 | 17 | 40 | 57 | 47 | 103 | | 150 | 1,694 |
| United Kingdom | 258 | 32 | 35 | 67 | 127 | 22 | 42 | 191 | 2,365 |
| EU Total (24 MSs) | 4,641 | 332 | 1,098 | 1,430 | 1,755 | 1,136 | 320 | 3,211 | 44,191 |
| Norway | 251 | 40 | 68 | 108 | 104 | 39 | | 143 | 2,510 |
| Switzerland | 225 | 30 | 41 | 71 | 27 | 96 | 31 | 154 | 2,250 |

[a] 24 MSs and two non-MSs, Norway and Switzerland, conducted the survey**.** Greece, Malta and Romania did not participate in the survey.

### 4.3. Correlation between the prevalence of *Salmonella*-positive breeding and production holdings

Correlation between the prevalence estimates of *Salmonella* spp., *S.* Typhimurium, *S.* Derby and serovars other than *S.* Typhimurium and/or *S.* Derby in breeding and in production holdings in each participating country was graphically explored via scatter diagrams. The correlation was assessed

using the Spearman's rank correlation coefficient ρ, a nonparametric rank correlation procedure which can be used when few data pairs (in this case 26 data pairs: 24 MSs and two non-MSs) are available.

## 4.4. Analysis of factors associated with *Salmonella* pen positivity

The general assumptions and framework of the statistical analysis carried out are reported in detail in the Part A report (EFSA, 2009b). The effects of factors potentially associated with *Salmonella* were analysed at pen-level, as this is considered to be the epidemiological unit, because many holdings had multiple pens that differed with regard to physical properties or managerial factors (e.g. feeding practices). A pen was considered positive if *Salmonella* was detected in the pooled faecal sample originating from the pen. At the EU-level, the prevalence of *Salmonella*-positive pens was defined as the proportion of *Salmonella*-positive pens over the one-year period of the baseline survey. When assessing *Salmonella* prevalence, the Part A report distinguished between the two types of holdings housing breeding pigs, namely breeding holdings and production holdings with breeding pigs, and provided separate prevalence estimates in these two groups of holdings[10]. In the Part B report however data on *Salmonella* pen positivity in holdings with breeding pigs were analysed using the combined dataset, pooling the results from breeding holdings and production holdings. This was done to augment the power of the analyses. Nevertheless, in order to explore the potential different associations between the investigated factors and *Salmonella* pen positivity in the two types of holdings, the interaction terms with 'holding type' (breeding holding, or production holdings) were also investigated in the analyses.

### 4.4.1. Definition of outcome variables

In the Part A report, the prevalence of *Salmonella*, *S*. Typhimurium, *S*. Derby and other serovars than *S*. Typhimurium and/or *S*. Derby was presented. The Part B report focused on investigating factors associated with the detection of *Salmonella* spp. at pen level, and consequently positivity for *Salmonella* spp. was considered as the only outcome variable. It is acknowledged, though, that risk factors may differ between serovars, but that such an analysis would be most efficiently done at the MS level, since the serovar distribution differs between MSs and some MS-specific factors (e.g. previous *Salmonella* status, status of suppliers, etc.) may influence the occurrence of individual serovars.

### 4.4.2. Factors investigated

Data on factors, both at holding- and at pen-level, potentially associated with the above mentioned outcome were collected using a mandatory questionnaire by the competent authorities or under their supervision at the time of sampling in the holdings. The following factors potentially associated with *Salmonella*-positivity of pens in breeding holdings and production holdings were considered:

Holding level potential risk factors:

• Factors related to the sensitivity of the sampling and testing process

    1. Delay between the sampling date and testing date at the laboratory ('testing delay', in days)

• Factors related to holding-positivity

    2. Date of sampling

    3. Type of breeding/production holdings (Nucleus, multiplier or supplier, farrow to finisher, farrow to grower, farrow to weaner)

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[10] Hereafter in this report, those two types of holding are respectively referred to as 'breeding holdings' and 'production holdings' for brevity. The breeding and production holding types included in the survey are defined in detail in the Definitions section, and their positions within the pyramidal structure of the pig primary production sector are displayed in Appendix A.

4. Holding size (<100, 100-399, 400-999, >999)

5. Gilt replacement policy (>90% gilts homebred, 10-90% gilts homebred, >90% gilts purchased)

6. Boar replacement policy (no boars on farm, >90% boars homebred, 10-90% boars purchased, >90% boars purchased)

Pen-level potential risk factors:

• Factors related to the sensitivity of the sampling and testing process

7. Type of sample (composite, swab)

• Factors related to pen-positivity

8. Number of pigs in the pen

9. Age category of the pigs (presence of gilts in the sampled pen: no gilts, mixed age, all gilts)

10. Gender of the pigs (female, male, mixed)

11. Production stage (maiden gilts, gilts, service area, pregnant, farrowing and lactating)

12. Indoor/outdoor production (yes, no)

13. Individual housing (yes, no)

14. Floor type (Slatted floor, partly slatted floor, solid floor with straw, solid floor with other bedding, solid floor without bedding, outdoors in fields or paddocks, others)

15. All in/all out and cleaned (yes, no)

16. Origin of the feed (commercial compounds, feed with maize, home-mill, other)

17. Type of diet (cobs/rolls/nuts/pellets, meal/mash, porridge/liquids, others)

18. Feed/water supplement (probiotic supplement, organic acid supplement, other supplement, no supplement, unknown)

19. Use of antibiotics (treatment, no treatment, unknown)

During the data analyses certain variables were recoded and certain data value categories of variables were grouped into broader categories, in order to deal with model fitting problems. Firstly, the variable 'time in days between sampling and testing' was recoded into the following classes: 0, 1, 2, 3-4 and ≥5. Secondly, the variable 'date of sampling' was recoded into three new variables: 'month of sampling', 'quarter of sampling' (first quarter, January to March; second quarter, April to June; third quarter, July to September; and fourth quarter, October to December 2008) and 'season of sampling' (winter: December to February; spring: March to May; summer: June to August; autumn: September to November). These three new variables were investigated in the descriptive analyses, while only the variable 'season of sampling' was considered in the bivariable and multivariable regression models. Thirdly, the two smallest categories of the variable 'size of the holding' (originally categorised in five ordered classes of numbers of breeding pigs; <50, 50-99, 100-399, 400-999, and >999) were merged as many countries reported no or only few holdings with less than 50 breeding pigs. The variable 'number of pigs in the pen' contained very high values for some records, up to 999. In order to prevent these outlying values having too much influence on the results of the multivariable regression analyses, a winsorization[11] was used. This implies that in all pens, where the number of pigs was

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[11] Winsorising or winsorization is the transformation of statistics by transforming extreme values in the statistical data. The distribution of many statistics can be heavily influenced by outliers. A typical strategy is to set all outliers to a specified percentile of the data; for example, a 90% winsorisation would see all data below the 5th percentile set to the 5th percentile, and data above the 95th percentile set to the 95th percentile. Winsorised estimators are usually more robust to outliers than their more standard forms, although there are alternatives, such as trimming, that will achieve the same effect.

higher than 100 (corresponding to 3.4% of the total number of pens) the number of pigs was set to 100. In the graphical and descriptive analysis the variable 'number of pigs per pen' was categorized into five ordered classes: 0-9, 10, 11-20, 21-100 and >100. Since less than 1% of the pens had 'male' pigs, the categorical variable "gender of the pigs" (female, male, mixed) was recoded in 'male/mixed' and 'female' for the inclusion in the multivariable regression model, while the original variable with the three categories was used for the descriptive analyses and graphs. The categorical pen level variables 'floor type', 'origin of the feed', 'type of diet' and 'feed/water supplement' required further re-categorization. 'Floor type' was finally re-coded in seven classes: slatted floor (corresponding to fully slatted floor), partly slatted floor, solid floor with straw, solid floor with other bedding, solid floor without bedding, outdoors in fields or paddocks, and others. 'Origin of the feed' was re-coded into four classes; commercial compounds, feed with maize, home-mill, and other. 'Type of diet' was also re-coded in four classes; 'cobs/rolls/nuts/pellets', 'meal/mash', 'porridge/liquids', and 'others'. From the original variable 'feed/water supplement' three binary variables were created to be included separately in the regression analyses: probiotic supplement added (yes, no), organic acid supplement added (yes, no), other supplement added (yes, no). The 'unknown' data value category was only considered in descriptive analysis. Further details on the categorization and recoding of factors investigated in the present report are illustrated in Appendix B.

The variables 'time in days between sampling and testing' and the 'type of sample' were considered as factors related to the sensitivity of the sampling and testing process and not potential risk factors per se. Therefore, when one of these factors was retained in the final regression model, its results were just presented in the text, and not in the tables illustrating the output of the analysis, although it was used to adjust the odds ratios of the other factors included in the final regression model.

An exhaustive, detailed description of the MS-specific numbers and proportions of *Salmonella*-positive pens, by pen-level factors, is presented in Appendix C (Table 11). Descriptive statistics for the holding level variables were not shown in Table 11 because of potential data confidentiality issues. Indeed, in some countries it could be possible to identify the farms based on holding level information such as holding size, holding type (breeding or production holdings) and gilt/boar replacement policy.

Some additional (optional) data and variables were collected on a voluntary basis by some countries. However, the effects of these optional factors could not be evaluated due to the scarcity of the data reported. An overview of the optional data reported by MSs is presented in Appendix D.

### 4.4.3. Exploratory analysis of potentially associated factors

A thorough description was made of the samples by all recorded factors or variables. The association between each potentially associated factor and the outcome variable was visually explored using bar graphs of the proportion of *Salmonella*-positive pens and 95% confidence intervals (CIs), by different levels of categorical variables, for breeding and production holdings separately. The association between each factor and the outcome of interest was tested by Chi-square tests, Spearman correlation and Cochran-Mantel-Haenszel Chi-square tests for linear trends. Moreover, a bivariable analysis was performed using a logistic regression model with country as fixed effect and holding as random effect (see following section). Due to possible confounding[12] these results should be interpreted cautiously and only within the context of an exploratory analysis. The bivariable analyses were carried out at overall level, for breeding and production holdings pooled together.

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[12] A variable is a confounding factor if it satisfies two conditions: it is a risk factor for *Salmonella*-contamination of pens and it is associated with an investigated exposure factor, but it is not a consequence of exposure. The presence of confounding can distort the relationship between the exposure and the disease leading to an over- or under- estimation of the effect of a potential risk factor. In order to eliminate confounding, and to obtain valid estimates of the effect of risk factors, an adjustment for the variable 'country' as well as for the other recorded factors is necessary, which can be achieved by multivariable regression analysis. In certain cases, however, two or more potential risk factors may be so strongly associated that separate estimates of their respective effects cannot be obtained. In this case, the term collinearity or multicollinearity is used.

Descriptive analyses were performed in SAS 9.2, using Proc Report and Proc Tabulate to present the data from the SAS file directly in tabular form.

### 4.4.4. Identification of factors associated with *Salmonella* pen positivity

Multivariable regression analysis was applied to obtain adjusted estimates of the effect measure of factors associated with the *Salmonella* pen positivity in holdings with breeding pigs. The inclusion of multiple factors (predictors) in a regression model adjusts for confounding that may result from associations between these factors. Multiple regression analyses were carried out at EU-level, including 23 MSs and one non-MSs. Countries without any *Salmonella*-positive pens (Finland and Norway) were not included in the multivariable regression analysis as fitting such models is not possible when the prevalence is zero in one of the countries.

4.4.4.1.   Analysis of multicollinearity among potentially associated factors

Data were further analysed for evidence of association among potentially associated factors, since they may be correlated with each other or one factor may completely explain the observed association of another (collinearity). The Variance Inflation Factor (VIF) was used as a formal method to detect correlation among candidate variables for the multiple regression analysis (multicollinearity). Essentially, each potential risk factor is used as the outcome in a regression analysis (described in detail in Appendix E). A VIF value that equals 1 indicates that there is no correlation between risk factors, whereas VIF values higher than 1 indicate a correlation. VIF values exceeding 10 are interpreted as an indication of strong multicollinearity. In addition to the VIF, the condition index was used as collinearity diagnostics. Values of the condition index above 30 are indication of severe multicollinearity, while values between 15 and 30 can be reason of concern (further details in Appendix E).

4.4.4.2.   Statistical model

Given the use of a binary outcome variable (*Salmonella*-positive or negative pen status) taking only two mutually exclusive values (which were coded as "1" when the faeces sample was positive and "0" otherwise), logistic regression was the model of choice. However, as previously performed for the prevalence estimation presented in Report Part A (EFSA, 2009b), certain data properties needed to be taken into account in the analysis. The data analysed originated from a complex survey design and the aspects described in the following section were considered.

4.4.4.3.   Aspects of clustering and of weighting of results

Holdings to be sampled were enrolled in the survey by participating countries. Moreover, within each selected holding, samples were collected from 10 randomly chosen pens, which were the epidemiological units of the analyses. Pens belonging to the same holdings were exposed to similar conditions and to certain common risk factors, including those on which no information was available in the current survey, but that might be associated with *Salmonella*-positivity. Specifically, pens belonging to the same holdings are more likely to be characterised by similar rearing processes, including similar origins of breeding pigs as well as comparable managerial and hygiene practices of farming. It was therefore reasonable to assume that pens originating from the same holding could not be considered as independent observations in the statistical analysis. Consequently, correlation of outcomes in pens from the same holding was accounted for in the regression models.

For the analysis of potential EU-level risk factors for *Salmonella* pen positivity, a model was fitted where the effect of the holding was included as a random intercept, resulting in a random intercept logistic regression. The assumption underlying this type of model is that each holding, and consequently each pen belonging to that holding, is characterised by a certain baseline-level of risk of positivity, regardless of the exposure to risk factors considered in the survey. The inclusion of a

random intercept for holdings in the model allows taking into account the within-holding correlation of *Salmonella*-positive pens. The random intercept models consider the population of interest as infinite. This statistical approach, the so-called "model-based" inference (EFSA, 2009c), is different from the Part A report where a "design-based" approach was used to estimate prevalence in a well-specified population. It is noteworthy that the interpretation of the regression coefficients (odds ratios - ORs) in this model is conditional on the holding-specific effects and that they cannot be interpreted as describing population-averaged effects of factors. This means that the obtained ORs are to be interpreted relative to holdings having comparable risk factors. Possible country confounding effects were also taken account in the analysis. Thus, regression models were fitted, where the effect of the holding was included as a random intercept and the effect of the country as a fixed effect. These mixed-effects models enabled investigating differences in the outcome (*Salmonella* positive pens) between holdings, within countries.

In 3% of sampled holdings, the total number of pens was less than 10 and, in line with the survey design, certain pens were re-sampled in these holdings, in order to reach the required total of 10 routine samples. Such sample results from the same pen cannot be considered as independent observations. However, because an adjustment of the statistical analysis for this correlation was technically not feasible and because the number of re-sampled pens was small, this aspect of clustering was not taken into account in the analysis. A sensitivity analysis was carried out by analyzing the data using only a single sample per pen (randomly sampled from the available samples). This showed that the width of confidence intervals did not change appreciably and all effects that were statistically significant remained so.

When estimating the EU-level prevalence in Part A report, weighting of the MS prevalences with the reciprocal of sampling probabilities was necessary in order to derive a proper estimate of the prevalence in the EU population, which is an existing population that can be exactly specified. In the present report Part B however the aim was to investigate effects of factors associated with *Salmonella* pen positivity in the sampled population of holdings and less to extrapolate to the aforementioned existing population. Consequently, the choice of the methods of analysis was geared towards that aim implying no use of weighting as this would decrease the power of the analysis.

### 4.4.4.4. Model building for *Salmonella*-positivity, at EU-level

The full (initial) model investigating *Salmonella*-positivity included a global intercept, the factors of interest, and a random intercept for holding. One by one the factors which were non significant were discarded starting by the largest *P*-value based on the Type III test. Only factors with *P*-values smaller than 0.05 were retained in the final model. The model was fitted using the GLIMMIX procedure in the SAS system. More details on the statistical approach are given in Appendix E.

As the survey was originally designed for analysis of breeding holdings and production holdings separately, based on the expectation that different mechanisms might be in operation in those groups, the interactions with 'holding type' (breeding holding, or production holdings) were also investigated for all the variables retained in the final model after backward selection (detailed in Appendix E). Moreover, in order to check if any of the factors discarded during the backward selection procedure had a different effect in breeding and production holdings, the interaction terms between 'holding type' and the variables that were discarded during the backward selection procedure were also tested, and included in the final model when statistically significant.

As in the Part A report, this Part B presents observed prevalence estimates that do not account for test misclassification bias, i.e. imperfect sensitivity or specificity of the test.

4.4.4.5. Analysis of the variance explained by the holding random effect

According to the outcome of the random effects models, the total variability could be split into two parts: one part explained by the investigated factors included in the model and a remaining unexplained part. The latter unexplained variance might be due to factors for which no data were gathered during the survey. However, even in the hypothetical case that all existing risk factors for *Salmonella* would have been included in the model, there still could be a certain amount of unexplained variance due to the fact that *Salmonella* is an infective agent, leading to clustering of infected pens within holdings. This unexplained variance was further investigated to quantify the proportion attributable to random effects (holding-specific effects). Therefore, the intra-holding or intra-cluster correlation coefficient (ICC) was estimated and approximated as the ratio of the variance of the random effects over the sum of the variance of the random effects and the variance of the standard logistic density (Molenberghs and Verbeke, 2005). The ICC ranges between zero and one corresponding respectively to scenarios of low (closer to zero) or high (closer to one) proportions of unexplained variance that was due to random effects (holding-specific effects, between-holding variability). In the latter case the *Salmonella* positivity results of pens within a holding are very much associated (alike). Caution is warranted while interpreting the ICC, because no conclusions can be made as regards the sources of the unexplained variance captured by the random intercept. This is because the proportion of unexplained variance due to random intercept could be either attributed to uninvestigated holding-specific factors and/or to the clustering of *Salmonella* linked to its infectious character. Details on the calculations of the ICC in the context of the used random effects models are presented in Appendix E.

4.4.5. **Estimation of the Population Attributable Fractions**

In order to estimate the potential impact of the associations found in the final multivariable regression model including interaction terms with holding type 'Population Attributable Fractions (PAFs)' (Last, 1983; Deubner et al., 1980) were calculated. In the context of this report PAFs should be interpreted as "partial impact fractions" because they estimate the proportional (%) reduction of *Salmonella*-positives pens that would be observed if the exposure - of all pens in the population - to the risk factor was reduced to less than its current (actual) exposure pattern. The choice of the "reduced exposure" categories was based on a realistic approach, taking into account the feasibility of having the chosen reference categories for the whole population. Possible future changes in the pig production management system were also considered when selecting the "reduced exposure" categories of potential risk factors. In the present report, PAF calculation is used as a theoretical approach as no specific assumption of causal relationship can be made based on cross-sectional studies.

As PAFs aim at estimating effect sizes in a specified population, weighting of the results was relevant. The report therefore presents both unweighted and weighted PAFs. Unweighted PAFS can be interpreted as theoretical potential reductions of *Salmonella*-positive pens in all holdings included in the baseline survey. Weighted PAFs should be interpreted as theoretical potential reductions of *Salmonella*-positive pens in all holdings with more than 50 breeding pigs in the EU because they take account of the disproportionate sample in the MSs. The holdings were weighted with the reciprocal of the sampling proportion for holdings (the number of holdings in a MS divided by the number of sampled holdings in the same MS). More detailed explanations on estimation of the PAFs are given in Appendix E.

4.5. **Analysis of the *Salmonella* serovar distribution across the EU**

The analyses of the *Salmonella* serovars in breeding pigs in the EU were based on the dataset described in the Part A of this report. The descriptive analysis of the serovar data was performed in SAS Enterprise Guide 3.0 and Microsoft Excel. Phage typing data were only available for a few MSs and were not considered.

### 4.5.1. Comparison of the distribution of *Salmonella* serovars between countries

For this report, data including country level prevalences for each *Salmonella* serovar were analysed. ArcGIS 9.3 was used to produce prevalence maps showing the spatial distribution of *Salmonella* spp. and the ten most commonly reported *Salmonella* serovars in the EU among MSs and non-MSs participating in the baseline study. Since geographical data were only available at country-level, it was not possible to appropriately investigate the spatial distribution of *Salmonella* serovars across the EU using spatial statistics.

The serovar distributions in breeding and production holdings were compared to those in other animal sources, animal feed and humans. The serovar distributions in animal populations were those of the *Salmonella* BS in holdings with laying hens (EFSA, 2007a), in broiler flocks (EFSA, 2007b), in slaughter pigs (EFSA, 2008b), in turkey flocks (EFSA, 2008a) and on broiler carcasses (EFSA, 2010b). The serovar distributions in humans and in feed originated from the EU Summary Reports (EUSR) 2005-2008 (EFSA, 2006, 2007c, 2009a, 2010a). Tables and bar graphs were produced using Microsoft Office Excel 2008.

### 4.6. Analysis of the within-holding prevalence study

Five Member States (the Czech Republic, Denmark, Slovenia, Sweden, and the United Kingdom) participated in an additional within-holding prevalence study. Together, 10 holdings, selected at random in each of the five MSs from the overall sample of breeding holdings and of production holdings were subjected to more intensive sampling. On each of the total of 49 holdings (one of the five MSs was only able to implement the additional sampling scheme in nine holdings), 10 routine pooled samples were collected. In addition, in the selected pens where a routine pooled sample was taken, 10 individual samples were collected and identified in such a manner that these 10 individual samples could be associated with the routine sample from that pen. Thus in total, 10 routine samples and 100 ($10 \times 10$) individual samples were collected from each of the 10 holdings. A further artificially pooled sample, consisting of ten individual samples from a pen, was also subjected to testing for *Salmonella*. Further details on the sampling and testing methods are described in the Commission Decision 2008/55/EC[13].

The first purpose of the within-holding prevalence study was the quantification of the sensitivity of the pooled faecal sampling to detect *Salmonella* infection in pigs. These sensitivity results served the ultimate purpose of estimating the EU level and MS specific true prevalence of *Salmonella*-positive holdings with breeding pigs.

Bayesian analysis techniques were used to analyse the data of the within-holding prevalence study. The basic idea behind the Bayesian approach is that prior knowledge (the "priors") relating to the unknown parameters (the test characteristics of faecal sampling for detection of *Salmonella* in pigs: sensitivity of the individual and pooled faecal sampling) can be included in the statistical analysis and will influence the final estimates. Since the final estimates (the "posteriors") resulting from Bayesian models are based on both the priors and the data, they are supported by more information than the observed data alone. In this case, the Bayesian approach allowed to make use of findings from previous studies on the sensitivity of pooled and individual sampling for detection of *Salmonella* in pigs (Arnold and Cook, 2009; Arnold et al., 2005). Medians of posterior distributions for each parameter of interest are usually used as point estimates, while 95% credible intervals (CrI) can be calculated by using appropriate percentiles of the estimated posterior distributions. In a Bayesian analysis, a mathematical model is developed which utilises prior information and the observed study

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[13] Commission Decision 2008/55/EC of 20 December 2007 concerning a financial contribution from the Community towards a survey on the prevalence of *Salmonella* spp. and methicillin-resistant *Staphylococcus aureus* in herds of breeding pigs to be carried out in the Member States (notified under document number C(2007) 6579), OJ L 14, 17.1.2008, pp. 10–25.

results to perform a set of calculations that yield an estimate of the various parameters of interest, e.g. prevalence. Within the model, there are so-called stochastic components that take on a different value from a range of possible values each time the model is run. Thus, every run can deliver a different set of results. Many thousands of iterations are conducted and the results from every run are saved. The 95% credible interval for any output, such as the estimated prevalence, is that within which 95% of the model results lie. Thus, the 95% credible interval can be thought of as analogous to a conventional 95% confidence interval although the basis of estimation is very different.

The Bayesian model used in the present analyses can be described as a "two-step" model. First, the detailed data on routine pooled samples, artificially pooled samples and individual samples from the five MSs conducting the within-holding prevalence study were analysed to obtain an estimate of the sensitivity of the routine pooled samples. These data were also used to provide information on variation in the proportion of positive samples in each pen. The true within-holding prevalence was then estimated for every holding that participated in the study. Successively, the outputs of the "first step" model were used in the "second step" of the Bayesian model to perform analysis for all 26 countries participating in the survey, where only routine pooled samples were taken. In particular, the posterior estimates for the sensitivity of artificial pooled samples, and the degree of clustering of infection within infected pens from the "first step" model were used as priors for the "second step" of the analyses. This enabled the within-holding prevalence of *Salmonella* for each of the 5,117 holdings sampled in the survey and MSs' true prevalence of *Salmonella*-positive holdings to be estimated with much greater certainty by taking into account the imperfect test sensitivity. However, the representativeness of the inputs to the "second step" of the model was limited by the fact that only five countries participated in the within-holding prevalence study.

All model fitting was conducted in WinBUGS version 1.4.3. Further details on the statistical analysis are presented in Appendix N.

## 5. Results

### 5.1. Correlation between the prevalence of *Salmonella*-positive breeding and production holdings

The scatter diagram of the prevalence of *Salmonella*-positive breeding holdings versus production holdings is displayed in Figure 1. Similar scatter diagrams for *S*. Typhimurium, *S*. Derby and serovars other than *S*. Typhimurium and/or *S*. Derby are presented in Appendix F.

The scatter diagram shows that the prevalence of *Salmonella*-positive production holdings increases as the prevalence of *Salmonella*-positive breeding holdings increases, meaning that there is a positive correlation. This observation is notably clearer for countries with a prevalence above 5% for either breeding or production holdings. The estimated correlations are presented in Table 2. This table also includes *P*-values from testing the null hypothesis of no association between the prevalence estimates in the two types of holdings. Significant correlation was observed for *Salmonella*, *S*. Typhimurium, *S*. Derby and for serovars other than *S*. Typhimurium and/or *S*. Derby ($P<0.05$). These significant results are based on calculations that also take into account the results from MSs that reported no positive outcomes for both breeding and production holdings.

**Table 2:** Spearman's correlation coefficients and corresponding *P*-values for the correlation test between the prevalence of *Salmonella*-positive breeding and production holdings. *Salmonella* EU baseline survey, 2008 [a]

| Prevalence | Spearman ρ | *P*-value |
|---|---|---|
| *Salmonella* | 0.924 | <.0001 |
| *S*. Typhimurium | 0.868 | <.0001 |
| *S*. Derby | 0.725 | <.0001 |
| Other *S*. serovars | 0.765 | <.0001 |

[a] Greece, Malta and Romania did not conduct the survey and two non-MSs, Norway and Switzerland, participated.
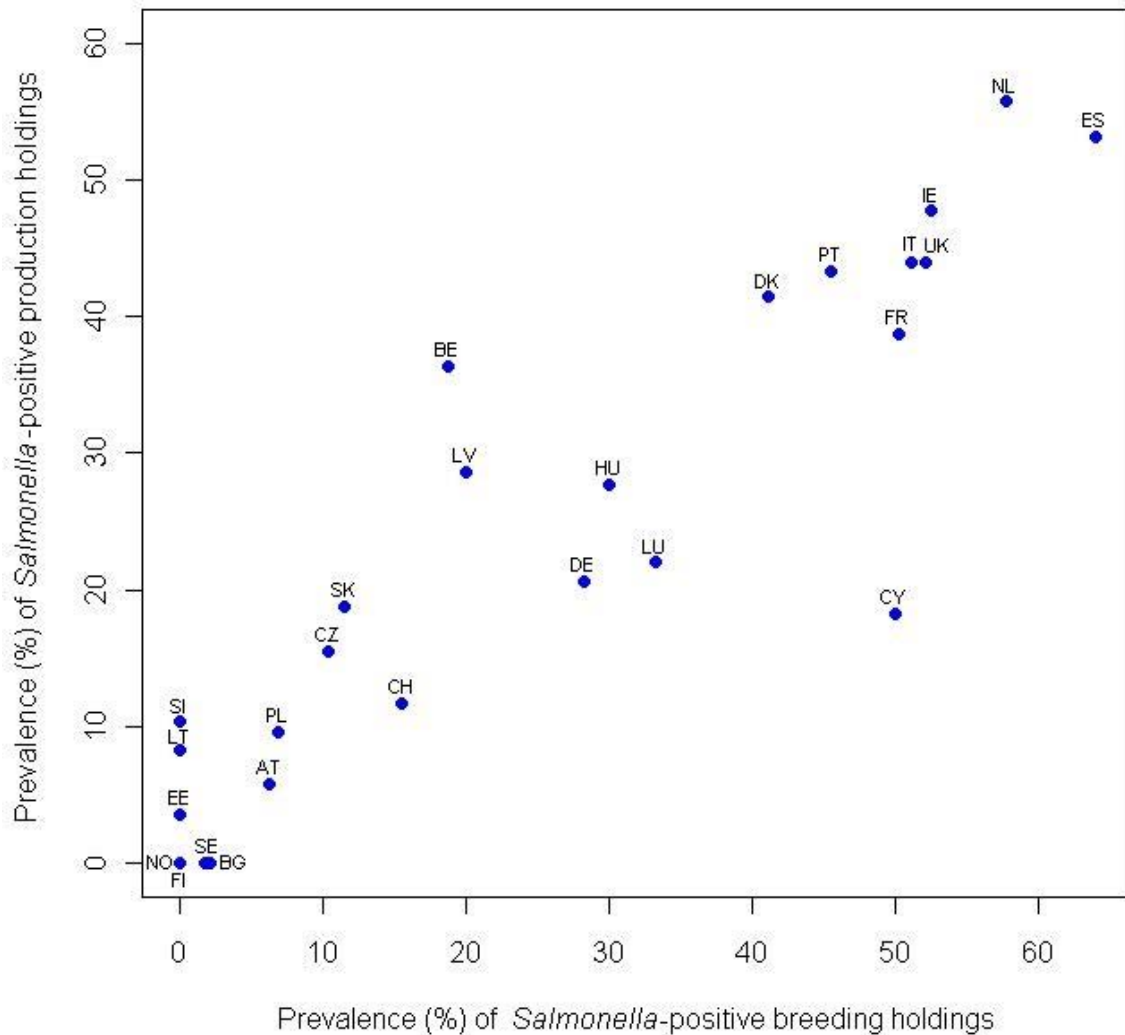
**Figure 1:** Scatter diagram of the prevalence of *Salmonella*-positive breeding holdings versus the prevalence of *Salmonella*-positive production holdings, *Salmonella* EU baseline survey, 2008

### 5.2. Analysis of factors associated with *Salmonella* pen positivity

### 5.2.1. Exploratory analysis of potentially associated factors

Detailed univariable description and bivariable association analyses results of factors potentially associated with *Salmonella*-positive pens are presented in Appendix G (Tables 14-15, Figures 14-31). The most interesting univariable descriptive results are illustrated hereafter. As already mentioned in the section on Materials and Methods, due to possible confounding these results should be interpreted cautiously and only within the context of an exploratory analysis.

• Holding size (number of breeding pigs present in the holding on the date of sampling)

Figure 2 displays the proportion of *Salmonella*-positive pens according to the size of the holding. The proportion of positive pens appeared to increase as the size of the holding increased up to a size of 999 pigs; following which, the proportion of positive pens tended to decrease.

Breeding pig holding
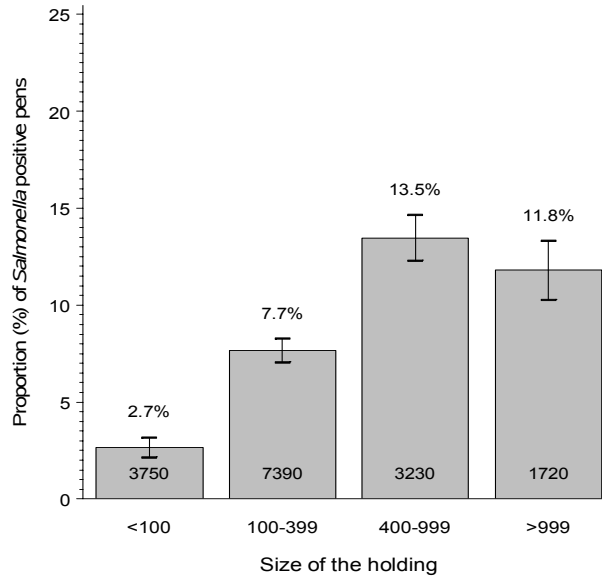


Production pig holding
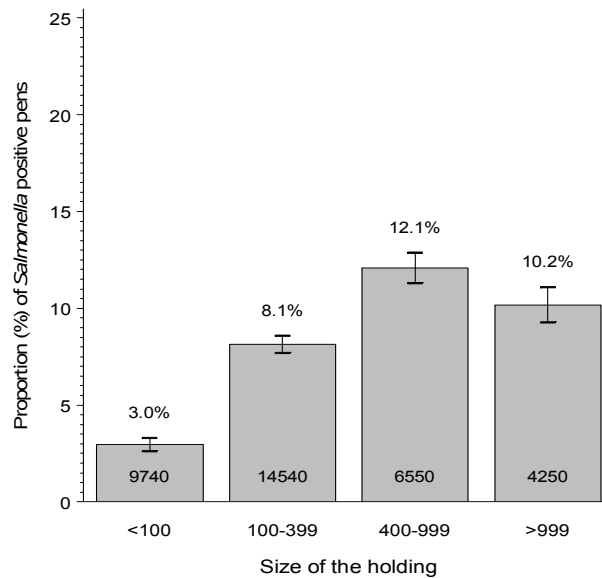


**Figure 2:** Proportion of *Salmonella*-positive pens in breeding and production holdings with 95% CI by holding size (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

• Floor type

Figure 3 displays the proportion of *Salmonella*-positive pens according to the type of floor. In both breeding and production holdings, the proportion of *Salmonella*-positive pens appeared to differ between pens having different types of floor. For example, the proportion of positive pens was higher in outdoor pens (field or paddock) than in indoor pens with diverse types of floor.

Breeding pig holding
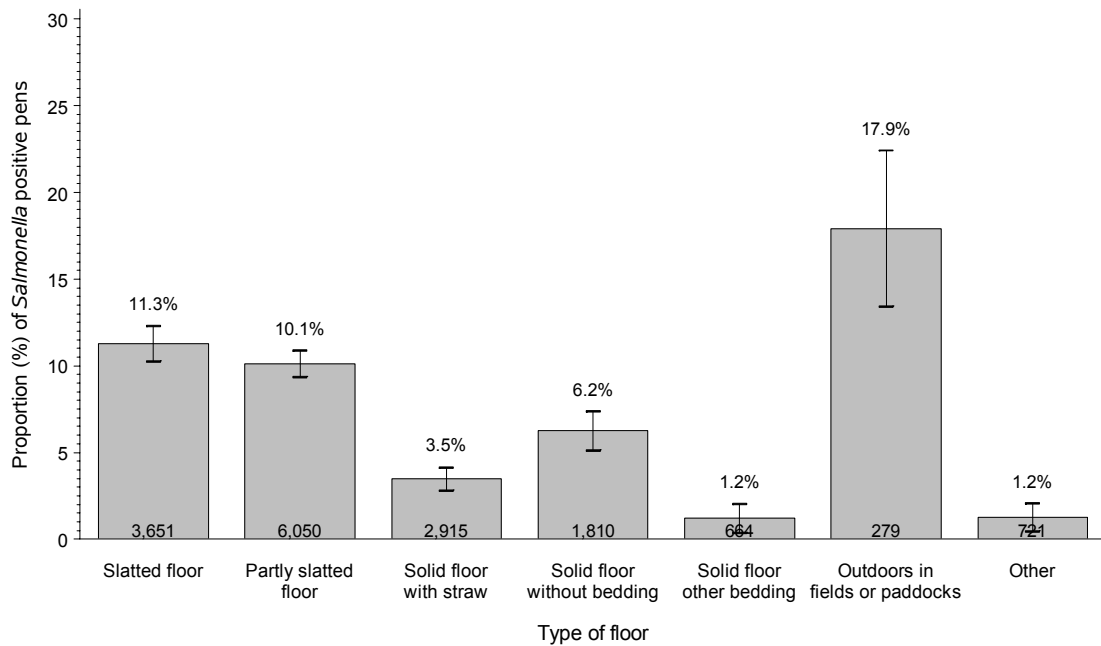


Production pig holding
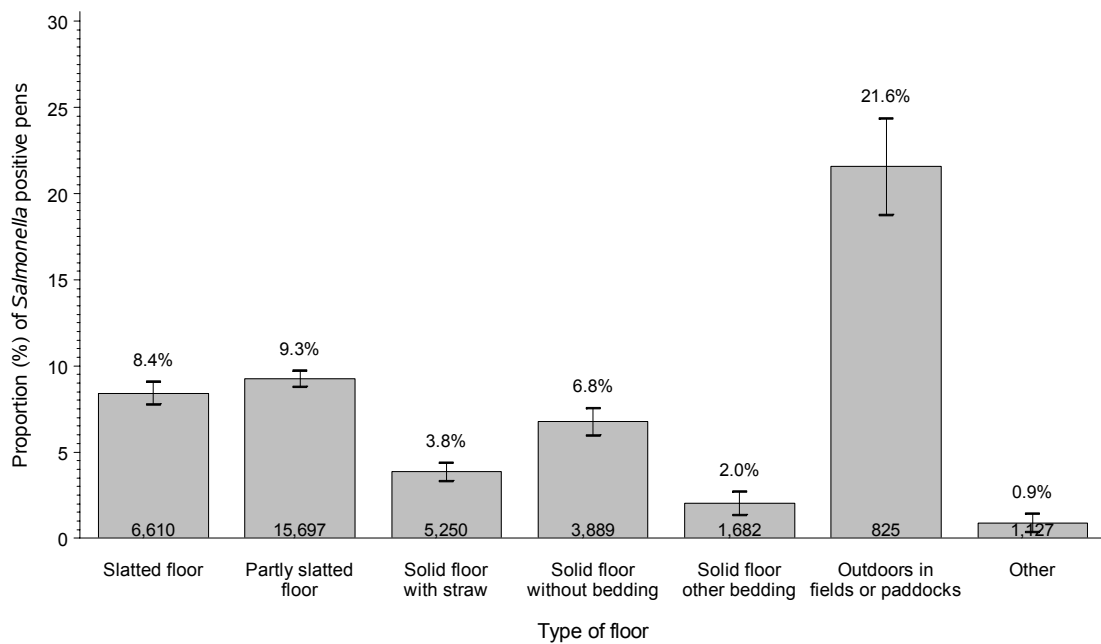


**Figure 3:**    Proportion of *Salmonella*-positive pens in breeding and production holdings with 95% CI by floor type (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

• Origin of the feed

Figure 4 illustrates the proportion of *Salmonella*-positive pens according to the origin of the feed used for pigs. Both in breeding and production holdings, the proportion of *Salmonella*-positive pens appeared to differ between pens where pigs were fed with feed of different origin. Specifically, a higher proportion positive was found for pens where pigs were fed with commercial compounds compared to pens with feed of non-commercial origin.

Breeding pig holding
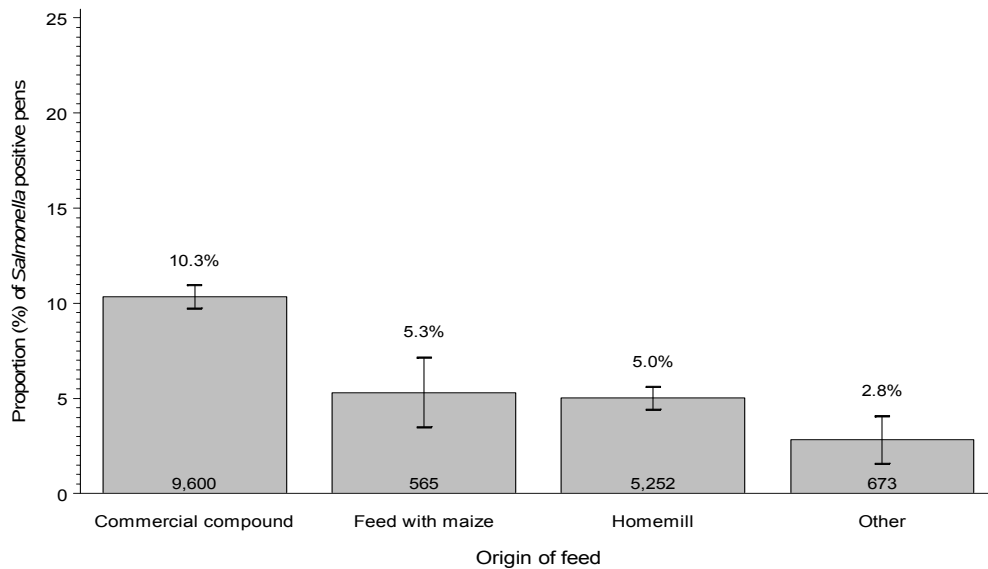


Production pig holding
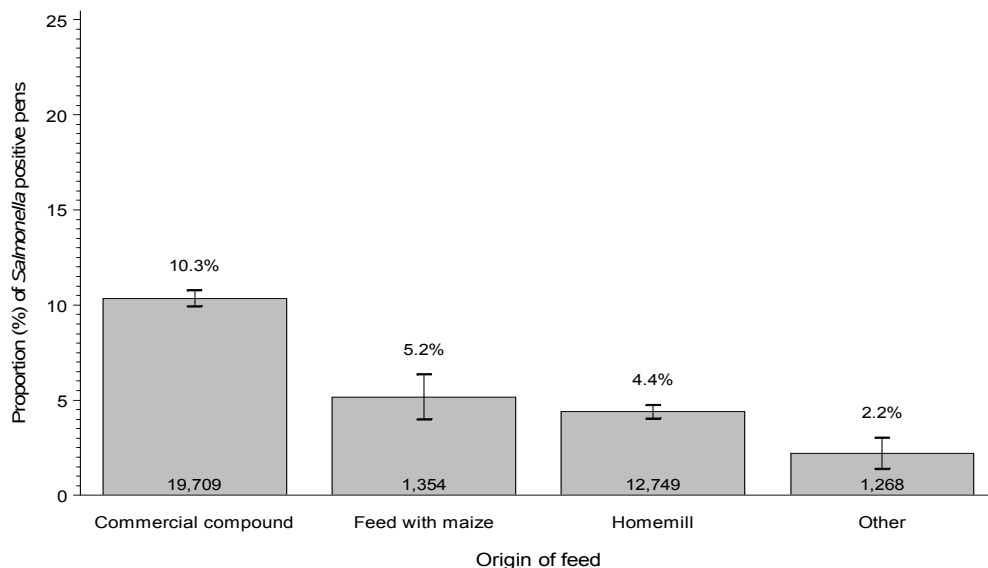


**Figure 4:** Proportion of *Salmonella*-positive pens in breeding and production holdings with 95% CI by feed origin (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

- Type of diet

Figure 5 illustrates the proportion of *Salmonella*-positive pens according to the diet of the pigs. In both breeding and production holdings, the proportion of *Salmonella*-positive pens appeared to be higher for pens where pigs were fed with a pelleted dry diet (cobs/rolls/nuts/pellets) compared to pens where pigs were fed with liquid (porridge/liquid), meal (meal/mash) and other/mixed diet (others).
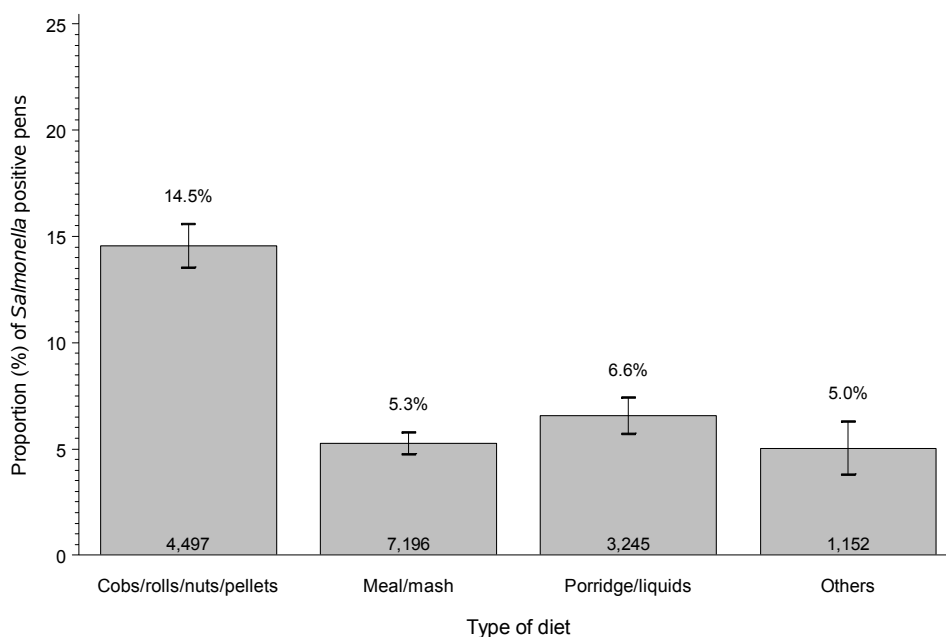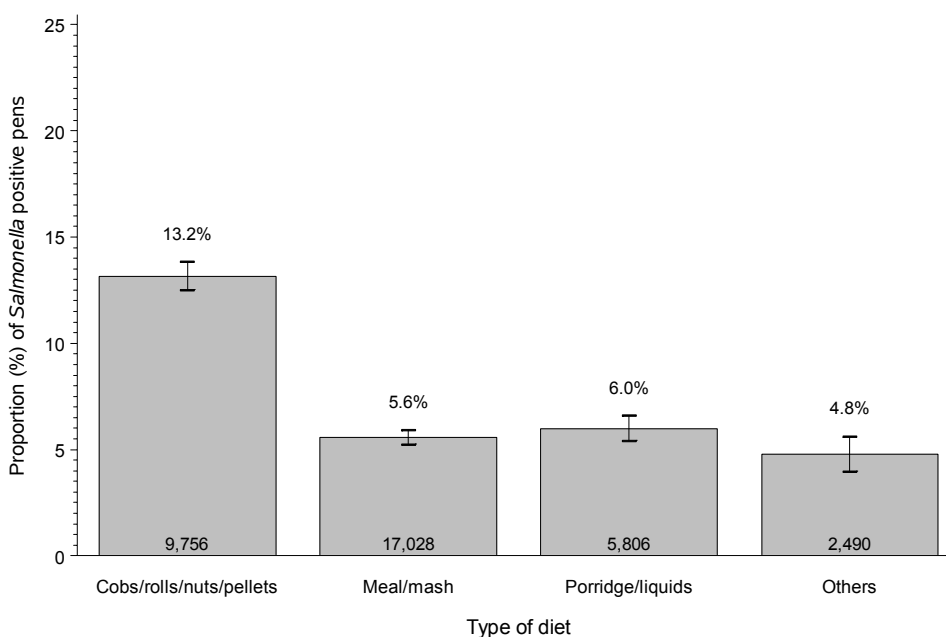


**Figure 5:** Proportion of *Salmonella*-positive pens in breeding and production holdings with 95% CI by type of diet (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

### 5.2.2. Analysis of multicollinearity among potentially associated factors

The VIF values calculated to test for the multicollinearity among the factors associated with *Salmonella* pen positivity in holdings with breeding pigs in the EU are presented in Appendix E. The most serious collinearity was between 'production stage' and 'gender of the pigs', which lead to a VIF of 9.95 for the variable 'gender of the pigs'. Therefore the variable 'gender of pigs' was left out of the multivariable analysis. Without this variable, the condition index became 18.1, and the higher VIF was 8.5. Inspection of the condition matrix revealed that this condition index was created by the correlations between country, production stage and age of the pigs.

### 5.2.3. Multivariable regression analysis at EU level

A full random effects model was fitted including the holding as random intercept and the following factors as fixed effects: country, delay between sampling and testing (in days), season, breeding/production type, holding size, gilt replacement policy, boar replacement policy, type of sample, number of pigs per pen, age of pigs, production stage, indoor/outdoor production, individual housing, floor type, all in/all out and clean, origin of feed, type of diet, probiotic feed/water supplement, organic acid feed/water supplement, other feed/water supplement, use of antibiotics. The OR estimates for the factors included in the full multiple random effect model are illustrated in Appendix H (Table 15).

The factors that were excluded based on the backward selection procedure were, consecutively: use of antibiotics, gilt replacement policy, individual housing, delay between sampling and testing, all in/all out and cleaned, breeding/production type, indoor/outdoor production, organic acid feed/water supplement, age of pigs, other feed/water supplement, probiotic feed/water supplement, and season.

The following factors for *Salmonella*-positive pens in holdings with breeding pigs were retained in the logistic mixed-effects model resulting from backwards selection: holding size, boar replacement policy, number of pigs per pen, production stage, floor type, origin of feed, type of diet and 'type of sample'.

Successively, interaction terms of the investigated variables with 'holding type' (breeding holding, or production holdings) were also included in the model. Significant interactions of 'holding type' with 'floor type' and 'gilt replacement policy' were detected. The OR estimates for these two factors are presented separately for breeding and production holdings in Table 3. As a consequence of including the interaction terms with 'holding type' in the model, the factor 'boar replacement policy' became non-significant (*P*-value=0.051) and was left out of the final model.

In Table 3, an OR > 1 indicates that exposure of pens to the factor increases the risk of *Salmonella* positivity, whereas an OR < 1 indicates a reduced risk of pen positivity due to exposure to the factor. An OR equal to 1 indicates no effect of the factor on *Salmonella* positivity. Consequently, if the 95% CI of the OR does not comprise 1, meaning that both the lower and the upper limits are either greater, or less than 1, it can be concluded that the association with a potential factor and *Salmonella* pen positivity is statistically significant (*P* < 0.05).

**Table 3:** Final logistic mixed-effects model[a] for factors associated with *Salmonella*-positive pens including interaction terms, *Salmonella* EU baseline survey, 2008

| Risk factor[a] | Comparison | OR[b] | 95% CI | | DF[c] | P-value |
|---|---|---|---|---|---|---|
| **SAME EFFECT IN BREEDING AND PRODUCTION HOLDINGS** | | | | | | |
| Holding size | 100-399 vs <100 | 1.84 | 1.34 | 2.53 | 3 | <.0001 |
| | 400-999 vs <100 | 3.23 | 2.26 | 4.62 | | |
| | >999 vs <100 | 5.25 | 3.48 | 7.93 | | |
| Number of Pigs in Pen | Per 10 pigs | 1.03 | 1.00 | 1.06 | 1 | 0.0230 |
| Production stage | Pregnant vs Maiden gilts | 0.81 | 0.67 | 0.96 | 4 | <.0001 |
| | Farrowing and lactating vs Maiden gilts | 0.65 | 0.53 | 0.80 | | |
| | Service area vs Maiden gilts | 1.06 | 0.86 | 1.30 | | |
| | Mixed vs Maiden gilts | 0.86 | 0.67 | 1.10 | | |
| Origin of feed | Other vs Commercial compound | 0.51 | 0.27 | 0.97 | 3 | 0.0001 |
| | Feed with maize vs Commercial compound | 0.62 | 0.36 | 1.04 | | |
| | Home-mill vs Commercial compound | 0.58 | 0.45 | 0.74 | | |
| Type of diet | Others vs Cobbs/rolls/nuts/pellets | 0.67 | 0.43 | 1.05 | 3 | <.0001 |
| | Meal/mash vs Cobbs/rolls/nuts/pellets | 0.52 | 0.41 | 0.67 | | |
| | Porridge/liquids vs Cobbs/rolls/nuts/pellets | 0.46 | 0.34 | 0.62 | | |
| **DIFFERENT EFFECT IN BREEDING AND PRODUCTION HOLDINGS** | | | | | | |
| **BREEDING HOLDINGS** | | | | | | |
| Floor type | Outdoors in fields or paddocks vs Slatted floor | 1.18 | 0.57 | 2.45 | | 1) |
| | Solid floor other bedding vs Slatted floor | 1.83 | 0.43 | 7.84 | | |
| | Solid floor with straw vs Slatted floor | 0.63 | 0.38 | 1.03 | | |
| | Solid floor without bedding vs Slatted floor | 1.30 | 0.77 | 2.20 | | |
| | Partly slatted floor vs Slatted floor | 1.01 | 0.76 | 1.35 | | |
| | Other vs Slatted floor | 3.82 | 1.21 | 12.10 | | |
| Gilt replacement policy | 10-90% Gilts homebred vs >90% Gilts homebred | 0.32 | 0.18 | 0.58 | | 2) |
| | >90% Gilts purchased vs >90% Gilts homebred | 0.76 | 0.52 | 1.10 | | |
| **PRODUCTION HOLDINGS** | | | | | | |
| Floor type | Outdoors in fields or paddocks vs Slatted floor | 3.32 | 2.04 | 5.39 | | 1) |
| | Solid floor other bedding vs Slatted floor | 2.37 | 1.08 | 5.19 | | |
| | Solid floor with straw vs Slatted floor | 1.12 | 0.75 | 1.67 | | |
| | Solid floor without bedding vs Slatted floor | 2.07 | 1.49 | 2.89 | | |
| | Partly slatted floor vs Slatted floor | 1.43 | 1.15 | 1.77 | | |
| | Other vs Slatted floor | 1.04 | 0.40 | 2.68 | | |
| Gilt replacement policy | 10-90% Gilts homebred vs >90% Gilts homebred | 1.37 | 0.96 | 1.95 | | 2) |
| | >90% Gilts purchased vs >90% Gilts homebred | 1.15 | 0.90 | 1.46 | | |

[a] Odds ratio estimates and standard errors were assessed using a mixed-effects model with the effect of holdings included as a random intercept and with the factor 'country' included as a fixed effect. The between holding variance (on the log-odds scale) is 4.20 with a 95% confidence interval of [3.79; 4.67]. Both the holding (random intercept) and the country effects were statistically significant (*P*-value<0.0001). Single country effects are not shown.

[b] All odds ratios were adjusted for the factor 'sample type', which was also retained in the final model.

[c] DF=degrees of freedom.

1) Type III *P*-value of the of the main effect: 0.0002 (6 DF); type III *P*-value of the interaction: 0.0001 (6 DF)

2) Type III *P*-value of the of the main effect: 0.078 (2 DF); type III *P*-value of the interaction: 0.0198 (2 DF)

The final model included country-specific effects (not shown) and the factor sample type and ORs are, therefore, adjusted for these variables. According to the analyses, the sample type appeared to be significantly related to the sensitivity of the sampling and testing process. In particular, the use of

composite sample was found to be associated with a lower *Salmonella* positivity compared to the swab sample (OR 0.74; 95%CI: 0.58-0.93; *P*-value 0.01).

The results showed that the probability of *Salmonella* pen positivity in holdings with breeding pigs increased as the size of the holding, as measured by the number of breeding pigs, increased. For example, the odds of detecting *Salmonella*- positive pens in a holding housing between 400 and 999 breeding pigs was 3.23 times higher than the odds for a holding housing less than 100 breeding pigs. The odds of having a positive *Salmonella* result increased with the number of pigs per pen, with a 3% increase per 10 additional pigs. The production stage of the pigs in the pen was also significantly associated with *Salmonella* pen positivity with pens hosting maiden gilts having higher odds of being positive compared to pens with pregnant or farrowing and lactating pigs. Home-mixing of feed was found to have a greater protective effect than sourcing feed from a company. In addition to the origin of the feed, the type of diet (formulation of the ration) was also found to be significantly associated with *Salmonella*. Specifically, the use of pelleted feed, which is usually finely ground, was associated with higher odds of pen positivity when compared to meal or wet feed.

The type of floor was also significantly associated with *Salmonella* pen positivity but its effect was different in breeding holdings and production holdings. In production holdings pens with '(fully) slatted floor' were found to be significantly associated with lower odds of *Salmonella* positivity than the other types of solid floor, except 'solid floor with straw' and 'other' with which there were no statistically significant differences. Pens with a floor type 'outdoor in field or paddock' had more than three times higher odds of *Salmonella* positivity than the 'fully slatted floor'. Conversely, in breeding holdings, only the category 'other' type of floor put pens significantly at risk for *Salmonella* positivity when compared to pens with 'slatted floor' and no other associations were found between the type of floor and the *Salmonella* positivity.

The gilt replacement policy was significantly associated with *Salmonella* pen positivity in breeding holdings, but not in production holdings. Specifically, pens in breeding holdings housing 10-90% of gilts homebred had lower odds of being *Salmonella*-positive than pens in holdings housing more than 90% of gilts homebred.

The random intercept (effect of holdings) was highly significant (*P*<0.0001). This indicated that the baseline risk of *Salmonella*-positive pens varied between the holdings, even when other factors such as country, holding size, number of pigs per pens, production stage, origin of feed, type of diet, floor type, gilt replacement policy and significant interactions with holding type were accounted for. Consequently, within countries, there were holdings with an overall higher prevalence and holdings with an overall lower prevalence of *Salmonella*-positive pens. The proportion of the total variance in the prevalence of *Salmonella* positive pens that could be either attributed to uninvestigated holding-specific factors and/or to the clustering of *Salmonella* linked to its infectious character was 56%.

### 5.2.4. Population Attributable Fractions

Table 4 illustrates the population attributable fractions (PAFs) as calculated from the final regression model with interactions (see Table 3). For each of the factors included in the final model, the PAF was calculated for one or two scenarios of reduced exposure. Only scenarios related to risk factors that are amenable for control measures were considered.

**Table 4:** Population attributable fractions estimating the expected reductions (%) in the number of *Salmonella*-positive pens by theoretical elimination of significant risk factors for the EU MSs, *Salmonella* EU baseline survey, 2008

| Variable | Theoretical scenarios of lower risk categories | Theoretical percentage reduction of *Salmonella*-positive pens [95% CL[(a)]] |
|---|---|---|
| **Holding size (scenario 1)** | All holdings would house less than 400 breeding pigs | 18.0 [8.2;25.3] |
| **Holding size (scenario 2)** | All holdings would house less than 1,000 breeding pigs | 4.4 [-5.1;11.6] |
| **Number of pigs per Pen** | All Pens would house 10 or less pigs | 3.2 [-5.9;9.3] |
| **Floor type (scenario 1)** | All floors (except solid floors with straw) would be (fully) slatted floors | 14.0 [2.2;21.7] |
| **Floor type (scenario 2)** | All floors (except slatted floors) would be solid floors with straw | 17.8 [-0.1;32.6] |
| **Origin of Feed** | All feed would be home-milled | 23.2 [10.7;33.7] |
| **Type of diet** | All diet would be porridge/liquid diet | 23.5 [8.7;33.4] |

[(a)] The confidence limits (CL) only reflect the uncertainty of investigated factors in the sampled holdings (see Materials and Methods). It was assumed that the risk factor distribution in the total population of holdings with breeding pigs in each country was equal to that in the sampled holdings.

For example, in a theoretical situation where all MSs would reduce the size of all their holdings to less than 400 breeding pigs, there would, in theory, be an 18.0 % reduction in the proportion of *Salmonella*-positive pens across the EU compared with the current holding size situation. If the holding sizes would be less than 1,000 breeding pigs (scenario 2), the theoretical reduction in *Salmonella* pen positivity, as compared to the current exposure pattern, would be 4.4%, which is much less than in scenario 1.

In Appendix I, Table 16 presents weighted PAFs that should be interpreted as theoretical potential reductions of *Salmonella*-positives pens in all holdings with more than 50 breeding pigs in the EU because they take account of the disproportionate sample in the MSs. It was concluded that weighting had very little impact on the results.

## 5.3. Analysis of the *Salmonella* serovar distribution across the EU

### 5.3.1. Frequency distribution of *Salmonella* serovars in holdings with breeding pigs

The *Salmonella* serovars isolated from the routine pooled faecal samples collected in breeding and in production holdings were previously reported in the part A report (EFSA, 2009b). A total of 1,430 breeding holdings and 3,211 production holdings from 24 MSs were sampled, in addition to 179 breeding holdings and 297 production holdings from Norway and Switzerland, adding up to 51,170 tested pooled faecal samples.

The number of holdings tested, number and percentage of positives and number of serovars found in each country in breeding and production holdings are shown in Appendix J (Tables 18 and 19).

In breeding holdings, 54 different serovars were isolated in the 22 countries where *Salmonella* was detected in at least one sample. The leading isolated serovar was *S*. Derby (23.9% of isolates and 29.6% of positive holdings), followed by *S*. Typhimurium (17.9% of isolates, 25.4% of positive holdings) and *S*. Infantis (5.0% isolates, 7.7% of positive holdings). The latter was mainly due to a large number of isolates from France and Denmark. *S*. Rissen had similar percentages to *S*. Infantis (4.5% and 7.3%), but included a large number of isolates from Spain. The occurrence of *S*. London appeared less frequent than *S*. Infantis and *S*. Rissen, but was highly affected by the Netherlands. It was, however, more widespread than *S*. Infantis and *S*. Rissen and would be present in a larger proportion if Dutch, French and Spanish isolates were removed. The top 20 serovars isolated from breeding holdings in the study are presented in Appendix J (Table 19), ordered by the percentage of holdings positive to specific serovars.

In production holdings, 87 serovars were reported in the EU, and only one was found in Switzerland (*S*. Javiana), adding up to 88 serovars in total. As observed for the breeding holdings, the leading serovars were *S*. Derby, observed for 23.7% of isolates and 21.6% of positive holdings, and *S*. Typhimurium (13.7% and 15.2%). *S*. London appeared in third place (8.5% and 7.2%), followed by *S*. Infantis and *S*. Rissen. The proportions of these serovars were heavily influenced by data from the Netherlands, Denmark and Spain, respectively. The top 20 serovars isolated from production holdings are presented in Appendix J (Table 20), ordered by the percentage of holdings positive to specific serovars.

MS-specific overviews of the frequency distribution of serovars are shown in the Part A report (EFSA, 2009b). Among breeding holdings, in countries with positive samples, the number of isolated serovars varied from one in Luxembourg and Sweden to 27 in Spain. Among production holdings, this number varied from two in Estonia to 31 in the United Kingdom.

*S*. Derby and *S*. Typhimurium were the predominant serovars in both breeding holdings and productions holdings. In breeding holdings, *S*. Derby and *S*. Typhimurium were present in 18 and 17 countries, respectively, and in production holding in 20 and 16 countries, respectively. In general, these two serovars occurred in both breeding and production holdings within the same country. Notable exceptions included Austria, where no *S*. Typhimurium was found in production holdings, Switzerland where no *S*. Typhimurium was found in breeding holdings, and Luxembourg where these serovars were only found in production holdings. *S*. Derby was the dominant serovar in Cyprus, Germany, Denmark, France and Latvia, while *S*. Typhimurium had this position in Belgium, Ireland and Poland, and was isolated from the only positive sample in Sweden. *S*. Livingstone, although only present in substantive proportions in Austria, Belgium, Germany and Denmark, was one of the most widespread serovars, found in 11 countries in breeding holdings and 13 countries in production holdings. Similarly, *S*. London, present in breeding holdings in eight countries, was found in proportions larger than 10% in Hungary, the Netherlands, Portugal and Slovakia. In production holdings, *S*. London was found in 15 countries, but only in Italy, the Netherlands, Portugal and the United Kingdom did it constitute more than 10.0% of isolates.

Several serovars occurred more widespread in production holdings as compared to breeding holdings, but often high proportions of occurrence were confined to a few countries. These serovars include *S*. Infantis, which was found in production holdings in 13 countries and in breeding holdings in 7 countries. However, large proportion only occurred in specific countries such as Denmark (17.3%) and Slovenia (30.8%). *S*. Bredeney was also more geographically widespread in production holdings (13 versus 6 countries), but with large proportions occurring in Switzerland (26.2%) and Latvia (17.4%). *S*. Anatum and *S*. Enteritidis were isolated in 10 countries in production holdings, but also with large proportions in a small number of countries, such as Slovenia and Slovakia for *S*. Enteritidis (26.9% and 25.6%) and Spain for *S*. Anatum (16.2%).

Finally, some serovars predominated in a few countries. For instance, the Czech Republic had *S*. Bovismorbificans in over 30% of its isolates from breeding herds and S. Agona in 42.5% of its

isolates from production holdings. In Latvia 43.5% of the isolates was *S*. Kimuenza. Switzerland and Italy were the only countries with over 50% of isolates made by serovars not included in the top 20.

### 5.3.2. Spatial distribution of *Salmonella* serovars in holdings with breeding pigs in the EU

The EU geographic distribution of the prevalence of breeding and production holdings positive to *Salmonella* spp., *S*. Typhimurium, *S*. Derby, *S*. Enteritidis, *S*. Infantis, *S*. Rissen, *S*. Livingstone, *S*. London, *S*. Anatum*, S*. Goldcoast and *S*. Bredeney is displayed in Figures 33-54 in Appendix K. These figures visualised the heterogeneous geographical distribution of *Salmonella* serovars across the EU.

### 5.3.3. Comparison between *Salmonella* serovar distributions in breeding pigs, other animal sources, feed and humans.

Nearly all of the serovars isolated from breeding pigs were also isolated from pig lymph nodes and carcasses in a previous baseline survey in slaughter pigs (Table 5). Among breeding holdings, production holdings, slaughter pig lymph nodes and carcass swabs, *S*. Derby and *S*. Typhmurium are the predominant serovars in most countries. An exception is observed in Cyprus, where no *S*. Typhimurium was found in breeding holdings and no *S*. Derby was observed in slaughter pigs. *S*. Enteritidis was generally more frequent in lymph nodes than in carcass swabs from slaughter pigs. Although *S*. Mbandaka and *S*. Meleagridis were not isolated from carcass swabs, it is important to note that these serovars were only isolated in Spain in production holdings and in Denmark, France and Spain in breeding holdings, with Spain responsible for 62% of the isolates. Of these three countries, only Denmark submitted carcass swab results as part of the baseline survey in slaughter pigs. The observed absence of these serovars in carcass swabs may, therefore, be merely a reflection of the serovar and prevalence variation between countries and detection limits of the various sampling protocols and may not reflect differences in transmission between steps in the production line.

When comparing the overall serovar distribution in pigs with other animal sources and feed, the number of serovars in common varies from 13 on broiler carcasses to 18 in laying hen flocks out of the top-20 serovars in holdings with breeding pigs (Table 5). However, despite this overlap, the proportion of some of the most important serovars differs markedly between the different animal reservoirs.

**Table 5:** Frequency of *Salmonella* serovars reported in the Community Summary Report on feed and in the baseline surveys in holdings with breeding pigs, in slaughter pigs, on broiler carcasses, in broiler flocks, laying hen holdings, and turkey fattening flocks

| *Salmonella* serovar | Breeding pigs[a] (breeding holdings) | Breeding pigs[a] (production holdings) | Slaughter pigs[b] (lymph nodes with serovar) | Slaughter pigs[b] (carcass swabs* with serovar) | Broiler carcasses with serovar[c] | Broiler flocks[d] | Laying hen flocks[e] | Fattening turkey flocks[f] | Detected in feed[g] (unspecified poultry or pig feed, or oil seed and fruit) |
|---|---|---|---|---|---|---|---|---|---|
| *S.* Derby | 134 | 271 | 380 | 94 | 9 | 13 | 14 | 123 | Yes |
| *S.* Typhimurium | 115 | 191 | 1,040 | 191 | 66 | 65 | 123 | 86 | Yes |
| *S.* Infantis | 35 | 58 | 49 | 13 | 358 | 295 | 171 | 72 | Yes |
| *S.* Enteritidis | 8 | 21 | 126 | 5 | 167 | 538 | 899 | 55 | Yes |
| *S.* London | 29 | 90 | 33 | 2 | 0 | 3 | 6 | 31 | Yes |
| *S.* Rissen | 33 | 56 | 151 | 2 | 0 | 3 | 17 | 26 | Yes |
| *S.* Livingstone | 25 | 50 | 9 | 4 | 12 | 39 | 50 | 1 | Yes |
| *S.* Bredeney | 13 | 40 | 51 | 8 | 53 | 10 | 26 | 186 | Yes |
| *S.* Anatum | 25 | 43 | 63 | 1 | 7 | 32 | 21 | 4 | No |
| *S.* Goldcoast | 13 | 39 | 14 | 1 | 0 | 1 | 2 | 0 | No |
| *S.* Agona | 9 | 24 | 28 | 4 | 37 | 16 | 38 | 31 | Yes |
| *S.* Bovismorbificans | 9 | 31 | 14 | 1 | 0 | 1 | 4 | 0 | No |
| *S.* Brandenburg | 8 | 27 | 31 | 7 | 3 | 2 | 7 | 0 | Yes |
| *S.* Mbandaka | 3 | 9 | 7 | 0 | 30 | 114 | 101 | 9 | Yes |
| *S.* Give | 8 | 18 | 11 | 1 | 0 | 0 | 5 | 1 | Yes |
| *S.* Panama | 8 | 16 | 5 | 3 | 0 | 0 | 0 | 0 | No |
| *S.* 4,5,12:i:- [h] | 6 | 15 | 104 | 4 | 1 | 0 | 0 | 0 | No |
| *S.* Kedougou | 15 | 11 | 7 | 1 | 11 | 19 | 35 | 12 | Yes |
| *S.* Meleagridis | 7 | 11 | 7 | 0 | 10 | 3 | 2 | 90 | Yes |
| *S.* Reading | 8 | 18 | 5 | 6 | 0 | 0 | 2 | 0 | Yes |

(a) EU survey in breeding pigs 2008 (EFSA, 2009b); (b) EU survey in slaughter pigs 2006-2007 (EFSA, 2008b); (c) EU survey in broiler carcasses 2008 (EFSA, 2010b); (d) EU survey in broiler flocks 2005-2006 (EFSA, 2007b); (e) EU survey in laying hens 2004-2005 (EFSA, 2007a); (f) EU survey in turkeys 2006-2007 (EFSA, 2008a); (g) EFSA Community Summary Report 2008 (EFSA, 2010a).

* Only 13 MSs reported on the results of carcass swabs in the slaughter pig baseline study 2006-2007.

(h) According to EFSA's BIOHAZ panel scientific opinion on monitoring and assessment of the public health risk of "*Salmonella* Typhimurium-like" strains (EFSA, 2010d), this *Salmonella* antigenic formula is recommended to be reported as 'monophasic *Salmonella* Typhimurium'. However, to ensure consistency with the previously published Part A report (EFSA, 2009b), the *Salmonella* antigenic formula is kept here.

In Figure 6, the 10 most important serovars in humans in 2008 (EFSA, 2010a) are compared in terms of their relative distribution with those from pig breeding holdings, production holdings, pig lymph nodes, pig carcass swabs, broiler flocks, broiler carcasses, laying hen flocks and fattening turkey flocks. *S*. Enteritidis and *S*. Typhimurium are by far the most dominant serovars in humans, and it is notable that *S*. Derby and *S*. Typhimurium constitute a larger proportion in pigs, whereas *S*. Enteritidis and *S*. Infantis dominate in broilers and laying hens (i.e. *Gallus gallus*), suggesting a variable ranking of sources for human salmonellosis involving specific serovars.
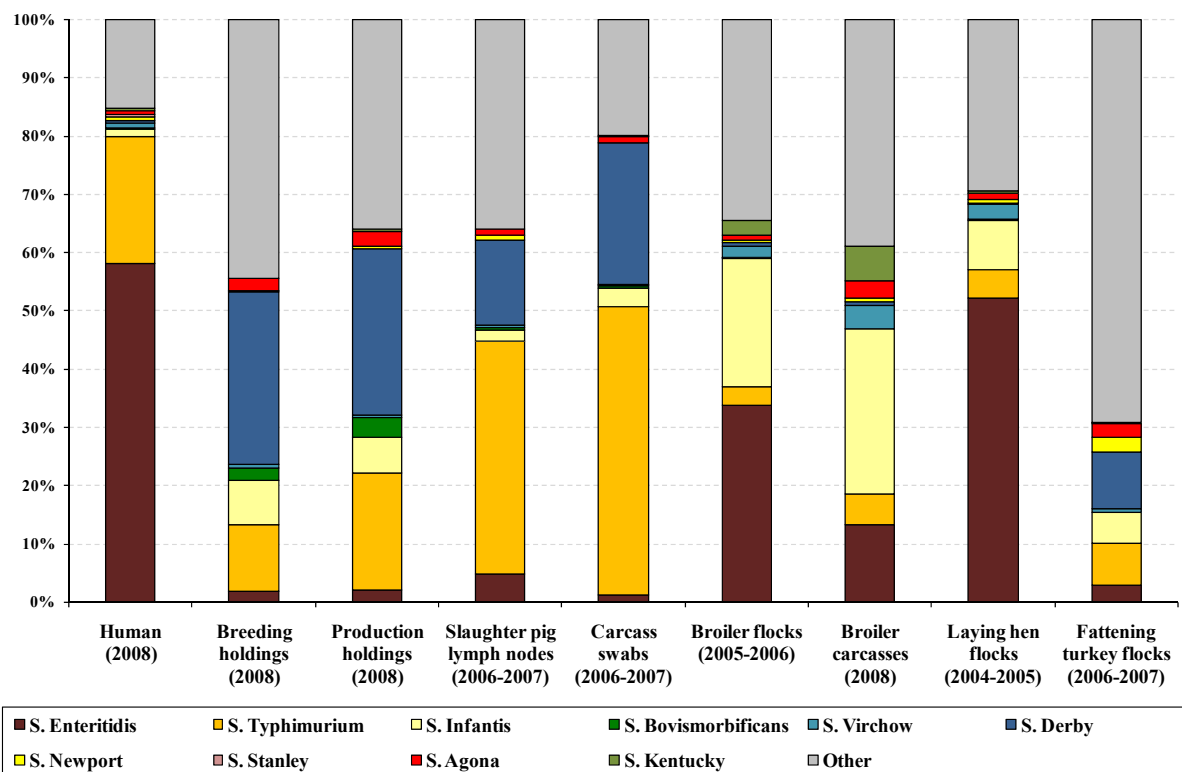


**Figure 6:** Comparison of the *Salmonella* serovar distribution in humans and animal sources in the EU, *Salmonella* EU baseline survey, 2008.

Data on human cases caused by the most frequent serovars in all reporting countries were derived from the EUSR from 2005 to 2008 (EFSA, 2006, 2007c, 2009a, 2010a). Human data were reported through The European Surveillance System (TESSy) and represent case-based and aggregated data that have been approved by each MS. In the EUSR reports, the top-10 serovars isolated in humans are reported, but since the ranking of serovars differs between years, more than 10 different serovars are presented in Table 21 (Appendix L). The aggregation, however, has a disadvantage in that serovars reported individually in one year may be reported in the group of 'other' in other years (for example *S*. Bovismorbificans, which was reported individually in 2005 and 2008, was most likely included in the group of 'other' in 2006 and 2007).

**5.3.4. Correlation between the prevalence of *Salmonella*-positive slaughter pigs in the EU baseline survey in 2006 to 2007 and the prevalence of *Salmonella*-positive holdings with breeding pigs in the EU baseline survey in 2008**

Correlation between the 2006 to 2007 baseline survey prevalence results of *Salmonella* in lymph nodes of slaughter pigs (EFSA, 2008b) with the 2008 prevalence results of *Salmonella*-positive holdings with breeding pigs in each MS and non-MS (EFSA, 2009b) was analysed in the present report using the Spearman rank correlation coefficient, ρ.

The estimated correlations are presented in Table 6, as well as the *P*-values from testing the null hypothesis of no association between the prevalences observed in the two surveys. The results indicate a significant positive correlation (*P*-values <0.0001) between prevalence of *Salmonella*-positive holdings with breeding pigs and lymph nodes of slaughter pigs in countries that participated to both surveys. The scatter graph illustrated in Figure 7 further indicates that countries having high prevalence of *Salmonella*-positive holdings with breeding pigs had a high prevalence of *Salmonella*-positive lymph nodes taken from slaughter pigs during the 2006-2007 survey. A significant positive correlation between the prevalence of *S*. Typhimurium positive holdings with breeding pigs in 2008 and the prevalence of *S*. Typhimurium positive lymph nodes in slaughter pigs in 2006-2007 baseline survey was also found (Table 7). Figure 8 shows that countries having a high prevalence of *S*. Typhimurium-positive holdings with breeding pigs had a high prevalence of *S*. Typhimurium-positive lymph nodes taken from slaughter pigs during the 2006-2007 survey. Additional scatter graphs comparing the prevalence of *Salmonella* and *S*. Typhimurium positive holdings, separately for breeding and production holdings, and the prevalence of *Salmonella* and *S*. Typhimurium positive lymph nodes in slaughter pigs are presented in Appendix M.

**Table 6:** Spearman correlation coefficients for testing the correlation between the prevalence of lymph nodes *Salmonella*-positive slaughter pigs in 2006-2007 and the prevalence of *Salmonella*-positive holdings with breeding pigs in 2008 [a]

| *Salmonella* prevalence | Spearman ρ | *P*-value |
|---|---|---|
| Holdings with breeding pigs[b] & lymph nodes of slaughter pigs[c] | 0.751 | <.0001 |
| Breeding holdings[b] & lymph nodes of slaughter pigs[c] | 0.770 | <.0001 |
| Production holdings[b] & lymph nodes of slaughter pigs[c] | 0.708 | <.0001 |

[a] Twenty-five pairwise prevalence results were included in the analysis, corresponding to results from 24 MSs and Norway, which participated to both the 2008 EU baseline survey on *Salmonella* in breeding pigs and the 2006-2007 EU baseline survey on *Salmonella* in slaughter pigs.
[b] 2008 EU baseline survey on *Salmonella* in breeding pigs
[c] 2006-2007 EU baseline survey on *Salmonella* in slaughter pigs

**Table 7:** Spearman correlation coefficients for testing the correlation between the prevalence of lymph nodes *S*. Typhimurium-positive slaughter pigs in 2006-2007 and the prevalence of *S*. Typhimurium-positive holdings with breeding pigs in 2008[a]

| Prevalence of *Salmonella* Typhimurium | Spearman ρ | *P*-value |
|---|---|---|
| Holdings with breeding pigs[b] & lymph nodes of slaughter pigs[c] | 0.79083 | <.0001 |
| Breeding holdings[b] & lymph nodes of slaughter pigs[c] | 0.69477 | 0.0001 |
| Production holdings[b] & lymph nodes of slaughter pigs[c] | 0.79151 | <.0001 |

[a] Twenty-five pairwise prevalence results were included in the analysis, corresponding to results from 24 MSs and Norway, which participated to both the 2008 EU baseline survey on *Salmonella* in breeding pigs and the 2006-2007 EU baseline survey on *Salmonella* in slaughter pigs
[b] 2008 EU baseline survey on *Salmonella* in breeding pigs
[c] 2006-2007 EU baseline survey on *Salmonella* in slaughter pigs
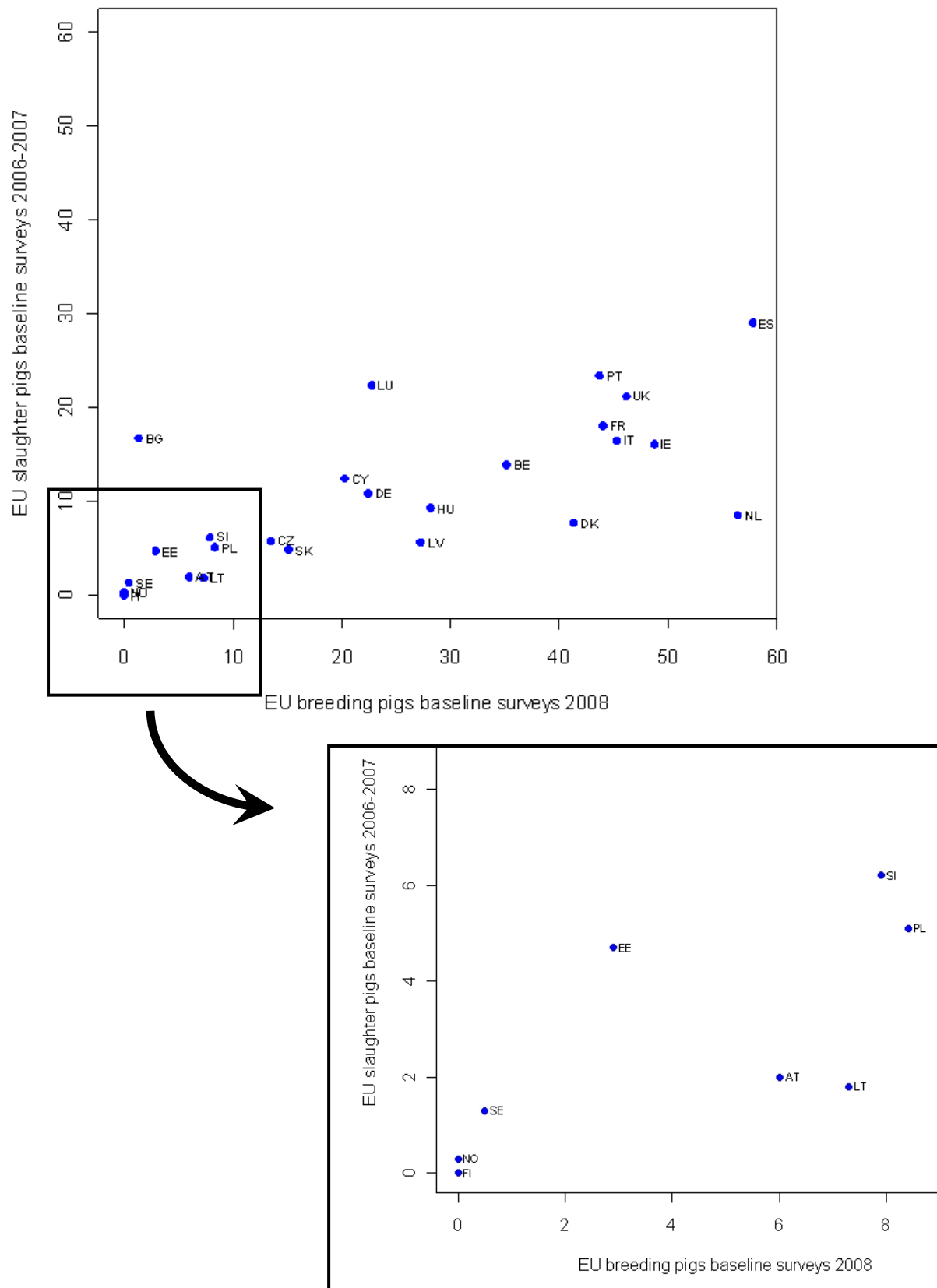
**Figure 7:** Comparison between the prevalence of lymph node *Salmonella*-positive slaughter pigs in the EU baseline survey in 2006-2007 and the prevalence of *Salmonella*-positive holdings with breeding pigs in the EU baseline survey in 2008
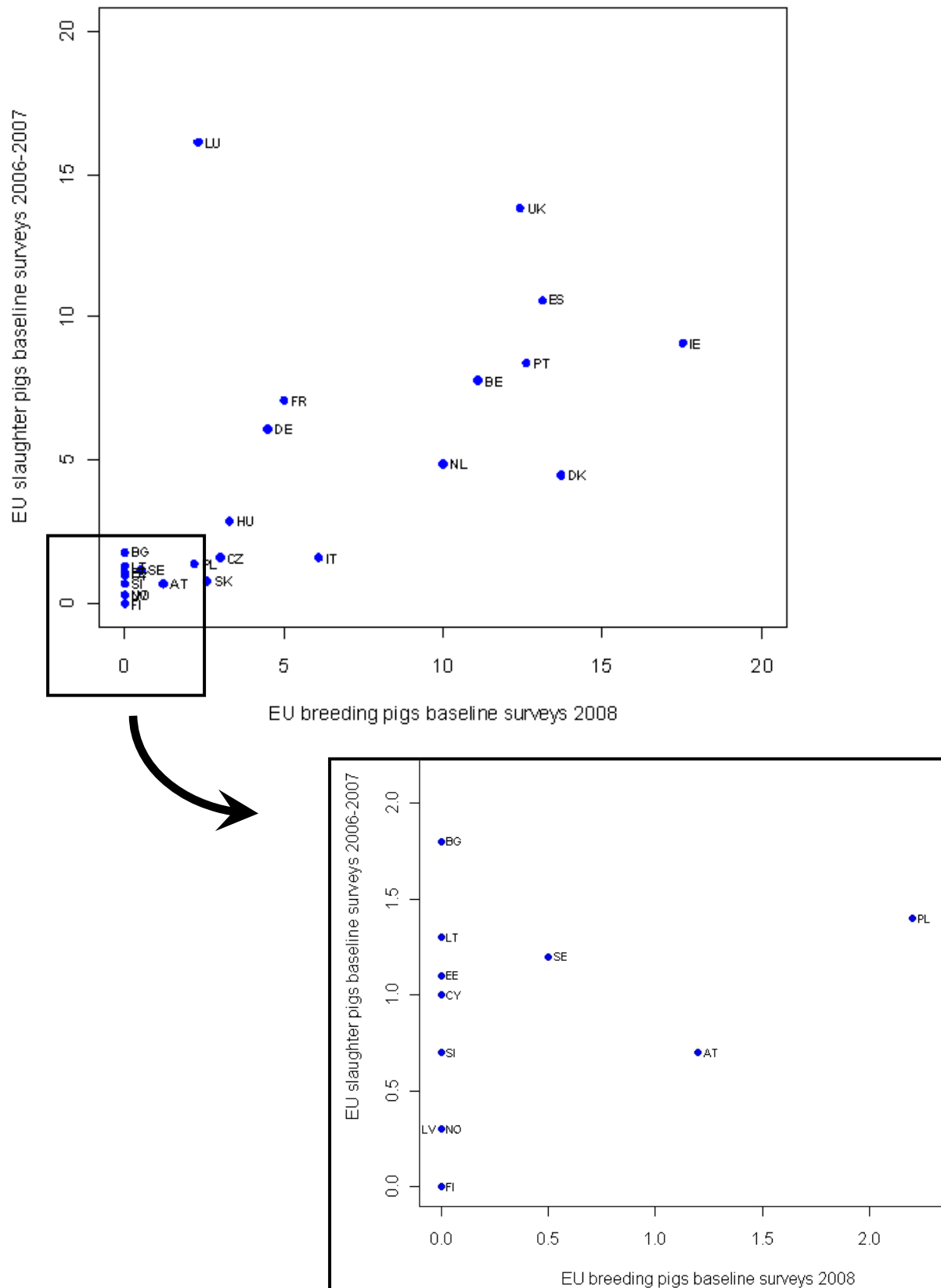
**Figure 8:** Comparison between the prevalence of lymph node *S.* Typhimurium-positive slaughter pigs in the EU baseline survey in 2006-2007 and the prevalence of *S.* Typhimurium-positive holdings with breeding pigs in the EU baseline survey in 2008

## 5.4. Analysis of within-holding prevalence study

### 5.4.1. Descriptive results of the within-holding prevalence study

Table 8 displays the descriptive summary statistics for the data provided by the five participating MSs.

**Table 8:** Descriptive summary of the data for the five Member States that participated in the within-holding prevalence study, *Salmonella* EU baseline survey, 2008

|  | Czech Republic | Denmark | Sweden | Slovenia | United Kingdom | Total (five MSs) |
|---|---|---|---|---|---|---|
| Positive holdings (%)[a] | 3 (33.3%) | 6 (60.0%) | 1 (10.0%) | 2 (20.0%) | 7 (70.0%) | 19 (38.8%) |
| Positive individual samples (%)[b] | 58 (6.4%) | 83 (8.3%) | 1 (0.1%) | 14 (1.4%) | 207 (20.7%) | 363 (7.4%) |
| Positive artificially pooled samples (%)[c] | 6 (6.7%) | 15 (15.0%) | 0 (0%) | 4 (4.0%) | 30 (30.0%) | 55 (11.2%) |
| Positive routine pooled samples (%)[d] | 7 (7.8%) | 12 (12.0%) | 0 (0%) | 1 (1.0%) | 30 (30.0%) | 50 (10.2%) |

[a]   The number (percentage) of holdings that had at least one *Salmonella*-positive (individual or pooled) faecal sample out of those tested (10 holdings in total in each MS, except in the Czech Republic where 9 holdings were tested).

[b]   The total number (percentage) of *Salmonella*-positive individual faecal samples (1000 samples in total in each MS, except in the Czech Republic where 900 individual samples were tested).

[c]   The total number (percentage) of *Salmonella*-positive artificially pooled samples (100 samples in total in each MS, except in the Czech Republic where 90 artificially pooled samples were tested)

[d]   The total number (percentage) of *Salmonella*-positive routine samples (100 samples in total in each MS, except in the Czech Republic where 90 pooled samples were collected)

In the within-holding prevalence study 10.7% of the pooled samples (combining routine and artificially pooled samples) across all the holdings were positive compared to 7.4% of the individual samples.

Further results obtained for the five countries participating in the within-prevalence study are illustrated in Appendix O.

### 5.4.2. Sensitivity of tests for detection of *Salmonella* in breeding pigs

The sensitivity of an individual faecal sample for detection of *Salmonella* in breeding pigs was estimated to be 87% [95% CI: 82-93%].

Since the sensitivity of the artificially pooled sample did not differ significantly from the sensitivity of the routine pooled sample (see Appendix N), these were treated as equal and hereafter the term 'sensitivity of the pooled sample' is used. Testing a pooled sample consisting entirely of positive samples had a sensitivity of 92% (95% CI 86-95%), which is apparently higher than that of a single individual faecal sample (87%). However, this difference was not statistically significant. A plot of the predicted sensitivity of pooled sample versus the within-pen prevalence is shown in Figure 9. This indicates that the sensitivity of testing a pooled sample increases as the prevalence of positive pigs within the pen increases.

![EFSA logo](European Food Safety Authority)

Analysis of the baseline survey on *Salmonella* in breeding pigs in the EU, 2008
Part B: factors associated with *Salmonella* pen positivity
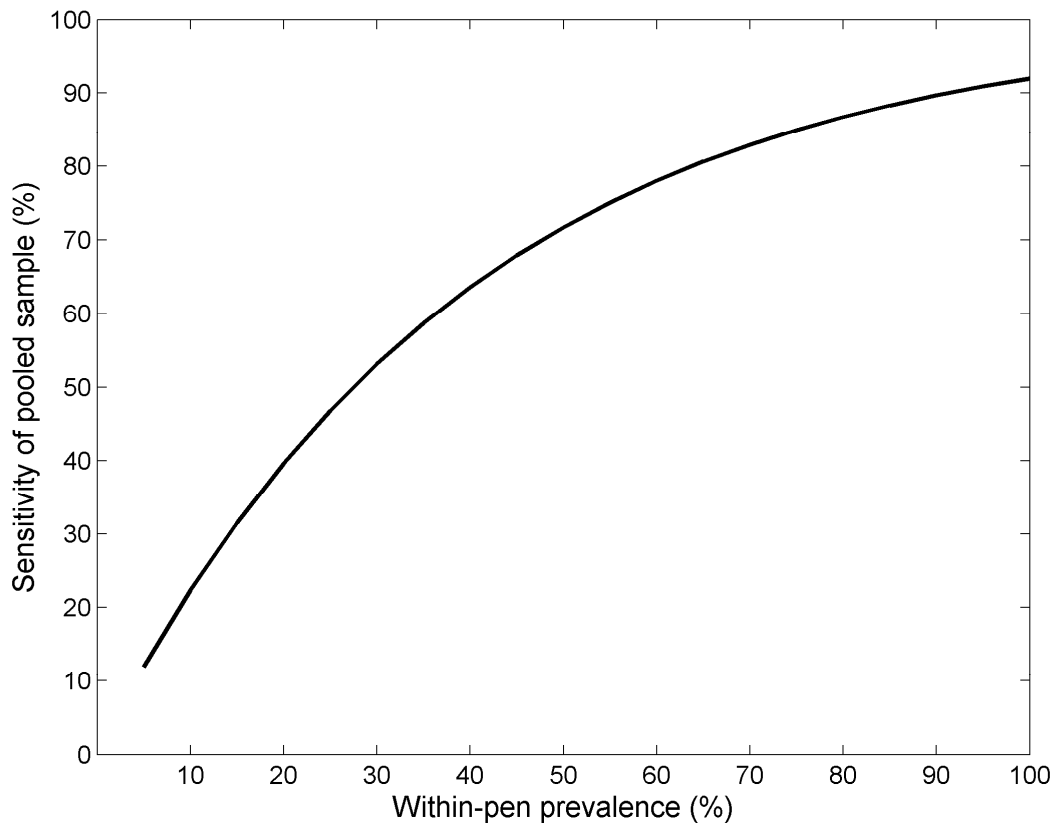
**Figure 9:** Sensitivity of routine and artificially pooled samples for detection of *Salmonella* versus the *Salmonella* within-pen prevalence.

In order to examine the effect of holding size upon pooled faecal sample sensitivity, a model stratifying the farms by holding size, with a cut-off of 400 pigs, was also investigated. However, the model was deemed inappropriate, as the size of the holdings presented were biased towards one strata or the other for three of the five countries. This possible confounding between holding size and country was judged to be unacceptable and this putative association was not investigated further.

Figure 10 shows how the percentage of positive pens varies according to the prevalence of individual *Salmonella*-infected pigs within a holding (within-holding prevalence). The observed percentages of positive pens for the positive holdings in the study are given by asterisks. The observed values are generally slightly lower than the predicted percentage of positive pens since it is likely that *Salmonella* will not be isolated from some true positive pens which will therefore give false negative results, especially at low prevalence.
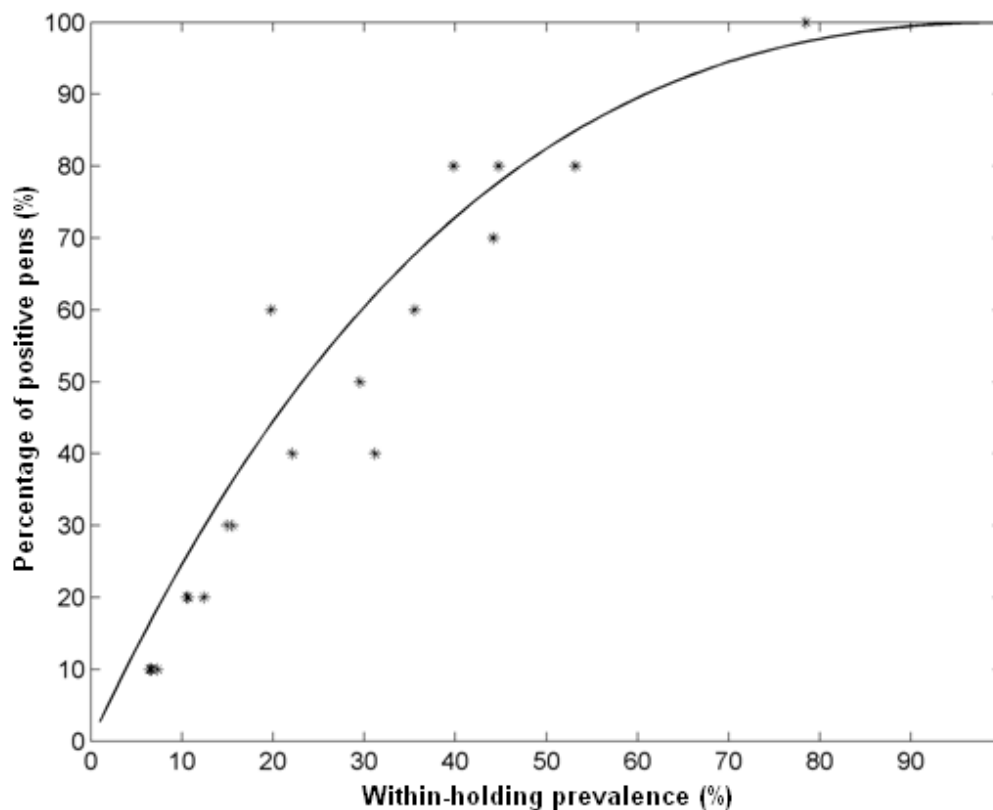
**Figure 10:** Percentage of positive pens versus the estimated prevalence of *Salmonella*-infected pigs within a holding ('within-holding prevalence') for the positive holdings in the within-holding prevalence study

### 5.4.3. True prevalence of *Salmonella*- positive holdings with breeding pigs

The results showed that the observed MS-level prevalence of *Salmonella*-positive holdings with breeding pigs is roughly 80% of the estimated true MS-level prevalence, although this proportion varies between MSs. Details on the country specific estimates of the true prevalence are included in Table 26 (Appendix N). The estimated distribution of median within-holding prevalence for each of the 24 countries where the within-holding prevalence was greater than zero is shown in Appendix O (Figure 62).

The true EU-level prevalence was estimated to be 40.6% (95% CrI: 35.0-46.8) and further details on this estimation are in Appendix O (Table 29).

## 6. Discussion

*Salmonella* infection in pigs is often sub-clinical and shedding of *Salmonella* may occur intermittently for long periods, leading to the persistence of infection in some herds. Although breeding pigs do enter the food chain at the end of their productive lives, such animals are probably a minor contributor to the risk of *Salmonella* infections in humans. More importantly, persistent infection in breeding pigs may play an important role in the maintenance and transmission of *Salmonella* infection, either to the slaughter pig generation (production herds), or act as a source of infection to the breeding pigs whose progeny will become the slaughter generation (nucleus and multiplier herds). Where the progeny is destined for slaughter, there is a direct risk of transmission of *Salmonella* through the food chain with resulting implications for food safety.

### 6.1. Context of the *Salmonella* baseline survey and study limitations

The EU-wide baseline survey estimated the prevalence of *Salmonella*-positive breeding and production holdings across the EU, and these estimates were published in the Part A report (EFSA, 2009b). The present part B report provides the results of the association between the investigated pen- and holding level risk factors and the *Salmonella* pen positivity in holdings with breeding pigs. Also, the association between the prevalence of *Salmonella*-positive breeding holdings and the prevalence of *Salmonella*-positive production holdings in a country was investigated. Moreover, more in-depth analyses of the identified *Salmonella* serovar distributions are presented in this Part B report. Lastly, the results are provided from the additional voluntary within-holding prevalence study, in which the Czech Republic, Denmark, Slovenia, Sweden, and the United Kingdom participated.

During the conduct of the survey, information was gathered through a mandatory questionnaire, which has had a major beneficial impact on the quality and completeness of the data received and the ability to carry out meaningful risk factor analysis. The choice of the potential risk factors to be investigated was made by the MSs, partly based upon EFSA's proposal for the survey design (EFSA, 2007d). This Part B report considers whether any of these factors can be associated with *Salmonella* pen positivity in holdings with breeding pigs. It should be kept in mind that a statistical association between an investigated factor and the odds of yielding a *Salmonella*-positive result does not necessarily indicate a causal relationship. Furthermore, cross sectional surveys only measure a single point in time and do not differentiate between factors that may influence persistence of *Salmonella* and those associated with introduction of the agent. As a consequence, this analysis only generates hypotheses for potential risk factors associated with *Salmonella* and possible biases must be carefully considered. It should be noted that some factors that are known to be associated with *Salmonella*, such as the age of the herd, cleaning and disinfection practices, the design of pens, manure removal systems and the presence of rodents and wild birds in the holding were not investigated and therefore potential confounding from these factors could not be controlled for in the epidemiological analysis.

The risk factor analysis was carried out at EU-level (including the two reporting non-MSs) and it is important to emphasize that in some cases it may not be valid to transpose EU-level risk factors to a country-level, and the findings presented in this report should be used as a guide to inform general control measures. Further work to assess the validity of interventions aimed at reducing exposure to specific risk factors is recommended. It should also be noted that the epidemiological unit of the risk factor analysis was the pen housing breeding pigs, which may not always correlate with the risk of infection at holding level.

### 6.2. Correlation between the prevalence of *Salmonella*-positive breeding and production holdings

There was a strong and significant positive association between the prevalence of *Salmonella* in breeding and production holdings across the different MSs. This result indicates that primary breeding holdings may have the potential to disseminate *Salmonella* down the production pyramid to holdings

![efsa logo] European Food Safety Authority

*Analysis of the baseline survey on Salmonella in breeding pigs in the EU, 2008*
*Part B: factors associated with Salmonella pen positivity*

producing pigs for breeding and fattening. The serovar distributions did not contradict this, being broadly similar between different holding types, with *S*. Derby and *S*. Typhimurium dominating in both groups and with several less common serovars occurring in both populations within and between countries. Some serovars that are known to occur in countries that have exported breeding pigs to other European countries were found in multiple locations, although another common source, such as a widely used contaminated feed ingredient can not be ruled out (Wales et al., 2009). Furthermore, the significant association between the prevalence of *Salmonella* in breeding and production holdings may be also attributed to other country level factors.

The potential of holdings with breeding pigs to disseminate *Salmonella* is likely underestimated because the survey sampling strategy was designed to include a small number of samples from each sector of the adult herd in the holding. This means that if the infection was clustered by sector of the holding (some holdings may have hundreds of pens distributed in a large number of separate buildings), *Salmonella,* or the presence of a specific serovar such as *S*. Typhimurium*,* on the holding was less likely to be detected than if a larger number of pen samples had been taken in all parts of the herd. In particular, the exclusion of sampling the progeny of breeding pigs, which are more likely to be infected than adult pigs, especially with *S*. Typhimurium (Wales et al., 2009), could have contributed to an important underestimation of the potential of breeding herds to disseminate *Salmonella*.

## 6.3.    Factors associated with *Salmonella* pen positivity in breeding and production holdings

EU-level analysis identified a number of factors significantly associated with *Salmonella* in breeding pigs. The final model combined breeding and production holdings and considered results at the pen- rather than at holding level to give the analysis greater power to detect important associations. The inclusion of interaction terms for holding type (breeding or production holding) allowed evaluating the potential differences between the two types of holdings, while also permitting variables that did not differ to be investigated with greater power.

There was a significant increase in the pen-level *Salmonella* risk with increasing holding size; pens within holdings of 1,000 or more breeding pigs had over five times higher odds to be positive for *Salmonella* compared to those with less than 100 pigs. Holding size has been shown in a number of studies to be a key factor in determining the risk of *Salmonella* and other infectious diseases in pig herds (Carstensen and Christensen, 1998; Gardner et al., 2002). This effect might reflect a greater risk of introduction and/or of within-holding dissemination of *Salmonella* in larger holdings, for example through a more intensive introduction of replacement breeding stock or shared service areas or other facilities for a large number of pigs. Larger holdings also typically have larger volumes of inputs to the holding in terms of feed, movement of people and equipment. The majority of pigs exposed to *Salmonella* develop an immune response and once clear of the infection, do not continue to shed the organism. However, a small number of animals remain persistent carriers and may act as reservoirs and infect newly introduced stock, or recovered animals in which immunity has waned, thus maintaining *Salmonella* on the holding. The more pigs present, the more likely that some will not clear the infection and that infection will persist and recycle. There was also a significant association between the number of pigs per pen and *Salmonella* risk, with a 3% higher odds per 10 additional pigs. The impact of other unmeasured underlying risk factors that may be associated with structural characteristics and/or managerial practices typical for larger holdings could not be quantified in this survey.

Pens containing pregnant or farrowing and lactating pigs were less likely to be positive for *Salmonella* compared to pens housing maiden gilts. Similar findings have been reported previously (Davies and Wray, 1997, Wales et al., 2009) and are likely to be related to the susceptibility or carrier status of newly introduced gilts and a reduction of shedding of *Salmonella* during the early stages of lactation.

Pens where pigs were fed with commercial feed had higher odds to be *Salmonella*-positive compared to those where pigs were fed with home-mill mixed feed, or feed with maize, or feed from other sources. Home-mill mixed feed usually has a greater protective effect than sourcing feed from a company, this may be due to coarser grinding of grain and the reduced chance of contamination from the more limited range of ingredients used and locally sourced cereals. It has also been suggested that the contaminated dust present in some soya bean and oil seed processing plants and feed mills, particularly dust from persistently contaminated pellet cooling systems, may be an important source of contamination for feed (Jones and Richardson, 2004; EFSA, 2008c, Davies and Wales, 2010). Compound feed from a commercial company is also more likely to be finely ground and pelleted, although the analysis did not disclose collineary between the variables 'origin of feed' and 'type of diet'.

In addition to the source of the feed, the type of diet (formulation of the ration) was found to be significantly associated with *Salmonella*-positive pens. Pens where pigs were fed with pelleted feed had higher odds of positivity, while mash (meal/mash) or wet (porridge liquid) feed was found to have a protective effect. This finding confirmed what was previously indicated in other studies (Beloeil et al., 2004, Lo Fo Wong et al., 2004; Garcia-Feliz et al., 2009). The fine grinding and processing involved in the production of pelleted feed is thought to promote favourable conditions for the colonisation of *Salmonella* in the gut of the animals due to rapid transit through the stomach acid barrier and intestine and production of intra-luminal conditions that suppress protective flora such as lactobacilli and anaerobes (Hedemann et al., 2005; Lo Fo Wong et al., 2004, Hansen et al., 2001; Jorgensen et al., 2001). A number of other studies have shown liquid feed to have a protective effect. Liquid feeds are often naturally or specifically fermented or acidified and several studies indicated that a combination of certain organic acids and a low pH has a negative impact on the development of *Salmonella* in the gut of the pigs (van Winsen et al., 2000; Lo Fo Wong et al., 2004). Liquid diets that include whey are also protective due to stimulation of lactobacilli (van Winsen et al., 2000).

Furthermore, the type of floor was significantly associated with *Salmonella* pen positivity but its effect was different in breeding holdings and production holdings. In production holdings, pens with (fully) 'slatted floors' were found to be significantly associated with lower odds of *Salmonella* positivity than pens having solid floors with other-than-straw bedding or without bedding, or pens with partly slatted floors, except 'solid floor with straw' and the type of floor classified as 'other' with which there were no statistically significant differences. Pens with a floor type 'outdoor in field or paddock' had more than three times higher odds of *Salmonella* positivity than the 'fully slatted floor'. Slatted floors allow faecal matter to drain away from the pen, thereby reducing potential for other pigs in the pen to come into contact with contaminated material. Spread of contamination between pens is also reduced by slatted floor systems as solid floor pens often involve common scraper systems that move between pens, pens where pigs are moved sequentially from one end of a building to the other as the oldest pigs are removed from one end, seepage of effluents between pens or removal of contaminated bedding between batches. Pens with deep straw bedding are also likely to be more self contained in terms of spread of effluent, and there may be some contribution of a bioactive 'litter effect' (Olesiuk et al., 1971) in which *Salmonella* is reduced by the activity of competing micro-organisms. It can in some cases also be more difficult to collect representative faeces from deep straw bedded sow pens, so it could be hypothesised that the sensitivity for detection may be reduced compared with solid floored pens where faecal material can normally be readily gathered. Conversely, in breeding holdings, only the category 'other' type of floor put pens significantly at risk for *Salmonella* positivity when compared to pens with 'slatted floor' and no other associations were found between the type of floor and the *Salmonella* positivity. This is likely to be related to the more widespread use of solid floors (so less opportunity for statistical comparison) in holdings that supply breeding pigs, since foot and leg strength is an important requirement (Anil et al., 2007).

The baseline survey also collected information on feed and water supplements, including organic acids and probiotics, however no significant associations were detected in this survey, despite some studies suggesting a limited beneficial effect from feed or water acidification (Wingstrand et al., 1997;

Martín-Peláez et al., 2010) and its widespread use in fattening pigs. However, several studies failed to show any beneficial effect (Lo Fo Wong, 2001; Cook, 2004; Cook et al., 2006).

Pens in breeding holdings housing 10-90% of gilts homebred had lower odds of being *Salmonella*-positive than pens in holdings housing more than 90% of gilts homebred. Conversely, in production holdings no statistical link was found between the gilt replacement policy and the *Salmonella* pen positivity. Both findings on gilt replacement policy in breeding and production holdings were surprising, given the known association between *Salmonella* prevalence in breeding herds, production herds and slaughter pigs. These unexpected results could be due to the predominant effect of other farm-related factors that were not recorded in the survey, such as housing systems and mixing of pigs, the annual replacement rate of breeding stock and the average age of the breeding herd, which may have an effect on the within-herd prevalence and the susceptibly to *Salmonella* and other pathogens because of the effect on natural immunological protection after previous exposure of sows (Wilcock and Schwartz 1992).

Two types of sample were permitted in the survey; a large fabric swab passed through accumulated naturally mixed faeces in the pen or, where this was not possible, a composite faecal sample comprising a minimum of 10 individual pinches from faeces. The type of sample that was taken had a significant impact on the likelihood of recovering *Salmonella* with the composite faecal samples proving less sensitive than swab samples. The swab sample can therefore be considered a more sensitive sampling method in detecting *Salmonella* positivity than the composite sample. This is consistent with the faecal swab collecting material from a larger number of earlier defecations, thus producing a sample with contributions from a larger number of individual pigs as shown in the within-holding study (see further) and previous publications (Arnold et al., 2005; Arnold and Cook, 2009).

In this survey, no statistically significant associations were found between the prevalence of the *Salmonella*-positive pens and several holding- and pen-level factors, such as time between sampling and testing, season, type of breeding or production holding, boar replacement policy, gender of the pigs, indoor/outdoor production, individual housing, whether production was all-in/all-out, or the use of antibiotics in the groups of pigs. Nevertheless, these findings should be interpreted with caution since the risk factor analysis was performed pooling data at EU level. Significant associations may still exist at MS level due to differences in the primary pig production management between countries.

### 6.3.1. Effect of the holding on the risk of *Salmonella* pen positivity

The between holding variability was also considered in the analyses of risk factors potentially associated with *Salmonella* pen positivity. The results showed that the baseline risk of *Salmonella*-positive pens varied between the holdings, even when other factors such as country, holding size, floor type, production stage, number of pigs per pen, origin of feed, type of diet and significant interactions with holding type were taken into account in the statistical model. Thus, within countries the prevalence of *Salmonella*-positive pens varied between holdings, with some holdings having higher pen prevalence and other holdings having a lower prevalence of positive pens. The proportion of variance that remained unexplained by the investigated factors and that was due to between-holding variability was 56%. This proportion of unexplained variance could be either attributed to uninvestigated holding-specific factors or to the clustering of *Salmonella* linked to its infectious character. Such unidentified factors could include the serovar and strain of *Salmonella* present, as some strains are able to spread prolifically by virtue of high levels of excretion in faeces, enhanced environmental survival or infectivity for pigs (Jones and Falkow, 1996). The type of pen and pen management also has an important effect, as in some pen types manure is regularly scraped through all pens to remove it or pigs are moved between uncleaned pens (Davies, 1998).

### 6.3.2. Population Attributable Fraction

The Population Attributable Fractions (PAFs) presented in this report provided a theoretical indication of the percentage of *Salmonella*-positive pens that might be attributable to the risk factor in question, and which may be prevented if specific control measures acting to reduce the exposure to the risk factor in the population of pens were in place. In the context of this report, the calculation of the PAFs should be considered as a theoretical exercise and so interpreted with caution, as no assumptions of a specific causal link between the risk factors and *Salmonella* pen positivity can be made based on data collected in this cross-sectional study.

The PAF results indicated that the type of feed used is a major determinant of *Salmonella* pen positivity in holdings with breeding pigs. Feed may impact the risk of *Salmonella* infection for two reasons: firstly, the type of feed influences gut physiology and may make the gut environment more or less favourable for multiplication of *Salmonella* if it is present (Hedemann et al., 2005; van Winsen et al., 2000; Lo Fo Wong et al., 2004, Hansen et al., 2001; Jorgensen et al., 2001); secondly, feed may be contaminated by *Salmonella* and thus be the vehicle through which infection is introduced into a pig holding. Feeding pigs on a porridge/liquid diet may be considered as a valuable control measure for *Salmonella*, leading to a theoretical reduction of 23.5% of the *Salmonella* pen positivity. Also, changes in feed formulation (e.g. meal versus pellets) or sources (home-mill mixed versus commercial compounds) may lead to a reduction in *Salmonella* prevalence. The main effect of the different feed related factors is dysbacteriosis caused by diets with high wheat content that are finely ground and pelleted and so lead to conditions in the gut that favour intestinal colonisation and persistence of *Salmonella* from any source (EFSA, 2008c). A Quantitative Microbiological Risk Assessment (QMRA) of *Salmonella* in slaughter and breeding pigs considered feed as a potential source of *Salmonella* and indicated that the control of *Salmonella* in feedstuffs should represent one of the key control measures of *Salmonella* in breeding pig farms. The QMRA analysis indicated that by feeding pigs with only *Salmonella*-free feedstuffs, a reduction in the prevalence of *Salmonella* of 10-20% in high prevalence MSs and 60-70% in low prevalence MSs could theoretically be achieved (EFSA, 2010c).

Furthermore, the PAF results suggested that the floor type and the holding size are other important determinants of *Salmonella* pen positivity and intervention strategies targeting these factors may contribute to a reduction of *Salmonella* in holdings with breeding pigs. Although the number of pigs per pen was found to be significantly associated with *Salmonella* pen positivity in the risk factor analysis, the PAF for this variable was low suggesting that control measures aimed at reducing the number of pigs per pen might not have a worthwhile impact on the *Salmonella* prevalence. The different PAFs estimated for the two holding/group size-related factors (holding size and pen size) suggested that spread of *Salmonella* between pens may be more important than spread within a pen, as predicted by earlier mathematical models (Hill et al., 2008).

Although PAFs make a number of assumptions, including causality between the risk factors and *Salmonella*, which cannot be verified by means of cross-sectional survey analyses such as those presented here, they can be informative in terms of assessing the potential impact of possible intervention strategies. Such theoretical assumptions must, however, be confirmed in controlled intervention trials as control of certain risk factors may be ineffective if other, sometimes unidentified, risks are not also effectively controlled.

### 6.4. Analysis of the *Salmonella* serovar distribution across the EU

*S.* Typhimurium and *S.* Derby were widespread and dominant in most MSs, while other serovars, such as *S.* London, *S.* Infantis or *S.* Rissen were frequently isolated in some Western MSs and their relevance cannot be generalised to the whole EU. The heterogeneous geographical distribution of *Salmonella* serovars across the EU may indicate the presence of common sources of infection within regions such as infected breeding holdings, contaminated feed production or trade in breeding pigs.

Geographic clustering is also consistent with the potential for the clonal spreading of a particular *Salmonella* serovar among holdings following the introduction into a region, e.g. through feed or animal transport vehicles. This may also relate to differences in prevalence and serovars between Western pig producing countries (possibly associated with industrialised pig production, large integrated specialist breeding companies, large trade in breeding pigs and high annual replacement rate, and the wide use of pelleted feed) and other regions (VLA-DTU-RIVM, 2010; EFSA, 2010c). In Eastern Europe, pig production may be organised mostly in small self-contained holdings. The small number of larger holdings use home-milled meal rations, and until recently have had little importation of breeding stock from other high prevalence countries. In certain regions, other factors (e.g. temperature, implementation of *Salmonella* control programmes, use of 'antibiotics' for *Salmonella* control) might also be involved (D'Souza et al., 2004; EFSA, 2011; Usera et al., 2002). The heterogeneous geographical distribution of *Salmonella* serovars across the EU may also reflect a selection pressure for specific serovars or clones driven by e.g. the preferences for using particular antimicrobials in some regions.

The difference in *Salmonella* prevalence between the Western and Eastern MSs was also observed in the EU baseline study in slaughter pigs and might partly be explained by the differences in pig farming structure, with predominantly larger and more industrialised productions in Western MSs and more extensive and mixed productions in Eastern MSs. MSs in which particular serovars are prevalent should attempt to identify specific risk and/or protective factors enabling appropriate control measures in their country.

### 6.4.1. Comparison of *Salmonella* serovar distribution in breeding pigs, slaughter pigs, poultry, feed and humans

*S*. Derby had a higher frequency of isolation than *S*. Typhimurium in both breeding and production holdings, whereas the opposite was observed in lymph nodes and carcass swabs from slaughter pigs (EFSA, 2008b). Such a difference could be explained by a higher invasiveness and ability of many strains of *S*. Typhimurium to persist in lymphatic tissue, higher numbers of organisms in gut contents of infected pigs, different age groups of the pigs sampled or a better ability of *S*. Typhimurium to survive along the slaughtering process (Stevens et al., 2009). It is also well known that *S*. Typhimurium is more likely than other serovars to be found in the rearing and fattening sectors of breeding herds (Wales et al., 2009). It cannot be ruled out, although unlikely since the distribution of the two serovars is relatively stable, that the difference could just be a reflection of the fact that the two baseline surveys were conducted two years apart, in which period a general shift in the serovar distribution may have occurred.

Looking at the comparison in the distribution of serovars from different animal sources, *S*. Typhimurium is the foremost common serovar reported in humans, breeding and production holdings, lymph nodes and carcass swabs, confirming the important potential role of pigs and pork products in the epidemiology of human salmonellosis caused by *S*. Typhimurium in the EU. At the individual MS level, atypical situations can be found, such as the high proportion of isolates, in production holdings, of *S*. London in Italy, the Netherlands, Portugal and the United Kingdom and of *S*. Infantis in Denmark and Slovenia. This is likely to be associated with the establishment of certain serovars at nucleus herd level, but the original origin is likely to be contaminated feed. The large proportions of *S*. Enteritidis in production holdings in Slovakia and Slovenia may suggest a transmission from the poultry reservoir due to more extensive pig production and mixed species farming. The rapid spread of monophasic strains of *Salmonella* Typhimurium in pig and human populations across Europe demonstrates the potential for rapid dissemination of infection via the pig industry (EFSA, 2010d).

Feed is recognised as a source of primary introduction of *Salmonella* in pig herds, particularly in the case of new serovars that may then be able to establish themselves as resident infections in pig production (Hald et al., 2006). The common pool of serovars isolated from both pig herds and feed

suggest that feed is one of the possible sources of infection in breeding and production holdings. However, the irregular and unharmonised reporting of the findings of *Salmonella* in animal feeding stuffs makes it difficult to draw any strong conclusion about the quantitative role of feed (O'Connor et al., 2008), which is also likely to vary between MSs depending on the current epidemiological status. A QMRA conducted on *Salmonella* in slaughter and breeding pigs recently concluded that the *Salmonella* prevalence in pig herds could be significantly reduced by *Salmonella*-free feed, but that the effect is expected to have a much higher impact in MSs having a low prevalence of *Salmonella* in pig herds compared to MSs with higher herd prevalence (EFSA, 2010c).

*S*. Enteritidis and *S*. Typhimurium are the predominant serovars causing illness in humans. The fact that *S*. Derby and *S*. Typhimurium constitute a larger proportion in pigs, whereas *S*. Enteritidis and *S*. Infantis dominate in broilers and laying hens (i.e. *Gallus gallus*), suggests a variable ranking of sources for human salmonellosis involving specific serovars, their exposure routes and virulence for humans. Based on a detailed comparison of the serovar distribution in different animal sources and humans, the above-mentioned QMRA concluded that the majority of human *S*. Typhimurium and *S*. Derby infections may be attributed to the pig reservoir. However, it was underlined that the relative importance of the different sources most likely varies between MSs depending for instance on the serovar-specific prevalence in the different animal sources, farming practices and consumption preferences (EFSA, 2010c). It is also notable that, during 2006-2009, the incidence of human *S*. Enteritidis infections has been decreasing and the incidence of human *S*. Typhimurium infections seemed more stable while the relative importance of human *S*. Typhimurium infections increased (EFSA, 2010a). This may at least to some extent be a result of the control efforts implemented in the poultry reservoir after the baseline surveys in laying hen and broiler flocks (EFSA, 2010a), whereas pig production is still awaiting the results of this baseline survey and the subsequent discussion on how best to control *Salmonella* in the pig herds.

## 6.5. Correlation between the prevalence of *Salmonella*-positive slaughter pigs and *Salmonella*-positive holdings with breeding pigs

Comparison of the 2008 prevalence results of *Salmonella*-positive holdings with breeding pigs with the results of the 2006-2007 baseline survey prevalence results of *Salmonella* in lymph nodes of slaughter pigs (EFSA, 2008b) is not without difficulties. The results of the former survey might not represent the actual slaughter pig prevalence situation in 2008 and the surveys differed in the type of prevalence parameters studied. The 2008 survey estimated the *Salmonella* holding prevalence while the 2006-2007 survey estimated the prevalence at individual animal level, i.e. *Salmonella*-infected pigs. Prevalence estimation at holding level would very likely tend to be higher than the one at individual animal level, because infections like *Salmonella* cluster at group or holding level wherein it persists. Also, the designs of the surveys targeted different points in the food chain. The holding survey was conducted at primary production level whereas the carcass survey was carried out at slaughterhouse level. This implies that some carcasses sampled could have originated from non-domestic slaughter pigs, jeopardising a meaningful comparison between both survey results. Moreover, the present holding survey was based on faecal samples while the carcass survey was based on lymph node samples. Nevertheless, the descriptive comparison made between the *Salmonella* MS prevalence figures of both surveys disclosed a significant positive correlation. These results suggest that *Salmonella* has a potential to disseminate from breeding pigs to fattening and then slaughter pigs and it confirms what already suggested by the positive correlation between the prevalence of *Salmonella*-positive breeding holdings and production holdings. The findings of the correlation analysis are further supported by the conclusions of the QMRA conducted on *Salmonella* in slaughter and breeding pigs (EFSA, 2010c) that indicated the breeding pig herd prevalence as the major determinant of slaughter pig lymph node prevalence at EU level. The above mentioned QMRA also concluded that to achieve control of *Salmonella* in slaughter pigs the two major sources should be controlled: *Salmonella*-infected breeding pig herds, and *Salmonella*-contaminated feed.

## 6.6.    Analysis of the within-holding prevalence study

The *Salmonella* within-holding prevalence study provided further information enabling the estimation of the true prevalence of *Salmonella*-positive holdings with breeding pigs, at EU and MS level. It is worthwhile reminding that, for pragmatic reasons only, the routine survey sampling strategy aimed at detecting with a 95% confidence holdings having a 10% or higher true within-holding prevalence. Therefore, the survey design potentially misclassified some holdings as negative when actually they were positive.

The MS level true prevalence of *Salmonella*-positive holdings was estimated using a Bayesian model in which data on the observed number of positive pens from each holding sampled in each MS were combined with the following information: the diagnostic sensitivity of a pooled faecal sample, the clustering of infection within pens and the relationship between the within-holding prevalence and the proportion of pens infected. However, the representativeness of the inputs to the Bayesian model estimating the true prevalence of *Salmonella*-positive holdings in 24 MSs and two non-MSs was limited by the fact that only five countries participated in the within-holding prevalence study.

The estimate of the diagnostic sensitivity of a 25g individual faecal sample for detection of *Salmonella* in breeding pigs was 87%, similar to that found in a previous study that focussed on finisher pigs (Arnold et al., 2005). These findings suggest that there are no large differences in the sensitivity of the individual faecal sampling between breeding pigs and finishing pigs. However, the previous study was based on data from the United Kingdom only, while the present study is based on data from five volunteer MSs although highly influenced by the results from the United Kingdom since a large proportion of the positive results were from there. Consistent with previous findings (Arnold et al., 2005), the diagnostic sensitivity of a pooled faecal sample was estimated to be 92% which is higher than that of the individual faecal sample; although this difference was not statistically significant. The sensitivity of pooled sample was shown to increase as the prevalence of positive pigs within the pen increases, as would be expected and as reported previously (Arnold and Cook, 2009; Arnold et al., 2005). However, the small number of countries that participated in the within-holding prevalence study, combined with the low prevalence of some of those participating countries means that this study only provided relatively weak evidence of a lack of variability. The applied methods and models described in this report could be adopted by other MSs wishing to conduct similar research in the future.

In the within-holding prevalence study 10.7% of the pooled samples across all the holdings were positive compared to 7.4% of the individual samples. In terms of detecting positive holdings, the routine pooled sampling process was estimated to detect approximately 80% of truly *Salmonella*-positive holdings across the Member States. This indicated that the EU level true prevalence of *Salmonella*-positive holdings with breeding pigs could be underestimated by 20%, leading to an EU true prevalence of *Salmonella*-positive holdings with breeding pigs of about 41% when the current sampling method is used. This proportion is highly dependent on the distribution of within-holding prevalence in each MS. In particular, the proportion of holdings with a low within-holding prevalence in a MS will have a large impact on the power of the sampling scheme within that MS, since low prevalence holdings are less likely to be detected. For the present study, no prior information on the distribution of within-holding prevalence within each MS was available, and while the within-holding prevalence study gave some indication of this distribution, only a few countries participated and furthermore, the estimate for those countries is likely not fully bias-free.

It would be interesting to explore whether there was any relationship between the MS true prevalence of *Salmonella*-positive holdings and the distribution of within-holding prevalence in each MS e.g. do positive holdings in MSs with a large true prevalence tend to have a higher within-holding prevalence than positive holdings in MSs with a low true prevalence? If such a relationship were found it would strengthen the power of the model to estimate MS true prevalence, although a plot of the distribution of estimated within-holding prevalence for each MS showed no obvious pattern.

## CONCLUSIONS

This Part B report provides results from further analyses of the baseline survey on *Salmonella* in holdings with breeding pigs. These are results regarding the association of several pen- and holding level factors, on which data were collected, and *Salmonella* pen positivity. In addition, the correlation between the prevalence of *Salmonella*-positive breeding holdings and production holdings, as well as the distribution of the isolated serovars of *Salmonella* across the EU is included in the current report. Lastly, results are reported from the within-holding prevalence study.

- The risk for *Salmonella* pen positivity varied significantly between countries and between holdings within a country, even when adjusting for the effect of other associated risk factors. Thus, within countries there were holdings with a higher prevalence and holdings with a lower prevalence of *Salmonella*-positive pens.

- At EU level, the odds of *Salmonella* pen positivity in holdings with breeding pigs increased with the size of the holding, as well as with the number of pigs in the pen. Pens containing pregnant or farrowing and lactating pigs were less likely to be positive for *Salmonella* compared to pens housing maiden gilts. Pens where pigs were fed with commercial feed had higher odds of being positive compared to those where pigs were fed with home-mill mixed feed, or feed with maize, or feed from other sources. In addition to the source of the feed, the type of diet (formulation of the ration) was found to be significantly associated with *Salmonella*-positive pens. Pens where pigs were fed with pelleted feed had higher odds of positivity, while mash (meal/mash) or wet (porridge liquid) feed was found to have a protective effect.

- At EU level, in production holdings, pens with (fully) 'slatted floors' were significantly associated with lower odds of *Salmonella* positivity than pens having solid floors with other-than-straw bedding or without bedding, or pens with partly slatted floors. No significant differences were found when comparing 'solid floor with straw' and the type of floor classified as 'other' with (fully) 'slatted floors'. Pens with a floor type 'outdoor in field or paddock' had more than three times higher odds of *Salmonella* positivity than the 'fully slatted floor'. Conversely, in breeding holdings, the category 'other' type of floor put pens significantly at risk for *Salmonella* positivity when compared to pens with 'slatted floor' and no other associations were found between the type of floor and the *Salmonella* positivity.

- The pooled swab sample was a more sensitive sampling method for detecting *Salmonella* positivity compared to the pooled composite faecal sample.

- The analyses showed that 56% of the unexplained variance in the prevalence of *Salmonella*-positive pens in holdings with breeding pigs could be either attributed to uninvestigated holding-specific factors and/or to the clustering of *Salmonella* linked to its infectious character. It was not possible to estimate the association of these factors with *Salmonella* pen positivity and their potential confounding role on the effect of factors on which data were available.

- The results of the analyses of Population Attributable Fractions suggested that the type of feed used is a major determinant of *Salmonella* pen positivity in holdings with breeding pigs. Feeding pigs on a porridge/liquid diet may be considered as a valuable control measure for *Salmonella*, leading to a reduction of the *Salmonella* pen positivity. It was also suggested that intervention strategies targeting other factors such as floor type and holding size may contribute to reduce *Salmonella* in holdings with breeding pigs. Conversely, control measures aimed at reducing the number of pigs per pen might not have a worthwhile impact on the *Salmonella* prevalence.

- Heterogeneity in the distribution of *Salmonella* serovars between Member States indicated that some serovars tend to occur in pig production in specific geographic regions within the EU. This

spatial distribution, as well as the variation in prevalences across the countries might be related to differences in policies for trade in pigs, feeding and housing practices.

- The analyses of the *Salmonella* serovar distribution revealed agreement between the most frequently reported serovars in breeding pigs, those isolated in slaughter pigs and some serovars involved in human cases. This supports the role of pigs and pig meat as a potential source of *Salmonella* infection in humans; even though it is acknowledged that other food producing animal species and food thereof also play a role as sources of infection.

- *Salmonella* Typhimurium is the second most common serovar in humans in the EU and its relative importance has increased during recent years. This serovar was common in pigs, and relatively more common than in poultry, suggesting that the pig reservoir is likely to be an important source of some human *S*. Typhimurium infections.

- Even though the baseline surveys on *Salmonella* in slaughter pigs and in holdings with breeding pigs were conducted one year apart, the descriptive comparison made between the *Salmonella* Member States prevalence figures of both surveys disclosed a significant positive correlation, indicating that *Salmonella* has a potential to disseminate from breeding pigs to fattening and then slaughter pigs. This link was further evidenced by the strong association found between the prevalence of *Salmonella*-positive breeding holdings and the prevalence of *Salmonella*-positive production holdings in countries suggesting dissemination of *Salmonella* from breeding pigs to fattening and then slaughter pigs.

- The results of the within-holding prevalence study indicated that, due to a non-perfect diagnostic test sensitivity, the observed EU-level prevalence of *Salmonella*-positive holdings with breeding pigs was roughly 80% of the estimated true EU-level prevalence. But this proportion varied between Member States. The diagnostic sensitivity of pooled and individual faecal samples was estimated to be 92% and 87%, respectively.

## RECOMMENDATIONS

- Member States are invited to consider the factors found to be associated, at EU level, with *Salmonella*-positive pens in holdings with breeding pigs when they are designing and implementing national *Salmonella* control programmes for breeding pigs.

- Further national studies identifying more closely the factors that put pens with breeding pigs at risk of becoming infected with *Salmonella* in a country are recommended, taking into account the national *Salmonella* prevalence and the characteristics of the national breeding pig population. Also national investigations on prevention and intervention measures to contain *Salmonella* and achieve *Salmonella* reduction in holdings with breeding pigs are recommended.

- Since risk factors may vary between EU countries and/or serovars, Member States are also encouraged to conduct serovar-specific analysis using their country specific data in order to identify risk factors for relevant serovars within their own country.

- Member States are encouraged to develop and enhance *Salmonella* controls in breeding holdings because these holdings may have a unique potential role in the dissemination of *Salmonella* contamination throughout the whole production chain, as well as in contamination of the environment.

- Pooled faecal samples proved to be a robust and economic sampling method for surveys and should be used in future studies, as well as for monitoring the *Salmonella* status of breeding herds. Sampling procedures require standardisation to enhance sensitivity and comparability of monitoring results. Those Member States that did not participate in the within-holding prevalence study may wish to conduct their own research to validate pooling in their own situations.

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**APPENDICES**

## A. OVERVIEW OF THE PYRAMIDAL STRUCTURE OF THE PRIMARY PRODUCTION IN THE EU *SALMONELLA* BASELINE SURVEY IN BREEDING PIGS, 2008[14]



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[14]    Weaner-to-finish holdings and finisher holdings are not covered by the survey.

## B. FACTORS INVESTIGATED IN THE ANALYSIS

**Table 9:** Categorisation of the factors investigated in the analysis, *Salmonella* EU baseline survey, 2008

| *Mandatory explanatory variables collected at holding level in the baseline survey* | | |
|---|---|---|
| **Variable** | **Categories** | **Content in terms of the original variables** |
| Country | Country | Country |
| Period of sampling (month, quarter, season) | <u>Descriptive tables and graphs</u>: Month, quarter, season <br> <u>Regression models</u>: Season | ▪ Quarter of sampling: January-March, April-June, July-September, October-December <br> ▪ Season of sampling: Winter (December – February), Spring (March – May); Summer (June – August), Autumn (September – November) |
| Type of breeding holdings | ▪ Nucleus <br> ▪ Multiplier or supplier | ▪ Nucleus <br> ▪ Multiplier or supplier |
| Type of production holding | ▪ Farrow to weaner <br> ▪ Farrow to grower <br> ▪ Farrow to finish | ▪ Farrow to weaner <br> ▪ Farrow to grower <br> ▪ Farrow to finish |
| Size of the holding[a] | ▪ <100 <br> ▪ 100-399 <br> ▪ 400-999 <br> ▪ >999 | ▪ <50, 50-99 <br> ▪ 100-399 <br> ▪ 400-999 <br> ▪ >999 |
| Gilt replacement policy | ▪ >90% homebred <br> ▪ 10-90% homebred <br> ▪ >90% purchased | ▪ >90% homebred <br> ▪ 10-90% homebred <br> ▪ >90% purchased |
| Boar replacement policy | ▪ No boars on farm <br> ▪ >90% homebred <br> ▪ 10-90% homebred <br> ▪ >90% purchased | ▪ No boars on farm <br> ▪ >90% homebred <br> ▪ 10-90% homebred <br> ▪ >90% purchased |
| *Mandatory explanatory variables collected at pen level in the baseline survey* | | |
| **Variable** | **Categories** | **Content in terms of the original variables** |
| Number of pigs in the pen | <u>Descriptive tables and graphs</u>: 0-9, 10, 11-20, 21-99, >100 <br> <u>Regression model</u>: Continuous, winsorized at 100 | Continuous |
| Indoor/outdoor production[a] | Yes / No | Yes / No |
| Individual housing[a] | Yes / No | Yes / No |
| Age category of the pigs[a] | ▪ No gilts <br> ▪ At least one gilt <br> ▪ All gilts | ▪ No gilts <br> ▪ At least one gilt <br> ▪ All gilts |
| Gender of the pigs | <u>Descriptive tables and graphs</u>: <br> ▪ Male / mixed <br> ▪ Female <br> <u>Regression model</u>: Excluded (collinearity issue) | ▪ Male + mixed <br> ▪ Female |
| Production stage | ▪ Maiden gilts <br> ▪ Pregnant pigs <br> ▪ Farrowing and lactating pigs <br> ▪ Service area <br> ▪ Mixed | ▪ Maiden gilts <br> ▪ Pregnant pigs <br> ▪ Farrowing and lactating pigs <br> ▪ Service area <br> ▪ Mixed |

[a] A description of these factors can be found in Table 10

**Table 9 (Contd):** Categorisation of the factors investigated in the analysis, *Salmonella* EU baseline survey, 2008

| *Mandatory explanatory variables collected at pen level in the baseline survey* | | |
|---|---|---|
| **Variable** | **Categories** | **Content in terms of the original variables** |
| Floor type | ▪ Slatted floor | ▪ Fully slatted floor |
| | ▪ Partly slatted floor | ▪ Partly slatted floor |
| | ▪ Solid floor with straw | ▪ Solid floor with straw, solid floor with deep straw |
| | ▪ Solid floor other bedding | ▪ Solid floor with peat, solid floor with compost, solid floor with wood shavings |
| | ▪ Solid floor without bedding | ▪ Solid floor without bedding |
| | ▪ Outdoors in fields or paddocks | ▪ Outdoors in fields or paddocks |
| | ▪ Other | ▪ Other |
| All in/all out and cleaned[a] | Yes / No | Yes / No |
| Type of diet | ▪ Cobs/rolls/nuts/pellets | ▪ Cobs/rolls/nuts/pellets |
| | ▪ Meal/mash | ▪ Meal/mash |
| | ▪ Porridge/liquids | ▪ Porridge/liquids |
| | ▪ Other | ▪ Other, including combinations of the categories above when reported for the same pen |
| Feed origin | ▪ Commercial compound | ▪ Commercial compound |
| | ▪ Feed with maize | ▪ Maize+commercial supplement, including where maize was given in combination with other feed categories in the same pen |
| | ▪ Home-mill | ▪ Home-mill mix |
| | ▪ Other | ▪ Other, including combinations of different categories (not including maize) when reported for the same pen |
| Organic acid feed/ water supplement[b] (v1) | ▪ Organic acid added | ▪ Organic acid added |
| | ▪ No organic acid added | ▪ No supplement added or supplement other than organic acid supplement added |
| | ▪ Unknown (only considered in descriptive analysis) | ▪ Unknown |
| Probiotic feed/water supplement[b] (v2) | ▪ No probiotic added | ▪ No supplement added or supplement other than probiotic supplement added |
| | ▪ Probiotic added | ▪ Probiotic added |
| | ▪ Unknown (only considered in descriptive analysis) | ▪ Unknown |
| Other feed/water supplements[b] (v3) | ▪ No other added | ▪ No supplement added or supplement different that "other" supplement added |
| | ▪ Other added | ▪ Other added |
| | ▪ Unknown (only considered in descriptive analysis) | ▪ Unknown |
| Use of antibiotics[a] | ▪ No treatment | ▪ No treatment |
| | ▪ Treatment | ▪ In feed, in water, injection whole group, injection one or more individuals |
| | ▪ Unknown | ▪ Unknown |
| Type of sample | ▪ Swab | ▪ Swab |
| | ▪ Composite | ▪ Composite |
| Delay between sampling and testing (in days) | ▪ 0 | ▪ 0 |
| | ▪ 1 | ▪ 1 |
| | ▪ 2 | ▪ 2 |
| | ▪ 3-4 | ▪ 3-4 |
| | ▪ >= 5 | ▪ >= 5 |

[a]  A description of these factors can be found in Table 10

[b]  Distinct binary variables ('v1', 'v2', 'v3') have been created from the categories of the original variable "Feed/water supplement": these were entered separately in the multiple logistic regression models as fixed effect.

**Table 10:** Additional description of factors investigated in the analyses, *Salmonella* EU baseline survey, 2008

| Variable | Description |
|---|---|
| Size of the holding | Total number of breeding pigs over 6 months of age present in the holding at the date of sampling |
| Indoor/outdoor production | It replies to the question 'Are the pigs in the sampled pen going outdoors?' providing information on outdoor access |
| Individual housing | Nature of accommodation within the sampled group (or pen) for breeding pigs: are the all breeding pigs in the sampled pen housed individually (unable to mix freely with other breeding pigs in the sampling group)? |
| Age category of the pigs | Presence of gilts in the sampled pen |
| All in/all out and cleaned | It replies to the question 'does this pen operate on an all in /all out basis?' All in/all out means that pigs are only moved into the pen when all previous have been removed and the pen has been cleaned. |
| Use of antibiotics | It replies to the question 'Have antimicrobials been used in food, water or by injections during the last 4 weeks in the animals in the pen?' |

## C. DESCRIPTIVE TABLES OF *SALMONELLA* POSITIVE PENS BY RISK FACTOR PER COUNTRY

The table below presents data on positivity only for the pen level variables. Data for the holding level variables were not shown because of potential data confidentiality issues.

**Table 11:** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Austria | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 495 | 2 | 0.40 | 1,220 | 15 | 1.23 |
| | 11-20 | 174 | 6 | 3.45 | 307 | 1 | 0.33 |
| | 21-100 | 121 | 4 | 3.31 | 195 | 2 | 1.03 |
| | >100 | 0 | | | 8 | 2 | 25.00 |
| Indoor/outdoor | No | 697 | 12 | 1.72 | 1,400 | 16 | 1.14 |
| production | Yes | 93 | 0 | 0.00 | 330 | 4 | 1.21 |
| Individual housing | No | 422 | 3 | 0.71 | 796 | 5 | 0.63 |
| | Yes | 368 | 9 | 2.45 | 934 | 15 | 1.61 |
| Age of pigs | No gilts | 149 | 6 | 4.03 | 451 | 10 | 2.22 |
| | Mixed age | 437 | 6 | 1.37 | 1,133 | 9 | 0.79 |
| | All gilts | 204 | 0 | 0.00 | 146 | 1 | 0.68 |
| Gender of pigs | Male | 22 | 0 | 0.00 | 26 | 1 | 3.85 |
| | Female | 681 | 9 | 1.32 | 1,599 | 19 | 1.19 |
| | Mixed | 87 | 3 | 3.45 | 105 | 0 | 0.00 |
| Production stage | Maiden gilts | 152 | 0 | 0.00 | 78 | 0 | 0.00 |
| | Pregnant | 298 | 4 | 1.34 | 866 | 11 | 1.27 |
| | Farrowing and lactating | 175 | 2 | 1.14 | 432 | 8 | 1.85 |
| | Service area | 75 | 0 | 0.00 | 161 | 1 | 0.62 |
| | Mixed | 90 | 6 | 6.67 | 193 | 0 | 0.00 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 6 | 0 | 0.00 |
| | Solid floor other bedding | 1 | 0 | 0.00 | 3 | 1 | 33.33 |
| | Solid floor with straw | 207 | 0 | 0.00 | 308 | 2 | 0.65 |
| | Solid floor without bedding | 20 | 0 | 0.00 | 43 | 0 | 0.00 |
| | Partly slatted floor | 440 | 11 | 2.50 | 1,051 | 16 | 1.52 |
| | Slatted floor | 113 | 1 | 0.88 | 267 | 1 | 0.37 |
| | Other | 9 | 0 | 0.00 | 52 | 0 | 0.00 |
| All in/all out | No | 435 | 7 | 1.61 | 998 | 8 | 0.80 |
| | Yes | 355 | 5 | 1.41 | 732 | 12 | 1.64 |
| Type of diet | Cobs/rolls/nuts/pellets | 39 | 6 | 15.38 | 110 | 3 | 2.73 |
| | Others | 30 | 0 | 0.00 | 55 | 0 | 0.00 |
| | Meal/mash | 652 | 6 | 0.92 | 1,460 | 12 | 0.82 |
| | Porridge/liquids | 69 | 0 | 0.00 | 105 | 5 | 4.76 |
| Origin of feed | Commercial compound | 84 | 6 | 7.14 | 145 | 3 | 2.07 |
| | Other | 1 | 0 | 0.00 | 18 | 0 | 0.00 |
| | Feed with maize | 53 | 2 | 3.77 | 271 | 0 | 0.00 |
| | Home-mill | 652 | 4 | 0.61 | 1,296 | 17 | 1.31 |
| Feed/water supplement | Not added | 606 | 3 | 0.50 | 1,333 | 13 | 0.98 |
| | Organic acid | 116 | 6 | 5.17 | 239 | 5 | 2.09 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 0 | | | 0 | | |
| | Probiotic | 15 | 0 | 0.00 | 60 | 0 | 0.00 |
| | Unknown/other | 53 | 3 | 5.66 | 98 | 2 | 2.04 |
| Use of antibiotics | No treatment | 686 | 8 | 1.17 | 1,532 | 19 | 1.24 |
| | Treatment | 104 | 4 | 3.85 | 198 | 1 | 0.51 |
| | Unknown | 0 | | | 0 | | |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Belgium | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 21 | 0 | 0.00 | 517 | 53 | 10.25 |
| | 11-20 | 67 | 1 | 1.49 | 748 | 70 | 9.36 |
| | 21-100 | 68 | 5 | 7.35 | 737 | 81 | 10.99 |
| | >100 | 4 | 0 | 0.00 | 88 | 5 | 5.68 |
| Indoor/outdoor | No | 158 | 6 | 3.80 | 2,070 | 206 | 9.95 |
| production | Yes | 2 | 0 | 0.00 | 20 | 3 | 15.00 |
| Individual housing | No | 60 | 3 | 5.00 | 479 | 49 | 10.23 |
| | Yes | 100 | 3 | 3.00 | 1,611 | 160 | 9.93 |
| Age of pigs | No gilts | 101 | 3 | 2.97 | 1,376 | 125 | 9.08 |
| | Mixed age | 39 | 2 | 5.13 | 569 | 69 | 12.13 |
| | All gilts | 20 | 1 | 5.00 | 145 | 15 | 10.34 |
| Gender of pigs | Male | 7 | 0 | 0.00 | 5 | 0 | 0.00 |
| | Female | 142 | 6 | 4.23 | 1,968 | 197 | 10.01 |
| | Mixed | 11 | 0 | 0.00 | 117 | 12 | 10.26 |
| Production stage | Maiden gilts | 15 | 1 | 6.67 | 129 | 12 | 9.30 |
| | Pregnant | 84 | 5 | 5.95 | 1,062 | 106 | 9.98 |
| | Farrowing and lactating | 35 | 0 | 0.00 | 494 | 49 | 9.92 |
| | Service area | 19 | 0 | 0.00 | 170 | 21 | 12.35 |
| | Mixed | 7 | 0 | 0.00 | 235 | 21 | 8.94 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 0 | | |
| | Solid floor other bedding | 1 | 0 | 0.00 | 4 | 0 | 0.00 |
| | Solid floor with straw | 9 | 0 | 0.00 | 28 | 2 | 7.14 |
| | Solid floor without bedding | 0 | | | 20 | 4 | 20.00 |
| | Partly slatted floor | 127 | 6 | 4.72 | 1,617 | 176 | 10.88 |
| | Slatted floor | 23 | 0 | 0.00 | 420 | 27 | 6.43 |
| | Other | 0 | | | 1 | 0 | 0.00 |
| All in/all out | No | 115 | 6 | 5.22 | 1,534 | 157 | 10.23 |
| | Yes | 45 | 0 | 0.00 | 556 | 52 | 9.35 |
| Type of diet | Cobbs/rolls/nuts/pellets | 60 | 6 | 10.00 | 719 | 110 | 15.30 |
| | Others | 9 | 0 | 0.00 | 88 | 11 | 12.50 |
| | Meal/mash | 91 | 0 | 0.00 | 1,256 | 86 | 6.85 |
| | Porridge/liquids | 0 | | | 27 | 2 | 7.41 |
| Origin of feed | Commercial compound | 121 | 6 | 4.96 | 1,780 | 173 | 9.72 |
| | Other | 1 | 0 | 0.00 | 26 | 1 | 3.85 |
| | Feed with maize | 38 | 0 | 0.00 | 184 | 27 | 14.67 |
| | Home-mill | 0 | | | 100 | 8 | 8.00 |
| Feed/water supplement | Not added | 146 | 6 | 4.11 | 1,780 | 171 | 9.61 |
| | Organic acid | 4 | 0 | 0.00 | 76 | 3 | 3.95 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 10 | 0 | 0.00 | 177 | 28 | 15.82 |
| | Probiotic | 0 | | | 0 | | |
| | Unknown/other | 0 | | | 57 | 7 | 12.28 |
| Use of antibiotics | No treatment | 145 | 6 | 4.14 | 1,847 | 191 | 10.34 |
| | Treatment | 15 | 0 | 0.00 | 230 | 17 | 7.39 |
| | Unknown | 0 | | | 13 | 1 | 7.69 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Bulgaria | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 70 | 0 | 0.00 | 32 | 0 | 0.00 |
| | 11-20 | 101 | 0 | 0.00 | 82 | 0 | 0.00 |
| | 21-100 | 249 | 0 | 0.00 | 112 | 0 | 0.00 |
| | >100 | 50 | 1 | 2.00 | 24 | 0 | 0.00 |
| Indoor/outdoor production | No | 0 | | | 0 | | |
| | Yes | 470 | 1 | 0.21 | 250 | 0 | 0.00 |
| Individual housing | No | 3 | 0 | 0.00 | 12 | 0 | 0.00 |
| | Yes | 467 | 1 | 0.21 | 238 | 0 | 0.00 |
| Age of pigs | No gilts | 23 | 0 | 0.00 | 15 | 0 | 0.00 |
| | Mixed age | 334 | 0 | 0.00 | 181 | 0 | 0.00 |
| | All gilts | 113 | 1 | 0.88 | 54 | 0 | 0.00 |
| Gender of pigs | Male | 25 | 1 | 4.00 | 21 | 0 | 0.00 |
| | Female | 237 | 0 | 0.00 | 109 | 0 | 0.00 |
| | Mixed | 208 | 0 | 0.00 | 120 | 0 | 0.00 |
| Production stage | Maiden gilts | 4 | 0 | 0.00 | 3 | 0 | 0.00 |
| | Pregnant | 72 | 0 | 0.00 | 39 | 0 | 0.00 |
| | Farrowing and lactating | 110 | 0 | 0.00 | 50 | 0 | 0.00 |
| | Service area | 149 | 0 | 0.00 | 52 | 0 | 0.00 |
| | Mixed | 135 | 1 | 0.74 | 106 | 0 | 0.00 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 0 | | |
| | Solid floor other bedding | 10 | 0 | 0.00 | 40 | 0 | 0.00 |
| | Solid floor with straw | 0 | | | 0 | | |
| | Solid floor without bedding | 0 | | | 0 | | |
| | Partly slatted floor | 0 | | | 0 | | |
| | Slatted floor | 0 | | | 0 | | |
| | Other | 460 | 1 | 0.22 | 210 | 0 | 0.00 |
| All in/all out | No | 0 | | | 0 | | |
| | Yes | 470 | 1 | 0.21 | 250 | 0 | 0.00 |
| Type of diet | Cobbs/rolls/nuts/pellets | 0 | | | 0 | | |
| | Others | 10 | 0 | 0.00 | 40 | 0 | 0.00 |
| | Meal/mash | 460 | 1 | 0.22 | 210 | 0 | 0.00 |
| | Porridge/liquids | 0 | | | 0 | | |
| Origin of feed | Commercial compound | 460 | 1 | 0.22 | 210 | 0 | 0.00 |
| | Other | 10 | 0 | 0.00 | 40 | 0 | 0.00 |
| | Feed with maize | 0 | | | 0 | | |
| | Home-mill | 0 | | | 0 | | |
| Feed/water supplement | Not added | 2 | 0 | 0.00 | 4 | 0 | 0.00 |
| | Organic acid | 0 | | | 0 | | |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 0 | | | 0 | | |
| | Probiotic | 0 | | | 0 | | |
| | Unknown/other | 468 | 1 | 0.21 | 246 | 0 | 0.00 |
| Use of antibiotics | No treatment | 470 | 1 | 0.21 | 250 | 0 | 0.00 |
| | Treatment | 0 | | | 0 | | |
| | Unknown | 0 | | | 0 | | |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Cyprus | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 38 | 5 | 13.16 | 528 | 19 | 3.60 |
| | 11-20 | 2 | 0 | 0.00 | 59 | 2 | 3.39 |
| | 21-100 | 0 | | | 12 | 1 | 8.33 |
| | >100 | 0 | | | 1 | 0 | 0.00 |
| Indoor/outdoor production | No | 40 | 5 | 12.50 | 459 | 20 | 4.36 |
| | Yes | 0 | | | 141 | 2 | 1.42 |
| Individual housing | No | 10 | 1 | 10.00 | 320 | 12 | 3.75 |
| | Yes | 30 | 4 | 13.33 | 280 | 10 | 3.57 |
| Age of pigs | No gilts | 33 | 4 | 12.12 | 483 | 17 | 3.52 |
| | Mixed age | 0 | | | 31 | 2 | 6.45 |
| | All gilts | 7 | 1 | 14.29 | 86 | 3 | 3.49 |
| Gender of pigs | Male | 6 | 0 | 0.00 | 14 | 0 | 0.00 |
| | Female | 34 | 5 | 14.71 | 560 | 21 | 3.75 |
| | Mixed | 0 | | | 26 | 1 | 3.85 |
| Production stage | Maiden gilts | 7 | 1 | 14.29 | 86 | 3 | 3.49 |
| | Pregnant | 12 | 1 | 8.33 | 292 | 11 | 3.77 |
| | Farrowing and lactating | 8 | 0 | 0.00 | 120 | 3 | 2.50 |
| | Service area | 13 | 3 | 23.08 | 69 | 3 | 4.35 |
| | Mixed | 0 | | | 33 | 2 | 6.06 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 5 | 0 | 0.00 |
| | Solid floor other bedding | 0 | | | 13 | 0 | 0.00 |
| | Solid floor with straw | 0 | | | 1 | 0 | 0.00 |
| | Solid floor without bedding | 3 | 0 | 0.00 | 79 | 2 | 2.53 |
| | Partly slatted floor | 22 | 4 | 18.18 | 471 | 20 | 4.25 |
| | Slatted floor | 15 | 1 | 6.67 | 31 | 0 | 0.00 |
| | Other | 0 | | | 0 | | |
| All in/all out | No | 14 | 2 | 14.29 | 263 | 9 | 3.42 |
| | Yes | 26 | 3 | 11.54 | 337 | 13 | 3.86 |
| Type of diet | Cobbs/rolls/nuts/pellets | 0 | | | 40 | 2 | 5.00 |
| | Others | 0 | | | 0 | | |
| | Meal/mash | 38 | 5 | 13.16 | 542 | 20 | 3.69 |
| | Porridge/liquids | 2 | 0 | 0.00 | 18 | 0 | 0.00 |
| Origin of feed | Commercial compound | 0 | | | 57 | 2 | 3.51 |
| | Other | 0 | | | 13 | 2 | 15.38 |
| | Feed with maize | 0 | | | 0 | | |
| | Home-mill | 40 | 5 | 12.50 | 530 | 18 | 3.40 |
| Feed/water supplement | Not added | 30 | 5 | 16.67 | 553 | 22 | 3.98 |
| | Organic acid | 0 | | | 10 | 0 | 0.00 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 7 | 0 | 0.00 | 0 | | |
| | Probiotic | 0 | | | 0 | | |
| | Unknown/other | 3 | 0 | 0.00 | 37 | 0 | 0.00 |
| Use of antibiotics | No treatment | 28 | 5 | 17.86 | 491 | 14 | 2.85 |
| | Treatment | 6 | 0 | 0.00 | 104 | 8 | 7.69 |
| | Unknown | 6 | 0 | 0.00 | 5 | 0 | 0.00 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Czech Republic | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 670 | 21 | 3.13 | 902 | 30 | 3.33 |
| | 11-20 | 325 | 13 | 4.00 | 556 | 39 | 7.01 |
| | 21-100 | 65 | 3 | 4.62 | 145 | 18 | 12.41 |
| | >100 | 0 | | | 7 | 1 | 14.29 |
| Indoor/outdoor | No | 903 | 36 | 3.99 | 1,520 | 78 | 5.13 |
| production | Yes | 157 | 1 | 0.64 | 90 | 10 | 11.11 |
| Individual housing | No | 417 | 13 | 3.12 | 661 | 44 | 6.66 |
| | Yes | 643 | 24 | 3.73 | 949 | 44 | 4.64 |
| Age of pigs | No gilts | 359 | 17 | 4.74 | 613 | 38 | 6.20 |
| | Mixed age | 406 | 12 | 2.96 | 719 | 30 | 4.17 |
| | All gilts | 295 | 8 | 2.71 | 278 | 20 | 7.19 |
| Gender of pigs | Male | 4 | 1 | 25.00 | 6 | 0 | 0.00 |
| | Female | 876 | 29 | 3.31 | 1,276 | 75 | 5.88 |
| | Mixed | 180 | 7 | 3.89 | 328 | 13 | 3.96 |
| Production stage | Maiden gilts | 219 | 10 | 4.57 | 177 | 10 | 5.65 |
| | Pregnant | 431 | 18 | 4.18 | 801 | 52 | 6.49 |
| | Farrowing and lactating | 193 | 5 | 2.59 | 286 | 7 | 2.45 |
| | Service area | 73 | 2 | 2.74 | 68 | 3 | 4.41 |
| | Mixed | 144 | 2 | 1.39 | 278 | 16 | 5.76 |
| Floor type | Outdoors in fields or paddocks | 8 | 0 | 0.00 | 0 | | |
| | Solid floor other bedding | 0 | | | 0 | | |
| | Solid floor with straw | 68 | 4 | 5.88 | 87 | 16 | 18.39 |
| | Solid floor without bedding | 567 | 20 | 3.53 | 470 | 26 | 5.53 |
| | Partly slatted floor | 329 | 11 | 3.34 | 878 | 39 | 4.44 |
| | Slatted floor | 88 | 2 | 2.27 | 175 | 7 | 4.00 |
| | Other | 0 | | | 0 | | |
| All in/all out | No | 272 | 7 | 2.57 | 258 | 11 | 4.26 |
| | Yes | 788 | 30 | 3.81 | 1,352 | 77 | 5.70 |
| Type of diet | Cobbs/rolls/nuts/pellets | 265 | 19 | 7.17 | 409 | 31 | 7.58 |
| | Others | 22 | 0 | 0.00 | 10 | 0 | 0.00 |
| | Meal/mash | 695 | 18 | 2.59 | 1,034 | 52 | 5.03 |
| | Porridge/liquids | 78 | 0 | 0.00 | 157 | 5 | 3.18 |
| Origin of feed | Commercial compound | 637 | 25 | 3.92 | 1,089 | 64 | 5.88 |
| | Other | 0 | | | 0 | | |
| | Feed with maize | 0 | | | 0 | | |
| | Home-mill | 423 | 12 | 2.84 | 521 | 24 | 4.61 |
| Feed/water supplement | Not added | 946 | 35 | 3.70 | 1,438 | 75 | 5.22 |
| | Organic acid | 64 | 2 | 3.13 | 103 | 9 | 8.74 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 10 | 0 | 0.00 | 10 | 0 | 0.00 |
| | Probiotic | 40 | 0 | 0.00 | 59 | 4 | 6.78 |
| | Unknown/other | 0 | | | 0 | | |
| Use of antibiotics | No treatment | 998 | 37 | 3.71 | 1,524 | 86 | 5.64 |
| | Treatment | 61 | 0 | 0.00 | 85 | 2 | 2.35 |
| | Unknown | 1 | 0 | 0.00 | 1 | 0 | 0.00 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Denmark | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 450 | 72 | 16.00 | 1,146 | 132 | 11.52 |
| | 11-20 | 341 | 33 | 9.68 | 466 | 54 | 11.59 |
| | 21-100 | 154 | 34 | 22.08 | 329 | 55 | 16.72 |
| | >100 | 5 | 2 | 40.00 | 39 | 8 | 20.51 |
| Indoor/outdoor | No | 950 | 141 | 14.84 | 1,955 | 246 | 12.58 |
| production | Yes | 0 | | | 25 | 3 | 12.00 |
| Individual housing | No | 354 | 47 | 13.28 | 677 | 81 | 11.96 |
| | Yes | 596 | 94 | 15.77 | 1,303 | 168 | 12.89 |
| Age of pigs | No gilts | 375 | 61 | 16.27 | 976 | 115 | 11.78 |
| | Mixed age | 331 | 50 | 15.11 | 721 | 95 | 13.18 |
| | All gilts | 244 | 30 | 12.30 | 283 | 39 | 13.78 |
| Gender of pigs | Male | 5 | 0 | 0.00 | 2 | 1 | 50.00 |
| | Female | 909 | 135 | 14.85 | 1,854 | 235 | 12.68 |
| | Mixed | 36 | 6 | 16.67 | 124 | 13 | 10.48 |
| Production stage | Maiden gilts | 159 | 26 | 16.35 | 154 | 18 | 11.69 |
| | Pregnant | 113 | 10 | 8.85 | 177 | 35 | 19.77 |
| | Farrowing and lactating | 267 | 51 | 19.10 | 651 | 71 | 10.91 |
| | Service area | 215 | 29 | 13.49 | 562 | 73 | 12.99 |
| | Mixed | 196 | 25 | 12.76 | 436 | 52 | 11.93 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 16 | 1 | 6.25 |
| | Solid floor other bedding | 14 | 4 | 28.57 | 74 | 18 | 24.32 |
| | Solid floor with straw | 58 | 0 | 0.00 | 107 | 7 | 6.54 |
| | Solid floor without bedding | 3 | 2 | 66.67 | 12 | 1 | 8.33 |
| | Partly slatted floor | 751 | 117 | 15.58 | 1,481 | 187 | 12.63 |
| | Slatted floor | 121 | 16 | 13.22 | 275 | 34 | 12.36 |
| | Other | 3 | 2 | 66.67 | 15 | 1 | 6.67 |
| All in/all out | No | 788 | 118 | 14.97 | 1,579 | 194 | 12.29 |
| | Yes | 162 | 23 | 14.20 | 401 | 55 | 13.72 |
| Type of diet | Cobbs/rolls/nuts/pellets | 213 | 48 | 22.54 | 630 | 107 | 16.98 |
| | Others | 83 | 4 | 4.82 | 148 | 17 | 11.49 |
| | Meal/mash | 365 | 59 | 16.16 | 730 | 86 | 11.78 |
| | Porridge/liquids | 289 | 30 | 10.38 | 472 | 39 | 8.26 |
| Origin of feed | Commercial compound | 301 | 52 | 17.28 | 822 | 140 | 17.03 |
| | Other | 8 | 0 | 0.00 | 24 | 3 | 12.50 |
| | Feed with maize | 106 | 12 | 11.32 | 154 | 12 | 7.79 |
| | Home-mill | 535 | 77 | 14.39 | 980 | 94 | 9.59 |
| Feed/water supplement | Not added | 778 | 110 | 14.14 | 1,766 | 227 | 12.85 |
| | Organic acid | 91 | 9 | 9.89 | 107 | 15 | 14.02 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 33 | 16 | 48.48 | 78 | 1 | 1.28 |
| | Probiotic | 27 | 5 | 18.52 | 9 | 4 | 44.44 |
| | Unknown/other | 21 | 1 | 4.76 | 20 | 2 | 10.00 |
| Use of antibiotics | No treatment | 574 | 69 | 12.02 | 1,153 | 129 | 11.19 |
| | Treatment | 358 | 64 | 17.88 | 820 | 118 | 14.39 |
| | Unknown | 18 | 8 | 44.44 | 7 | 2 | 28.57 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Estonia | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 41 | 0 | 0.00 | 160 | 0 | 0.00 |
| | 11-20 | 19 | 0 | 0.00 | 92 | 1 | 1.09 |
| | 21-100 | 0 | | | 28 | 2 | 7.14 |
| | >100 | 0 | | | 0 | | |
| Indoor/outdoor production | No | 60 | 0 | 0.00 | 203 | 3 | 1.48 |
| | Yes | 0 | | | 77 | 0 | 0.00 |
| Individual housing | No | 35 | 0 | 0.00 | 261 | 3 | 1.15 |
| | Yes | 25 | 0 | 0.00 | 19 | 0 | 0.00 |
| Age of pigs | No gilts | 3 | 0 | 0.00 | 82 | 0 | 0.00 |
| | Mixed age | 55 | 0 | 0.00 | 124 | 2 | 1.61 |
| | All gilts | 2 | 0 | 0.00 | 74 | 1 | 1.35 |
| Gender of pigs | Male | 0 | | | 5 | 0 | 0.00 |
| | Female | 56 | 0 | 0.00 | 244 | 1 | 0.41 |
| | Mixed | 4 | 0 | 0.00 | 31 | 2 | 6.45 |
| Production stage | Maiden gilts | 3 | 0 | 0.00 | 45 | 0 | 0.00 |
| | Pregnant | 9 | 0 | 0.00 | 87 | 1 | 1.15 |
| | Farrowing and lactating | 17 | 0 | 0.00 | 10 | 0 | 0.00 |
| | Service area | 11 | 0 | 0.00 | 96 | 0 | 0.00 |
| | Mixed | 20 | 0 | 0.00 | 42 | 2 | 4.76 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 0 | | |
| | Solid floor other bedding | 40 | 0 | 0.00 | 170 | 0 | 0.00 |
| | Solid floor with straw | 0 | | | 0 | | |
| | Solid floor without bedding | 10 | 0 | 0.00 | 43 | 0 | 0.00 |
| | Partly slatted floor | 10 | 0 | 0.00 | 60 | 3 | 5.00 |
| | Slatted floor | 0 | | | 7 | 0 | 0.00 |
| | Other | 0 | | | 0 | | |
| All in/all out | No | 3 | 0 | 0.00 | 36 | 1 | 2.78 |
| | Yes | 57 | 0 | 0.00 | 244 | 2 | 0.82 |
| Type of diet | Cobbs/rolls/nuts/pellets | 0 | | | 50 | 3 | 6.00 |
| | Others | 10 | 0 | 0.00 | 20 | 0 | 0.00 |
| | Meal/mash | 40 | 0 | 0.00 | 180 | 0 | 0.00 |
| | Porridge/liquids | 10 | 0 | 0.00 | 30 | 0 | 0.00 |
| Origin of feed | Commercial compound | 40 | 0 | 0.00 | 130 | 3 | 2.31 |
| | Other | 0 | | | 0 | | |
| | Feed with maize | 0 | | | 0 | | |
| | Home-mill | 20 | 0 | 0.00 | 150 | 0 | 0.00 |
| Feed/water supplement | Not added | 60 | 0 | 0.00 | 268 | 2 | 0.75 |
| | Organic acid | 0 | | | 11 | 1 | 9.09 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 0 | | | 0 | | |
| | Probiotic | 0 | | | 1 | 0 | 0.00 |
| | Unknown/other | 0 | | | 0 | | |
| Use of antibiotics | No treatment | 50 | 0 | 0.00 | 269 | 2 | 0.74 |
| | Treatment | 10 | 0 | 0.00 | 11 | 1 | 9.09 |
| | Unknown | 0 | | | 0 | | |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Finland | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 251 | 0 | 0.00 | 770 | 0 | 0.00 |
| | 11-20 | 175 | 0 | 0.00 | 502 | 0 | 0.00 |
| | 21-100 | 74 | 0 | 0.00 | 257 | 0 | 0.00 |
| | >100 | 0 | | | 41 | 0 | 0.00 |
| Indoor/outdoor | No | 490 | 0 | 0.00 | 1,549 | 0 | 0.00 |
| production | Yes | 10 | 0 | 0.00 | 21 | 0 | 0.00 |
| Individual housing | No | 380 | 0 | 0.00 | 970 | 0 | 0.00 |
| | Yes | 120 | 0 | 0.00 | 600 | 0 | 0.00 |
| Age of pigs | No gilts | 310 | 0 | 0.00 | 1,228 | 0 | 0.00 |
| | Mixed age | 80 | 0 | 0.00 | 227 | 0 | 0.00 |
| | All gilts | 110 | 0 | 0.00 | 115 | 0 | 0.00 |
| Gender of pigs | Male | 2 | 0 | 0.00 | 3 | 0 | 0.00 |
| | Female | 436 | 0 | 0.00 | 1,407 | 0 | 0.00 |
| | Mixed | 62 | 0 | 0.00 | 160 | 0 | 0.00 |
| Production stage | Maiden gilts | 77 | 0 | 0.00 | 96 | 0 | 0.00 |
| | Pregnant | 216 | 0 | 0.00 | 697 | 0 | 0.00 |
| | Farrowing and lactating | 83 | 0 | 0.00 | 382 | 0 | 0.00 |
| | Service area | 22 | 0 | 0.00 | 140 | 0 | 0.00 |
| | Mixed | 102 | 0 | 0.00 | 255 | 0 | 0.00 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 1 | 0 | 0.00 |
| | Solid floor other bedding | 65 | 0 | 0.00 | 244 | 0 | 0.00 |
| | Solid floor with straw | 171 | 0 | 0.00 | 427 | 0 | 0.00 |
| | Solid floor without bedding | 3 | 0 | 0.00 | 52 | 0 | 0.00 |
| | Partly slatted floor | 246 | 0 | 0.00 | 779 | 0 | 0.00 |
| | Slatted floor | 15 | 0 | 0.00 | 67 | 0 | 0.00 |
| | Other | 0 | | | 0 | | |
| All in/all out | No | 409 | 0 | 0.00 | 1,339 | 0 | 0.00 |
| | Yes | 91 | 0 | 0.00 | 231 | 0 | 0.00 |
| Type of diet | Cobbs/rolls/nuts/pellets | 27 | 0 | 0.00 | 202 | 0 | 0.00 |
| | Others | 57 | 0 | 0.00 | 132 | 0 | 0.00 |
| | Meal/mash | 183 | 0 | 0.00 | 678 | 0 | 0.00 |
| | Porridge/liquids | 233 | 0 | 0.00 | 558 | 0 | 0.00 |
| Origin of feed | Commercial compound | 67 | 0 | 0.00 | 244 | 0 | 0.00 |
| | Other | 50 | 0 | 0.00 | 261 | 0 | 0.00 |
| | Feed with maize | 0 | | | 0 | | |
| | Home-mill | 383 | 0 | 0.00 | 1,065 | 0 | 0.00 |
| Feed/water supplement | Not added | 375 | 0 | 0.00 | 1,273 | 0 | 0.00 |
| | Organic acid | 85 | 0 | 0.00 | 251 | 0 | 0.00 |
| | Organic acid and probiotic | 10 | 0 | 0.00 | 0 | | |
| | Other | 10 | 0 | 0.00 | 0 | | |
| | Probiotic | 0 | | | 1 | 0 | 0.00 |
| | Unknown/other | 20 | 0 | 0.00 | 45 | 0 | 0.00 |
| Use of antibiotics | No treatment | 431 | 0 | 0.00 | 1,388 | 0 | 0.00 |
| | Treatment | 60 | 0 | 0.00 | 151 | 0 | 0.00 |
| | Unknown | 9 | 0 | 0.00 | 31 | 0 | 0.00 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| France | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 119 | 13 | 10.92 | 174 | 13 | 7.47 |
| | 10 | 434 | 46 | 10.60 | 641 | 61 | 9.52 |
| | 11-20 | 442 | 45 | 10.18 | 446 | 57 | 12.78 |
| | 21-100 | 439 | 63 | 14.35 | 461 | 45 | 9.76 |
| | >100 | 136 | 13 | 9.56 | 138 | 12 | 8.70 |
| Indoor/outdoor production | No | 1,557 | 180 | 11.56 | 1,818 | 176 | 9.68 |
| | Yes | 13 | 0 | 0.00 | 42 | 12 | 28.57 |
| Individual housing | No | 337 | 42 | 12.46 | 383 | 44 | 11.49 |
| | Yes | 1233 | 138 | 11.19 | 1,477 | 144 | 9.75 |
| Age of pigs | No gilts | 555 | 60 | 10.81 | 654 | 62 | 9.48 |
| | Mixed age | 902 | 105 | 11.64 | 1,124 | 113 | 10.05 |
| | All gilts | 113 | 15 | 13.27 | 82 | 13 | 15.85 |
| Gender of pigs | Male | 9 | 0 | 0.00 | 6 | 0 | 0.00 |
| | Female | 1,433 | 169 | 11.79 | 1,677 | 160 | 9.54 |
| | Mixed | 128 | 11 | 8.59 | 177 | 28 | 15.82 |
| Production stage | Maiden gilts | 43 | 4 | 9.30 | 24 | 2 | 8.33 |
| | Pregnant | 861 | 101 | 11.73 | 1,060 | 110 | 10.38 |
| | Farrowing and lactating | 347 | 36 | 10.37 | 436 | 36 | 8.26 |
| | Service area | 231 | 28 | 12.12 | 222 | 27 | 12.16 |
| | Mixed | 88 | 11 | 12.50 | 118 | 13 | 11.02 |
| Floor type | Outdoors in fields or paddocks | 12 | 0 | 0.00 | 27 | 11 | 40.74 |
| | Solid floor other bedding | 0 | | | 8 | 0 | 0.00 |
| | Solid floor with straw | 99 | 4 | 4.04 | 135 | 5 | 3.70 |
| | Solid floor without bedding | 0 | | | 30 | 5 | 16.67 |
| | Partly slatted floor | 206 | 26 | 12.62 | 308 | 17 | 5.52 |
| | Slatted floor | 1,253 | 150 | 11.97 | 1,352 | 150 | 11.09 |
| | Other | 0 | | | 0 | | |
| All in/all out | No | 1,017 | 121 | 11.90 | 1,210 | 120 | 9.92 |
| | Yes | 553 | 59 | 10.67 | 650 | 68 | 10.46 |
| Type of diet | Cobbs/rolls/nuts/pellets | 273 | 49 | 17.95 | 319 | 46 | 14.42 |
| | Others | 51 | 11 | 21.57 | 109 | 19 | 17.43 |
| | Meal/mash | 527 | 51 | 9.68 | 652 | 61 | 9.36 |
| | Porridge/liquids | 719 | 69 | 9.60 | 780 | 62 | 7.95 |
| Origin of feed | Commercial compound | 1,178 | 142 | 12.05 | 1,265 | 144 | 11.38 |
| | Other | 10 | 0 | 0.00 | 28 | 0 | 0.00 |
| | Feed with maize | 10 | 1 | 10.00 | 50 | 4 | 8.00 |
| | Home-mill | 372 | 37 | 9.95 | 517 | 40 | 7.74 |
| Feed/water supplement | Not added | 1,166 | 114 | 9.78 | 1,369 | 150 | 10.96 |
| | Organic acid | 67 | 2 | 2.99 | 77 | 6 | 7.79 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 307 | 53 | 17.26 | 373 | 32 | 8.58 |
| | Probiotic | 20 | 11 | 55.00 | 21 | 0 | 0.00 |
| | Unknown/other | 10 | 0 | 0.00 | 20 | 0 | 0.00 |
| Use of antibiotics | No treatment | 1,233 | 145 | 11.76 | 1,462 | 144 | 9.85 |
| | Treatment | 321 | 33 | 10.28 | 388 | 44 | 11.34 |
| | Unknown | 16 | 2 | 12.50 | 10 | 0 | 0.00 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Germany | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 12 | 0 | 0.00 | 27 | 0 | 0.00 |
| | 10 | 137 | 8 | 5.84 | 451 | 21 | 4.66 |
| | 11-20 | 142 | 11 | 7.75 | 529 | 34 | 6.43 |
| | 21-100 | 133 | 11 | 8.27 | 478 | 28 | 5.86 |
| | >100 | 36 | 5 | 13.89 | 65 | 7 | 10.77 |
| Indoor/outdoor | No | 424 | 34 | 8.02 | 1,435 | 85 | 5.92 |
| production | Yes | 36 | 1 | 2.78 | 115 | 5 | 4.35 |
| Individual housing | No | 255 | 24 | 9.41 | 678 | 46 | 6.78 |
| | Yes | 205 | 11 | 5.37 | 872 | 44 | 5.05 |
| Age of pigs | No gilts | 99 | 3 | 3.03 | 500 | 35 | 7.00 |
| | Mixed age | 237 | 18 | 7.59 | 823 | 41 | 4.98 |
| | All gilts | 124 | 14 | 11.29 | 227 | 14 | 6.17 |
| Gender of pigs | Male | 4 | 0 | 0.00 | 1 | 0 | 0.00 |
| | Female | 395 | 28 | 7.09 | 1,395 | 83 | 5.95 |
| | Mixed | 61 | 7 | 11.48 | 154 | 7 | 4.55 |
| Production stage | Maiden gilts | 118 | 13 | 11.02 | 178 | 9 | 5.06 |
| | Pregnant | 144 | 10 | 6.94 | 546 | 34 | 6.23 |
| | Farrowing and lactating | 118 | 8 | 6.78 | 483 | 25 | 5.18 |
| | Service area | 78 | 4 | 5.13 | 341 | 22 | 6.45 |
| | Mixed | 2 | 0 | 0.00 | 2 | 0 | 0.00 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 4 | 0 | 0.00 |
| | Solid floor other bedding | 3 | 1 | 33.33 | 0 | | |
| | Solid floor with straw | 45 | 0 | 0.00 | 126 | 1 | 0.79 |
| | Solid floor without bedding | 30 | 2 | 6.67 | 72 | 6 | 8.33 |
| | Partly slatted floor | 209 | 14 | 6.70 | 777 | 51 | 6.56 |
| | Slatted floor | 173 | 18 | 10.40 | 571 | 32 | 5.60 |
| | Other | 0 | | | 0 | | |
| All in/all out | No | 188 | 8 | 4.26 | 799 | 38 | 4.76 |
| | Yes | 272 | 27 | 9.93 | 751 | 52 | 6.92 |
| Type of diet | Cobbs/rolls/nuts/pellets | 125 | 21 | 16.80 | 497 | 53 | 10.66 |
| | Others | 4 | 1 | 25.00 | 0 | | |
| | Meal/mash | 253 | 13 | 5.14 | 891 | 29 | 3.25 |
| | Porridge/liquids | 78 | 0 | 0.00 | 162 | 8 | 4.94 |
| Origin of feed | Commercial compound | 183 | 22 | 12.02 | 689 | 69 | 10.01 |
| | Other | 2 | 1 | 50.00 | 0 | | |
| | Feed with maize | 0 | | | 10 | 0 | 0.00 |
| | Home-mill | 275 | 12 | 4.36 | 851 | 21 | 2.47 |
| Feed/water supplement | Not added | 97 | 4 | 4.12 | 504 | 42 | 8.33 |
| | Organic acid | 114 | 3 | 2.63 | 236 | 4 | 1.69 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 12 | 6 | 50.00 | 50 | 0 | 0.00 |
| | Probiotic | 0 | | | 0 | | |
| | Unknown/other | 237 | 22 | 9.28 | 760 | 44 | 5.79 |
| Use of antibiotics | No treatment | 125 | 5 | 4.00 | 500 | 39 | 7.80 |
| | Treatment | 63 | 8 | 12.70 | 237 | 7 | 2.95 |
| | Unknown | 272 | 22 | 8.09 | 813 | 44 | 5.41 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Hungary | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 114 | 10 | 8.77 | 358 | 15 | 4.19 |
| | 11-20 | 169 | 11 | 6.51 | 618 | 27 | 4.37 |
| | 21-100 | 101 | 6 | 5.94 | 394 | 24 | 6.09 |
| | >100 | 16 | 0 | 0.00 | 40 | 6 | 15.00 |
| Indoor/outdoor | No | 296 | 24 | 8.11 | 942 | 45 | 4.78 |
| production | Yes | 104 | 3 | 2.88 | 468 | 27 | 5.77 |
| Individual housing | No | 267 | 19 | 7.12 | 1,024 | 53 | 5.18 |
| | Yes | 133 | 8 | 6.02 | 386 | 19 | 4.92 |
| Age of pigs | No gilts | 171 | 6 | 3.51 | 725 | 40 | 5.52 |
| | Mixed age | 140 | 11 | 7.86 | 469 | 16 | 3.41 |
| | All gilts | 89 | 10 | 11.24 | 216 | 16 | 7.41 |
| Gender of pigs | Male | 36 | 0 | 0.00 | 31 | 1 | 3.23 |
| | Female | 352 | 27 | 7.67 | 1,302 | 68 | 5.22 |
| | Mixed | 12 | 0 | 0.00 | 77 | 3 | 3.90 |
| Production stage | Maiden gilts | 88 | 9 | 10.23 | 214 | 17 | 7.94 |
| | Pregnant | 141 | 8 | 5.67 | 731 | 37 | 5.06 |
| | Farrowing and lactating | 63 | 3 | 4.76 | 234 | 9 | 3.85 |
| | Service area | 58 | 0 | 0.00 | 72 | 3 | 4.17 |
| | Mixed | 50 | 7 | 14.00 | 159 | 6 | 3.77 |
| Floor type | Outdoors in fields or paddocks | 12 | 0 | 0.00 | 10 | 0 | 0.00 |
| | Solid floor other bedding | 0 | | | 18 | 2 | 11.11 |
| | Solid floor with straw | 140 | 9 | 6.43 | 304 | 13 | 4.28 |
| | Solid floor without bedding | 165 | 7 | 4.24 | 852 | 50 | 5.87 |
| | Partly slatted floor | 5 | 2 | 40.00 | 42 | 1 | 2.38 |
| | Slatted floor | 37 | 4 | 10.81 | 81 | 1 | 1.23 |
| | Other | 41 | 5 | 12.20 | 103 | 5 | 4.85 |
| All in/all out | No | 163 | 7 | 4.29 | 499 | 22 | 4.41 |
| | Yes | 237 | 20 | 8.44 | 911 | 50 | 5.49 |
| Type of diet | Cobbs/rolls/nuts/pellets | 30 | 5 | 16.67 | 76 | 11 | 14.47 |
| | Others | 147 | 10 | 6.80 | 509 | 17 | 3.34 |
| | Meal/mash | 223 | 12 | 5.38 | 812 | 44 | 5.42 |
| | Porridge/liquids | 0 | | | 13 | 0 | 0.00 |
| Origin of feed | Commercial compound | 154 | 14 | 9.09 | 298 | 11 | 3.69 |
| | Other | 36 | 0 | 0.00 | 134 | 6 | 4.48 |
| | Feed with maize | 20 | 1 | 5.00 | 136 | 2 | 1.47 |
| | Home-mill | 190 | 12 | 6.32 | 842 | 53 | 6.29 |
| Feed/water supplement | Not added | 251 | 21 | 8.37 | 1,040 | 55 | 5.29 |
| | Organic acid | 98 | 6 | 6.12 | 249 | 16 | 6.43 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 1 | 0 | 0.00 | 47 | 1 | 2.13 |
| | Probiotic | 0 | | | 0 | | |
| | Unknown/other | 50 | 0 | 0.00 | 74 | 0 | 0.00 |
| Use of antibiotics | No treatment | 315 | 25 | 7.94 | 1,139 | 48 | 4.21 |
| | Treatment | 85 | 2 | 2.35 | 271 | 24 | 8.86 |
| | Unknown | 0 | | | 0 | | |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Ireland | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 175 | 32 | 18.29 | 571 | 63 | 11.03 |
| | 11-20 | 145 | 21 | 14.48 | 580 | 76 | 13.10 |
| | 21-100 | 70 | 9 | 12.86 | 294 | 44 | 14.97 |
| | >100 | 10 | 2 | 20.00 | 45 | 9 | 20.00 |
| Indoor/outdoor | No | 390 | 60 | 15.38 | 1,469 | 190 | 12.93 |
| production | Yes | 10 | 4 | 40.00 | 21 | 2 | 9.52 |
| Individual housing | No | 151 | 26 | 17.22 | 550 | 75 | 13.64 |
| | Yes | 249 | 38 | 15.26 | 940 | 117 | 12.45 |
| Age of pigs | No gilts | 198 | 26 | 13.13 | 716 | 86 | 12.01 |
| | Mixed age | 143 | 28 | 19.58 | 543 | 72 | 13.26 |
| | All gilts | 59 | 10 | 16.95 | 231 | 34 | 14.72 |
| Gender of pigs | Male | 1 | 0 | 0.00 | 3 | 1 | 33.33 |
| | Female | 361 | 54 | 14.96 | 1,393 | 183 | 13.14 |
| | Mixed | 38 | 10 | 26.32 | 94 | 8 | 8.51 |
| Production stage | Maiden gilts | 38 | 6 | 15.79 | 137 | 17 | 12.41 |
| | Pregnant | 200 | 31 | 15.50 | 772 | 102 | 13.21 |
| | Farrowing and lactating | 107 | 16 | 14.95 | 386 | 54 | 13.99 |
| | Service area | 22 | 2 | 9.09 | 93 | 12 | 12.90 |
| | Mixed | 33 | 9 | 27.27 | 102 | 7 | 6.86 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 0 | | |
| | Solid floor other bedding | 0 | | | 3 | 0 | 0.00 |
| | Solid floor with straw | 14 | 0 | 0.00 | 21 | 6 | 28.57 |
| | Solid floor without bedding | 27 | 10 | 37.04 | 49 | 2 | 4.08 |
| | Partly slatted floor | 144 | 21 | 14.58 | 576 | 64 | 11.11 |
| | Slatted floor | 215 | 33 | 15.35 | 841 | 120 | 14.27 |
| | Other | 0 | | | 0 | | |
| All in/all out | No | 188 | 29 | 15.43 | 709 | 88 | 12.41 |
| | Yes | 212 | 35 | 16.51 | 781 | 104 | 13.32 |
| Type of diet | Cobbs/rolls/nuts/pellets | 180 | 33 | 18.33 | 490 | 70 | 14.29 |
| | Others | 10 | 4 | 40.00 | 4 | 0 | 0.00 |
| | Meal/mash | 75 | 14 | 18.67 | 447 | 50 | 11.19 |
| | Porridge/liquids | 135 | 13 | 9.63 | 549 | 72 | 13.11 |
| Origin of feed | Commercial compound | 316 | 58 | 18.35 | 1,027 | 144 | 14.02 |
| | Other | 10 | 4 | 40.00 | 0 | | |
| | Feed with maize | 0 | | | 11 | 1 | 9.09 |
| | Home-mill | 74 | 2 | 2.70 | 452 | 47 | 10.40 |
| Feed/water supplement | Not added | 395 | 64 | 16.20 | 1,443 | 189 | 13.10 |
| | Organic acid | 0 | | | 38 | 3 | 7.89 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 5 | 0 | 0.00 | 9 | 0 | 0.00 |
| | Probiotic | 0 | | | 0 | | |
| | Unknown/other | 0 | | | 0 | | |
| Use of antibiotics | No treatment | 365 | 60 | 16.44 | 1,402 | 175 | 12.48 |
| | Treatment | 35 | 4 | 11.43 | 88 | 17 | 19.32 |
| | Unknown | 0 | | | 0 | | |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Italy | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 5 | 2 | 40.00 | 89 | 6 | 6.74 |
| | 10 | 144 | 16 | 11.11 | 633 | 87 | 13.74 |
| | 11-20 | 184 | 23 | 12.50 | 663 | 79 | 11.92 |
| | 21-100 | 68 | 17 | 25.00 | 227 | 24 | 10.57 |
| | >100 | 29 | 4 | 13.79 | 98 | 17 | 17.35 |
| Indoor/outdoor | No | 317 | 46 | 14.51 | 1,323 | 150 | 11.34 |
| production | Yes | 113 | 16 | 14.16 | 387 | 63 | 16.28 |
| Individual housing | No | 263 | 33 | 12.55 | 937 | 119 | 12.70 |
| | Yes | 167 | 29 | 17.37 | 773 | 94 | 12.16 |
| Age of pigs | No gilts | 226 | 19 | 8.41 | 1,085 | 139 | 12.81 |
| | Mixed age | 119 | 20 | 16.81 | 382 | 36 | 9.42 |
| | All gilts | 85 | 23 | 27.06 | 243 | 38 | 15.64 |
| Gender of pigs | Male | 14 | 2 | 14.29 | 9 | 2 | 22.22 |
| | Female | 398 | 52 | 13.07 | 1,598 | 204 | 12.77 |
| | Mixed | 18 | 8 | 44.44 | 103 | 7 | 6.80 |
| Production stage | Maiden gilts | 89 | 25 | 28.09 | 234 | 35 | 14.96 |
| | Pregnant | 245 | 23 | 9.39 | 953 | 126 | 13.22 |
| | Farrowing and lactating | 34 | 7 | 20.59 | 222 | 17 | 7.66 |
| | Service area | 25 | 1 | 4.00 | 112 | 13 | 11.61 |
| | Mixed | 37 | 6 | 16.22 | 189 | 22 | 11.64 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 1 | 0 | 0.00 |
| | Solid floor other bedding | 0 | | | 1 | 1 | 100.00 |
| | Solid floor with straw | 1 | 0 | 0.00 | 14 | 0 | 0.00 |
| | Solid floor without bedding | 85 | 24 | 28.24 | 297 | 58 | 19.53 |
| | Partly slatted floor | 151 | 9 | 5.96 | 799 | 94 | 11.76 |
| | Slatted floor | 192 | 29 | 15.10 | 580 | 59 | 10.17 |
| | Other | 1 | 0 | 0.00 | 18 | 1 | 5.56 |
| All in/all out | No | 154 | 16 | 10.39 | 730 | 83 | 11.37 |
| | Yes | 276 | 46 | 16.67 | 980 | 130 | 13.27 |
| Type of diet | Cobbs/rolls/nuts/pellets | 87 | 15 | 17.24 | 270 | 59 | 21.85 |
| | Others | 18 | 12 | 66.67 | 161 | 33 | 20.50 |
| | Meal/mash | 204 | 12 | 5.88 | 953 | 80 | 8.39 |
| | Porridge/liquids | 121 | 23 | 19.01 | 326 | 41 | 12.58 |
| Origin of feed | Commercial compound | 165 | 43 | 26.06 | 819 | 143 | 17.46 |
| | Other | 20 | 1 | 5.00 | 35 | 6 | 17.14 |
| | Feed with maize | 21 | 1 | 4.76 | 115 | 5 | 4.35 |
| | Home-mill | 224 | 17 | 7.59 | 741 | 59 | 7.96 |
| Feed/water supplement | Not added | 299 | 46 | 15.38 | 1,356 | 183 | 13.50 |
| | Organic acid | 32 | 3 | 9.38 | 86 | 6 | 6.98 |
| | Organic acid and probiotic | 30 | 2 | 6.67 | 17 | 0 | 0.00 |
| | Other | 20 | 0 | 0.00 | 66 | 5 | 7.58 |
| | Probiotic | 10 | 0 | 0.00 | 31 | 0 | 0.00 |
| | Unknown/other | 39 | 11 | 28.21 | 154 | 19 | 12.34 |
| Use of antibiotics | No treatment | 306 | 43 | 14.05 | 1,245 | 166 | 13.33 |
| | Treatment | 124 | 19 | 15.32 | 465 | 47 | 10.11 |
| | Unknown | 0 | | | 0 | | |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Lithuania | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 41 | 0 | 0.00 | 147 | 0 | 0.00 |
| | 11-20 | 54 | 0 | 0.00 | 437 | 5 | 1.14 |
| | 21-100 | 5 | 0 | 0.00 | 136 | 7 | 5.15 |
| | >100 | 0 | | | 0 | | |
| Indoor/outdoor | No | 100 | 0 | 0.00 | 713 | 12 | 1.68 |
| production | Yes | 0 | | | 7 | 0 | 0.00 |
| Individual housing | No | 90 | 0 | 0.00 | 678 | 12 | 1.77 |
| | Yes | 10 | 0 | 0.00 | 42 | 0 | 0.00 |
| Age of pigs | No gilts | 0 | | | 0 | | |
| | Mixed age | 71 | 0 | 0.00 | 625 | 9 | 1.44 |
| | All gilts | 29 | 0 | 0.00 | 95 | 3 | 3.16 |
| Gender of pigs | Male | 0 | | | 0 | | |
| | Female | 58 | 0 | 0.00 | 141 | 1 | 0.71 |
| | Mixed | 42 | 0 | 0.00 | 579 | 11 | 1.90 |
| Production stage | Maiden gilts | 18 | 0 | 0.00 | 126 | 1 | 0.79 |
| | Pregnant | 9 | 0 | 0.00 | 4 | 1 | 25.00 |
| | Farrowing and lactating | 0 | | | 0 | | |
| | Service area | 4 | 0 | 0.00 | 20 | 0 | 0.00 |
| | Mixed | 69 | 0 | 0.00 | 570 | 10 | 1.75 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 0 | | |
| | Solid floor other bedding | 36 | 0 | 0.00 | 175 | 1 | 0.57 |
| | Solid floor with straw | 0 | | | 9 | 0 | 0.00 |
| | Solid floor without bedding | 64 | 0 | 0.00 | 526 | 11 | 2.09 |
| | Partly slatted floor | 0 | | | 0 | | |
| | Slatted floor | 0 | | | 0 | | |
| | Other | 0 | | | 10 | 0 | 0.00 |
| All in/all out | No | 12 | 0 | 0.00 | 73 | 1 | 1.37 |
| | Yes | 88 | 0 | 0.00 | 647 | 11 | 1.70 |
| Type of diet | Cobbs/rolls/nuts/pellets | 20 | 0 | 0.00 | 99 | 0 | 0.00 |
| | Others | 0 | | | 9 | 0 | 0.00 |
| | Meal/mash | 80 | 0 | 0.00 | 602 | 11 | 1.83 |
| | Porridge/liquids | 0 | | | 10 | 1 | 10.00 |
| Origin of feed | Commercial compound | 60 | 0 | 0.00 | 470 | 10 | 2.13 |
| | Other | 0 | | | 2 | 0 | 0.00 |
| | Feed with maize | 0 | | | 0 | | |
| | Home-mill | 40 | 0 | 0.00 | 248 | 2 | 0.81 |
| Feed/water supplement | Not added | 0 | | | 30 | 0 | 0.00 |
| | Organic acid | 40 | 0 | 0.00 | 153 | 7 | 4.58 |
| | Organic acid and probiotic | 0 | | | 39 | 3 | 7.69 |
| | Other | 60 | 0 | 0.00 | 374 | 2 | 0.53 |
| | Probiotic | 0 | | | 31 | 0 | 0.00 |
| | Unknown/other | 0 | | | 93 | 0 | 0.00 |
| Use of antibiotics | No treatment | 60 | 0 | 0.00 | 546 | 5 | 0.92 |
| | Treatment | 20 | 0 | 0.00 | 100 | 6 | 6.00 |
| | Unknown | 20 | 0 | 0.00 | 74 | 1 | 1.35 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Latvia | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 10 | 0 | 0.00 | 74 | 6 | 8.11 |
| | 11-20 | 32 | 2 | 6.25 | 193 | 16 | 8.29 |
| | 21-100 | 8 | 1 | 12.50 | 13 | 1 | 7.69 |
| | >100 | 0 | | | 0 | | |
| Indoor/outdoor production | No | 50 | 3 | 6.00 | 272 | 23 | 8.46 |
| | Yes | 0 | | | 8 | 0 | 0.00 |
| Individual housing | No | 32 | 1 | 3.13 | 201 | 19 | 9.45 |
| | Yes | 18 | 2 | 11.11 | 79 | 4 | 5.06 |
| Age of pigs | No gilts | 18 | 1 | 5.56 | 172 | 8 | 4.65 |
| | Mixed age | 14 | 1 | 7.14 | 38 | 4 | 10.53 |
| | All gilts | 18 | 1 | 5.56 | 70 | 11 | 15.71 |
| Gender of pigs | Male | 3 | 0 | 0.00 | 2 | 0 | 0.00 |
| | Female | 31 | 2 | 6.45 | 202 | 15 | 7.43 |
| | Mixed | 16 | 1 | 6.25 | 76 | 8 | 10.53 |
| Production stage | Maiden gilts | 22 | 2 | 9.09 | 47 | 9 | 19.15 |
| | Pregnant | 7 | 0 | 0.00 | 108 | 4 | 3.70 |
| | Farrowing and lactating | 14 | 1 | 7.14 | 64 | 4 | 6.25 |
| | Service area | 2 | 0 | 0.00 | 19 | 1 | 5.26 |
| | Mixed | 5 | 0 | 0.00 | 42 | 5 | 11.90 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 0 | | |
| | Solid floor other bedding | 10 | 0 | 0.00 | 78 | 8 | 10.26 |
| | Solid floor with straw | 2 | 0 | 0.00 | 11 | 3 | 27.27 |
| | Solid floor without bedding | 0 | | | 24 | 1 | 4.17 |
| | Partly slatted floor | 35 | 3 | 8.57 | 122 | 8 | 6.56 |
| | Slatted floor | 3 | 0 | 0.00 | 45 | 3 | 6.67 |
| | Other | 0 | | | 0 | | |
| All in/all out | No | 1 | 0 | 0.00 | 12 | 0 | 0.00 |
| | Yes | 49 | 3 | 6.12 | 268 | 23 | 8.58 |
| Type of diet | Cobbs/rolls/nuts/pellets | 20 | 3 | 15.00 | 130 | 14 | 10.77 |
| | Others | 10 | 0 | 0.00 | 1 | 0 | 0.00 |
| | Meal/mash | 10 | 0 | 0.00 | 140 | 9 | 6.43 |
| | Porridge/liquids | 10 | 0 | 0.00 | 9 | 0 | 0.00 |
| Origin of feed | Commercial compound | 30 | 3 | 10.00 | 153 | 14 | 9.15 |
| | Other | 10 | 0 | 0.00 | 1 | 0 | 0.00 |
| | Feed with maize | 0 | | | 0 | | |
| | Home-mill | 10 | 0 | 0.00 | 126 | 9 | 7.14 |
| Feed/water supplement | Not added | 30 | 0 | 0.00 | 240 | 23 | 9.58 |
| | Organic acid | 20 | 3 | 15.00 | 20 | 0 | 0.00 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 0 | | | 0 | | |
| | Probiotic | 0 | | | 10 | 0 | 0.00 |
| | Unknown/other | 0 | | | 10 | 0 | 0.00 |
| Use of antibiotics | No treatment | 33 | 2 | 6.06 | 224 | 21 | 9.38 |
| | Treatment | 17 | 1 | 5.88 | 48 | 2 | 4.17 |
| | Unknown | 0 | | | 8 | 0 | 0.00 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Luxembourg | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 30 | 2 | 6.67 | 408 | 19 | 4.66 |
| | 11-20 | 0 | | | 2 | 0 | 0.00 |
| | 21-100 | 0 | | | 0 | | |
| | >100 | 0 | | | 0 | | |
| Indoor/outdoor production | No | 29 | 2 | 6.90 | 407 | 18 | 4.42 |
| | Yes | 1 | 0 | 0.00 | 3 | 1 | 33.33 |
| Individual housing | No | 15 | 2 | 13.33 | 238 | 11 | 4.62 |
| | Yes | 15 | 0 | 0.00 | 172 | 8 | 4.65 |
| Age of pigs | No gilts | 0 | | | 13 | 0 | 0.00 |
| | Mixed age | 18 | 2 | 11.11 | 360 | 18 | 5.00 |
| | All gilts | 12 | 0 | 0.00 | 37 | 1 | 2.70 |
| Gender of pigs | Male | 0 | | | 1 | 0 | 0.00 |
| | Female | 23 | 0 | 0.00 | 404 | 19 | 4.70 |
| | Mixed | 7 | 2 | 28.57 | 5 | 0 | 0.00 |
| Production stage | Maiden gilts | 14 | 2 | 14.29 | 45 | 0 | 0.00 |
| | Pregnant | 11 | 0 | 0.00 | 217 | 15 | 6.91 |
| | Farrowing and lactating | 5 | 0 | 0.00 | 127 | 2 | 1.57 |
| | Service area | 0 | | | 1 | 0 | 0.00 |
| | Mixed | 0 | | | 20 | 2 | 10.00 |
| Type of floor | Outdoors in fields or paddocks | 0 | | | 0 | | |
| | Solid floor other bedding | 0 | | | 0 | | |
| | Solid floor with straw | 0 | | | 87 | 1 | 1.15 |
| | Solid floor without bedding | 0 | | | 25 | 1 | 4.00 |
| | Partly slatted floor | 20 | 2 | 10.00 | 219 | 7 | 3.20 |
| | Slatted floor | 10 | 0 | 0.00 | 79 | 10 | 12.66 |
| | Other | 0 | | | 0 | | |
| All in/all out | No | 20 | 2 | 10.00 | 374 | 15 | 4.01 |
| | Yes | 10 | 0 | 0.00 | 36 | 4 | 11.11 |
| Type of diet | Cobbs/rolls/nuts/pellets | 20 | 2 | 10.00 | 263 | 15 | 5.70 |
| | Others | 0 | | | 89 | 0 | 0.00 |
| | Meal/mash | 0 | | | 49 | 0 | 0.00 |
| | Porridge/liquids | 10 | 0 | 0.00 | 9 | 4 | 44.44 |
| Origin of feed | Commercial compound | 29 | 2 | 6.90 | 309 | 19 | 6.15 |
| | Other | 0 | | | 0 | | |
| | Feed with maize | 0 | | | 0 | | |
| | Home-mill | 1 | 0 | 0.00 | 101 | 0 | 0.00 |
| Feed/water supplement | Not added | 30 | 2 | 6.67 | 399 | 19 | 4.76 |
| | Organic acid | 0 | | | 0 | | |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 0 | | | 11 | 0 | 0.00 |
| | Probiotic | 0 | | | 0 | | |
| | Unknown/other | 0 | | | 0 | | |
| Use of antibiotics | No treatment | 30 | 2 | 6.67 | 409 | 19 | 4.65 |
| | Treatment | 0 | | | 0 | | |
| | Unknown | 0 | | | 1 | 0 | 0.00 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Netherlands | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 4 | 1 | 25.00 | 0 | | |
| | 10 | 173 | 30 | 17.34 | 333 | 51 | 15.32 |
| | 11-20 | 216 | 33 | 15.28 | 403 | 61 | 15.14 |
| | 21-100 | 500 | 95 | 19.00 | 1,011 | 208 | 20.57 |
| | >100 | 197 | 45 | 22.84 | 373 | 73 | 19.57 |
| Indoor/outdoor | No | 1,082 | 204 | 18.85 | 2,112 | 391 | 18.51 |
| production | Yes | 8 | 0 | 0.00 | 8 | 2 | 25.00 |
| Individual housing | No | 294 | 72 | 24.49 | 503 | 121 | 24.06 |
| | Yes | 796 | 132 | 16.58 | 1,617 | 272 | 16.82 |
| Age of pigs | No gilts | 239 | 37 | 15.48 | 411 | 70 | 17.03 |
| | Mixed age | 775 | 147 | 18.97 | 1,568 | 286 | 18.24 |
| | All gilts | 76 | 20 | 26.32 | 141 | 37 | 26.24 |
| Gender of pigs | Male | 0 | | | 0 | | |
| | Female | 1,079 | 203 | 18.81 | 2,116 | 393 | 18.57 |
| | Mixed | 11 | 1 | 9.09 | 4 | 0 | 0.00 |
| Production stage | Maiden gilts | 90 | 24 | 26.67 | 137 | 32 | 23.36 |
| | Pregnant | 518 | 90 | 17.37 | 1,005 | 164 | 16.32 |
| | Farrowing and lactating | 219 | 32 | 14.61 | 431 | 55 | 12.76 |
| | Service area | 232 | 49 | 21.12 | 490 | 126 | 25.71 |
| | Mixed | 31 | 9 | 29.03 | 57 | 16 | 28.07 |
| Floor type | Outdoors in fields or paddocks | 1 | 0 | 0.00 | 0 | | |
| | Solid floor other bedding | 0 | | | 0 | | |
| | Solid floor with straw | 24 | 11 | 45.83 | 45 | 26 | 57.78 |
| | Solid floor without bedding | 0 | | | 11 | 2 | 18.18 |
| | Partly slatted floor | 983 | 176 | 17.90 | 1,912 | 354 | 18.51 |
| | Slatted floor | 82 | 17 | 20.73 | 152 | 11 | 7.24 |
| | Other | 0 | | | 0 | | |
| All in/all out | No | 792 | 151 | 19.07 | 1,560 | 322 | 20.64 |
| | Yes | 298 | 53 | 17.79 | 560 | 71 | 12.68 |
| Type of diet | Cobbs/rolls/nuts/pellets | 855 | 151 | 17.66 | 1,824 | 352 | 19.30 |
| | Others | 0 | | | 8 | 1 | 12.50 |
| | Meal/mash | 0 | | | 20 | 3 | 15.00 |
| | Porridge/liquids | 235 | 53 | 22.55 | 268 | 37 | 13.81 |
| Origin of feed | Commercial compound | 903 | 161 | 17.83 | 1,904 | 363 | 19.07 |
| | Other | 10 | 0 | 0.00 | 10 | 3 | 30.00 |
| | Feed with maize | 10 | 2 | 20.00 | 1 | 0 | 0.00 |
| | Home-mill | 167 | 41 | 24.55 | 205 | 27 | 13.17 |
| Feed/water supplement | Not added | 982 | 187 | 19.04 | 1,886 | 365 | 19.35 |
| | Organic acid | 25 | 2 | 8.00 | 120 | 6 | 5.00 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 2 | 0 | 0.00 | 14 | 9 | 64.29 |
| | Probiotic | 11 | 2 | 18.18 | 0 | | |
| | Unknown/other | 70 | 13 | 18.57 | 100 | 13 | 13.00 |
| Use of antibiotics | No treatment | 1,025 | 197 | 19.22 | 1,872 | 362 | 19.34 |
| | Treatment | 55 | 7 | 12.73 | 228 | 26 | 11.40 |
| | Unknown | 10 | 0 | 0.00 | 20 | 5 | 25.00 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Poland | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 746 | 8 | 1.07 | 777 | 8 | 1.03 |
| | 11-20 | 522 | 5 | 0.96 | 649 | 14 | 2.16 |
| | 21-100 | 172 | 11 | 6.40 | 332 | 18 | 5.42 |
| | >100 | 0 | | | 22 | 1 | 4.55 |
| Indoor/outdoor | No | 1,353 | 22 | 1.63 | 1,726 | 40 | 2.32 |
| production | Yes | 87 | 2 | 2.30 | 54 | 1 | 1.85 |
| Individual housing | No | 648 | 20 | 3.09 | 682 | 5 | 0.73 |
| | Yes | 792 | 4 | 0.51 | 1,098 | 36 | 3.28 |
| Age of pigs | No gilts | 542 | 5 | 0.92 | 778 | 17 | 2.19 |
| | Mixed age | 374 | 4 | 1.07 | 492 | 12 | 2.44 |
| | All gilts | 524 | 15 | 2.86 | 510 | 12 | 2.35 |
| Gender of pigs | Male | 28 | 0 | 0.00 | 13 | 0 | 0.00 |
| | Female | 1,112 | 12 | 1.08 | 1,083 | 20 | 1.85 |
| | Mixed | 300 | 12 | 4.00 | 684 | 21 | 3.07 |
| Production stage | Maiden gilts | 386 | 4 | 1.04 | 291 | 12 | 4.12 |
| | Pregnant | 453 | 5 | 1.10 | 595 | 15 | 2.52 |
| | Farrowing and lactating | 171 | 1 | 0.58 | 161 | 0 | 0.00 |
| | Service area | 25 | 1 | 4.00 | 18 | 0 | 0.00 |
| | Mixed | 405 | 13 | 3.21 | 715 | 14 | 1.96 |
| Floor type | Outdoors in fields or paddocks | 6 | 0 | 0.00 | 0 | | |
| | Solid floor other bedding | 10 | 0 | 0.00 | 0 | | |
| | Solid floor with straw | 903 | 7 | 0.78 | 1,028 | 15 | 1.46 |
| | Solid floor without bedding | 65 | 0 | 0.00 | 151 | 11 | 7.28 |
| | Partly slatted floor | 307 | 6 | 1.95 | 401 | 14 | 3.49 |
| | Slatted floor | 129 | 11 | 8.53 | 153 | 1 | 0.65 |
| | Other | 20 | 0 | 0.00 | 47 | 0 | 0.00 |
| All in/all out | No | 802 | 7 | 0.87 | 953 | 14 | 1.47 |
| | Yes | 638 | 17 | 2.66 | 827 | 27 | 3.26 |
| Type of diet | Cobbs/rolls/nuts/pellets | 166 | 12 | 7.23 | 264 | 22 | 8.33 |
| | Others | 21 | 0 | 0.00 | 21 | 4 | 19.05 |
| | Meal/mash | 761 | 7 | 0.92 | 839 | 10 | 1.19 |
| | Porridge/liquids | 492 | 5 | 1.02 | 656 | 5 | 0.76 |
| Origin of feed | Commercial compound | 216 | 15 | 6.94 | 485 | 29 | 5.98 |
| | Other | 224 | 0 | 0.00 | 248 | 3 | 1.21 |
| | Feed with maize | 61 | 0 | 0.00 | 81 | 0 | 0.00 |
| | Home-mill | 939 | 9 | 0.96 | 966 | 9 | 0.93 |
| Feed/water supplement | Not added | 1,064 | 23 | 2.16 | 1,206 | 36 | 2.99 |
| | Organic acid | 129 | 0 | 0.00 | 200 | 0 | 0.00 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 106 | 1 | 0.94 | 146 | 2 | 1.37 |
| | Probiotic | 90 | 0 | 0.00 | 100 | 0 | 0.00 |
| | Unknown/other | 51 | 0 | 0.00 | 128 | 3 | 2.34 |
| Use of antibiotics | No treatment | 1,307 | 11 | 0.84 | 1,605 | 27 | 1.68 |
| | Treatment | 93 | 11 | 11.83 | 129 | 9 | 6.98 |
| | Unknown | 40 | 2 | 5.00 | 46 | 5 | 10.87 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Portugal | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 283 | 30 | 10.60 | 1,133 | 90 | 7.94 |
| | 11-20 | 38 | 6 | 15.79 | 156 | 22 | 14.10 |
| | 21-100 | 9 | 2 | 22.22 | 48 | 11 | 22.92 |
| | >100 | 0 | | | 3 | 0 | 0.00 |
| Indoor/outdoor | No | 243 | 23 | 9.47 | 1,019 | 97 | 9.52 |
| production | Yes | 87 | 15 | 17.24 | 321 | 26 | 8.10 |
| Individual housing | No | 40 | 7 | 17.50 | 295 | 27 | 9.15 |
| | Yes | 290 | 31 | 10.69 | 1,045 | 96 | 9.19 |
| Age of pigs | No gilts | 106 | 18 | 16.98 | 573 | 39 | 6.81 |
| | Mixed age | 208 | 15 | 7.21 | 718 | 83 | 11.56 |
| | All gilts | 16 | 5 | 31.25 | 49 | 1 | 2.04 |
| Gender of pigs | Male | 0 | | | 1 | 0 | 0.00 |
| | Female | 327 | 38 | 11.62 | 1,263 | 112 | 8.87 |
| | Mixed | 3 | 0 | 0.00 | 76 | 11 | 14.47 |
| Production stage | Maiden gilts | 14 | 4 | 28.57 | 37 | 3 | 8.11 |
| | Pregnant | 175 | 20 | 11.43 | 702 | 69 | 9.83 |
| | Farrowing and lactating | 83 | 5 | 6.02 | 332 | 19 | 5.72 |
| | Service area | 56 | 9 | 16.07 | 188 | 17 | 9.04 |
| | Mixed | 2 | 0 | 0.00 | 81 | 15 | 18.52 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 55 | 3 | 5.45 |
| | Solid floor other bedding | 0 | | | 10 | 0 | 0.00 |
| | Solid floor with straw | 0 | | | 7 | 0 | 0.00 |
| | Solid floor without bedding | 0 | | | 44 | 3 | 6.82 |
| | Partly slatted floor | 280 | 34 | 12.14 | 1,122 | 107 | 9.54 |
| | Slatted floor | 48 | 3 | 6.25 | 100 | 10 | 10.00 |
| | Other | 2 | 1 | 50.00 | 2 | 0 | 0.00 |
| All in/all out | No | 181 | 27 | 14.92 | 794 | 76 | 9.57 |
| | Yes | 149 | 11 | 7.38 | 546 | 47 | 8.61 |
| Type of diet | Cobbs/rolls/nuts/pellets | 73 | 4 | 5.48 | 191 | 29 | 15.18 |
| | Others | 10 | 1 | 10.00 | 35 | 4 | 11.43 |
| | Meal/mash | 247 | 33 | 13.36 | 1,071 | 87 | 8.12 |
| | Porridge/liquids | 0 | | | 43 | 3 | 6.98 |
| Origin of feed | Commercial compound | 310 | 36 | 11.61 | 1,139 | 114 | 10.01 |
| | Other | 0 | | | 19 | 0 | 0.00 |
| | Feed with maize | 0 | | | 0 | | |
| | Home-mill | 20 | 2 | 10.00 | 182 | 9 | 4.95 |
| Feed/water supplement | Not added | 258 | 34 | 13.18 | 830 | 71 | 8.55 |
| | Organic acid | 13 | 2 | 15.38 | 140 | 9 | 6.43 |
| | Organic acid and probiotic | 0 | | | 46 | 1 | 2.17 |
| | Other | 0 | | | 7 | 3 | 42.86 |
| | Probiotic | 0 | | | 27 | 3 | 11.11 |
| | Unknown/other | 59 | 2 | 3.39 | 290 | 36 | 12.41 |
| Use of antibiotics | No treatment | 259 | 32 | 12.36 | 1,139 | 110 | 9.66 |
| | Treatment | 51 | 4 | 7.84 | 190 | 8 | 4.21 |
| | Unknown | 20 | 2 | 10.00 | 11 | 5 | 45.45 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Slovakia | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 960 | 23 | 2.40 | 959 | 39 | 4.07 |
| | 11-20 | 0 | | | 0 | | |
| | 21-100 | 0 | | | 0 | | |
| | >100 | 0 | | | 1 | 0 | 0.00 |
| Indoor/outdoor production | No | 923 | 22 | 2.38 | 940 | 38 | 4.04 |
| | Yes | 37 | 1 | 2.70 | 20 | 1 | 5.00 |
| Individual housing | No | 695 | 14 | 2.01 | 650 | 32 | 4.92 |
| | Yes | 265 | 9 | 3.40 | 310 | 7 | 2.26 |
| Age of pigs | No gilts | 51 | 1 | 1.96 | 46 | 4 | 8.70 |
| | Mixed age | 19 | 0 | 0.00 | 16 | 2 | 12.50 |
| | All gilts | 890 | 22 | 2.47 | 898 | 33 | 3.67 |
| Gender of pigs | Male | 49 | 1 | 2.04 | 44 | 4 | 9.09 |
| | Female | 898 | 22 | 2.45 | 901 | 33 | 3.66 |
| | Mixed | 13 | 0 | 0.00 | 15 | 2 | 13.33 |
| Production stage | Maiden gilts | 55 | 1 | 1.82 | 21 | 0 | 0.00 |
| | Pregnant | 400 | 7 | 1.75 | 306 | 13 | 4.25 |
| | Farrowing and lactating | 184 | 8 | 4.35 | 204 | 3 | 1.47 |
| | Service area | 199 | 6 | 3.02 | 256 | 12 | 4.69 |
| | Mixed | 122 | 1 | 0.82 | 173 | 11 | 6.36 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 0 | | |
| | Solid floor other bedding | 0 | | | 10 | 0 | 0.00 |
| | Solid floor with straw | 86 | 1 | 1.16 | 102 | 2 | 1.96 |
| | Solid floor without bedding | 626 | 11 | 1.76 | 644 | 27 | 4.19 |
| | Partly slatted floor | 214 | 10 | 4.67 | 160 | 9 | 5.63 |
| | Slatted floor | 34 | 1 | 2.94 | 44 | 1 | 2.27 |
| | Other | 0 | | | 0 | | |
| All in/all out | No | 1 | 0 | 0.00 | 2 | 0 | 0.00 |
| | Yes | 959 | 23 | 2.40 | 958 | 39 | 4.07 |
| Type of diet | Cobbs/rolls/nuts/pellets | 1 | 0 | 0.00 | 1 | 0 | 0.00 |
| | Others | 28 | 0 | 0.00 | 38 | 0 | 0.00 |
| | Meal/mash | 931 | 23 | 2.47 | 921 | 39 | 4.23 |
| | Porridge/liquids | 0 | | | 0 | | |
| Origin of feed | Commercial compound | 932 | 23 | 2.47 | 921 | 39 | 4.23 |
| | Other | 1 | 0 | 0.00 | 1 | 0 | 0.00 |
| | Feed with maize | 0 | | | 0 | | |
| | Home-mill | 27 | 0 | 0.00 | 38 | 0 | 0.00 |
| Feed/water supplement | Not added | 948 | 23 | 2.43 | 960 | 39 | 4.06 |
| | Organic acid | 10 | 0 | 0.00 | 0 | | |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 0 | | | 0 | | |
| | Probiotic | 2 | 0 | 0.00 | 0 | | |
| | Unknown/other | 0 | | | 0 | | |
| Use of antibiotics | No treatment | 940 | 23 | 2.45 | 960 | 39 | 4.06 |
| | Treatment | 20 | 0 | 0.00 | 0 | | |
| | Unknown | 0 | | | 0 | | |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Slovenia | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 151 | 0 | 0.00 | 486 | 17 | 3.50 |
| | 11-20 | 118 | 0 | 0.00 | 357 | 9 | 2.52 |
| | 21-100 | 1 | 0 | 0.00 | 20 | 0 | 0.00 |
| | >100 | 0 | | | 7 | 0 | 0.00 |
| Indoor/outdoor production | No | 202 | 0 | 0.00 | 806 | 22 | 2.73 |
| | Yes | 68 | 0 | 0.00 | 64 | 4 | 6.25 |
| Individual housing | No | 150 | 0 | 0.00 | 373 | 11 | 2.95 |
| | Yes | 120 | 0 | 0.00 | 497 | 15 | 3.02 |
| Age of pigs | No gilts | 52 | 0 | 0.00 | 281 | 11 | 3.91 |
| | Mixed age | 160 | 0 | 0.00 | 532 | 11 | 2.07 |
| | All gilts | 58 | 0 | 0.00 | 57 | 4 | 7.02 |
| Gender of pigs | Male | 0 | | | 0 | | |
| | Female | 211 | 0 | 0.00 | 727 | 26 | 3.58 |
| | Mixed | 59 | 0 | 0.00 | 143 | 0 | 0.00 |
| Production stage | Maiden gilts | 35 | 0 | 0.00 | 20 | 4 | 20.00 |
| | Pregnant | 87 | 0 | 0.00 | 243 | 9 | 3.70 |
| | Farrowing and lactating | 35 | 0 | 0.00 | 183 | 6 | 3.28 |
| | Service area | 16 | 0 | 0.00 | 62 | 1 | 1.61 |
| | Mixed | 97 | 0 | 0.00 | 362 | 6 | 1.66 |
| Floor type | Outdoors in fields or paddocks | 5 | 0 | 0.00 | 1 | 0 | 0.00 |
| | Solid floor other bedding | 0 | | | 31 | 2 | 6.45 |
| | Solid floor with straw | 38 | 0 | 0.00 | 127 | 5 | 3.94 |
| | Solid floor without bedding | 14 | 0 | 0.00 | 46 | 3 | 6.52 |
| | Partly slatted floor | 207 | 0 | 0.00 | 571 | 16 | 2.80 |
| | Slatted floor | 6 | 0 | 0.00 | 94 | 0 | 0.00 |
| | Other | 0 | | | 0 | | |
| All in/all out | No | 229 | 0 | 0.00 | 761 | 20 | 2.63 |
| | Yes | 41 | 0 | 0.00 | 109 | 6 | 5.50 |
| Type of diet | Cobbs/rolls/nuts/pellets | 6 | 0 | 0.00 | 70 | 5 | 7.14 |
| | Others | 25 | 0 | 0.00 | 94 | 2 | 2.13 |
| | Meal/mash | 239 | 0 | 0.00 | 698 | 19 | 2.72 |
| | Porridge/liquids | 0 | | | 8 | 0 | 0.00 |
| Origin of feed | Commercial compound | 10 | 0 | 0.00 | 83 | 6 | 7.23 |
| | Other | 44 | 0 | 0.00 | 98 | 2 | 2.04 |
| | Feed with maize | 132 | 0 | 0.00 | 122 | 9 | 7.38 |
| | Home-mill | 84 | 0 | 0.00 | 567 | 9 | 1.59 |
| Feed/water supplement | Not added | 202 | 0 | 0.00 | 610 | 25 | 4.10 |
| | Organic acid | 20 | 0 | 0.00 | 20 | 0 | 0.00 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 40 | 0 | 0.00 | 200 | 0 | 0.00 |
| | Probiotic | 8 | 0 | 0.00 | 30 | 1 | 3.33 |
| | Unknown/other | 0 | | | 10 | 0 | 0.00 |
| Use of antibiotics | No treatment | 268 | 0 | 0.00 | 844 | 26 | 3.08 |
| | Treatment | 2 | 0 | 0.00 | 26 | 0 | 0.00 |
| | Unknown | 0 | | | 0 | | |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Sweden | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 222 | 0 | 0.00 | 755 | 0 | 0.00 |
| | 11-20 | 174 | 0 | 0.00 | 337 | 0 | 0.00 |
| | 21-100 | 166 | 1 | 0.60 | 398 | 0 | 0.00 |
| | >100 | 8 | 0 | 0.00 | 10 | 0 | 0.00 |
| Outdoor production | No | 553 | 1 | 0.18 | 1,488 | 0 | 0.00 |
| | Yes | 17 | 0 | 0.00 | 12 | 0 | 0.00 |
| Individual housing | No | 389 | 1 | 0.26 | 810 | 0 | 0.00 |
| | Yes | 181 | 0 | 0.00 | 690 | 0 | 0.00 |
| Age of pigs | No gilts | 147 | 0 | 0.00 | 437 | 0 | 0.00 |
| | Mixed age | 357 | 1 | 0.28 | 1,016 | 0 | 0.00 |
| | All gilts | 66 | 0 | 0.00 | 47 | 0 | 0.00 |
| Gender of pigs | Male | 0 | | | 1 | 0 | 0.00 |
| | Female | 499 | 0 | 0.00 | 1,352 | 0 | 0.00 |
| | Mixed | 71 | 1 | 1.41 | 147 | 0 | 0.00 |
| Production stage | Maiden gilts | 17 | 0 | 0.00 | 13 | 0 | 0.00 |
| | Pregnant | 286 | 1 | 0.35 | 703 | 0 | 0.00 |
| | Farrowing and lactating | 152 | 0 | 0.00 | 577 | 0 | 0.00 |
| | Service area | 63 | 0 | 0.00 | 149 | 0 | 0.00 |
| | Mixed | 52 | 0 | 0.00 | 58 | 0 | 0.00 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 12 | 0 | 0.00 |
| | Solid floor other bedding | 2 | 0 | 0.00 | 27 | 0 | 0.00 |
| | Solid floor with straw | 387 | 1 | 0.26 | 846 | 0 | 0.00 |
| | Solid floor without bedding | 0 | | | 0 | | |
| | Partly slatted floor | 0 | | | 0 | | |
| | Slatted floor | 0 | | | 0 | | |
| | Other | 181 | 0 | 0.00 | 615 | 0 | 0.00 |
| All in/all out | No | 145 | 1 | 0.69 | 430 | 0 | 0.00 |
| | Yes | 425 | 0 | 0.00 | 1,070 | 0 | 0.00 |
| Type of diet | Cobbs/rolls/nuts/pellets | 133 | 0 | 0.00 | 325 | 0 | 0.00 |
| | Others | 10 | 0 | 0.00 | 4 | 0 | 0.00 |
| | Meal/mash | 189 | 1 | 0.53 | 509 | 0 | 0.00 |
| | Porridge/liquids | 238 | 0 | 0.00 | 662 | 0 | 0.00 |
| Origin of feed | Commercial compound | 245 | 0 | 0.00 | 572 | 0 | 0.00 |
| | Other | 10 | 0 | 0.00 | 34 | 0 | 0.00 |
| | Feed with maize | 0 | | | 0 | | |
| | Home-mill | 315 | 1 | 0.32 | 894 | 0 | 0.00 |
| Feed/water supplement | Not added | 553 | 1 | 0.18 | 1,388 | 0 | 0.00 |
| | Organic acid | 7 | 0 | 0.00 | 43 | 0 | 0.00 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 10 | 0 | 0.00 | 39 | 0 | 0.00 |
| | Probiotic | 0 | | | 20 | 0 | 0.00 |
| | Unknown/other | 0 | | | 10 | 0 | 0.00 |
| | No treatment | 457 | 1 | 0.22 | 1,078 | 0 | 0.00 |
| Use of antibiotics | Treatment | 107 | 0 | 0.00 | 401 | 0 | 0.00 |
| | Unknown | 6 | 0 | 0.00 | 21 | 0 | 0.00 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Spain | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 818 | 171 | 20.90 | 1,191 | 173 | 14.53 |
| | 11-20 | 319 | 56 | 17.55 | 467 | 64 | 13.70 |
| | 21-100 | 291 | 48 | 16.49 | 385 | 71 | 18.44 |
| | >100 | 72 | 19 | 26.39 | 47 | 12 | 25.53 |
| Indoor/outdoor production | No | 1,135 | 212 | 18.68 | 1,538 | 219 | 14.24 |
| | Yes | 365 | 82 | 22.47 | 552 | 101 | 18.30 |
| Individual housing | No | 616 | 116 | 18.83 | 947 | 156 | 16.47 |
| | Yes | 884 | 178 | 20.14 | 1,143 | 164 | 14.35 |
| Age of pigs | No gilts | 519 | 99 | 19.08 | 609 | 110 | 18.06 |
| | Mixed age | 770 | 143 | 18.57 | 1,211 | 155 | 12.80 |
| | All gilts | 211 | 52 | 24.64 | 270 | 55 | 20.37 |
| Gender of pigs | Male | 23 | 4 | 17.39 | 10 | 0 | 0.00 |
| | Female | 1,242 | 260 | 20.93 | 1,769 | 275 | 15.55 |
| | Mixed | 235 | 30 | 12.77 | 311 | 45 | 14.47 |
| Production stage | Maiden gilts | 167 | 37 | 22.16 | 242 | 42 | 17.36 |
| | Pregnant | 520 | 110 | 21.15 | 756 | 136 | 17.99 |
| | Farrowing and lactating | 362 | 68 | 18.78 | 451 | 47 | 10.42 |
| | Service area | 187 | 44 | 23.53 | 266 | 49 | 18.42 |
| | Mixed | 264 | 35 | 13.26 | 375 | 46 | 12.27 |
| Floor type | Outdoors in fields or paddocks | 153 | 23 | 15.03 | 190 | 37 | 19.47 |
| | Solid floor other bedding | 12 | 2 | 16.67 | 44 | 0 | 0.00 |
| | Solid floor with straw | 44 | 11 | 25.00 | 101 | 10 | 9.90 |
| | Solid floor without bedding | 88 | 26 | 29.55 | 230 | 34 | 14.78 |
| | Partly slatted floor | 618 | 120 | 19.42 | 963 | 172 | 17.86 |
| | Slatted floor | 583 | 112 | 19.21 | 554 | 64 | 11.55 |
| | Other | 2 | 0 | 0.00 | 8 | 3 | 37.50 |
| All in/all out | No | 524 | 83 | 15.84 | 785 | 133 | 16.94 |
| | Yes | 976 | 211 | 21.62 | 1,305 | 187 | 14.33 |
| Type of diet | Cobbs/rolls/nuts/pellets | 793 | 179 | 22.57 | 690 | 116 | 16.81 |
| | Others | 5 | 0 | 0.00 | 18 | 0 | 0.00 |
| | Meal/mash | 641 | 107 | 16.69 | 1,344 | 200 | 14.88 |
| | Porridge/liquids | 61 | 8 | 13.11 | 38 | 4 | 10.53 |
| Origin of feed | Commercial compound | 1,176 | 265 | 22.53 | 1,425 | 260 | 18.25 |
| | Other | 55 | 12 | 21.82 | 38 | 0 | 0.00 |
| | Feed with maize | 40 | 6 | 15.00 | 89 | 7 | 7.87 |
| | Home-mill | 229 | 11 | 4.80 | 538 | 53 | 9.85 |
| Feed/water supplement | Not added | 161 | 38 | 23.60 | 253 | 59 | 23.32 |
| | Organic acid | 252 | 43 | 17.06 | 179 | 28 | 15.64 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 106 | 12 | 11.32 | 109 | 27 | 24.77 |
| | Probiotic | 10 | 5 | 50.00 | 16 | 1 | 6.25 |
| | Unknown/other | 971 | 196 | 20.19 | 1,533 | 205 | 13.37 |
| Use of antibiotics | No treatment | 1,118 | 209 | 18.69 | 1,715 | 273 | 15.92 |
| | Treatment | 328 | 65 | 19.82 | 348 | 45 | 12.93 |
| | Unknown | 54 | 20 | 37.04 | 27 | 2 | 7.41 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| United Kingdom | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 203 | 37 | 18.23 | 517 | 59 | 11.41 |
| | 11-20 | 284 | 50 | 17.61 | 880 | 133 | 15.11 |
| | 21-100 | 169 | 30 | 17.75 | 444 | 93 | 20.95 |
| | >100 | 14 | 0 | 0.00 | 69 | 9 | 13.04 |
| Indoor/outdoor | No | 572 | 83 | 14.51 | 1,328 | 157 | 11.82 |
| production | Yes | 98 | 34 | 34.69 | 582 | 137 | 23.54 |
| Individual housing | No | 533 | 93 | 17.45 | 1,553 | 249 | 16.03 |
| | Yes | 137 | 24 | 17.52 | 357 | 45 | 12.61 |
| Age of pigs | No gilts | 335 | 44 | 13.13 | 942 | 130 | 13.80 |
| | Mixed age | 236 | 51 | 21.61 | 734 | 117 | 15.94 |
| | All gilts | 99 | 22 | 22.22 | 234 | 47 | 20.09 |
| Gender of pigs | Male | 8 | 3 | 37.50 | 6 | 1 | 16.67 |
| | Female | 555 | 90 | 16.22 | 1,465 | 222 | 15.15 |
| | Mixed | 107 | 24 | 22.43 | 439 | 71 | 16.17 |
| Production stage | Maiden gilts | 61 | 17 | 27.87 | 137 | 21 | 15.33 |
| | Pregnant | 394 | 58 | 14.72 | 1,132 | 177 | 15.64 |
| | Farrowing and lactating | 118 | 19 | 16.10 | 378 | 46 | 12.17 |
| | Service area | 69 | 15 | 21.74 | 150 | 32 | 21.33 |
| | Mixed | 28 | 8 | 28.57 | 113 | 18 | 15.93 |
| Floor type | Outdoors in fields or paddocks | 82 | 27 | 32.93 | 487 | 126 | 25.87 |
| | Solid floor other bedding | 4 | 1 | 25.00 | 12 | 1 | 8.33 |
| | Solid floor with straw | 435 | 50 | 11.49 | 926 | 80 | 8.64 |
| | Solid floor without bedding | 19 | 10 | 52.63 | 73 | 16 | 21.92 |
| | Partly slatted floor | 87 | 16 | 18.39 | 237 | 46 | 19.41 |
| | Slatted floor | 43 | 13 | 30.23 | 173 | 25 | 14.45 |
| | Other | 0 | | | 2 | 0 | 0.00 |
| All in/all out | No | 326 | 58 | 17.79 | 957 | 177 | 18.50 |
| | Yes | 344 | 59 | 17.15 | 953 | 117 | 12.28 |
| Type of diet | Cobbs/rolls/nuts/pellets | 515 | 99 | 19.22 | 1,178 | 230 | 19.52 |
| | Others | 10 | 6 | 60.00 | 30 | 7 | 23.33 |
| | Meal/mash | 118 | 11 | 9.32 | 544 | 40 | 7.35 |
| | Porridge/liquids | 27 | 1 | 3.70 | 158 | 17 | 10.76 |
| Origin of feed | Commercial compound | 545 | 99 | 18.17 | 1,157 | 237 | 20.48 |
| | Other | 11 | 0 | 0.00 | 29 | 0 | 0.00 |
| | Feed with maize | 0 | | | 0 | | |
| | Home-mill | 114 | 18 | 15.79 | 724 | 57 | 7.87 |
| Feed/water supplement | Not added | 620 | 110 | 17.74 | 1,709 | 254 | 14.86 |
| | Organic acid | 10 | 1 | 10.00 | 69 | 17 | 24.64 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 0 | | | 50 | 7 | 14.00 |
| | Probiotic | 10 | 0 | 0.00 | 22 | 6 | 27.27 |
| | Unknown/other | 30 | 6 | 20.00 | 60 | 10 | 16.67 |
| Use of antibiotics | No treatment | 590 | 108 | 18.31 | 1,635 | 235 | 14.37 |
| | Treatment | 60 | 9 | 15.00 | 158 | 36 | 22.78 |
| | Unknown | 20 | 0 | 0.00 | 117 | 23 | 19.66 |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Norway | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 0 | | |
| | 10 | 772 | 0 | 0.00 | 1,018 | 0 | 0.00 |
| | 11-20 | 278 | 0 | 0.00 | 347 | 0 | 0.00 |
| | 21-100 | 30 | 0 | 0.00 | 65 | 0 | 0.00 |
| | >100 | 0 | | | 0 | | |
| Indoor/outdoor production | No | 1,077 | 0 | 0.00 | 1,429 | 0 | 0.00 |
| | Yes | 3 | 0 | 0.00 | 1 | 0 | 0.00 |
| Individual housing | No | 879 | 0 | 0.00 | 1,077 | 0 | 0.00 |
| | Yes | 201 | 0 | 0.00 | 353 | 0 | 0.00 |
| Age of pigs | No gilts | 350 | 0 | 0.00 | 624 | 0 | 0.00 |
| | Mixed age | 405 | 0 | 0.00 | 622 | 0 | 0.00 |
| | All gilts | 325 | 0 | 0.00 | 184 | 0 | 0.00 |
| Gender of pigs | Male | 3 | 0 | 0.00 | 1 | 0 | 0.00 |
| | Female | 986 | 0 | 0.00 | 1,203 | 0 | 0.00 |
| | Mixed | 91 | 0 | 0.00 | 226 | 0 | 0.00 |
| Production stage | Maiden gilts | 308 | 0 | 0.00 | 150 | 0 | 0.00 |
| | Pregnant | 282 | 0 | 0.00 | 424 | 0 | 0.00 |
| | Farrowing and lactating | 204 | 0 | 0.00 | 374 | 0 | 0.00 |
| | Service area | 185 | 0 | 0.00 | 203 | 0 | 0.00 |
| | Mixed | 101 | 0 | 0.00 | 279 | 0 | 0.00 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 0 | | |
| | Solid floor other bedding | 451 | 0 | 0.00 | 709 | 0 | 0.00 |
| | Solid floor with straw | 89 | 0 | 0.00 | 85 | 0 | 0.00 |
| | Solid floor without bedding | 3 | 0 | 0.00 | 45 | 0 | 0.00 |
| | Partly slatted floor | 71 | 0 | 0.00 | 42 | 0 | 0.00 |
| | Slatted floor | 466 | 0 | 0.00 | 544 | 0 | 0.00 |
| | Other | 0 | | | 5 | 0 | 0.00 |
| All in/all out | No | 891 | 0 | 0.00 | 1,215 | 0 | 0.00 |
| | Yes | 189 | 0 | 0.00 | 215 | 0 | 0.00 |
| Type of diet | Cobbs/rolls/nuts/pellets | 540 | 0 | 0.00 | 711 | 0 | 0.00 |
| | Others | 510 | 0 | 0.00 | 630 | 0 | 0.00 |
| | Meal/mash | 0 | | | 40 | 0 | 0.00 |
| | Porridge/liquids | 30 | 0 | 0.00 | 49 | 0 | 0.00 |
| Origin of feed | Commercial compound | 980 | 0 | 0.00 | 1,269 | 0 | 0.00 |
| | Other | 100 | 0 | 0.00 | 133 | 0 | 0.00 |
| | Feed with maize | 0 | | | 0 | | |
| | Home-mill | 0 | | | 28 | 0 | 0.00 |
| Feed/water supplement | Not added | 692 | 0 | 0.00 | 1,109 | 0 | 0.00 |
| | Organic acid | 266 | 0 | 0.00 | 199 | 0 | 0.00 |
| | Organic acid and probiotic | 0 | | | 1 | 0 | 0.00 |
| | Other | 122 | 0 | 0.00 | 121 | 0 | 0.00 |
| | Probiotic | 0 | | | 0 | | |
| | Unknown/other | 0 | | | 0 | | |
| Use of antibiotics | No treatment | 1,060 | 0 | 0.00 | 1,393 | 0 | 0.00 |
| | Treatment | 20 | 0 | 0.00 | 37 | 0 | 0.00 |
| | Unknown | 0 | | | 0 | | |

**Table 11 (Contd.):** Number and proportion of *Salmonella*-positive pens by Member State and risk factor, *Salmonella* EU baseline survey, 2008

| Switzerland | | breeding holding | | | production holding | | |
|---|---|---|---|---|---|---|---|
| | | N | pos | % pos | N | pos | % pos |
| Number of pigs in pen | 0-9 | 0 | | | 3 | 0 | 0.00 |
| | 10 | 373 | 15 | 4.02 | 827 | 29 | 3.51 |
| | 11-20 | 199 | 8 | 4.02 | 345 | 19 | 5.51 |
| | 21-100 | 127 | 4 | 3.15 | 342 | 9 | 2.63 |
| | >100 | 11 | 1 | 9.09 | 23 | 4 | 17.39 |
| Indoor/outdoor | No | 400 | 18 | 4.50 | 765 | 43 | 5.62 |
| production | Yes | 310 | 10 | 3.23 | 775 | 18 | 2.32 |
| Individual housing | No | 506 | 18 | 3.56 | 1,165 | 38 | 3.26 |
| | Yes | 204 | 10 | 4.90 | 375 | 23 | 6.13 |
| Age of pigs | No gilts | 383 | 15 | 3.92 | 849 | 43 | 5.06 |
| | Mixed age | 234 | 10 | 4.27 | 597 | 13 | 2.18 |
| | All gilts | 93 | 3 | 3.23 | 94 | 5 | 5.32 |
| Gender of pigs | Male | 0 | | | 0 | | |
| | Female | 667 | 27 | 4.05 | 1,392 | 57 | 4.09 |
| | Mixed | 43 | 1 | 2.33 | 148 | 4 | 2.70 |
| Production stage | Maiden gilts | 64 | 2 | 3.13 | 65 | 3 | 4.62 |
| | Pregnant | 375 | 10 | 2.67 | 906 | 37 | 4.08 |
| | Farrowing and lactating | 163 | 8 | 4.91 | 306 | 9 | 2.94 |
| | Service area | 62 | 5 | 8.06 | 144 | 11 | 7.64 |
| | Mixed | 46 | 3 | 6.52 | 119 | 1 | 0.84 |
| Floor type | Outdoors in fields or paddocks | 0 | | | 10 | 0 | 0.00 |
| | Solid floor other bedding | 5 | 0 | 0.00 | 8 | 0 | 0.00 |
| | Solid floor with straw | 95 | 3 | 3.16 | 318 | 8 | 2.52 |
| | Solid floor without bedding | 18 | 1 | 5.56 | 51 | 0 | 0.00 |
| | Partly slatted floor | 588 | 24 | 4.08 | 1,109 | 53 | 4.78 |
| | Slatted floor | 2 | 0 | 0.00 | 5 | 0 | 0.00 |
| | Other | 2 | 0 | 0.00 | 39 | 0 | 0.00 |
| All in/all out | No | 576 | 21 | 3.65 | 1,295 | 56 | 4.32 |
| | Yes | 134 | 7 | 5.22 | 245 | 5 | 2.04 |
| Type of diet | Cobbs/rolls/nuts/pellets | 56 | 2 | 3.57 | 198 | 5 | 2.53 |
| | Others | 72 | 9 | 12.50 | 237 | 4 | 1.69 |
| | Meal/mash | 174 | 6 | 3.45 | 406 | 9 | 2.22 |
| | Porridge/liquids | 408 | 11 | 2.70 | 699 | 43 | 6.15 |
| Origin of feed | Commercial compound | 458 | 19 | 4.15 | 1,247 | 52 | 4.17 |
| | Other | 60 | 1 | 1.67 | 76 | 2 | 2.63 |
| | Feed with maize | 74 | 5 | 6.76 | 130 | 3 | 2.31 |
| | Home-mill | 118 | 3 | 2.54 | 87 | 4 | 4.60 |
| Feed/water supplement | Not added | 410 | 16 | 3.90 | 1,158 | 50 | 4.32 |
| | Organic acid | 149 | 6 | 4.03 | 147 | 4 | 2.72 |
| | Organic acid and probiotic | 0 | | | 0 | | |
| | Other | 71 | 3 | 4.23 | 130 | 5 | 3.85 |
| | Probiotic | 20 | 0 | 0.00 | 15 | 0 | 0.00 |
| | Unknown/other | 60 | 3 | 5.00 | 90 | 2 | 2.22 |
| Use of antibiotics | No treatment | 661 | 27 | 4.08 | 1,437 | 58 | 4.04 |
| | Treatment | 48 | 1 | 2.08 | 102 | 3 | 2.94 |
| | Unknown | 1 | 0 | 0.00 | 1 | 0 | 0.00 |

**D. OVERVIEW OF THE OPTIONAL DATA REPORTED IN THE FRAMEWORK OF THE BASELINE SURVEY**

| Country | Number of holdings | Number of pens | Number of pooled faecal samples | Holding location | | Diarrheal symptoms observed | | Days from last antimicrobial treatment | | *Salmonella* Enteritidis phage type | | *Salmonella* Typhimurium phage type | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | N (a) | % (a*) | N (b) | % (b*) | N (c) | % (c*) | N (c) | % (d) | N (c) | % (e) |
| Austria | 252 | 2,520 | 2,520 | 252 | 100 | 2,520 | 100 | 301 | 11.9 | - | - | 6 | 100.0 |
| Belgium | 225 | 1,657 | 2,250 | 225 | 100 | 1,655 | 99.9 | 193 | 11.6 | 0 | 0.0 | 1 | 2.3 |
| Bulgaria | 72 | 720 | 720 | 67 | 93.1 | 690 | 95.8 | 0 | 0.0 | - | - | - | - |
| Cyprus | 64 | 640 | 640 | 0 | 0.0 | 0 | 0.0 | 110 | 17.2 | - | - | - | - |
| Czech Republic | 267 | 2,670 | 2,670 | 262 | 98.1 | 2,670 | 100 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Denmark | 293 | 2,930 | 2,930 | 7 | 2.4 | 1 | 0.03 | 0 | 0.0 | 2 | 100.0 | 82 | 100.0 |
| Estonia | 34 | 340 | 340 | 34 | 100 | 0 | 0.0 | 21 | 6.2 | - | - | - | - |
| Finland | 207 | 1,629 | 2,070 | 0 | 0.0 | 1,604 | 98.5 | 121 | 7.4 | - | - | - | - |
| France | 343 | 3,430 | 3,430 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | - | - | 0 | 0.0 |
| Germany | 201 | 2,010 | 2,010 | 0 | 0.0 | 2,010 | 100 | 0 | 0.0 | - | - | 0 | 0.0 |
| Hungary | 181 | 1,809 | 1,810 | 181 | 100 | 1,809 | 100 | 353 | 19.5 | 1 | 100.0 | 9 | 100.0 |
| Ireland | 189 | 1,890 | 1,890 | 0 | 0.0 | 1,890 | 100 | 118 | 6.2 | - | - | 83 | 100.0 |
| Italy | 214 | 2,140 | 2,140 | 214 | 100 | 2,140 | 100 | 574 | 26.8 | - | - | 7 | 41.2 |
| Latvia | 33 | 330 | 330 | 33 | 100 | 330 | 100 | 0 | 0.0 | - | - | - | - |
| Lithuania | 82 | 820 | 820 | 82 | 100 | 820 | 100 | 7 | 0.9 | 1 | 100.0 | - | - |
| Luxembourg | 44 | 440 | 440 | 44 | 100 | 438 | 99.5 | 0 | 0.0 | - | - | 0 | 0.0 |
| Netherlands | 321 | 3,210 | 3,210 | 321 | 100 | 3,210 | 100 | 227 | 7.1 | 1 | 100.0 | 46 | 83.6 |
| Poland | 322 | 3,220 | 3,220 | 321 | 99.7 | 3,180 | 98.8 | 136 | 4.2 | 0 | 0.0 | 0 | 0.0 |
| Portugal | 167 | 1,592 | 1,670 | 167 | 100 | 1,592 | 100 | 190 | 11.9 | - | - | 0 | 0.0 |
| Slovakia | 192 | 1,920 | 1,920 | 190 | 99.0 | 1,919 | 99.9 | 19 | 1.0 | 0 | 0.0 | 0 | 0.0 |
| Slovenia | 114 | 625 | 1,140 | 111 | 97.4 | 625 | 100 | 12 | 1.9 | 0 | 0.0 | - | - |
| Spain | 359 | 3,590 | 3,590 | 0 | 0.0 | 3,534 | 98.4 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Sweden | 207 | 1,694 | 2,070 | 198 | 95.7 | 1,692 | 99.9 | 429 | 25.3 | - | - | 1 | 100.0 |
| United Kingdom | 258 | 2,365 | 2,580 | 258 | 100 | 2,365 | 100 | 162 | 6.8 | - | - | 0 | 0.0 |
| EU total | 4,641 | 44,191 | 46,410 | 2,967 | 63.9 | 36,694 | 83.0 | 2,973 | 6.7 | 5 | 8.3 | 235 | 39.0 |
| Norway | 251 | 2,510 | 2,510 | 251 | 100.0 | 2,508 | 99.9 | 0 | 0.0 | - | - | - | - |
| Switzerland | 225 | 2,250 | 2,250 | 224 | 99.6 | 2,250 | 100 | 138 | 6.1 | 0 | 0.0 | 0 | 0.0 |

(a)   Number of holdings for which the optional holding level data were reported; (a*) % of holdings (out of the total holdings sampled) for which the optional holding level data were reported

(b)   Number of pens for which the optional pen level data were reported; (b*) % of pens (out of the total pens sampled) for which the optional pens level data were reported

(c)   Number of routine samples for which the optional sample level data were reported; (c*) % of samples (out of the total samples) for which the optional sample level data were reported;

(d)   % of samples (out of the total samples positive for *S*. Enteritidis) for which the optional sample level data were reported;

(e)   % of samples (out of the total samples total samples positive for *S*. Typhimurium) for which the optional sample level data were reported.

(-)   No positive samples

### E. STATISTICAL METHODS USED IN THE RISK FACTOR ANALYSIS

*Collinearity diagnostics*

As collinearity diagnostics both VIF (variance inflation factors) and the condition index were calculated (using SAS PROC REG), both including and excluding country as a variable.

The VIF is an index that reflects how much the variance of an estimated regression coefficient is increased because of collinearity, compared to a situation were no correlation between independent variables is present (as in a completely balanced study design). The VIF for a particular regression coefficient is calculated by regressing the variable on all other independent variables in the model. The VIF is then calculated as $1/(1-R^2)$, where $R^2$ is the percentage of variance explained by this model. VIF Values larger than 10 indicate the presence of serious collinearity. The condition index is another measure reflecting that high values may indicate that the inversion of the covariance matrix of the independent variables (part of the regression procedure) is numerically unstable. Values of the condition index above 30 are indication of severe multicollinearity, while values above 15 can be a reason for concern. In that case the condition-matrix can be studied to see which variables contribute to the multicollinearity. Tables 13 summarize the findings of the collinearity analysis.

**Table 12:** Summary of findings from the collinearity analysis

| VIF value | Overall model |
|---|---|
| 9.95 | All female pigs |
| 7-9 | Sample type<br>Pregnant pigs |
| 5-7 | Boar replacement policy (>90% purchased)<br>testing delay of 1 day |
| **Highest condition index** | 18.9 |

The most serious collinearity was between production stage and gender of the pigs, which lead to a variance inflation factor of 9.95 in the variable gender of the pigs. Therefore the variable "gender of pigs" was left out of the multivariable analysis. Without this variable, the condition index became 18.1, and the higher VIF was 8.5. Inspection of the condition matrix revealed that this condition index was created by the correlation between country and production stage and age of the pigs.

Some correlations are expected in the data because variables are naturally related: for instance, pregnant pigs are mostly kept in pens with only female pigs. Similarly, maiden gilts (production stage) will only contain gilts (age of pigs). Also there is some correlation in the sense that pigs in fields or paddocks (floor type) almost always have outdoor access, while this is less the case with other pigs. Diet reported as 'cobs/roll/nuts/pellets' was for 95.6% commercial compounds. However, as feed that was commercial compound only consisted for less that 50% of 'cobs/roll/nuts/pellets', this did not cause problematic collinearity.

*Statistical models fitted*

Multivariable logistic models were fitted using holding as a random intercept, using full integration of the random effects (Sas PROC GLIMMIX with Gaussian quadrature). Such a model assumes that the prevalence rates from holdings are normally distributed on the log-odds scale. In case this assumption would be violated, the sandwich estimates were used (option EMPIRICAL) for calculating confidence intervals of the odds ratio's from these models, as these are robust towards misspecification of the model. We used the bias correction suggested by Morel et al. (2003), (option EMPIRICAL=MBN). Using the (bias corrected) sandwich estimator protects against drawing conclusions that are artefacts

from the assumptions in the model, rather than from the data. In order to fit these models, countries without any *Salmonella*-positive pens were removed from the analysis (Finland and Norway) as fitting such models is not possible when prevalence is 0 in a particular group.

In multivariate logistic regression the number of variables and levels of variables is restricted. As a rule of thumb, the number of cases should be at least 10 times the degrees of freedom of the model (Hosmer and Lemeshow, 2000). As the number of *Salmonella* cases available for overall analysis is around 4000, the above mentioned rule is not restrictive for the fitting of model. Therefore, country was entered in the model as a covariate and not as a random effect. Using a random effect forces a particular distribution of country-specific prevalences on the data, which might not be valid. When modelled as a covariate, country-specific effects are modelled in a non-parametric way, so there is no possibility of misspecifying these effects.

In 3% of sampled holdings, the total number of pens was less than 10. In these holdings pens were resampled in order to reach a total of 10 samples. Observations from the same pen cannot be considered independent observations in the statistical analysis. However, as adjusting for the correlation was not feasible for technical reasons and the number of pens which were resampled was small, this dependency was not considered in the analysis. The size of the effects found will not be biased by this decision, but the confidence intervals might be too small. Therefore a sensitivity analysis was carried out, using only a single sample per pen (randomly sampled from the available samples). This showed that the width of the confidence intervals hardly changed and all effects that were statistically significant remained so.

Given this possibility of fitting large models, first models were fitted simultaneously entering all covariates; then backward selection was used, where the least significant variable was removed until all variables in the model has a *P*-value of less than 0.05. Interactions with holding type were tested, as originally the survey was designed for analysis of breeding holdings and production holdings separately, based on the expectation that different mechanisms might be in operation in those groups. Interaction terms with holding type for all variables were added to the model resulting from backward selection. From this model, backward stepwise selection of the interaction terms was carried out. The only interaction terms with holding type retained in the final model were for floor-type and gilt replacement policy.

### Intra-cluster Correlation Coefficient

The intra-cluster correlation coefficient (ICC) is a measure to describe the similarity of the responses on the outcome within a holding (cluster). For a random intercept model, the ICC is considering the variance of the random intercepts and the variance of the standard logistic density (Molenberghs and Verbeke, 2005). The ICC was estimated and approximated as the ratio of the variance of the random effects and the sum of the variance of the random effects and the variance of the standard logistic density. The Intra-cluster Correlation Coefficient (ICC) ranges between 0 and 1 and correspond respectively to scenarios of low (closer to zero) or high (closer to one) proportions of unexplained variance that was due to random effects (holding-specific effects, between-holding variability). Let $z$ be a matrix of estimable functions and $D$ be the unstructured variance-covariance matrix of the random effects $b_i$. Thus, the ICC for a logistic regression model can be calculated using the following formula:

$$ICC = \frac{z\prime D z}{z\prime D z + \pi^2/3}$$

### Calculation of PAF values

In order to estimate the relative quantitative impact of the effects that were found, the Population Attributable Fractions (PAFs) were calculated. The PAF gives the percentage of reduction in *Salmonella* prevalence that would be observed if the population of pens was entirely unexposed (or lower exposed) for a certain risk factor, compared with its current (actual) exposure pattern.

The PAF was calculated based on the final model including significant interaction terms with holding type. The PAF calculation was carried out as follows:

*Step 1*

The final model to predict the prevalence of *Salmonella* under the existing pattern of exposure (Table 3) was used for the PAF calculation. For every pen, the observed value of the variables (like floor type, country, type of diet, etc.) in the model equation was filled in. This yields the probability that this pen is positive for *Salmonella* according to the model. For instance, for a first pen with 48 pigs per pen, the predicted probability of *Salmonella* is 39.1%, while for another pen from the same holding, with 29 pigs, but further having all the same variables, the predicted probability is 37.7%.

*Step 2*

By averaging the probabilities from all pens in the survey, the predicted prevalence in the entire baseline survey population of pens was calculated. This yields an overall predicted prevalence of 7.99%. This is slightly different from the observed pen prevalence of 8.6%, as the holding-effect predicted by the random effects model is "shrunken" towards the median value. As the distribution of holding prevalence rates is assumed to be normal on the log-odds scale, the average shrinkage is zero on the log-odds scale, but not on the predicted probability scale, where predictions of holdings above the median are shrunken more than those below the median, resulting in a slightly lower predicted prevalence compared to the observed prevalence.

*Step 3*

Steps 1 and 2 are repeated, but now for each pen not using the existing pattern of exposure, but a "lower" pattern of exposure. For instance, take the same two pens from step 1. They are from a holding with more than 999 breeding pigs. If having 100-399 breeding pigs would be defined as "unexposed", when filling in the model equation again, "100-399 breeding pigs" instead of "more than 999 breeding pigs" should be used. The new predicted probabilities of positivity for *Salmonella* for these pens then become 15.6% and 15.1%. By summing again these probabilities from all pens in the survey (making the holding size "100-399 breeding pigs" for all pens in the survey from holdings with 400 or more breeding pigs), an overall predicted prevalence for the unexposed situation of 5.55% would result.

*Step 4*

The PAF is now calculated as the difference between the predicted prevalence for the actual situation (7.99%) and that for the "unexposed" situation (5.55%), as fraction of the predicted prevalence for the actual situation. So the PAF here is equal to: (7.99-5.55)/7.99=18.0.

Confidence intervals for the PAFs are calculated using the fixed effect model parameters from the final model and their covariance matrix. These are used to randomly draw a set of model parameters from them, representing a set of model parameters that is randomly draw from the model parameters that are also likely, given the uncertainty of the fitted model. The procedure above (steps 1 to 4) then is carried out with this set of randomly drawn parameters, yielding a PAF value. This procedure is repeated 500 times, yielding 500 PAF values, which represent the distribution of PAF values stemming from the standard errors of the fixed effects. 95% confidence intervals were calculated from

this set of 500 PAF values by taking the 2.5[th] and 97.5[th] percentiles. In this procedure we did not take the uncertainty in the random effects into account, as the random effects will not importantly influence the PAF values. This procedure calculates the confidence interval of the PAF, when changing the exposures as observed into new exposures. The uncertainly on whether this observed exposure distribution is equal to the exposure distribution in the entire EU is not taken into account.

Calculations were carried out both unweighted (as described above) and weighted with the number of holdings with more than 50 breeding pigs in each country. In the latter case, only the holdings with more than 50 breeding pigs in the survey were used, and furthermore excluded Norway and Switzerland (as they are not EU member states). All predicted probabilities for each pen (both in step 2 and step 3 above) were then weighted using a weight corresponding to the inverse of the sampling fraction in the particular country and holding type combination. The sampling fraction was calculated for each holding type / country combination. For example, the sampling fraction for breeding holdings in France is the number of French breeding holdings with more than 50 breeding pigs in the survey, divided by the total number of breeding holdings housing at least 50 breeding pigs in France. The weights used are the same as those used in the report part A, and are discussed in more detail there.

**F.** **CORRELATION BETWEEN THE PREVALENCE OF *SALMONELLA*–POSITIVE BREEDING AND PRODUCTION HOLDINGS**
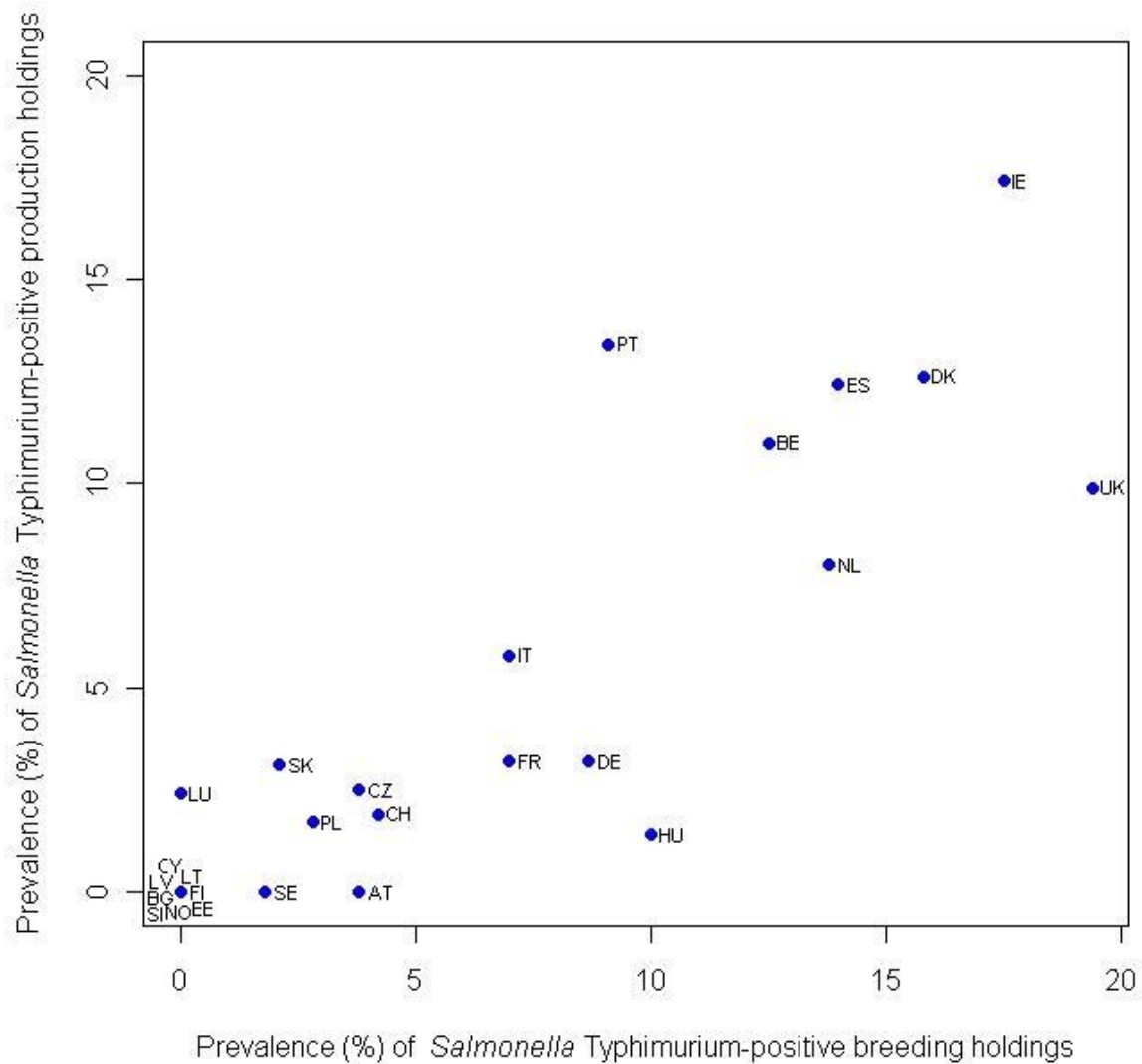


**Figure 11:** Scatter diagram of the prevalence[a] of *S*. Typhimurium-positive breeding holdings versus the prevalence of *S*. Typhimurium-positive production holdings, *Salmonella* EU baseline survey, 2008

[a] Bulgaria, Cyprus, Estonia, Finland, Latvia, Slovenia and Norway did not isolate any *S*. Typhimurium in both breeding and production holdings.
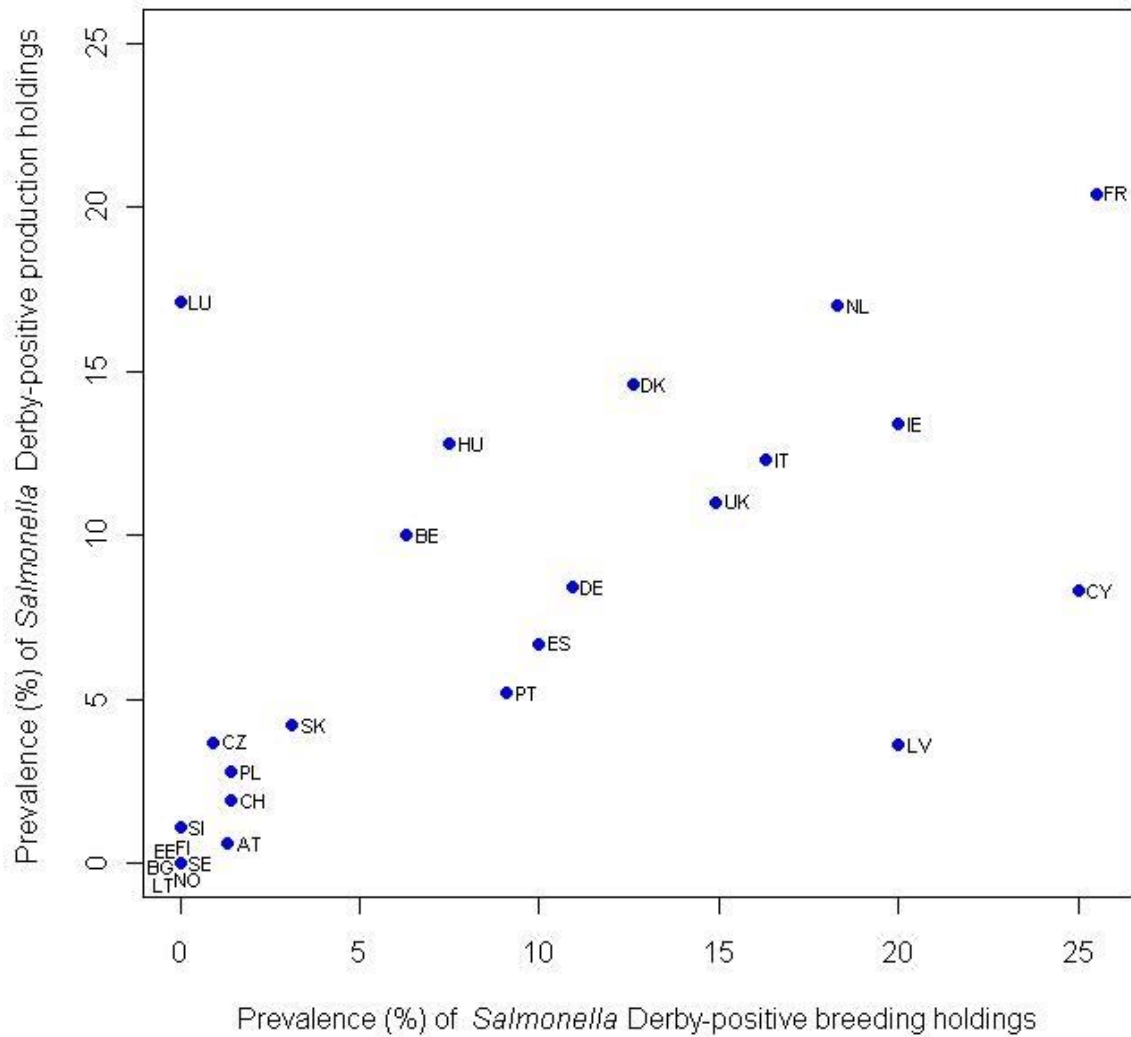
**Figure 12:** Scatter diagram of the prevalence[a] of *S*. Derby-positive breeding holdings versus the prevalence of *S*. Derby-positive production holdings, *Salmonella* EU baseline survey, 2008

[a]   Bulgaria, Estonia, Finland, Lithuania, Sweden and Norway did not isolate any *S*. Derby in both breeding and production holdings.
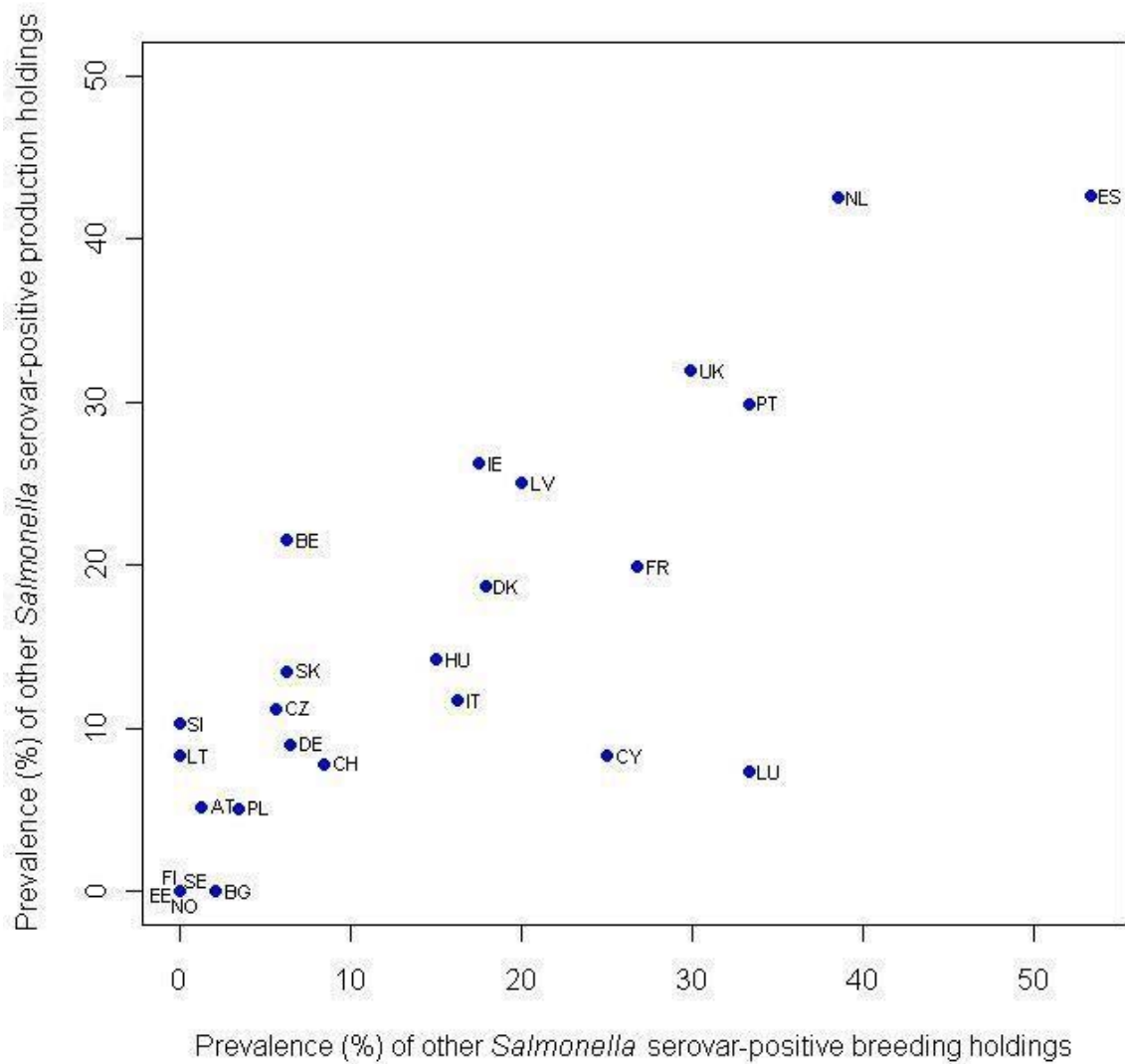
**Figure 13:** Scatter diagram of the prevalence[a] of breeding holdings positive to serovars other than *S*. Typhimurium and/or *S*. Derby versus the prevalence of production holdings positive to serovars other than *S*. Typhimurium and/or *S*. Derby , *Salmonella* EU baseline survey, 2008

[a]  Estonia, Finland, Sweden and Norway did not isolate any serovars other than *S*. Typhimurium and *S*. Derby in both breeding and production holdings.

**G. DESCRIPTIVE ANALYSIS OF FACTORS POTENTIALLY ASSOCIATED WITH *SALMONELLA* POSITIVITY IN BREEDING AND IN PRODUCTION HOLDINGS**

**Table 13:** Observed prevalence of pens with breeding pigs tested positive for *Salmonella* by risk factor, *Salmonella* EU baseline survey, 2008

| Risk factor | Category | Number | Positives | Percentage positive | *P*-value trend-test | *P*-value exact-test | *P*-value chi-square |
|---|---|---|---|---|---|---|---|
| Testing delay | 0 | 5,871 | 404 | 6.88 | <.0001 | <.0001 | <.0001 |
| | 1 | 26,256 | 1,776 | 6.76 | | | |
| | 2 | 10,793 | 840 | 7.78 | | | |
| | 3-4 | 7,395 | 895 | 12.10 | | | |
| | >= 5 | 855 | 86 | 10.06 | | | |
| Month | JAN08 | 1,410 | 80 | 5.67 | <.0001 | <.0001 | <.0001 |
| | FEB08 | 3,270 | 207 | 6.33 | | | |
| | MAR08 | 3,850 | 267 | 6.94 | | | |
| | APR08 | 4,130 | 304 | 7.36 | | | |
| | MAY08 | 4,030 | 338 | 8.39 | | | |
| | JUN08 | 4,660 | 321 | 6.89 | | | |
| | JUL08 | 3,840 | 269 | 7.01 | | | |
| | AUG08 | 3,610 | 211 | 5.84 | | | |
| | SEP08 | 5,010 | 441 | 8.80 | | | |
| | OCT08 | 5,770 | 538 | 9.32 | | | |
| | NOV08 | 5,990 | 566 | 9.45 | | | |
| | DEC08 | 5,600 | 459 | 8.20 | | | |
| Quarter | January-March | 8,530 | 554 | 6.49 | <.0001 | <.0001 | <.0001 |
| | April-June | 12,820 | 963 | 7.51 | | | |
| | July-September | 12,460 | 921 | 7.39 | | | |
| | October-December | 17,360 | 1,563 | 9.00 | | | |
| Season | Winter | 10,280 | 746 | 7.26 | <.0001 | <.0001 | <.0001 |
| | Spring | 12,010 | 909 | 7.57 | | | |
| | Summer | 12,110 | 801 | 6.61 | | | |
| | Autumn | 16,770 | 1,545 | 9.21 | | | |
| Breeding/Production type | Nucleus | 4,020 | 345 | 8.58 | 0.4292 | <.0001 | <.0001 |
| | Multiplier or supplier | 12,070 | 959 | 7.95 | | | |
| | Farrow to finish | 18,860 | 1,310 | 6.95 | | | |
| | Farrow to grower | 12,710 | 1,008 | 7.93 | | | |
| | Farrow to weaner | 3,510 | 379 | 10.80 | | | |
| Holding size | <100 | 13,490 | 388 | 2.88 | <.0001 | <.0001 | <.0001 |
| | 100-399 | 21,930 | 1,751 | 7.98 | | | |
| | 400-999 | 9,780 | 1,227 | 12.55 | | | |
| | >999 | 5,970 | 635 | 10.64 | | | |
| Gilt replacement policy | >90% gilts homebred | 25,500 | 2,019 | 7.92 | 0.0884 | <.0001 | <.0001 |
| | 10-90% gilts homebred | 6,750 | 382 | 5.66 | | | |
| | >90% gilts purchased | 18,920 | 1,600 | 8.46 | | | |
| Boar replacement policy | no boars on farm | 5,980 | 454 | 7.59 | <.0001 | <.0001 | <.0001 |
| | >90% homebred | 16,180 | 1,521 | 9.40 | | | |
| | 10-90% purchased | 3,730 | 331 | 8.87 | | | |
| | >90% purchased | 25,280 | 1,695 | 6.70 | | | |
| Type of sample | Swab | 15,743 | 1,580 | 10.04 | <.0001 | <.0001 | <.0001 |
| | Composite | 35,427 | 2,421 | 6.83 | | | |
| Number of pigs in pen | 0-9 | 433 | 35 | 8.08 | <.0001 | <.0001 | <.0001 |
| | 10 | 24,376 | 1,515 | 6.22 | | | |
| | 11-20 | 14,741 | 1,107 | 7.51 | | | |
| | 21-100 | 9,883 | 1,086 | 10.99 | | | |
| | >100 | 1,737 | 258 | 14.85 | | | |

| Risk factor | Category | Number | Positives | Percentage positive | *P*-value trend-test | *P*-value exact-test | *P*-value chi-square |
|---|---|---|---|---|---|---|---|
| Age of pigs | No gilts | 19,983 | 1,524 | 7.63 | 0.8099 | 0.0877 | 0.0819 |
| | Mixed age | 22,439 | 1,821 | 8.12 | | | |
| | All gilts | 8,748 | 656 | 7.50 | | | |
| Gender of pigs | Male | 460 | 23 | 5.00 | <.0001 | <.0001 | <.0001 |
| | Female | 44,398 | 3,587 | 8.08 | | | |
| | Mixed | 6,312 | 391 | 6.19 | | | |
| Production stage | Mixed | 7,238 | 421 | 5.82 | | | |
| | Maiden gilts | 5,149 | 438 | 8.51 | <.0001 | <.0001 | <.0001 |
| | Pregnant | 21,527 | 1,777 | 8.25 | | | |
| | Farrowing and lactating | 11,041 | 740 | 6.70 | | | |
| | Service area | 6,215 | 625 | 10.06 | | | |
| Indoor/outdoor production | No | 44,687 | 3,409 | 7.63 | <.0001 | <.0001 | <.0001 |
| | Yes | 6,483 | 592 | 9.13 | | | |
| Individual housing | No | 24,761 | 1,767 | 7.14 | <.0001 | <.0001 | <.0001 |
| | Yes | 26,409 | 2,234 | 8.46 | | | |
| Floor type | Outdoors in fields or paddocks | 1,104 | 228 | 20.65 | <.0001 | <.0001 | <.0001 |
| | Solid floor other bedding | 2,346 | 42 | 1.79 | | | |
| | Solid floor with straw | 8,165 | 303 | 3.71 | | | |
| | Solid floor without bedding | 5,699 | 376 | 6.60 | | | |
| | Partly slatted floor | 21,747 | 2,066 | 9.50 | | | |
| | Slatted floor | 10,261 | 967 | 9.42 | | | |
| | Other | 1,848 | 19 | 1.03 | | | |
| All in or all out | No | 27,411 | 2,216 | 8.08 | 0.0163 | 0.0167 | 0.0163 |
| | Yes | 23,759 | 1,785 | 7.51 | | | |
| Origin of feed | Commercial compound | 29,309 | 3,031 | 10.34 | <.0001 | <.0001 | <.0001 |
| | Feed with maize | 1,919 | 100 | 5.21 | | | |
| | Home-mill | 18,001 | 823 | 4.57 | | | |
| | Other | 1,941 | 47 | 2.42 | | | |
| Type of diet | Cobbs/rolls/nuts/pellets | 14,253 | 1,937 | 13.59 | <.0001 | <.0001 | <.0001 |
| | Others | 3,642 | 177 | 4.86 | | | |
| | Meal/mash | 24,224 | 1,326 | 5.47 | | | |
| | Porridge/liquids | 9,051 | 561 | 6.20 | | | |
| Organic acid supplement | No organic acid added | 40,666 | 3,167 | 7.79 | <.0001 | <.0001 | <.0001 |
| | Organic acid added | 4,528 | 233 | 5.15 | | | |
| | Unknown | 5,976 | 601 | 10.06 | | | |
| Probiotic supplement | No probiotic added | 44,335 | 3,352 | 7.56 | <.0001 | <.0001 | <.0001 |
| | Probiotic added | 859 | 48 | 5.59 | | | |
| | Unknown | 5,976 | 601 | 10.06 | | | |
| Other supplements | No other added | 42,098 | 3,184 | 7.56 | <.0001 | <.0001 | <.0001 |
| | Other added | 3,096 | 216 | 6.98 | | | |
| | Unknown | 5,976 | 601 | 10.06 | | | |
| Use of antibiotics | No treatment | 42,593 | 3,204 | 7.52 | <.0001 | <.0001 | <.0001 |
| | Treatment | 6,878 | 653 | 9.49 | | | |
| | Unknown | 1,699 | 144 | 8.48 | | | |

Breeding pig holding
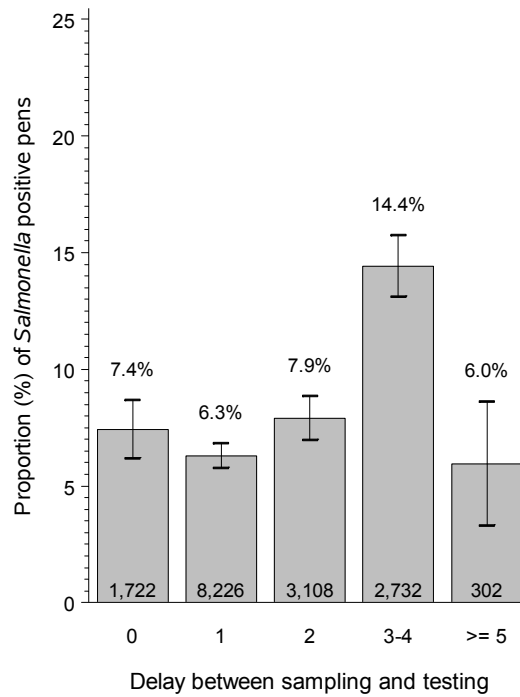


Production pig holding
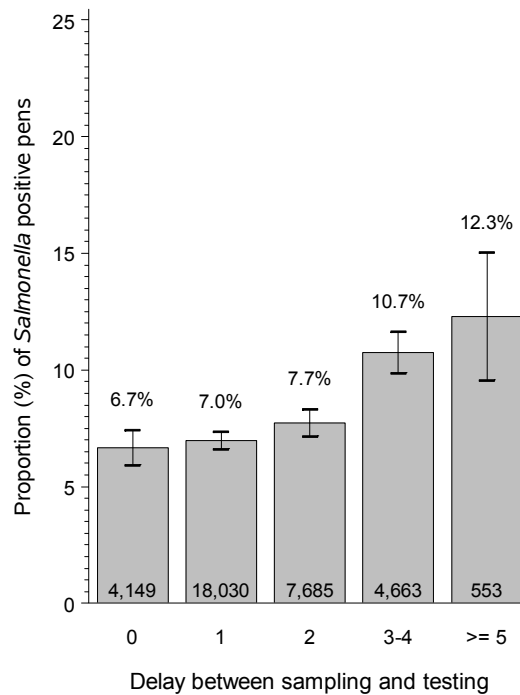


**Figure 14:** Proportion of *Salmonella*-positive pens with 95% confidence interval by testing delay in days (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

Breeding pig holding
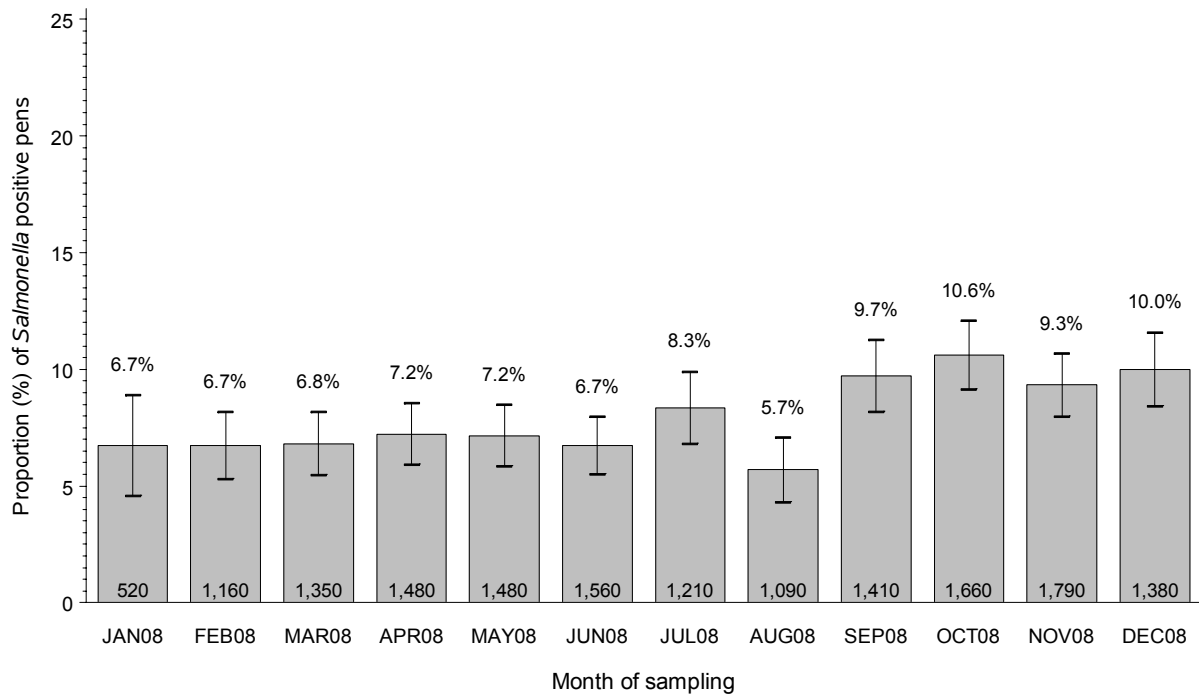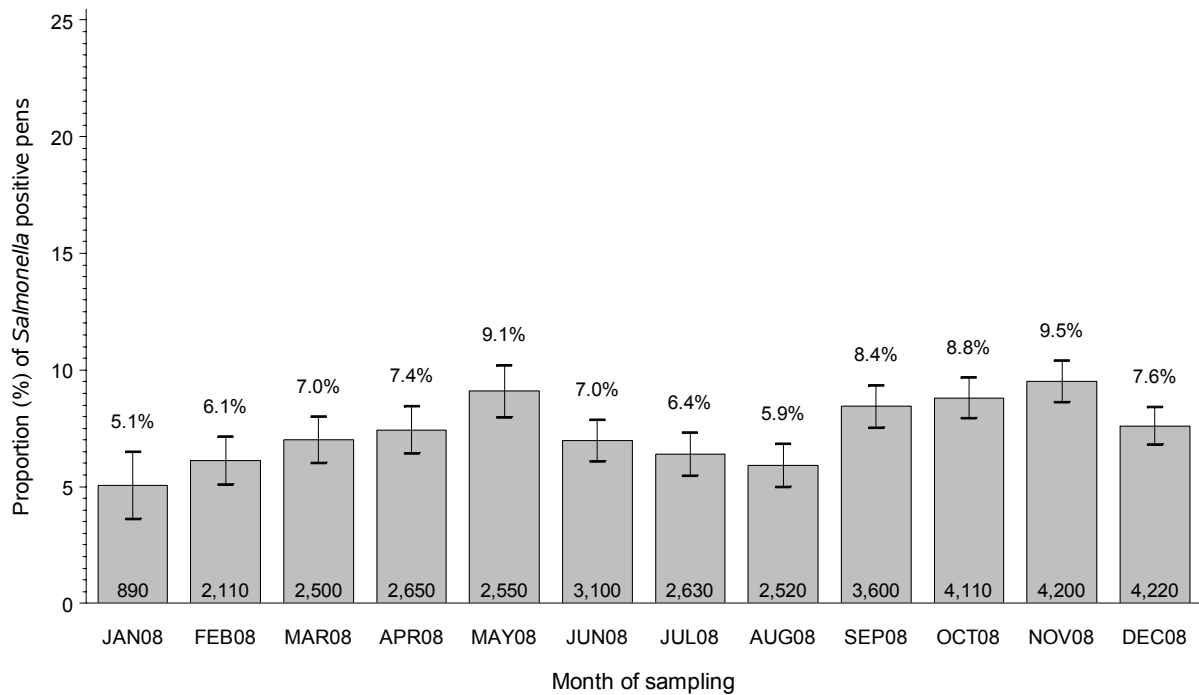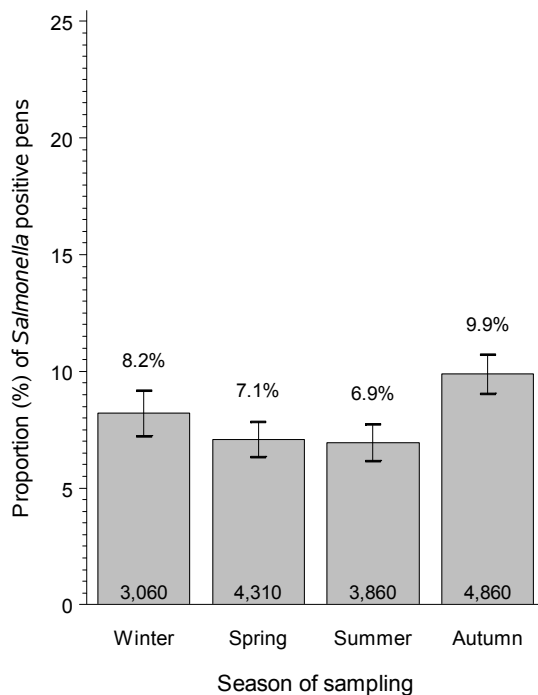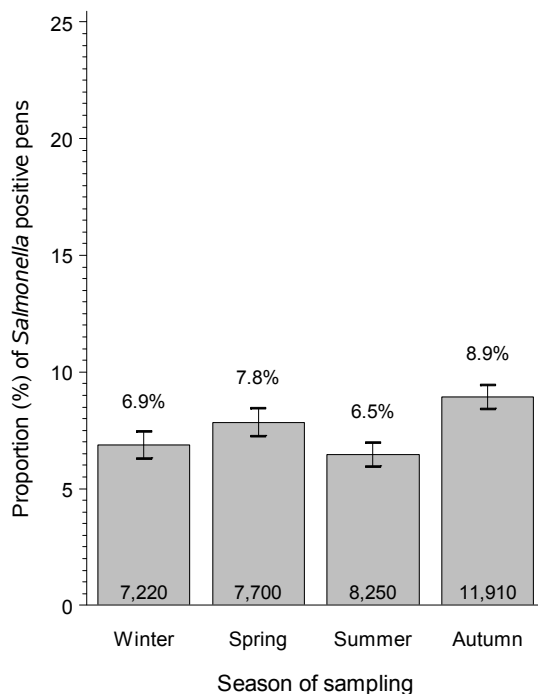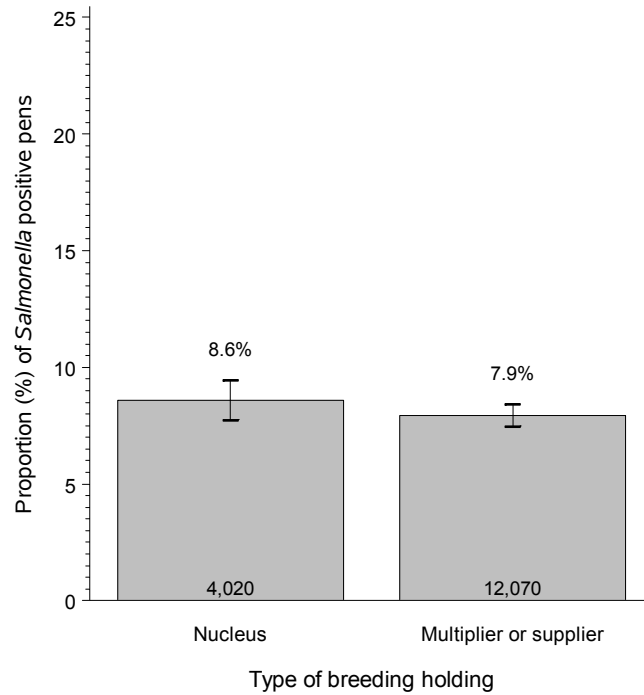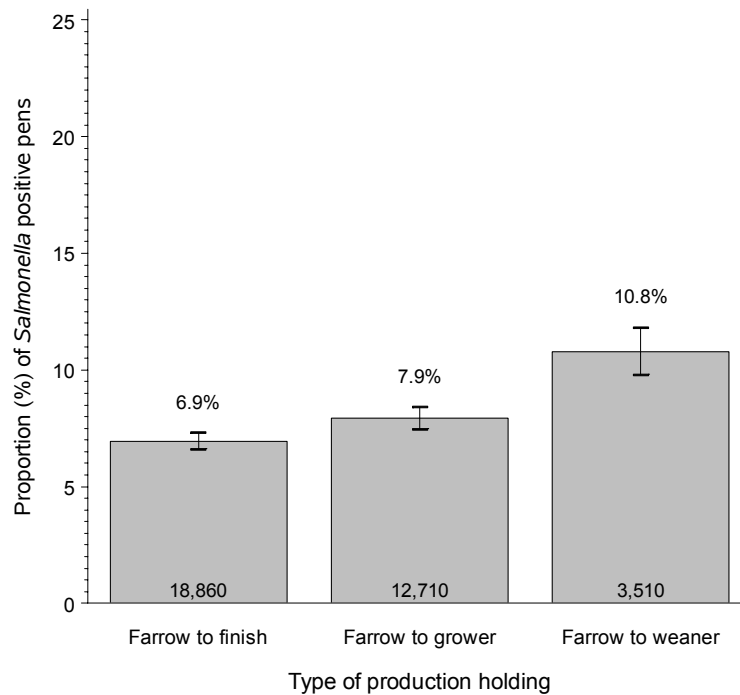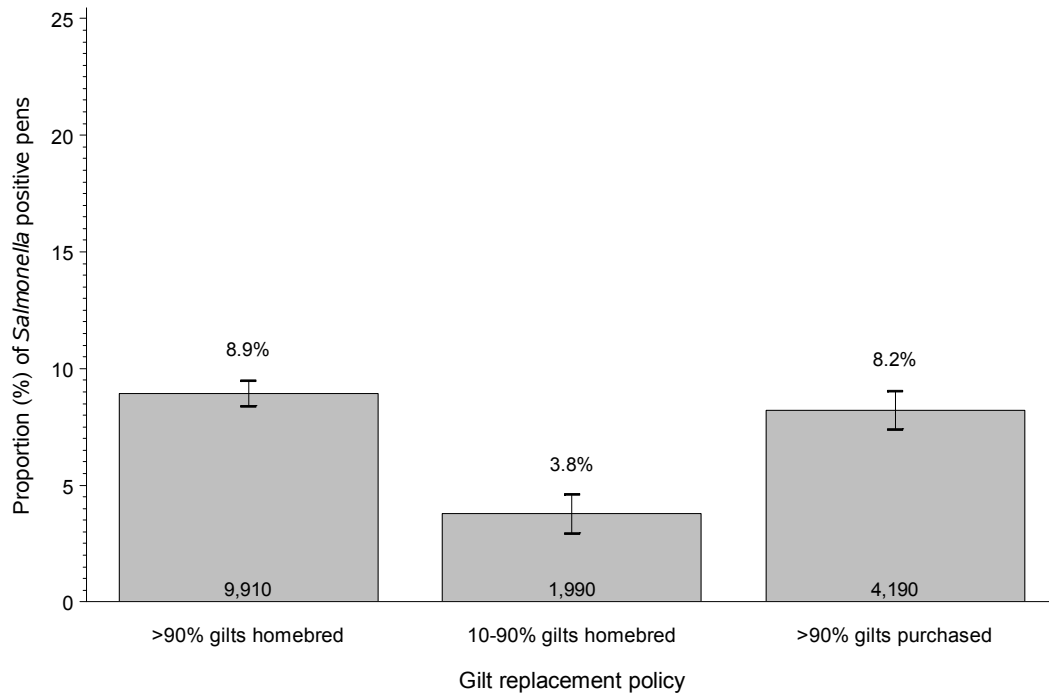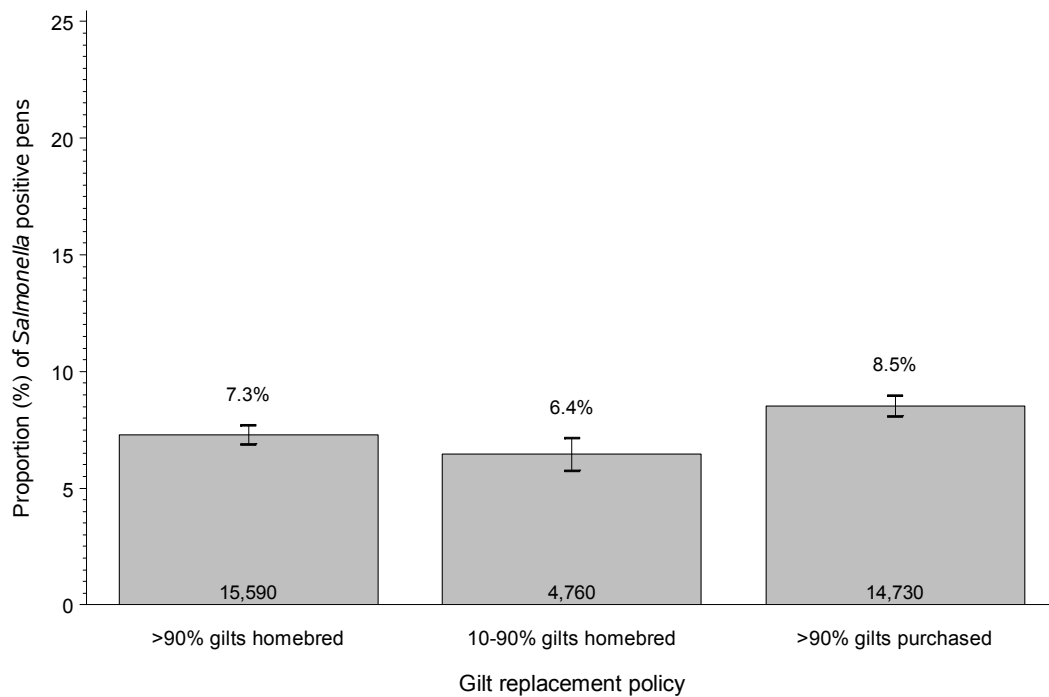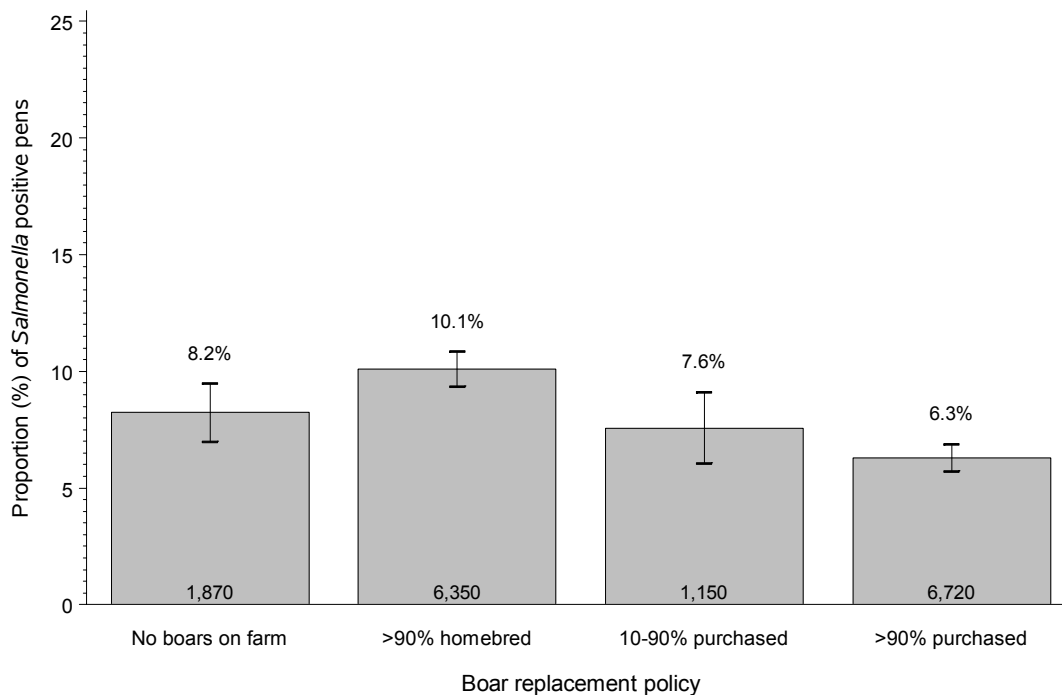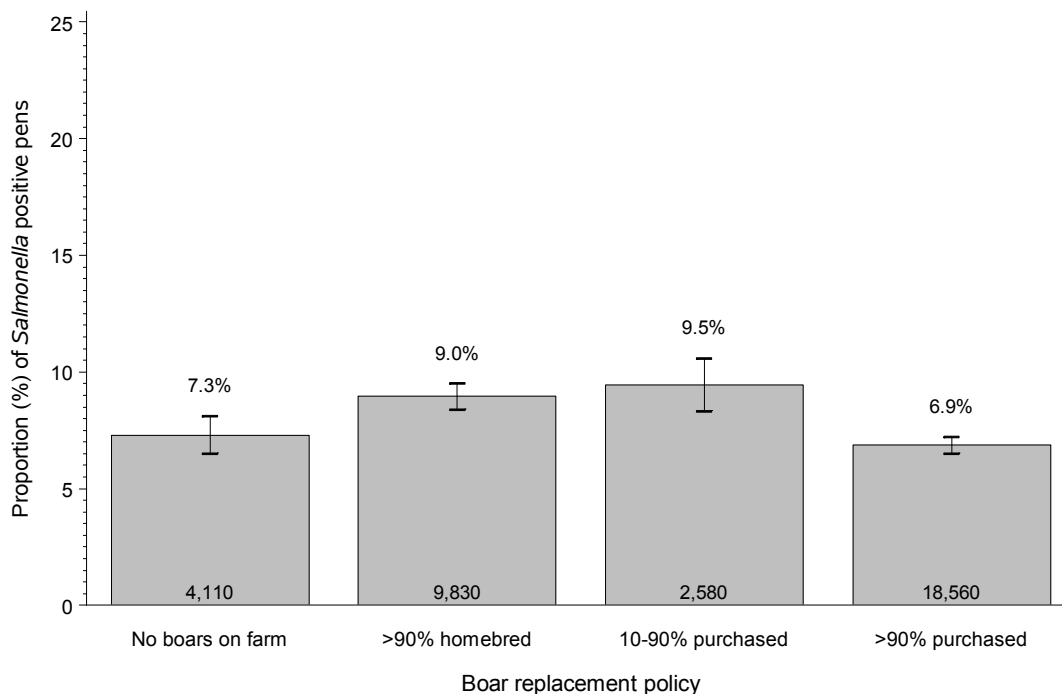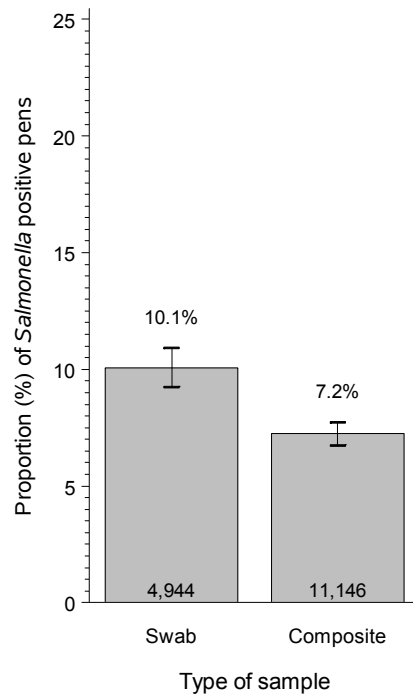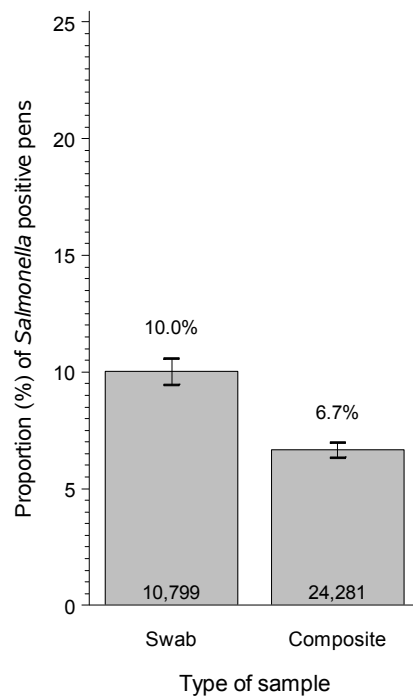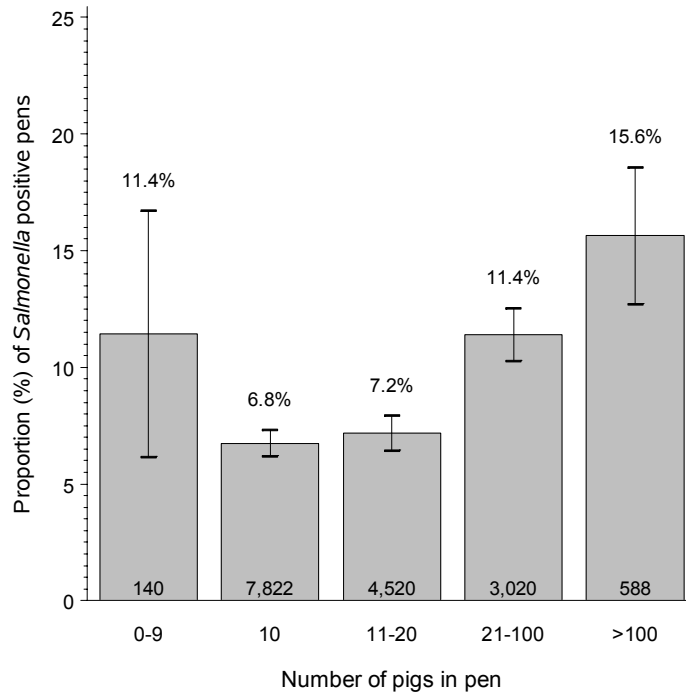


Production pig holding



**Figure 15:** Proportion of *Salmonella*-positive pens with 95% confidence interval by month of sampling (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

Breeding pig holding



Production pig holding



**Figure 16:** Proportion of *Salmonella*-positive pens with 95% confidence interval by season of sampling (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008
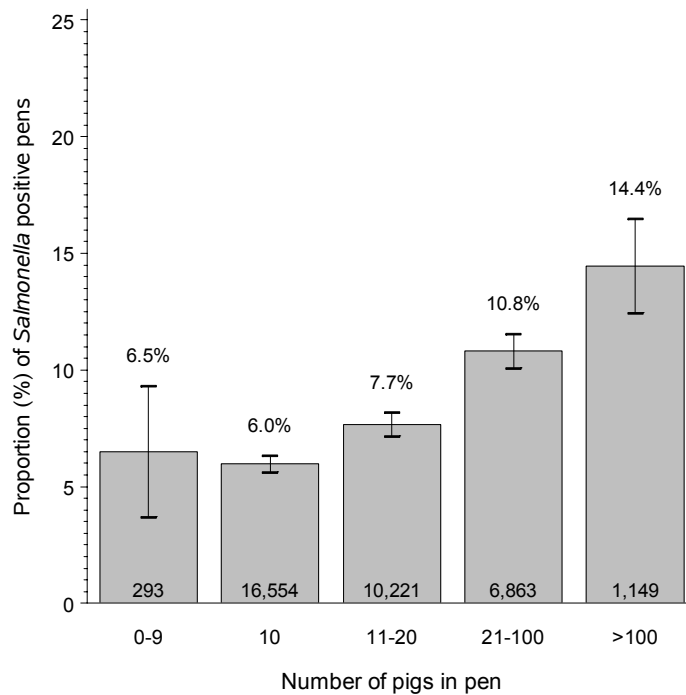
Breeding pig holding



Production pig holding



**Figure 17:** Proportion of *Salmonella*-positive pens with 95% confidence interval by type of breeding/production holding (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

Breeding pig holding



Production pig holding



**Figure 18:** Proportion of *Salmonella*-positive pens with 95% confidence interval by gilt replacement policy (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

Breeding pig holding



Production pig holding



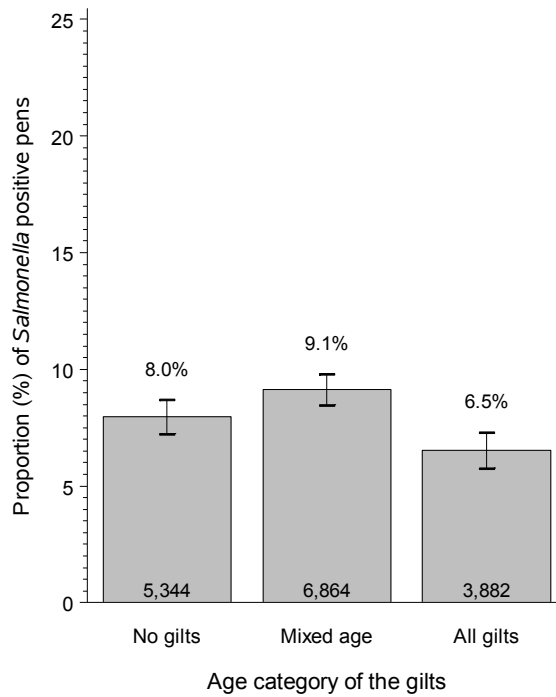**Figure 19:** Proportion of *Salmonella*-positive pens with 95% confidence interval by boar replacement policy (number of holdings represented inside each bar), *Salmonella* EU baseline survey, 2008

Breeding pig holding



Production pig holding



**Figure 20:** Proportion of *Salmonella*-positive pens with 95% confidence interval by type of sample (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008
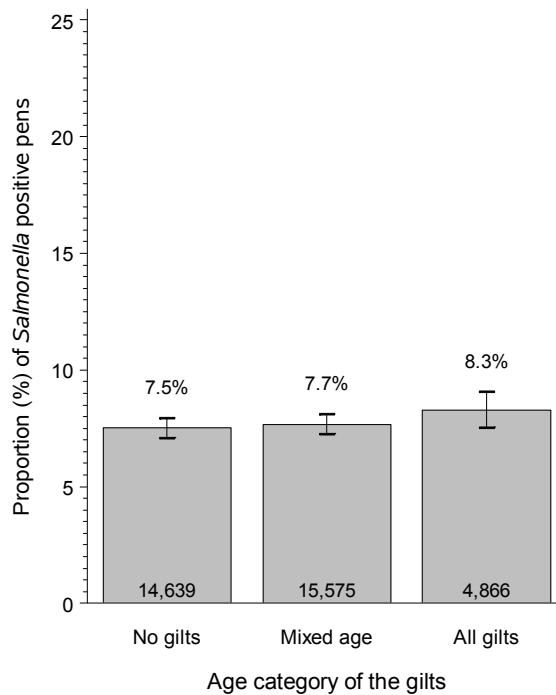
Breeding pig holding



Production pig holding



**Figure 21:** Proportion of *Salmonella*-positive pens with 95% confidence interval by number of pigs in the pen (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

Breeding pig holding
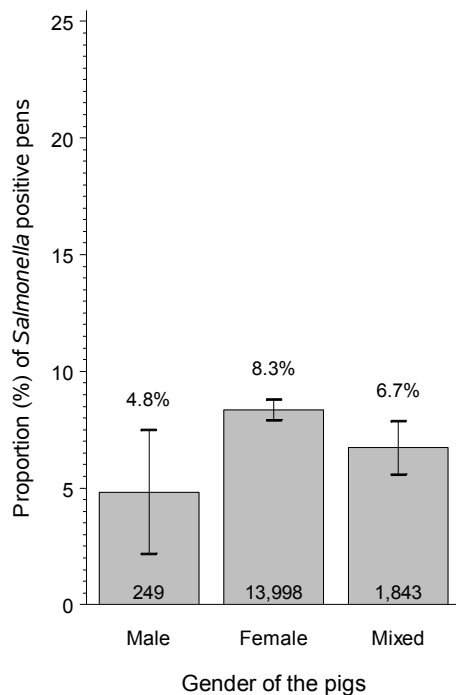


Production pig holding



**Figure 22:** Proportion of *Salmonella*-positive pens with 95% confidence interval by age category of the pigs (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

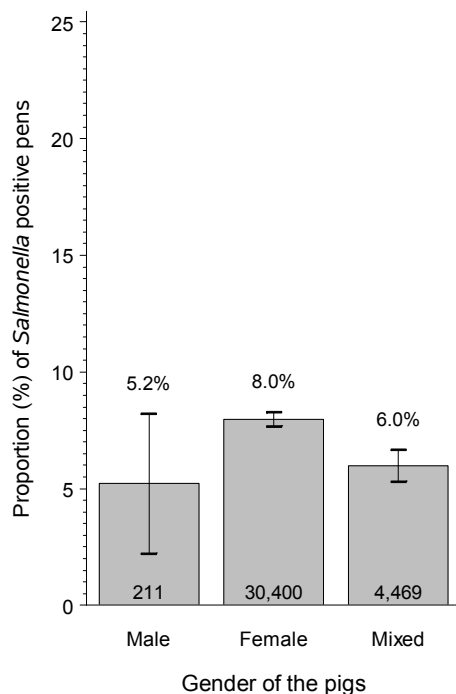Breeding pig holding
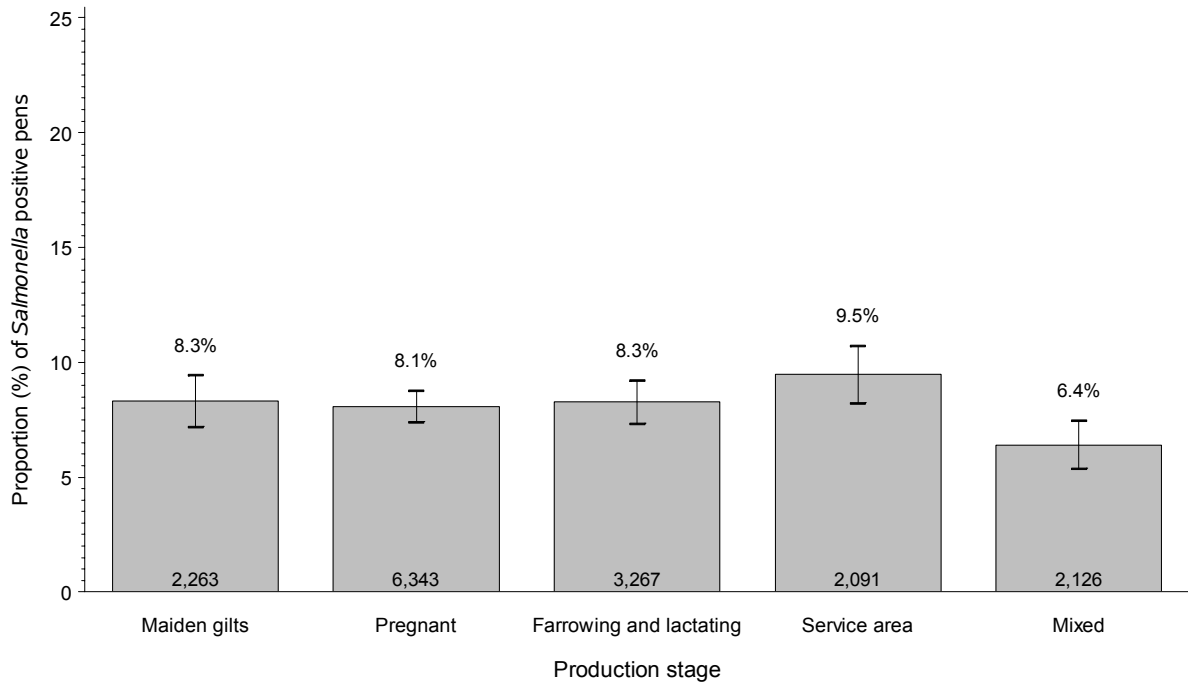


Production pig holding



**Figure 23:** Proportion of *Salmonella*-positive pens with 95% confidence interval by gender of the pigs (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008
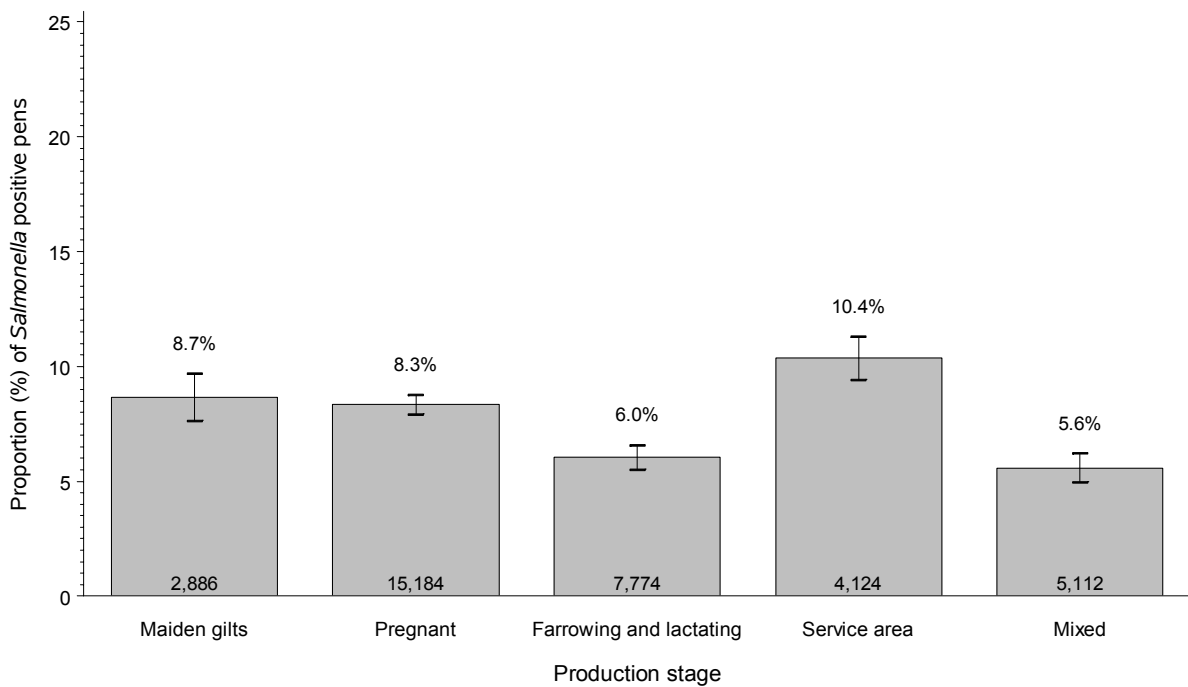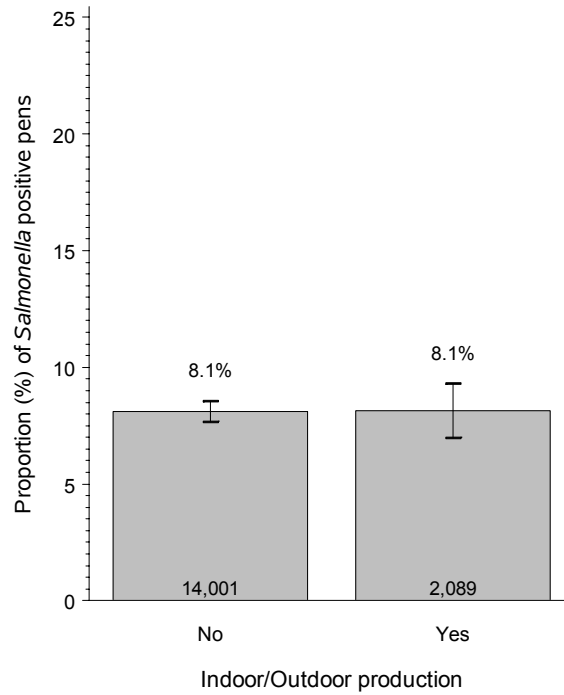
Breeding pig holding



Production pig holding



**Figure 24:** Proportion of *Salmonella*-positive pens with 95% confidence interval by production stage (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

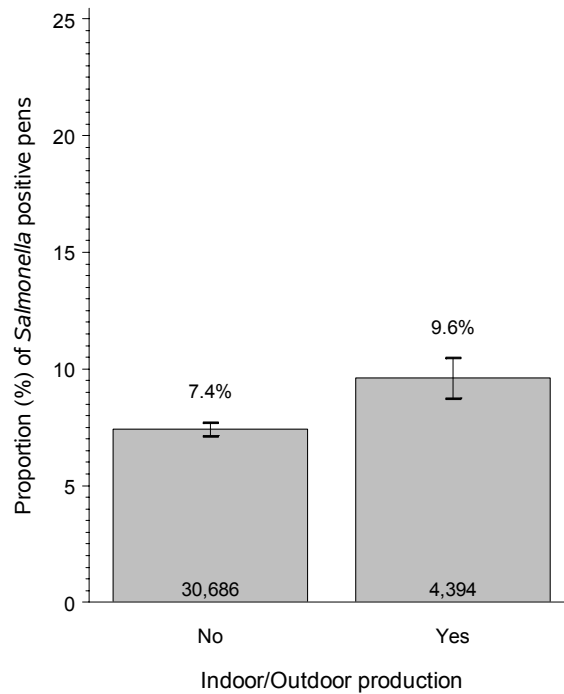Breeding pig holding



Production pig holding



**Figure 25:** Proportion of *Salmonella*-positive pens with 95% confidence interval by indoor/outdoor production (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

Breeding pig holding



Production pig holding



**Figure 26:** Proportion of *Salmonella*-positive pens with 95% confidence interval by individual housing (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

Breeding pig holding



Production pig holding



**Figure 27:** Proportion of *Salmonella*-positive pens with 95% confidence interval by all in/all out and cleaned (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008
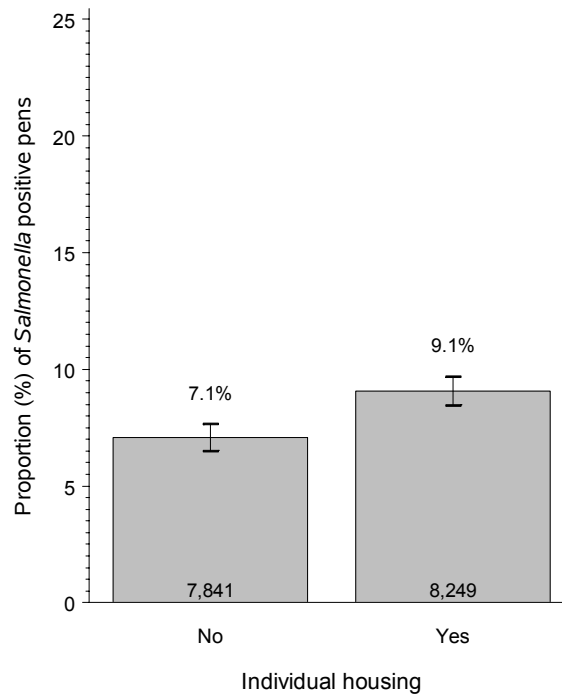
Breeding pig holding



Production pig holding
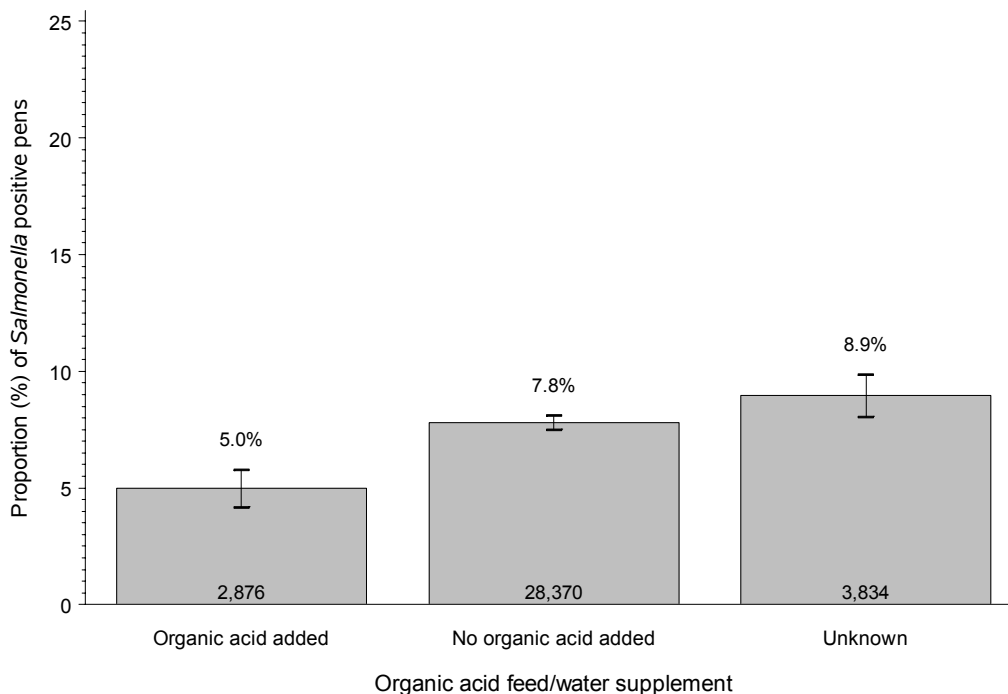


**Figure 28:** Proportion of *Salmonella*-positive pens with 95% confidence interval by use of organic acid as feed/water supplement (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008
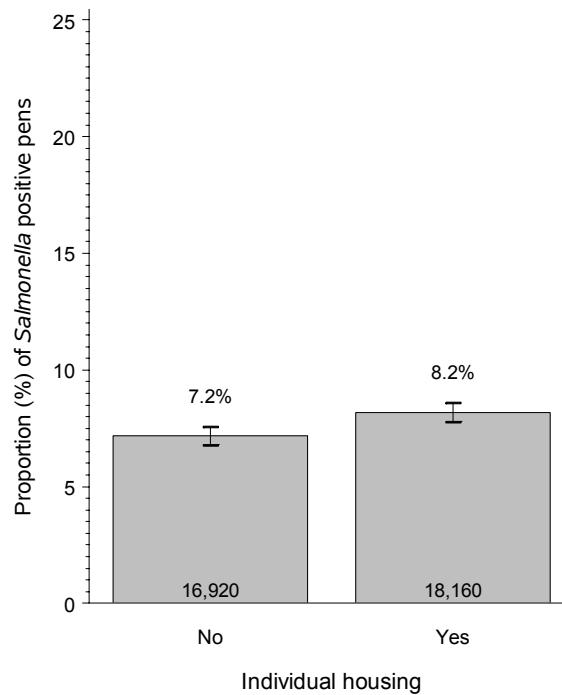
Breeding pig holding
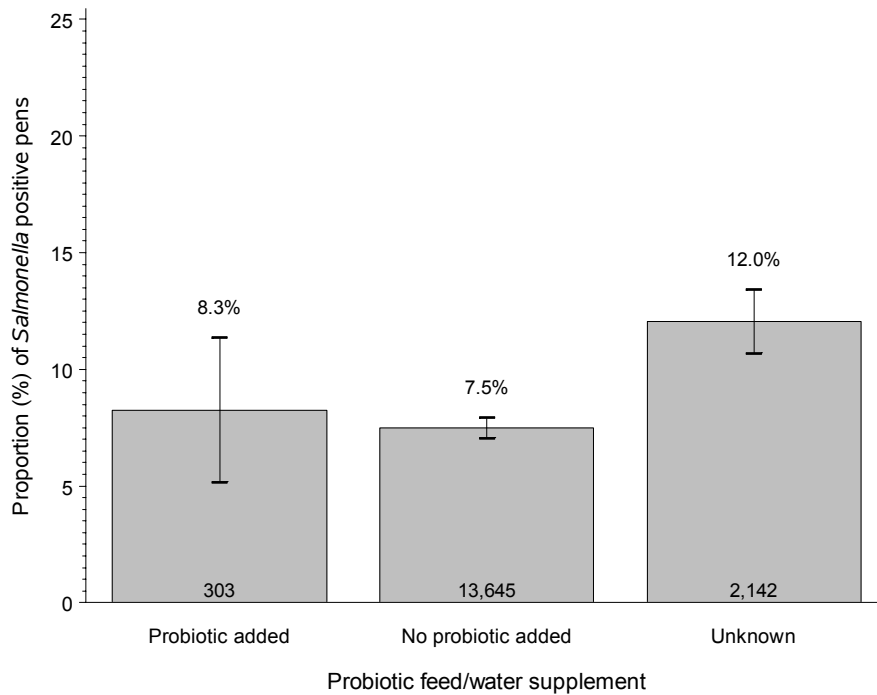


Production pig holding



**Figure 29:** Proportion of *Salmonella* positive pens with 95% confidence interval by use of probiotic as feed/water supplement (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

Breeding pig holding



Production pig holding



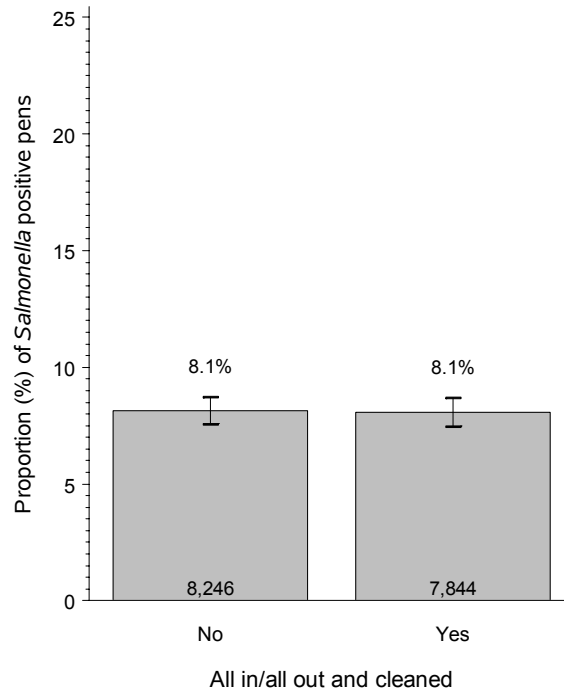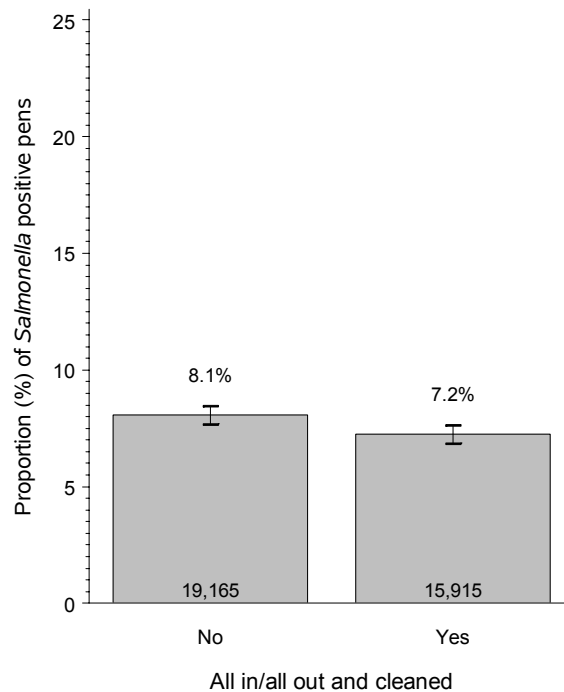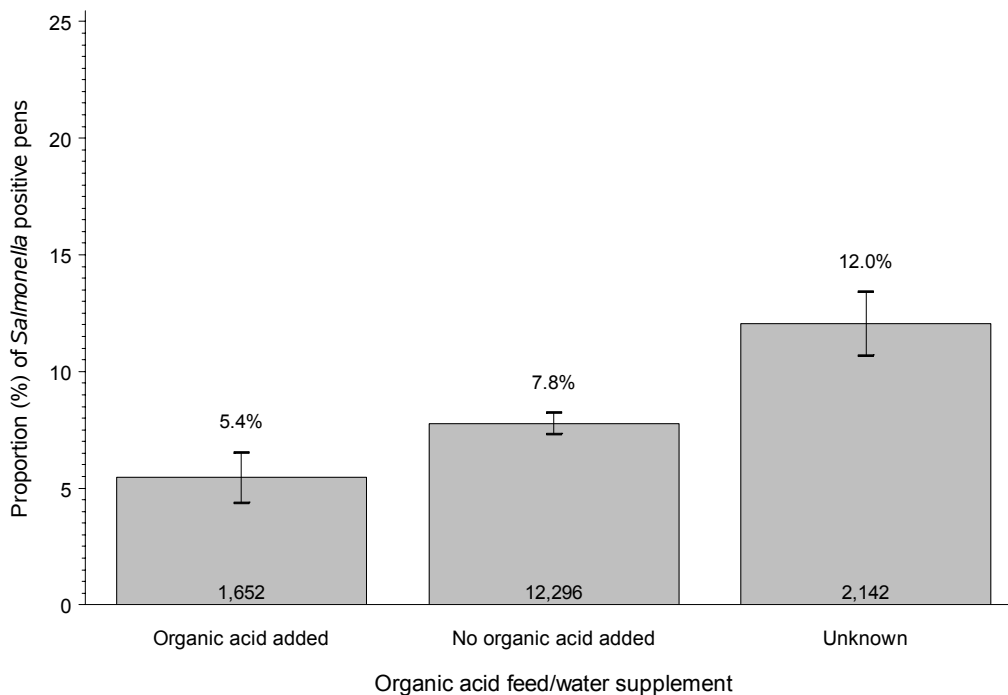**Figure 30:** Proportion of *Salmonella* positive pens with 95% confidence interval by use of other[a] feed/water supplement (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

[a] "Other feed/water supplement" includes combinations of different feed/water supplements, such as for example: organic acid/probiotic, probiotic/other, othes, organic acid/probiotic/other, etc.

Breeding pig holding



Production pig holding



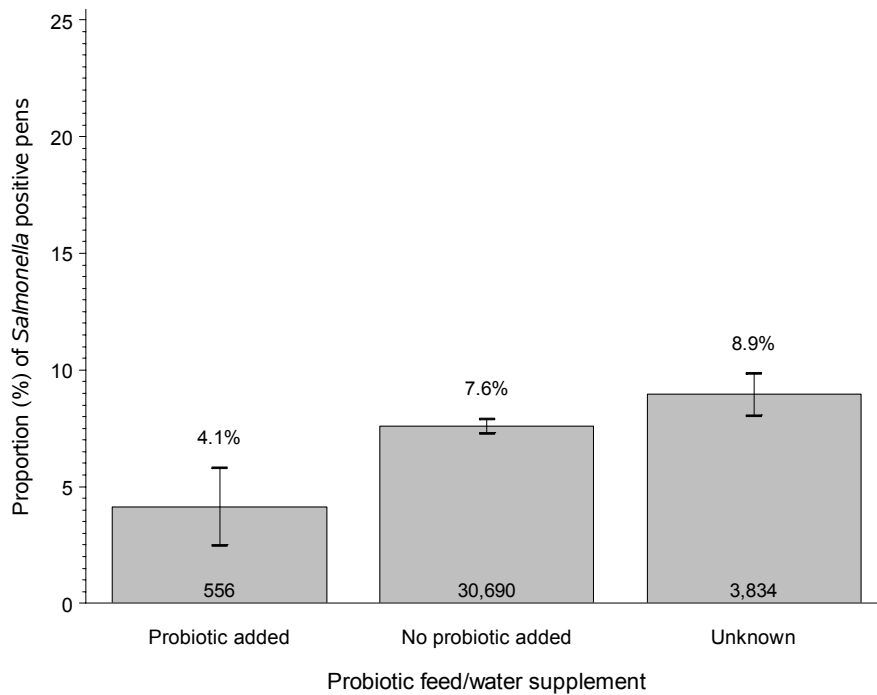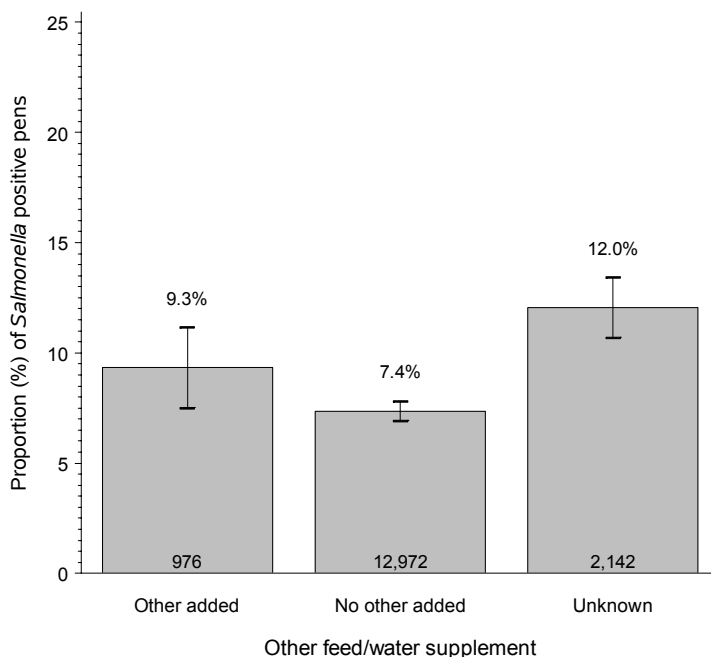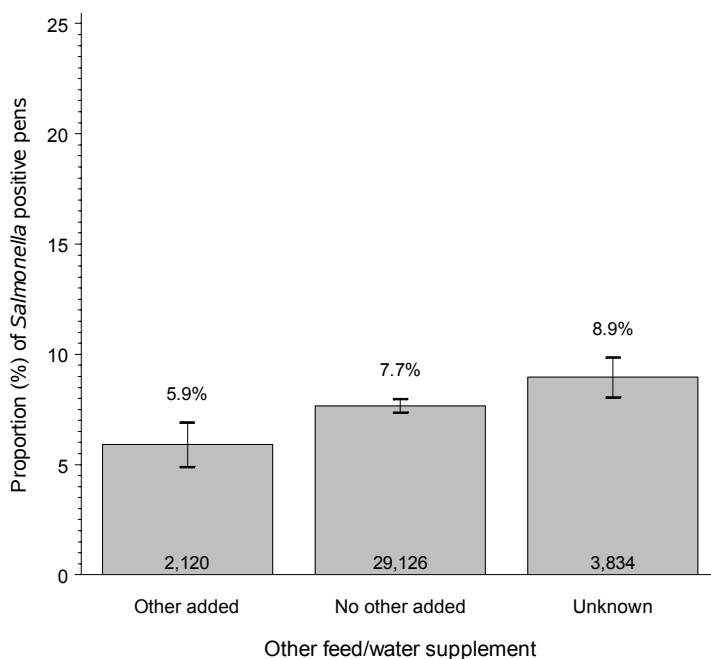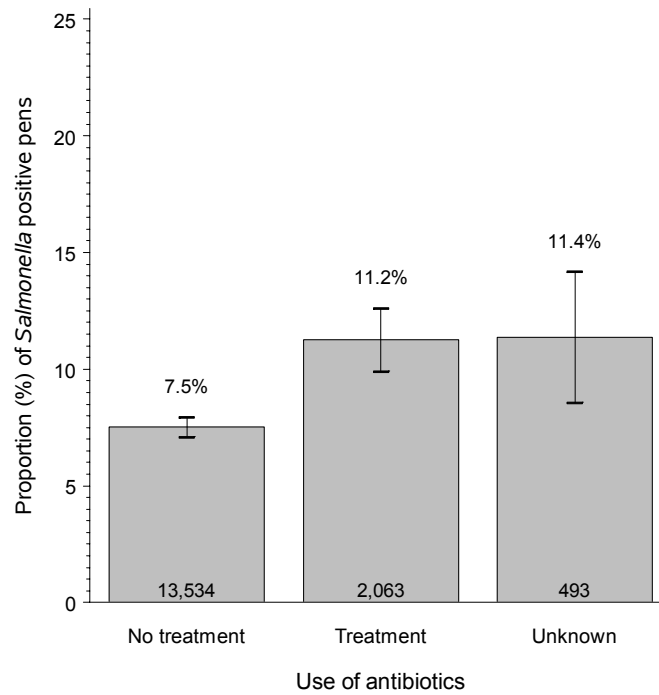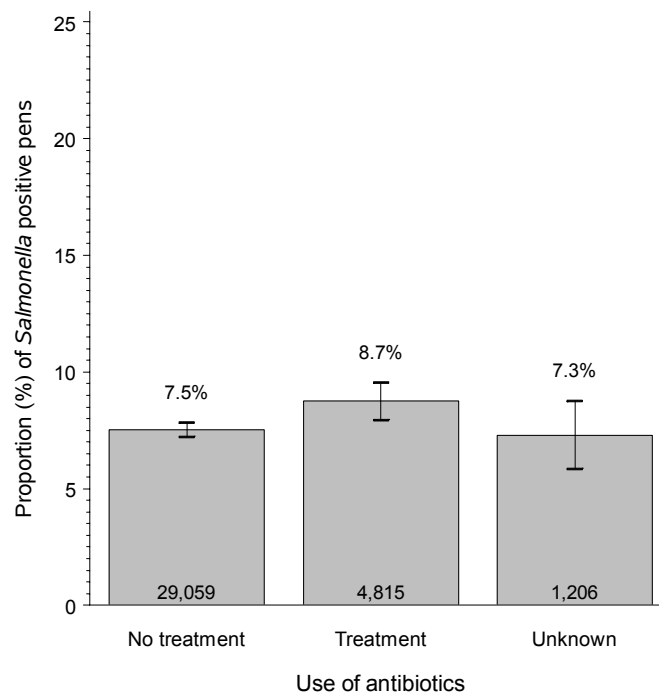**Figure 31:** Proportion of *Salmonella*-positive pens with 95% confidence interval by use of antibiotics (number of pens represented inside each bar), *Salmonella* EU baseline survey, 2008

**Table 14:** Bivariable odds ratios of *Salmonella*-positive pens in holdings with breeding pigs, by risk factor, from a model with country as fixed effect and holding as random intercept; EU *Salmonella* baseline survey, 2008

| Risk factor | Comparison | OR[a] | 95% CI[b] | | DF | *P*-value |
|---|---|---|---|---|---|---|
| Delay between sampling and testing | 1 vs 0 | 1.03 | 0.75 | 1.42 | 4 | 0.6717 |
| | 2 vs 0 | 1.19 | 0.82 | 1.73 | | |
| | 3-4 vs 0 | 1.15 | 0.74 | 1.79 | | |
| | >= 5 vs 0 | 1.51 | 0.75 | 3.01 | | |
| Season of sampling | Spring vs Winter | 0.98 | 0.73 | 1.32 | 3 | 0.0532 |
| | Summer vs Winter | 0.73 | 0.55 | 0.98 | | |
| | Autumn vs Winter | 1.00 | 0.76 | 1.30 | | |
| Breeding/production type | Nucleus vs Multiplier or supplier | 1.05 | 0.74 | 1.50 | 4 | 0.057 |
| | Farrow to finish vs Multiplier or supplier | 0.72 | 0.56 | 0.92 | | |
| | Farrow to grower vs Multiplier or supplier | 1.02 | 0.77 | 1.35 | | |
| | Farrow to weaner vs Multiplier or supplier | 1.24 | 0.85 | 1.80 | | |
| Size of the holding | 100-399 vs 1 <100 | 1.87 | 1.36 | 2.56 | 3 | <.0001 |
| | 400-999 vs 1 <100 | 3.35 | 2.36 | 4.76 | | |
| | >999 vs 1 <100 | 5.49 | 3.67 | 8.22 | | |
| Gilt replacement policy | 10-90% Gilts homebred vs >90% Gilts homebred | 0.80 | 0.59 | 1.08 | 2 | 0.3125 |
| | >90% Gilts purchased vs >90% Gilts homebred | 1.01 | 0.82 | 1.25 | | |
| Boar replacement policy | >90% Homebred vs No boars on farm | 0.61 | 0.45 | 0.84 | 3 | 0.0107 |
| | 10-90% Purchased vs No boars on farm | 0.74 | 0.48 | 1.14 | | |
| | >90% Purchased vs No boars on farm | 0.62 | 0.46 | 0.84 | | |
| Sample type | Composite vs Swab | 0.71 | 0.56 | 0.90 | 1 | 0.0038 |
| Pigs per pen | 0-9 vs 0 10 | 0.66 | 0.36 | 1.23 | 4 | <.0001 |
| | 11-20 vs 0 10 | 1.20 | 1.03 | 1.39 | | |
| | 21-100 vs 0 10 | 1.54 | 1.29 | 1.83 | | |
| | >100 vs 0 10 | 1.59 | 1.16 | 2.18 | | |
| Pigs per pen (continuous) | Per 10 pigs | 1.06 | 1.03 | 1.09 | 1 | <.0001 |
| Age group | Mixed age vs No gilts | 1.10 | 0.95 | 1.26 | 2 | 0.0046 |
| | All gilts vs No gilts | 1.32 | 1.12 | 1.56 | | |
| Gender | Male vs Female | 0.94 | 0.56 | 1.59 | 2 | 0.4447 |
| | Mixed vs Female | 1.14 | 0.93 | 1.40 | | |
| Production stage | Pregnant vs Maiden gilts | 0.82 | 0.68 | 0.98 | 4 | <.0001 |
| | Farrowing and lactating vs Maiden gilts | 0.59 | 0.48 | 0.72 | | |
| | Service area vs Maiden gilts | 1.00 | 0.82 | 1.23 | | |
| | Mixed vs Maiden gilts | 0.83 | 0.65 | 1.06 | | |
| Indoor/outdoor production | Yes vs No | 1.35 | 1.09 | 1.67 | 1 | 0.0067 |
| Individual housing | Yes vs No | 0.83 | 0.73 | 0.94 | 1 | 0.0042 |
| Floor type | Outdoors in fields or paddocks vs Other | 1.52 | 0.64 | 3.61 | 6 | <.0001 |
| | Partly slatted floor vs Other | 0.86 | 0.40 | 1.88 | | |
| | Slatted floor vs Other | 0.64 | 0.29 | 1.40 | | |
| | Solid floor other bedding vs Other | 1.23 | 0.43 | 3.52 | | |
| | Solid floor with straw vs Other | 0.60 | 0.27 | 1.35 | | |
| | Solid floor without bedding vs Other | 1.17 | 0.52 | 2.61 | | |
| All in all out | Gradual replacement vs All in all out | 1.17 | 1.03 | 1.34 | 1 | 0.0201 |
| Origin of feed | Feed with maize vs Commercial compound | 0.45 | 0.26 | 0.75 | 3 | <.0001 |
| | Home-mill vs Commercial compound | 0.39 | 0.31 | 0.48 | | |
| | Other vs Commercial compound | 0.40 | 0.21 | 0.77 | | |
| Type of diet | Meal/mash vs Cobbs/rolls/nuts/pellets | 0.38 | 0.30 | 0.47 | 3 | <.0001 |
| | Porridge/liquids vs Cobbs/rolls/nuts/pellets | 0.40 | 0.30 | 0.52 | | |
| | Others vs Cobbs/rolls/nuts/pellets | 0.55 | 0.36 | 0.83 | | |

[a] OR: odds ratio

[b] 95% Confidence Interval

| Risk factor | Comparison | OR[a] | 95% CI[b] | | DF | *P*-value |
|---|---|---|---|---|---|---|
| Supplements given | Organic acid added vs No organic acid added | 0.89 | 0.63 | 1.25 | 1 | 0.4964 |
| | Probiotic added vs No probiotic added | 0.53 | 0.24 | 1.19 | 1 | 0.1226 |
| | Other added vs No other added | 1.01 | 0.69 | 1.46 | 1 | 0.9677 |
| | Unknown if added vs Known if added | 1.23 | 0.89 | 1.70 | 1 | 0.2143 |
| Antibiotic used | Treatment vs No treatment | 0.94 | 0.79 | 1.11 | 2 | 0.4396 |
| | Unknown vs No treatment | 1.27 | 0.76 | 2.13 | | |

[a] OR: odds ratio

[b] 95% Confidence Interval

## H. RISK FACTOR ANALYSIS: FULL MODEL

**Table 15:** Full logistic mixed model[a] for factors associated with *Salmonella*-positive pens, *Salmonella* EU baseline survey, 2008

| Risk factor | Comparison | OR[b] | 95% CI[c] | | DF | *P*-value |
|---|---|---|---|---|---|---|
| Testing delay | 1 vs 0 | 0.96 | 0.70 | 1.32 | 4 | 0.7254 |
| | 2 vs 0 | 1.09 | 0.75 | 1.59 | | |
| | 3-4 vs 0 | 1.13 | 0.73 | 1.75 | | |
| | >= 5 vs 0 | 1.35 | 0.70 | 2.59 | | |
| Season | Spring vs Winter | 0.92 | 0.69 | 1.24 | 3 | 0.0689 |
| | Summer vs Winter | 0.73 | 0.55 | 0.98 | | |
| | Autumn vs Winter | 0.98 | 0.75 | 1.29 | | |
| Breeding/production type | Nucleus vs Multiplier or supplier | 1.05 | 0.74 | 1.51 | 4 | 0.5686 |
| | Farrow to finish vs Multiplier or supplier | 0.84 | 0.65 | 1.07 | | |
| | Farrow to grower vs Multiplier or supplier | 0.98 | 0.74 | 1.30 | | |
| | Farrow to weaner vs Multiplier or supplier | 0.93 | 0.64 | 1.35 | | |
| Holding size | 100-399 vs <100 | 1.80 | 1.30 | 2.48 | 3 | <.0001 |
| | 400-999 vs <100 | 3.08 | 2.14 | 4.43 | | |
| | >999 vs <100 | 4.89 | 3.23 | 7.42 | | |
| Gilt replacement policy | 10-90% Gilts homebred vs >90% Gilts homebred | 0.90 | 0.66 | 1.23 | 2 | 0.8018 |
| | >90% Gilts purchased vs >90% Gilts homebred | 0.97 | 0.78 | 1.21 | | |
| Boar replacement policy | >90% Homebred vs No boars on farm | 0.63 | 0.46 | 0.87 | 3 | 0.0280 |
| | 10-90% Purchased vs No boars on farm | 0.79 | 0.51 | 1.23 | | |
| | >90% Purchased vs No boars on farm | 0.67 | 0.49 | 0.91 | | |
| Number of Pigs in Pen | Per 10 pigs | 1.03 | 1.01 | 1.06 | 1 | 0.0174 |
| Age of Pigs | Mixed age vs No gilts | 1.08 | 0.93 | 1.24 | 2 | 0.3643 |
| | All gilts vs No gilts | 1.17 | 0.92 | 1.48 | | |
| Production stage | Pregnant vs Maiden gilts | 0.89 | 0.69 | 1.15 | 4 | <.0001 |
| | Farrowing and lactating vs Maiden gilts | 0.72 | 0.53 | 0.96 | | |
| | Service area vs Maiden gilts | 1.17 | 0.89 | 1.53 | | |
| | Mixed vs Maiden gilts | 0.94 | 0.70 | 1.28 | | |
| Indoor/outdoor production | Yes vs No | 1.09 | 0.86 | 1.40 | 1 | 0.4689 |
| Individual housing | Yes vs No | 1.03 | 0.88 | 1.20 | 1 | 0.7340 |
| Floor type | Outdoors in fields or paddocks vs Slatted floor | 2.22 | 1.38 | 3.59 | 6 | <.0001 |
| | Solid floor other bedding vs Slatted floor | 2.10 | 1.04 | 4.23 | | |
| | Solid floor with straw vs Slatted floor | 0.91 | 0.65 | 1.28 | | |
| | Solid floor without bedding vs Slatted floor | 1.79 | 1.32 | 2.42 | | |
| | Partly slatted floor vs Slatted floor | 1.27 | 1.07 | 1.53 | | |
| | Other vs Slatted floor | 1.46 | 0.64 | 3.31 | | |
| All in/all out and cleaned | Yes vs No | 1.04 | 0.90 | 1.21 | 1 | 0.5875 |
| Origin of feed | Other vs Commercial compound | 0.52 | 0.27 | 0.99 | 3 | 0.0002 |
| | Feed with maize vs Commercial compound | 0.62 | 0.37 | 1.04 | | |
| | Home-mill vs Commercial compound | 0.58 | 0.45 | 0.75 | | |

| Risk factor | Comparison | OR[b] | 95% CI[c] | | DF | P-value |
|---|---|---|---|---|---|---|
| Type of diet | Meal/mash vs Cobbs/rolls/nuts/pellets | 0.53 | 0.42 | 0.68 | 3 | <.0001 |
| | Porridge/liquids vs Cobbs/rolls/nuts/pellets | 0.47 | 0.35 | 0.64 | | |
| | Others vs Cobbs/rolls/nuts/pellets | 0.67 | 0.43 | 1.04 | | |
| Probiotic supplement | Probiotic added vs No probiotic added | 0.57 | 0.26 | 1.25 | 1 | 0.1623 |
| Organic acid supplement | Organic acid added vs No organic acid added | 0.86 | 0.61 | 1.21 | 1 | 0.3811 |
| Other supplement | Other added vs No other added | 1.03 | 0.71 | 1.50 | 1 | 0.8745 |
| Antibiotic | Treatment vs No treatment | 1.01 | 0.84 | 1.20 | 2 | 0.8155 |
| | Unknown vs No treatment | 1.17 | 0.72 | 1.91 | | |

[a] Odds ratio estimates and standard errors were assessed using a mixed model with a random effect on the intercept to take account of holding-effects and with the factor 'country' as a fixed effect. The between-holding variance is statistically significant and has a variance of 4.24 [3.82; 4.70] on the log odds scale.

[b] All odds ratios (OR) were adjusted for the factors 'country' and 'sample type', which were both significant. Although included in the model as fixed effect, the factor "sample type" was not illustrated in this table because it can not be considered a potential risk factor for *Salmonella* pen positivity. Indeed, "sample type" is a factor related to the sensitivity of the sampling method/process. Country effects were not shown.

[c] 95% Confidence Interval

The sample type resulted to be significantly related to the sensitivity of the sampling and testing process. In particular, the use of composite sample was found to be associated with a lower *Salmonella* positivity compared to the swab sample (OR 0.72; 95%CI: 0.57-0.92; *P*-value <0.0084). The swab sample can be therefore considered a more sensitive sampling method in detecting *Salmonella* positivity than the composite sample.

## I. WEIGHTED POPULATION ATTRIBUTABLE FRACTIONS

**Table 16:** Weighted Population Attributable Fractions estimating the expected reductions (%) in the number of *Salmonella*-positive pens by theoretical elimination of significant risk factors for the EU MSs, *Salmonella* EU baseline survey, 2008[a]

| Variable | Theoretical scenarios of lower risk categories | Theoretical percentage reduction of *Salmonella*-positive pens [b] [95% CL[c]] |
|---|---|---|
| **Holding size (scenario 1)** | All holdings would house less than 400 breeding pigs | 17.9 [7.0;26.4] |
| **Holding size (scenario 2)** | All holdings would house less than 1,000 breeding pigs | 4.9 [-5.2;13.2] |
| **Number of pigs per Pen** | All Pens would house 10 or less pigs | 3.4 [-5.2;9.8] |
| **Floor type (scenario 1)** | All floors (except solid floors with straw) would be (fully) slatted floors | 13.5 [1.9;21.2] |
| **Floor type (scenario 2)** | All floors (except slatted floors) would be solid floors with straw | 16.1 [-3.3;31.5] |
| **Origin of Feed** | All feed would be home-milled | 23.5 [9.7;34.1] |
| **Type of diet** | All diet would be porridge/liquid diet | 23.3[8.6;34.6] |

[a]  24 MSs and two non-MSs, Norway and Switzerland, conducted the survey. Greece, Malta and Romania did not participate in the survey.

[b]  Population attributable fractions were weighted for the number of holdings in the countries, in order to represent all holdings with more than 50 breeding pigs in the EU (see appendix E)

[c]  The confidence limits (CL) only reflect the uncertainty of investigated factors in the sampled holdings (see Materials and Methods). It was assumed that the risk factor distribution in the total population of holdings with breeding pigs in each country was equal to that in the sampled holdings.

### J. DETAILS ON THE ANALYSIS OF THE *SALMONELLA* SEROVAR DISTRIBUTION IN THE EU

**Table 17:** Number of tested and positive breeding holdings, positivity percentage and number of serovars reported in breeding holdings by 24 MSs, Norway and Switzerland, *Salmonella* EU baseline survey, 2008

| Country | Breeding holdings | | | No. of different serovars reported[a] |
|---|---|---|---|---|
| | Sampled | Positive | Pos % | |
| **Austria** | 79 | 5 | 6.3 | 3 |
| **Belgium** | 16 | 3 | 18.8 | 3 |
| **Bulgaria** | 47 | 1 | 2.1 | 1 |
| **Cyprus** | 4 | 2 | 50.0 | 2 |
| **Czech Republic** | 106 | 11 | 10.4 | 6 |
| **Denmark** | 95 | 39 | 41.1 | 9 |
| **Estonia** | 6 | 0 | 0.0 | 0 |
| **Finland** | 50 | 0 | 0.0 | 0 |
| **France** | 157 | 79 | 50.3 | 21 |
| **Germany** | 46 | 13 | 28.3 | 6 |
| **Hungary** | 40 | 12 | 30.0 | 10 |
| **Ireland** | 40 | 21 | 52.5 | 7 |
| **Italy** | 43 | 22 | 51.2 | 9 |
| **Latvia** | 5 | 1 | 20.0 | 2 |
| **Lithuania** | 10 | 0 | 0.0 | 0 |
| **Luxembourg** | 3 | 1 | 33.3 | 1 |
| **Netherlands** | 109 | 63 | 57.8 | 17 |
| **Poland** | 144 | 10 | 6.9 | 5 |
| **Portugal** | 33 | 15 | 45.5 | 10 |
| **Slovakia** | 96 | 11 | 11.5 | 8 |
| **Slovenia** | 27 | 0 | 0.0 | 0 |
| **Spain** | 150 | 96 | 64.0 | 27 |
| **Sweden** | 57 | 1 | 1.8 | 1 |
| **United Kingdom** | 67 | 35 | 52.2 | 18 |
| **EU Total** | 1,430 | 441 | 30.8 | 54 |
| **Norway** | 108 | 0 | 0.0 | 0 |
| **Switzerland** | 71 | 11 | 15.5 | 8 |
| **Total** | 1,609 | 452 | 28.1 | 54 |

[a] Untypeable isolates were not considered

In the EU, 30.8% of breeding holdings were positive for *Salmonella*, while the overall positivity was lower (28.1%), due to the fact that Norway had no positive samples. Highest positivity was observed in Spain (64.0%), followed by the Netherlands (57.8%). Estonia, Finland, Lithuania, Slovenia and Norway had no positive samples.

**Table 18:** Number of tested and positive production holdings, positivity percentage and number of serovars reported in production holdings with breeding pigs by 24 MSs, Norway and Switzerland, *Salmonella* EU baseline survey, 2008.

| Country | Production holdings | | | No. of different serovars reported[a] |
|---|---|---|---|---|
| | **Sampled** | **Positive** | **Pos %** | |
| **Austria** | 173 | 10 | 5.8 | 7 |
| **Belgium** | 209 | 76 | 36.4 | 26 |
| **Bulgaria** | 25 | 0 | 0.0 | 0 |
| **Cyprus** | 60 | 11 | 18.3 | 5 |
| **Czech Republic** | 161 | 25 | 15.5 | 9 |
| **Denmark** | 198 | 82 | 41.4 | 14 |
| **Estonia** | 28 | 1 | 3.6 | 1 |
| **Finland** | 157 | 0 | 0.0 | 0 |
| **France** | 186 | 72 | 38.7 | 24 |
| **Germany** | 155 | 32 | 20.6 | 15 |
| **Hungary** | 141 | 39 | 27.7 | 14 |
| **Ireland** | 149 | 71 | 47.7 | 19 |
| **Italy** | 171 | 75 | 43.9 | 10 |
| **Latvia** | 28 | 8 | 28.6 | 6 |
| **Lithuania** | 72 | 6 | 8.3 | 5 |
| **Luxembourg** | 41 | 9 | 22.0 | 5 |
| **Netherlands** | 212 | 118 | 55.7 | 26 |
| **Poland** | 178 | 17 | 9.6 | 10 |
| **Portugal** | 134 | 58 | 43.3 | 17 |
| **Slovakia** | 96 | 18 | 18.8 | 8 |
| **Slovenia** | 87 | 9 | 10.3 | 7 |
| **Spain** | 209 | 111 | 53.1 | 29 |
| **Sweden** | 150 | 0 | 0.0 | 0 |
| **United Kingdom** | 191 | 84 | 44.0 | 30 |
| **EU Total** | 3,211 | 932 | 29.0 | 87 |
| **Norway** | 143 | 0 | 0.0 | 0 |
| **Switzerland** | 154 | 18 | 11.7 | 10 |
| **Total** | 3,508 | 950 | 27.1 | 88 |

[a] Untypeable isolates were not considered

In the EU, 29.0% of production holdings were positive for *Salmonella*, while the overall percentage including Norway and Switzerland was 27.1%. Highest positivity was observed in the Netherlands (55.7%), followed by Spain (53.1%). Bulgaria, Finland, Sweden and Norway had no positive samples.

**Table 19:** Frequency distribution of the top 20 serovars from breeding pig holdings in the EU, Norway and Switzerland, *Salmonella* EU baseline survey, 2008

| Serovars | Isolates (N=1,303) | | Holdings (N=452[a]) | | Countries with serovars |
|---|---|---|---|---|---|
| | N | % | N | % | |
| *S.* **Derby** | 312 | 23.9 | 134 | 29.6 | 18 |
| *S.* **Typhimurium** | 233 | 17.9 | 115 | 25.4 | 17 |
| *S.* **Infantis** | 65 | 5.0 | 35 | 7.7 | 7 |
| *S.* **Rissen** | 59 | 4.5 | 33 | 7.3 | 5 |
| *S.* **London** | 83 | 6.4 | 29 | 6.4 | 8 |
| *S.* **Anatum** | 49 | 3.8 | 25 | 5.5 | 5 |
| *S.* **Livingstone** | 71 | 5.4 | 25 | 5.5 | 11 |
| *S.* **Kedougou** | 26 | 2.0 | 15 | 3.3 | 4 |
| *S.* **Muenchen** | 30 | 2.3 | 14 | 3.1 | 6 |
| *S.* **Bredeney** | 27 | 2.1 | 13 | 2.9 | 6 |
| *S.* **Goldcoast** | 29 | 2.2 | 13 | 2.9 | 3 |
| *S.* **Agona** | 20 | 1.5 | 9 | 2.0 | 7 |
| *S.* **Bovismorbificans** | 25 | 1.9 | 9 | 2.0 | 5 |
| *S.* **Brandenburg** | 11 | 0.8 | 8 | 1.8 | 4 |
| *S.* **Enteritidis** | 15 | 1.2 | 8 | 1.8 | 4 |
| *S.* **Panama** | 16 | 1.2 | 8 | 1.8 | 4 |
| *S.* **Reading** | 25 | 1.9 | 8 | 1.8 | 2 |
| *S.* **Wien** | 11 | 0.8 | 8 | 1.8 | 1 |
| *S.* **Meleagridis** | 17 | 1.3 | 7 | 1.5 | 1 |
| *S.* **4,5,12:i:-** [b] | 13 | 1.0 | 6 | 1.3 | 4 |
| **Others** | 130 | 10.1 | 66 | 14.3 | - |
| *Salmonella* **untypeable** | 36 | 2.8 | 21 | 4.6 | 6 |

[a] Holdings may have more than one serovar isolated, so the total for this column is larger than 452 and 100%

[b] According to EFSA's BIOHAZ panel scientific opinion on monitoring and assessment of the public health risk of "*Salmonella* Typhimurium-like" strains (EFSA, 2010d), this *Salmonella* antigenic formula is recommended to be reported as 'monophasic *Salmonella* Typhimurium'. However, to ensure consistency with the previously published Part A report (EFSA, 2010a), the *Salmonella* antigenic formula is kept here

**Table 20:** Frequency distribution of the top 20 serovars from production holdings with breeding pigs in the EU, Norway and Switzerland, *Salmonella* EU baseline survey, 2008

| Serovars | Isolates (N=2,699) | | Holdings (N=950[a]) | | Countries with serovars |
|---|---|---|---|---|---|
| | N | % | N | % | |
| *S.* Derby | 641 | 23.7 | 271 | 21.6 | 20 |
| *S.* Typhimurium | 369 | 13.7 | 191 | 15.2 | 16 |
| *S.* London | 229 | 8.5 | 90 | 7.2 | 15 |
| *S.* Infantis | 132 | 4.9 | 58 | 4.6 | 13 |
| *S.* Rissen | 82 | 3.0 | 56 | 4.5 | 6 |
| *S.* Livingstone | 89 | 3.3 | 50 | 4.0 | 13 |
| *S.* Anatum | 117 | 4.3 | 43 | 3.4 | 10 |
| *S.* Bredeney | 76 | 2.8 | 40 | 3.2 | 13 |
| *S.* Goldcoast | 108 | 4.0 | 39 | 3.1 | 10 |
| *S.* Bovismorbificans | 56 | 2.1 | 31 | 2.5 | 9 |
| *S.* Brandenburg | 75 | 2.8 | 27 | 2.2 | 9 |
| *S.* Agona | 59 | 2.2 | 24 | 1.9 | 7 |
| *S.* Enteritidis | 45 | 1.7 | 21 | 1.7 | 10 |
| *S.* Give | 29 | 1.1 | 18 | 1.4 | 8 |
| *S.* Reading | 38 | 1.4 | 18 | 1.4 | 2 |
| *S.* Panama | 39 | 1.4 | 16 | 1.3 | 6 |
| *S.* 4,5,12:i:- [b] | 25 | 0.9 | 15 | 1.2 | 7 |
| *S.* Kedougou | 26 | 1.0 | 11 | 0.9 | 3 |
| *S.* Meleagridis | 29 | 1.1 | 11 | 0.9 | 3 |
| *S.* Mbandaka | 14 | 0.5 | 9 | 0.7 | 8 |
| **Others** | 302 | 11.2 | 150 | 12.0 | - |
| *Salmonella* **untypeable** | 119 | 4.4 | 64 | 5.1 | 11 |

[a] Holdings may have more than one serovar isolated, so the total for this column is larger than 950 and 100%

[b] According to EFSA's BIOHAZ panel scientific opinion on monitoring and assessment of the public health risk of "*Salmonella* Typhimurium-like" strains (EFSA, 2010d), this *Salmonella* antigenic formula is recommended to be reported as 'monophasic *Salmonella* Typhimurium'. However, to ensure consistency with the previously published Part A report (EFSA, 2010a), the *Salmonella* antigenic formula is kept here

The relative percentage of *S*. Typhimurium, *S*. Derby, *S*. Enteritidis, *S*. Infantis, *S*. Rissen, *S*. Livingstone, *S*. London, *S*. Anatum, *S*. Goldcoast and *S*. Bredeney in countries with positive breeding and/or production holdings can be observed in Figure 32. Data on serovars not included in the top-20 list can be found in the part A report (EFSA, 2009b).
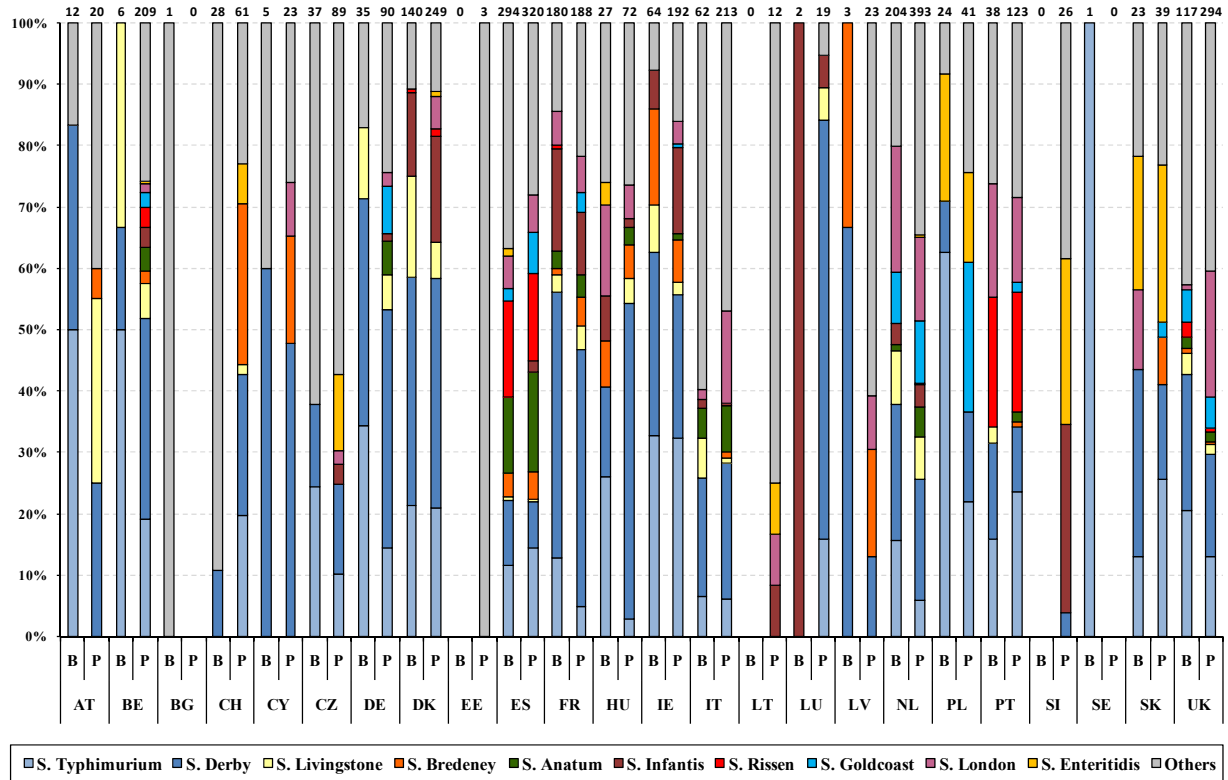


**Figure 32:** Relative frequency distribution (%) of *S*. Typhimurium, *S*. Derby, *S*. Enteritidis, *S*. Infantis, *S*. Rissen, *S*. Livingstone, *S*. London, *S*. Anatum, *S*. Goldcoast and *S*. Bredeney in breeding (B) and in production (P) holdings in EU MSs and Switzerland, *Salmonella* EU baseline survey, 2008[a]

[a]    The numbers on top of the bars show the total number of positive samples, corresponding to 100% for each bar

## K. PREVALENCE MAPS OF THE TOP-TEN SALMONELLA SEROVARS DETECTED IN THE SURVEY
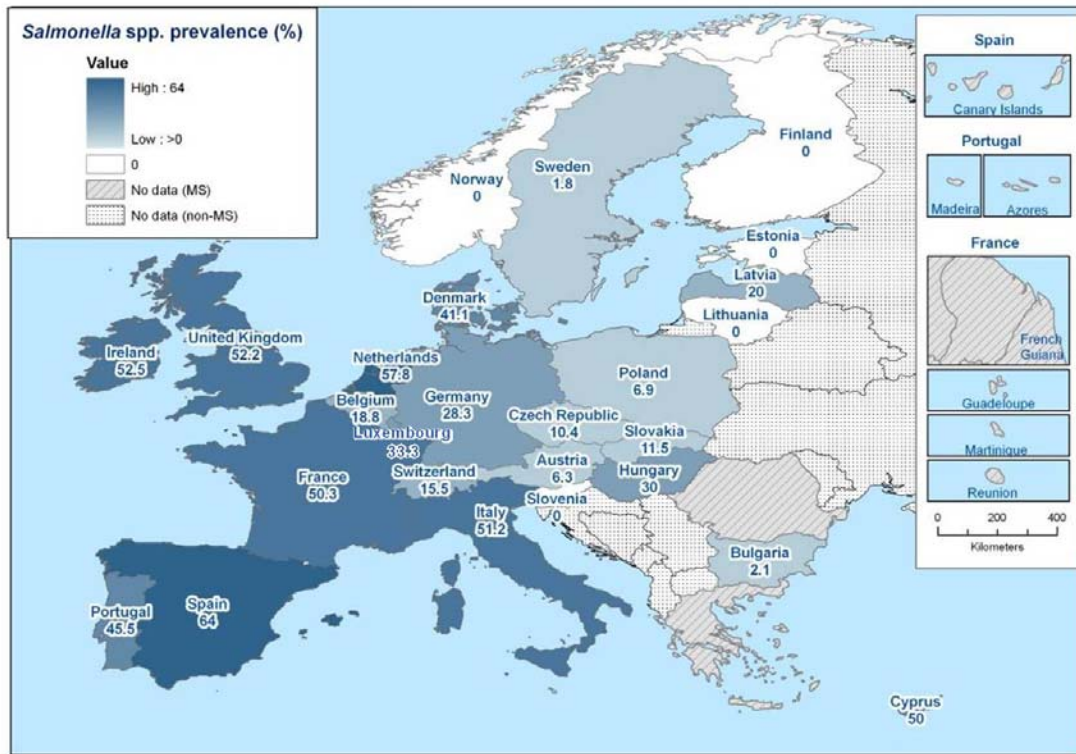


**Figure 33:** Prevalence of *Salmonella*-positive breeding holdings, *Salmonella* EU baseline survey, 2008
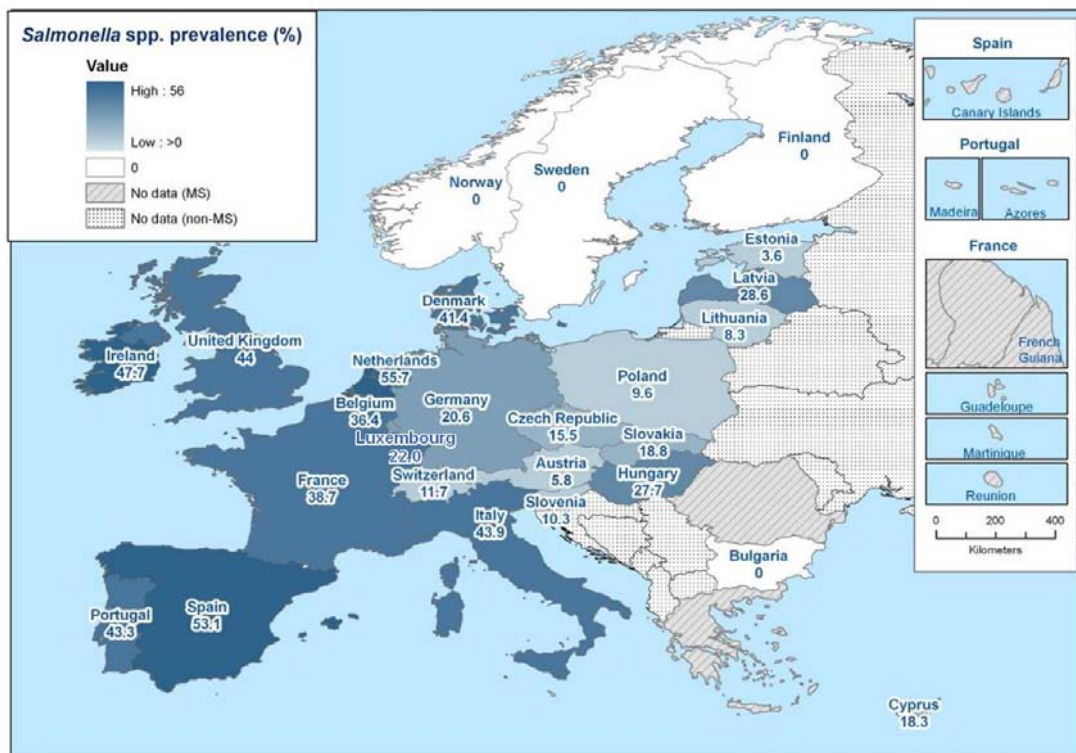


**Figure 34:** Prevalence of *Salmonella*-positive production holdings, *Salmonella* EU baseline survey, 2008
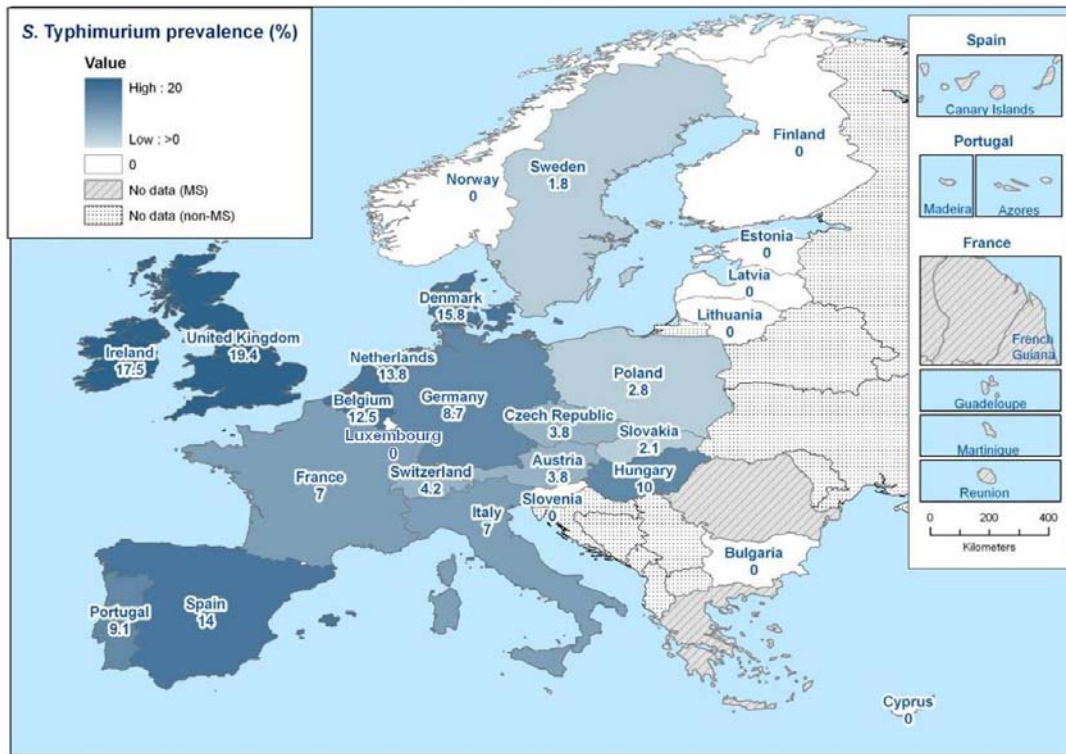
**Figure 35:** Prevalence of *S*. Typhimurium-positive breeding holdings, *Salmonella* EU baseline survey, 2008
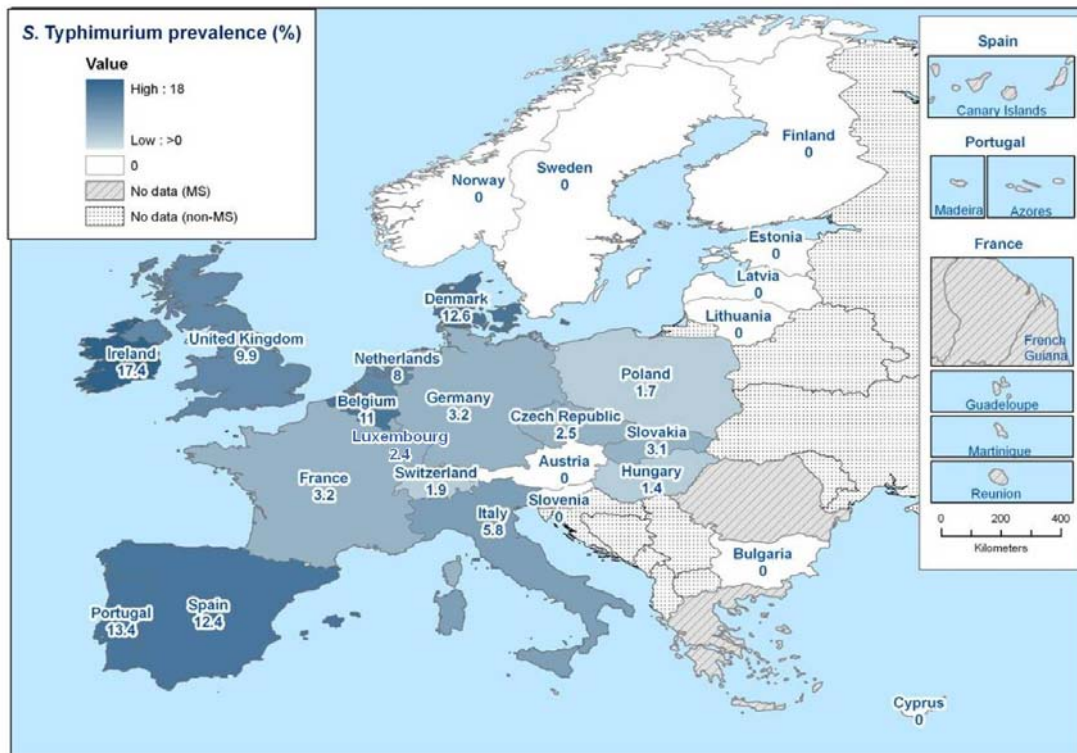


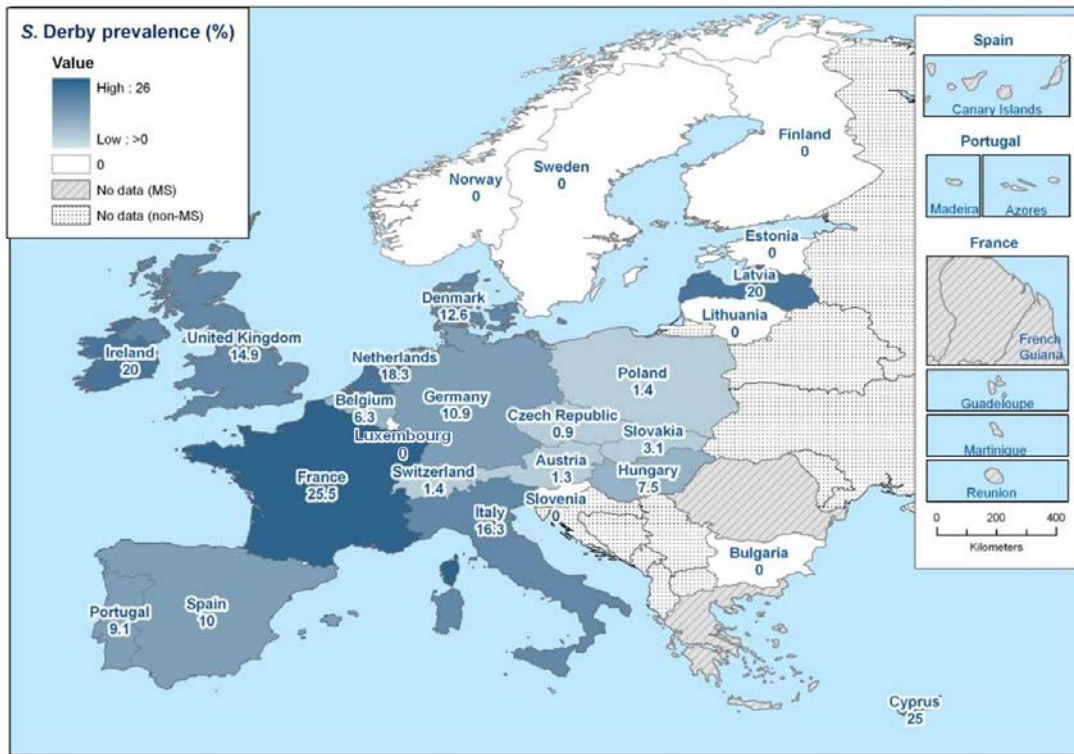**Figure 36:** Prevalence of *S*. Typhimurium-positive production holdings, *Salmonella* EU baseline survey, 2008

**Figure 37:** Prevalence of *S*. Derby-positive breeding holdings, *Salmonella* EU baseline survey, 2008
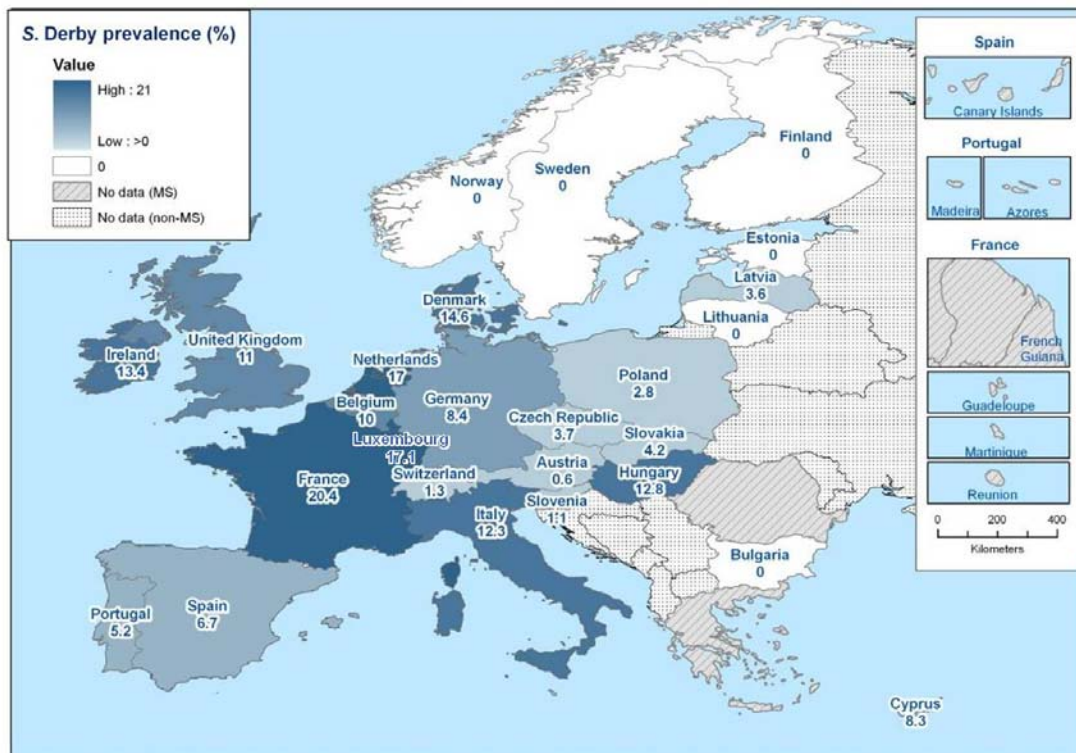


**Figure 38:** Prevalence of *S*. Derby-positive production holdings, *Salmonella* EU baseline survey, 2008
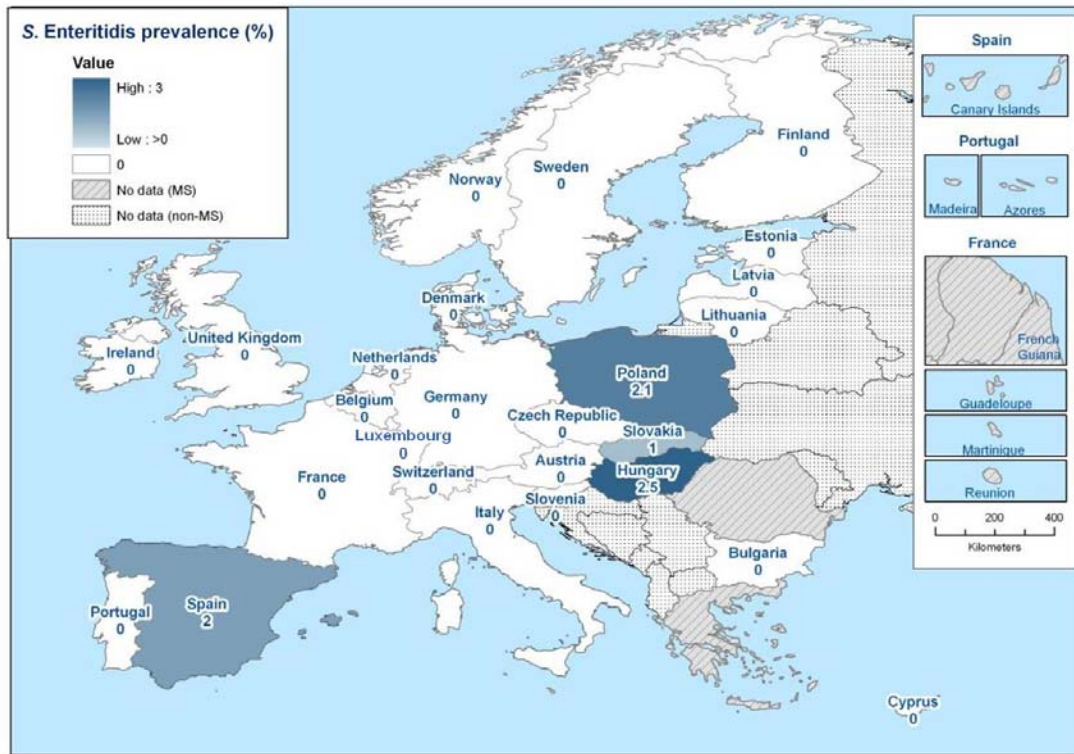
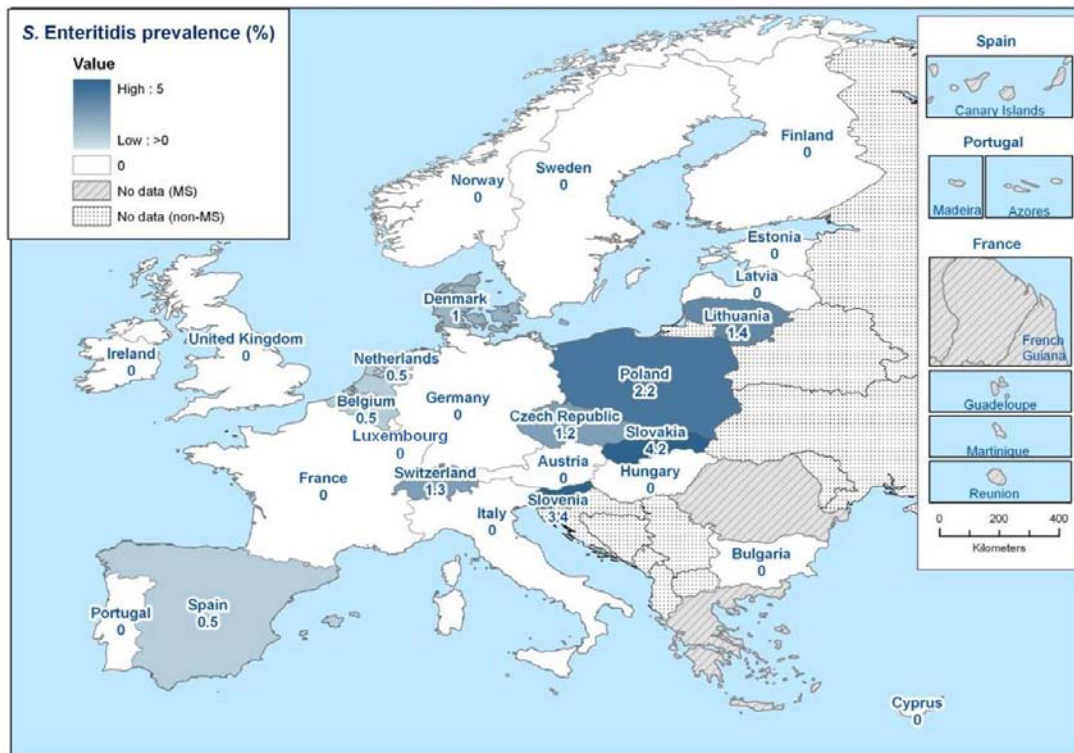**Figure 39:** Prevalence of *S*. Enteritidis-positive breeding holdings, *Salmonella* EU baseline survey, 2008



**Figure 40:** Prevalence of *S*. Enteritidis-positive production holdings, *Salmonella* EU baseline survey, 2008
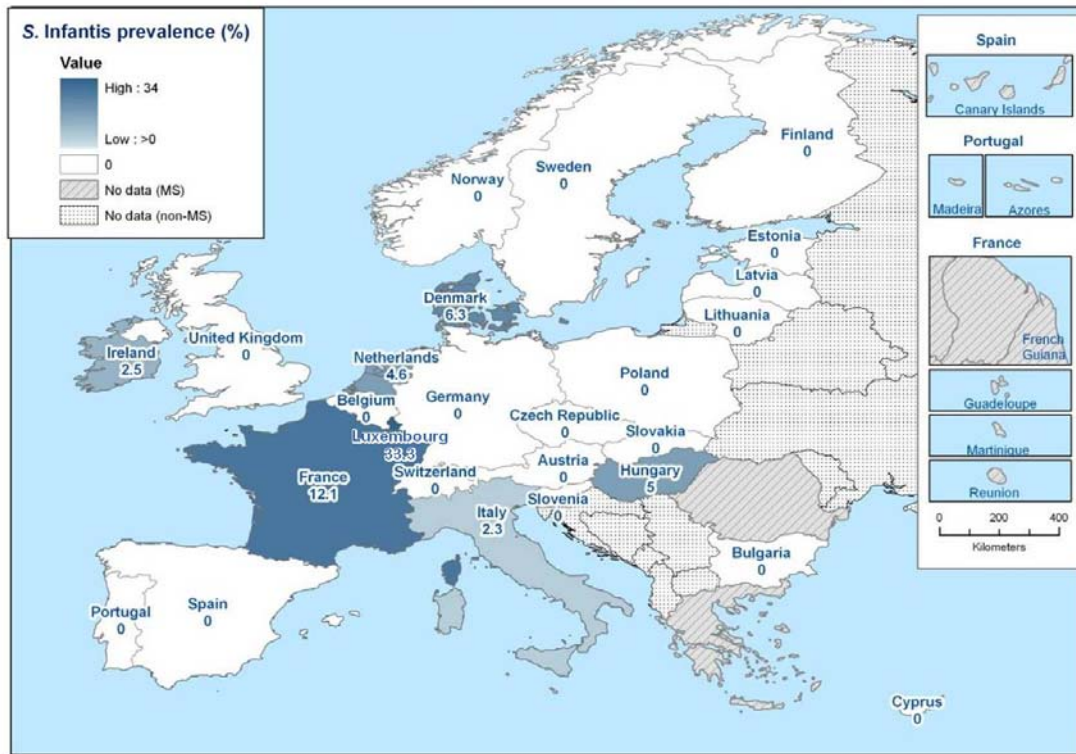
**Figure 41:** Prevalence of *S*. Infantis-positive breeding holdings, *Salmonella* EU baseline survey, 2008
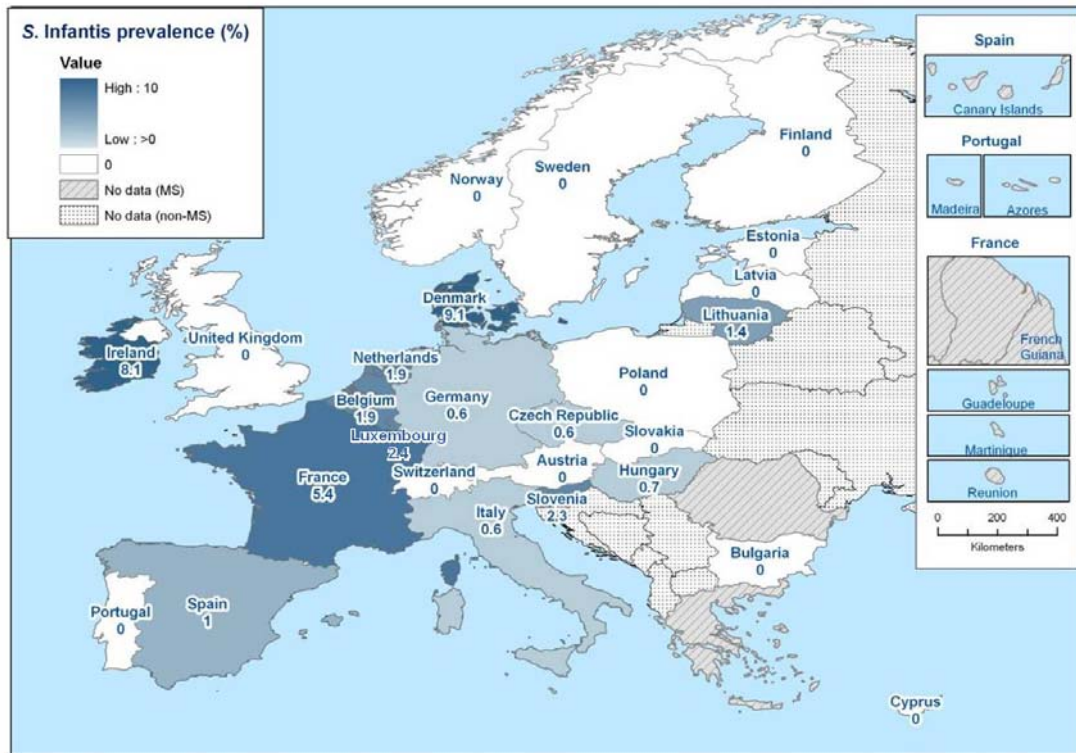


**Figure 42:** Prevalence of *S*. Infantis-positive production holdings, *Salmonella* EU baseline survey, 2008

**Figure 43:** Prevalence of *S*. Rissen-positive breeding holdings, *Salmonella* EU baseline survey, 2008



**Figure 44:** Prevalence of *S*. Rissen-positive production holdings, *Salmonella* EU baseline survey, 2008
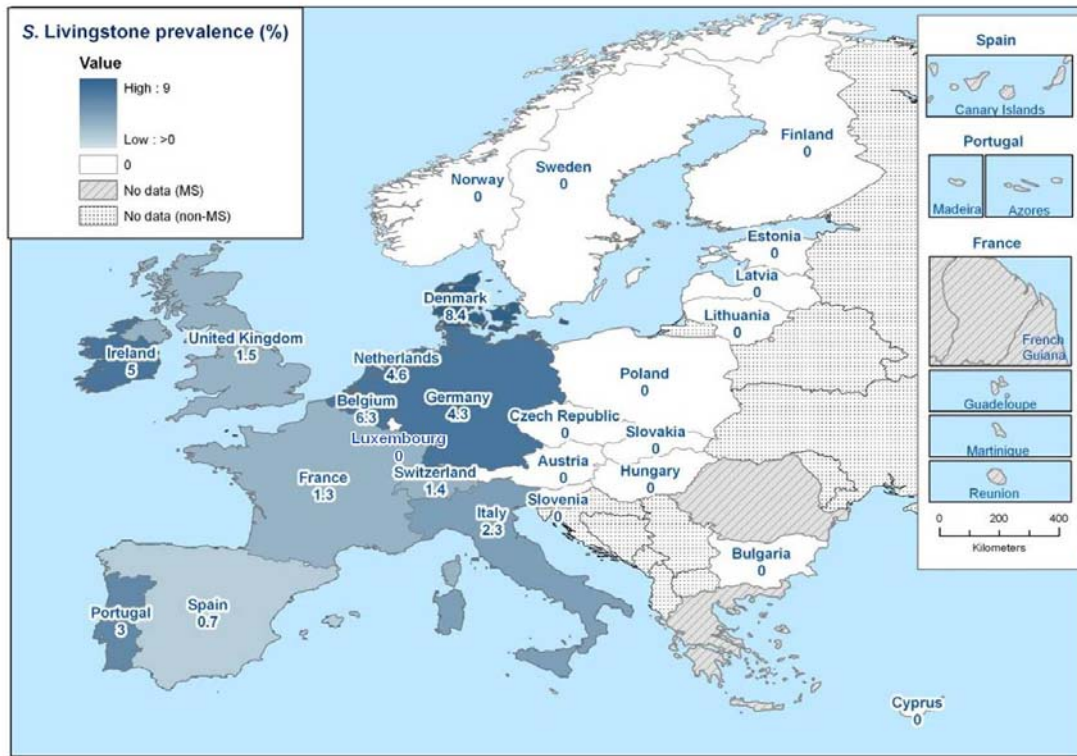
**Figure 45:** Prevalence of *S.* Livingstone-positive breeding holdings, *Salmonella* EU baseline survey, 2008
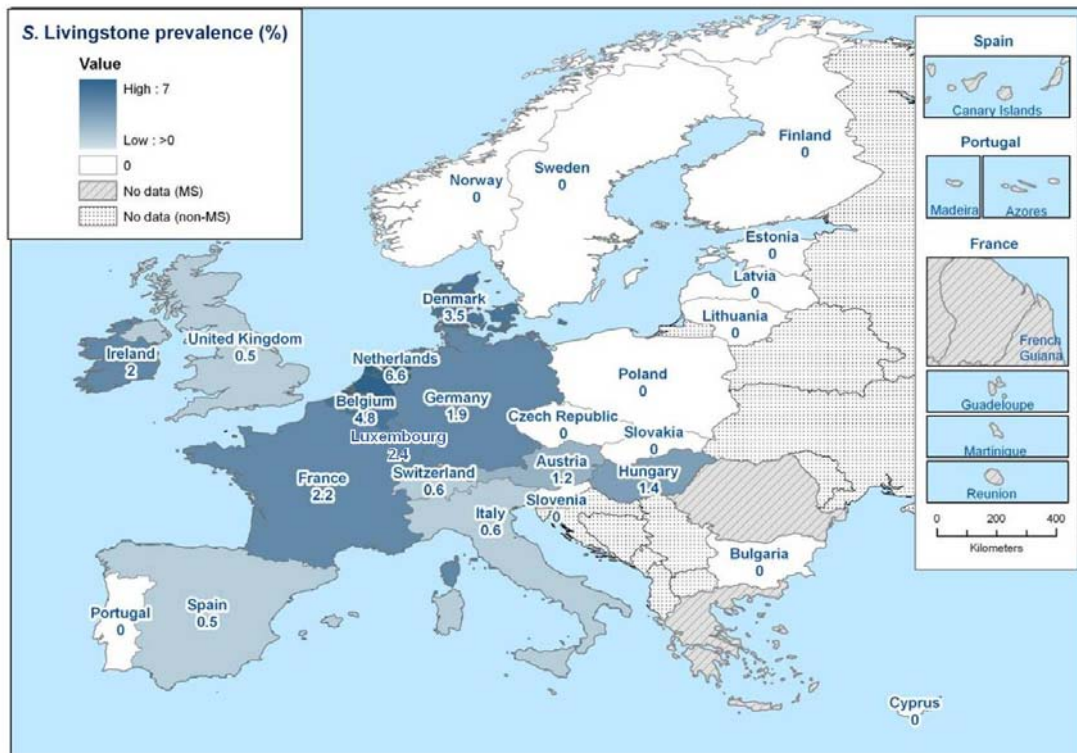


**Figure 46:** Prevalence of *S.* Livingstone-positive production holdings, *Salmonella* EU baseline survey, 2008
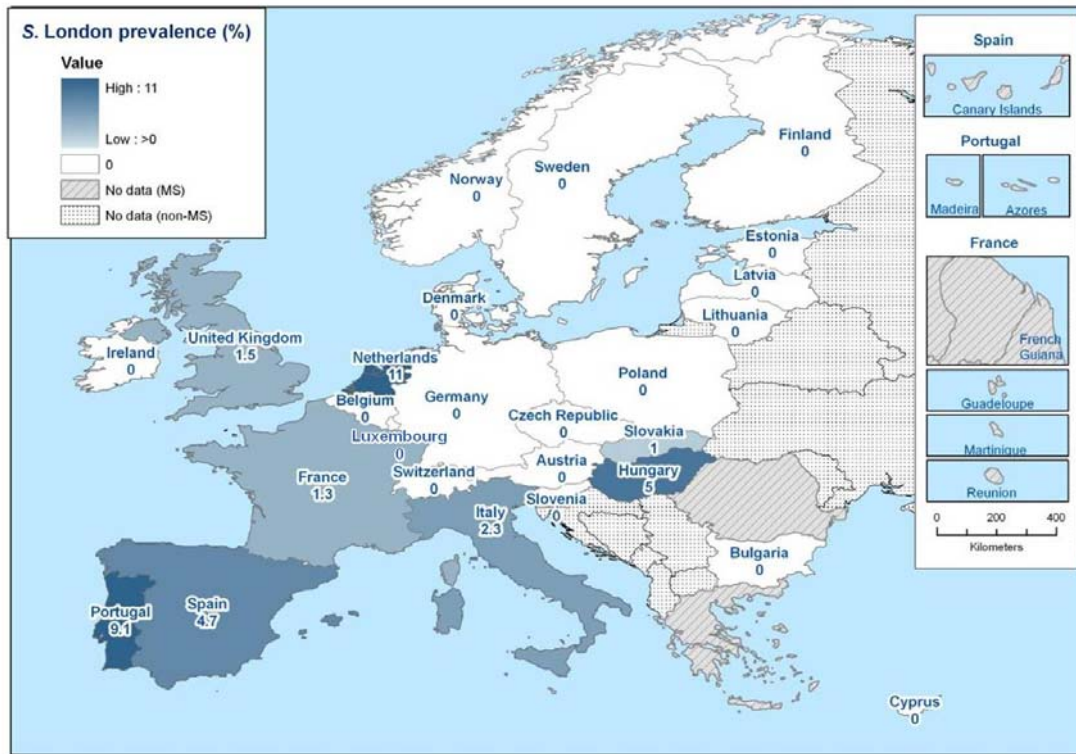
**Figure 47:** Prevalence of *S*. London-positive breeding holdings, *Salmonella* EU baseline survey, 2008
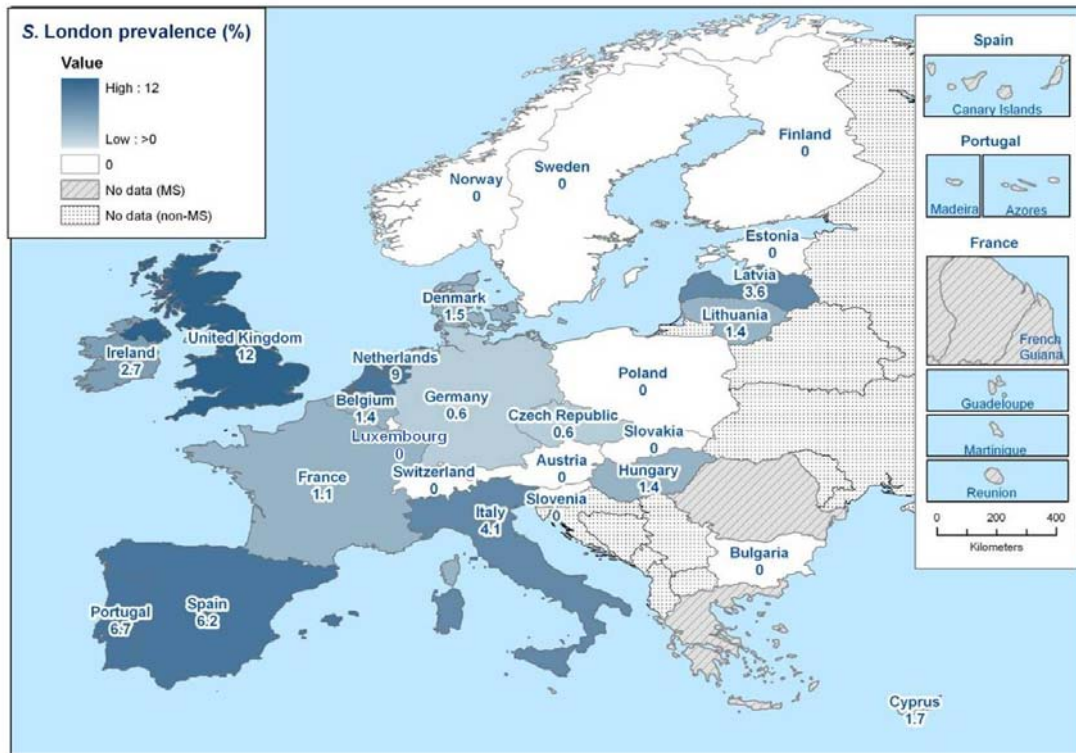


**Figure 48:** Prevalence of *S*. London-positive production holdings, *Salmonella* EU baseline survey, 2008
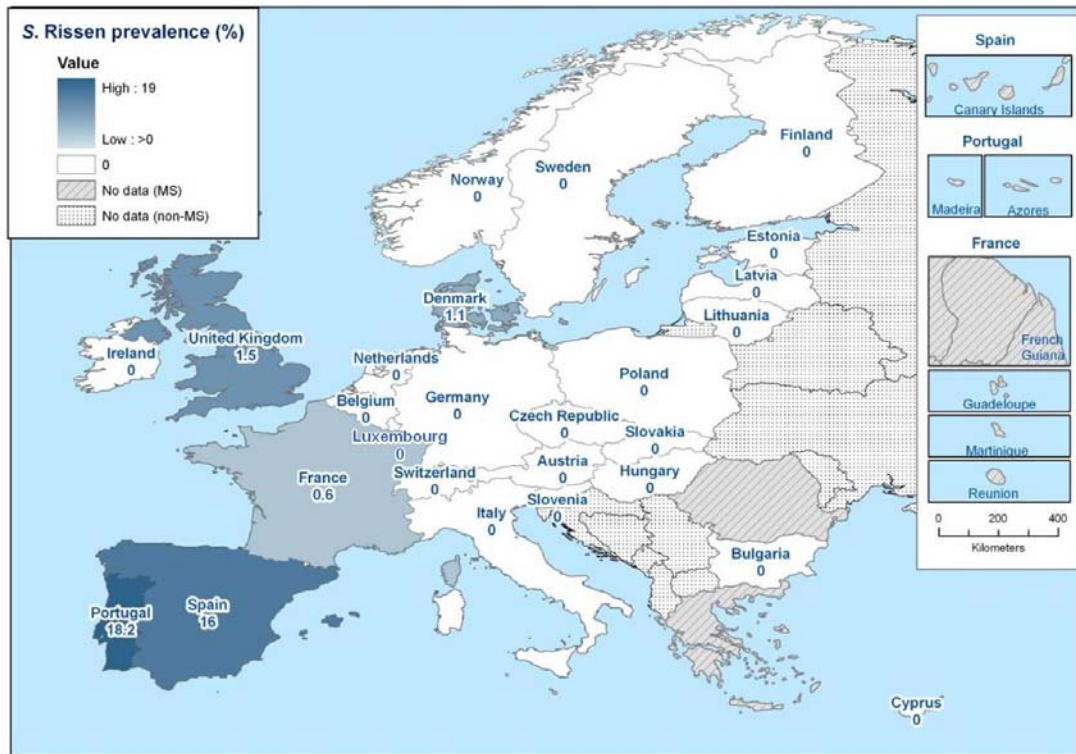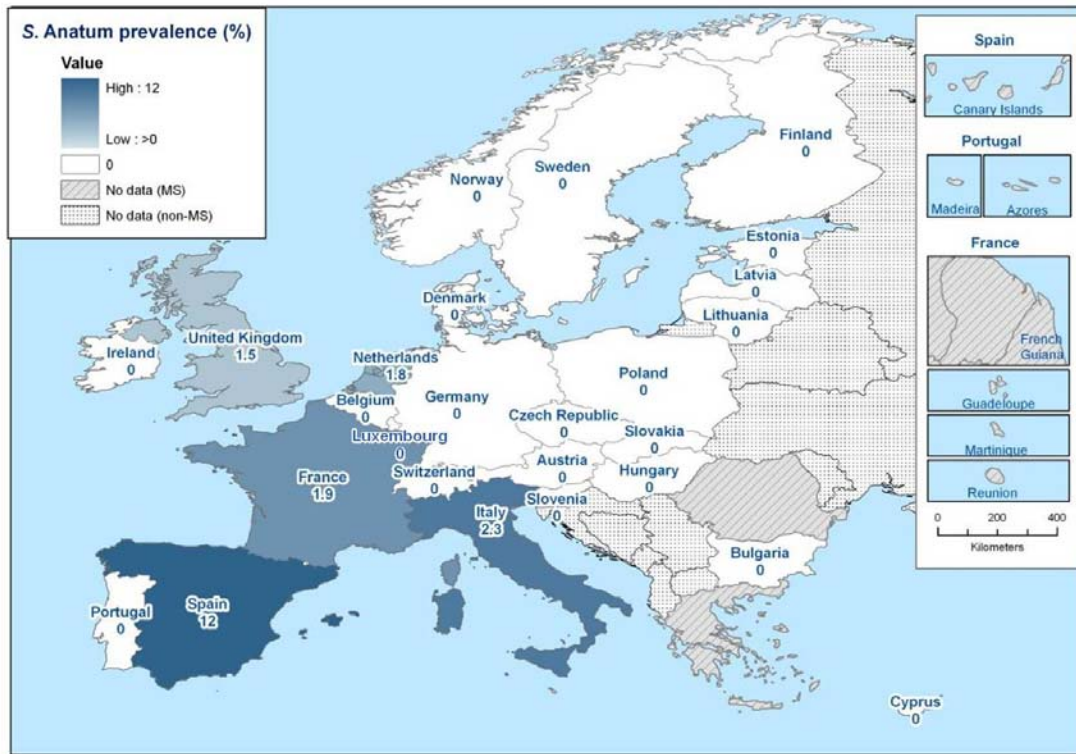
**Figure 49:** Prevalence of *S*. Anatum-positive breeding holdings, *Salmonella* EU baseline survey, 2008
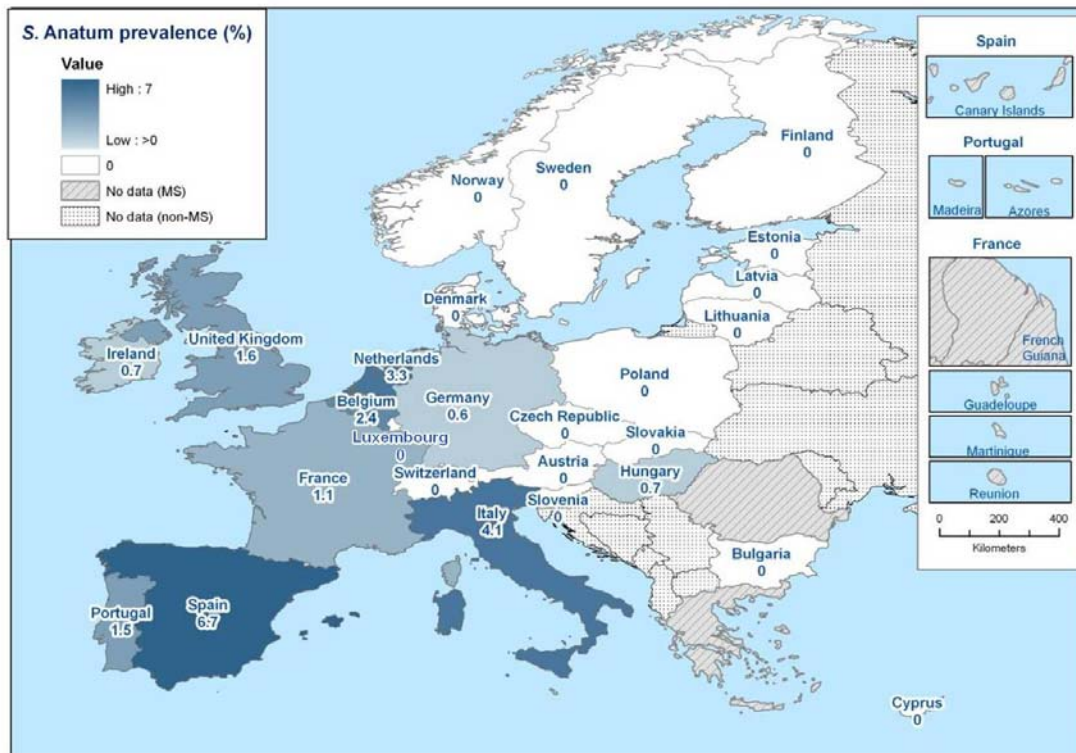


**Figure 50:** Prevalence of *S*. Anatum-positive production holdings, *Salmonella* EU baseline survey, 2008
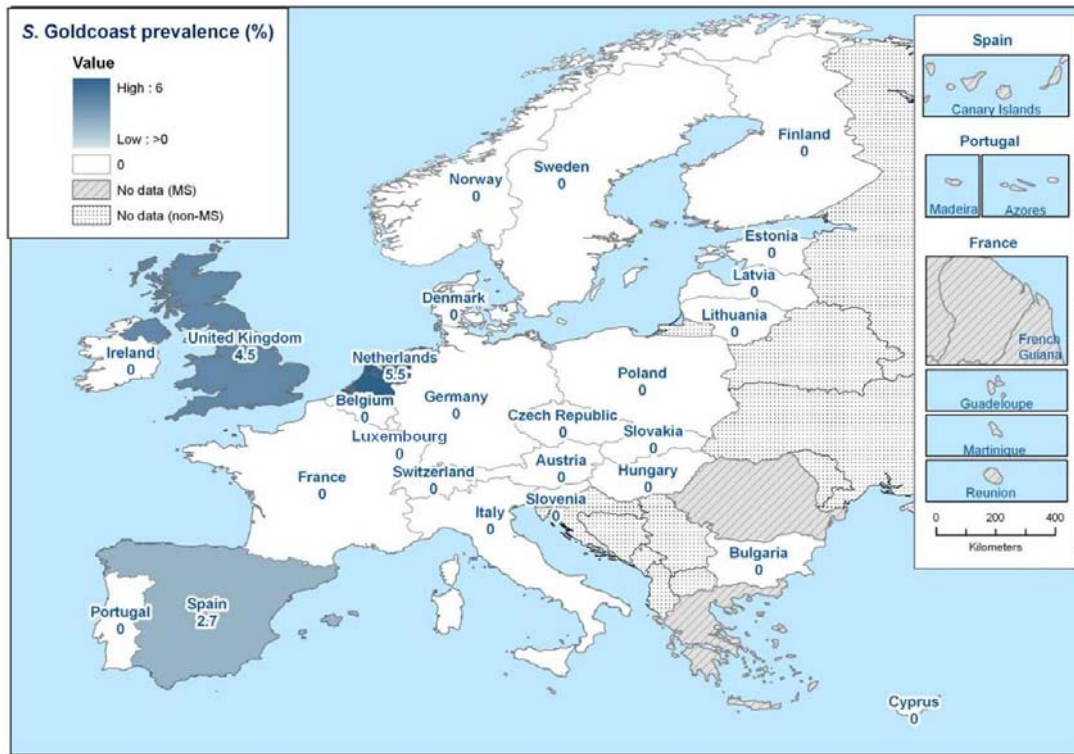
**Figure 51:** Prevalence of *S*. Goldcoast-positive breeding holdings, *Salmonella* EU baseline survey, 2008
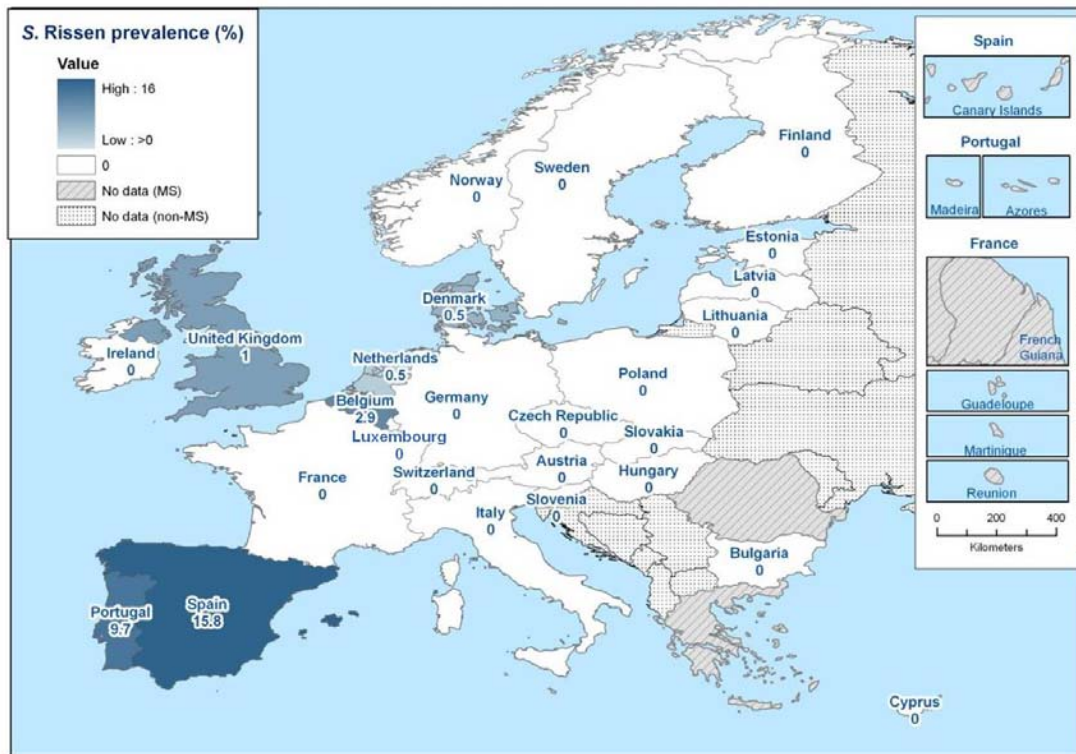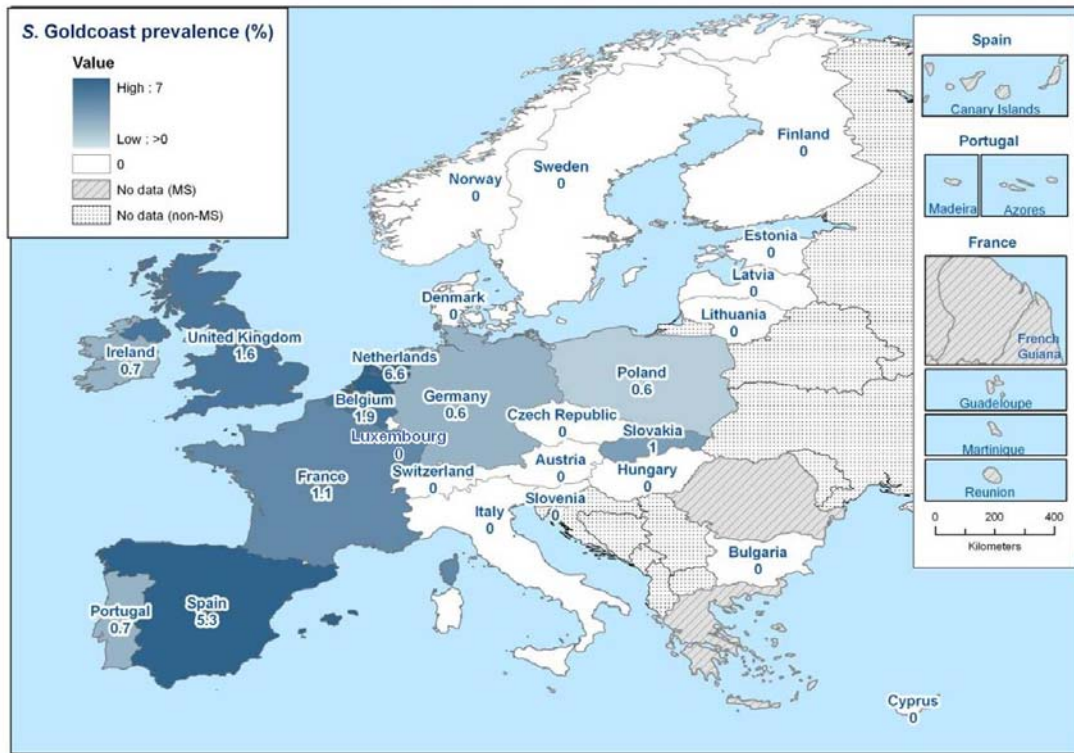


**Figure 52:** Prevalence of *S*. Goldcoast-positive production holdings, *Salmonella* EU baseline survey, 2008
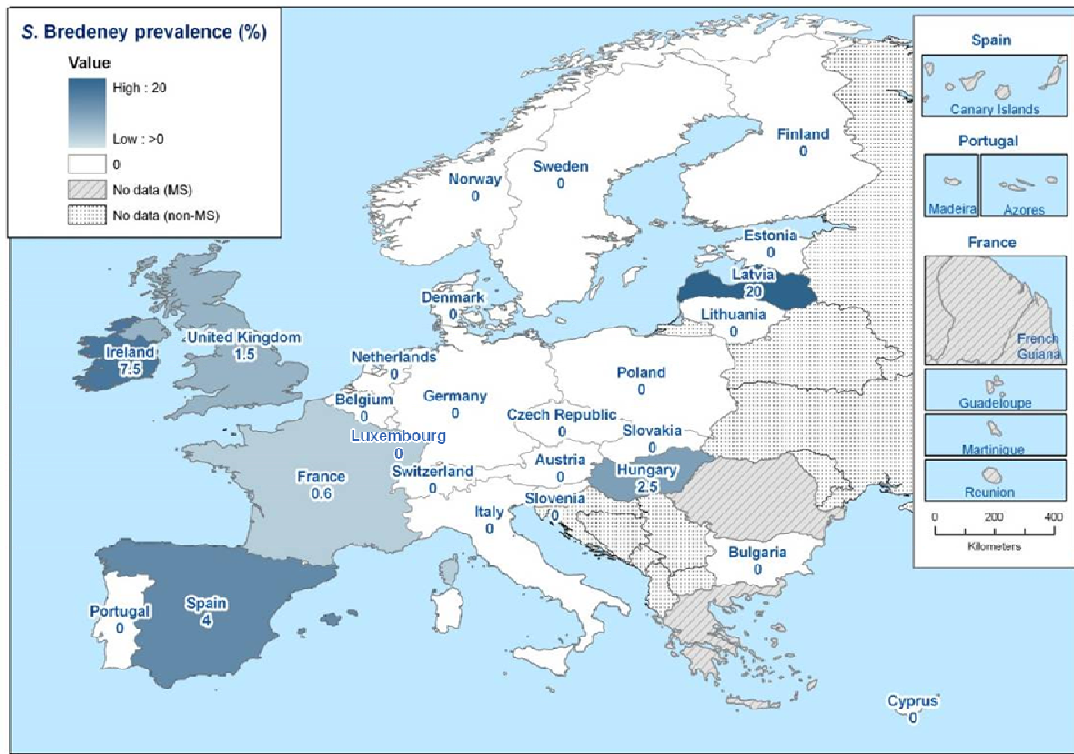
**Figure 53:** Prevalence of *S*. Bredeney-positive breeding holdings, *Salmonella* EU baseline survey, 2008
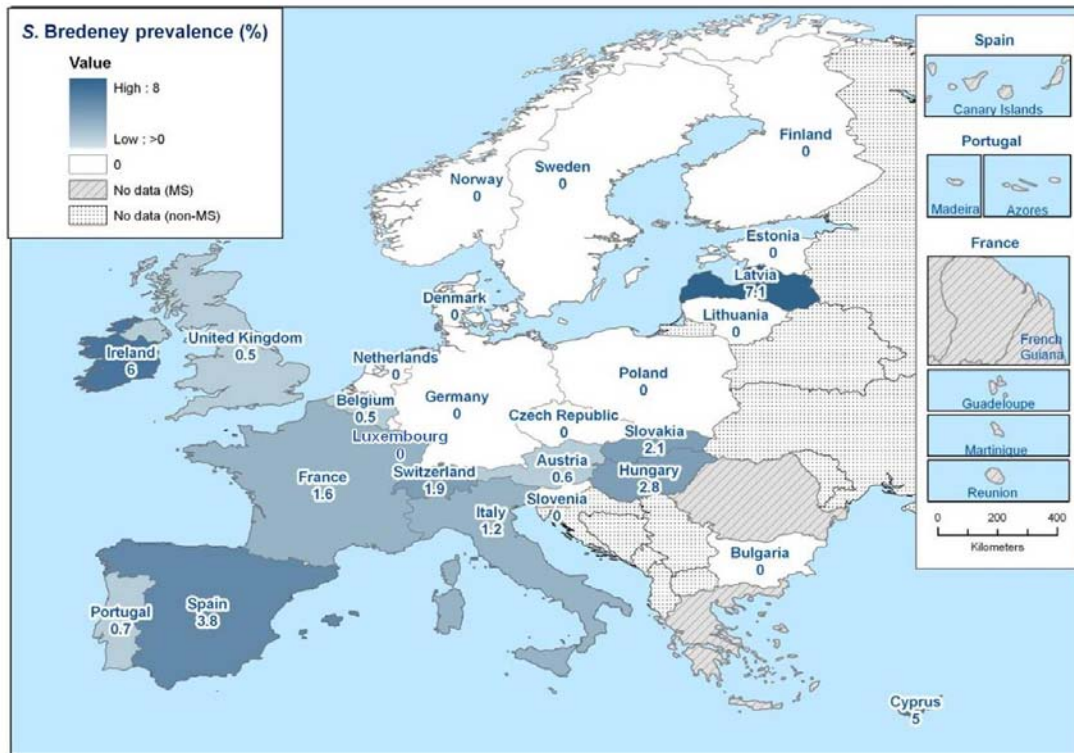


**Figure 54:** Prevalence of *S*. Bredeney-positive production holdings, *Salmonella* EU baseline survey, 2008

### L. COMPARISON BETWEEN *SALMONELLA* SEROVAR DISTRIBUTIONS IN DIFFERENT SOURCES
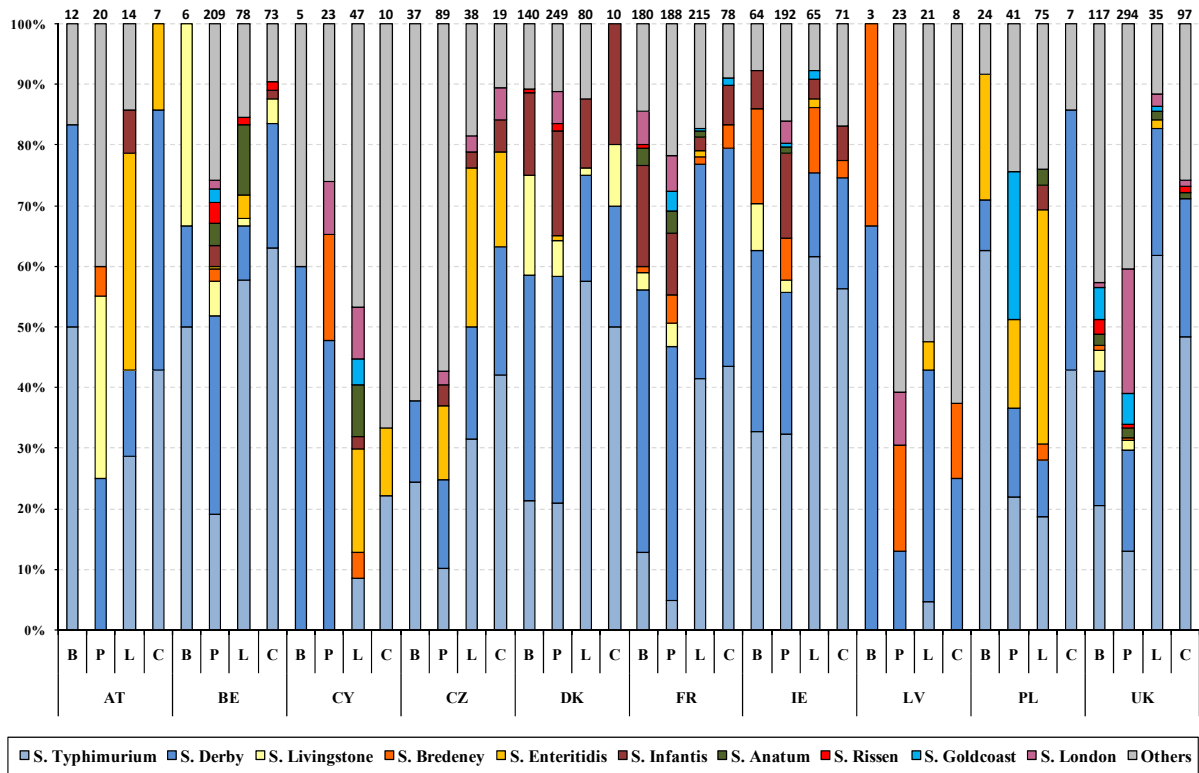


**Figure 55:** Relative distribution of *S.* Typhimurium, *S.* Derby, *S.* Enteritidis, *S.* Infantis, *S.* Rissen, *S.* Livingstone, *S.* London, *S.* Anatum, *S.* Goldcoast and *S.* Bredeney in breeding holdings (B), production holdings (P), carcass lymph nodes (L) and carcass swabs (C) in 10 MSs, *Salmonella* EU baseline survey, 2008

**Table 21:** *Salmonella* serovars reported in humans in the EU, EUSR, 2005-2008

| Serovar | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2005 (N=23 MSs + 2) | | 2006 (N=24 MSs + 4) | | 2007 (N=26 MSs + 3) | | 2008 (N=26 MSs + 3) | |
| | N | % | N | % | N | % | N | % |
| *S.* Enteritidis | 86,536 | 53.7 | 90,362 | 71.0 | 81,472 | 64.5 | 70,091 | 58.0 |
| *S.* Typhimurium | 15,058 | 9.3 | 18,685 | 14.7 | 20,781 | 16.5 | 26,423 | 21.9 |
| *S.* Infantis | 1,354 | 0.8 | 1,246 | 1.0 | 1,310 | 1.0 | 1,317 | 1.1 |
| *S.* Bovismorbificans | 621 | 0.4 | - | - | - | - | 501 | 0.4 |
| *S.* Hadar | 577 | 0.4 | 713 | 0.6 | 479 | 0.4 | - | - |
| *S.* Virchow | 535 | 0.3 | 1,056 | 0.8 | 1,068 | 0.8 | 860 | 0.7 |
| *S.* Derby | 259 | 0.2 | 477 | 0.4 | 469 | 0.4 | 624 | 0.5 |
| *S.* Newport | 245 | 0.2 | 730 | 0.6 | 733 | 0.6 | 787 | 0.7 |
| *S.* Stanley | - | - | 522 | 0.4 | 589 | 0.5 | 529 | 0.4 |
| *S.* Agona | - | - | 367 | 0.3 | 387 | 0.3 | 636 | 0.5 |
| *S.* Anatum | 179 | 0.1 | - | - | - | - | - | - |
| *S.* Goldcoast | 173 | 0.1 | - | - | - | - | - | - |
| *S.* Kentucky | - | - | 357 | 0.3 | 431 | 0.3 | 497 | 0.4 |
| Other | 55,619 | 34.5 | 12,790 | 10.0 | 18,562 | 14.7 | 18,495 | 15.3 |
| Total | 161,156 | | 127,305 | | 126,281 | | 120,760 | |
| Unknown | 56,619 | | 17,359 | | 9,814 | | 6,636 | |

## M. CORRELATION BETWEEN *SALMONELLA* PREVALENCE IN THE BREEDING AND SLAUGHTER PIG EU-WIDE BASELINE SURVEYS



**Figure 56:** Comparison between the prevalence of *Salmonella*-positive lymph nodes of slaughter pigs in the 2006-2007 EU baseline survey and the prevalence of *Salmonella*-positive breeding holdings observed in the 2008 EU baseline survey

**Figure 57:** Comparison between the prevalence of *Salmonella*-positive lymph nodes of slaughter pigs in the 2006-2007 EU baseline survey and the prevalence of *Salmonella*-positive production holdings observed in the 2008 EU baseline survey

**Figure 58:** Comparison between the prevalence of *S.* Typhimurium-positive lymph nodes of slaughter pigs in the 2006-2007 EU baseline survey and the prevalence of *S.* Typhimurium-positive breeding holdings observed in the 2008 EU baseline survey
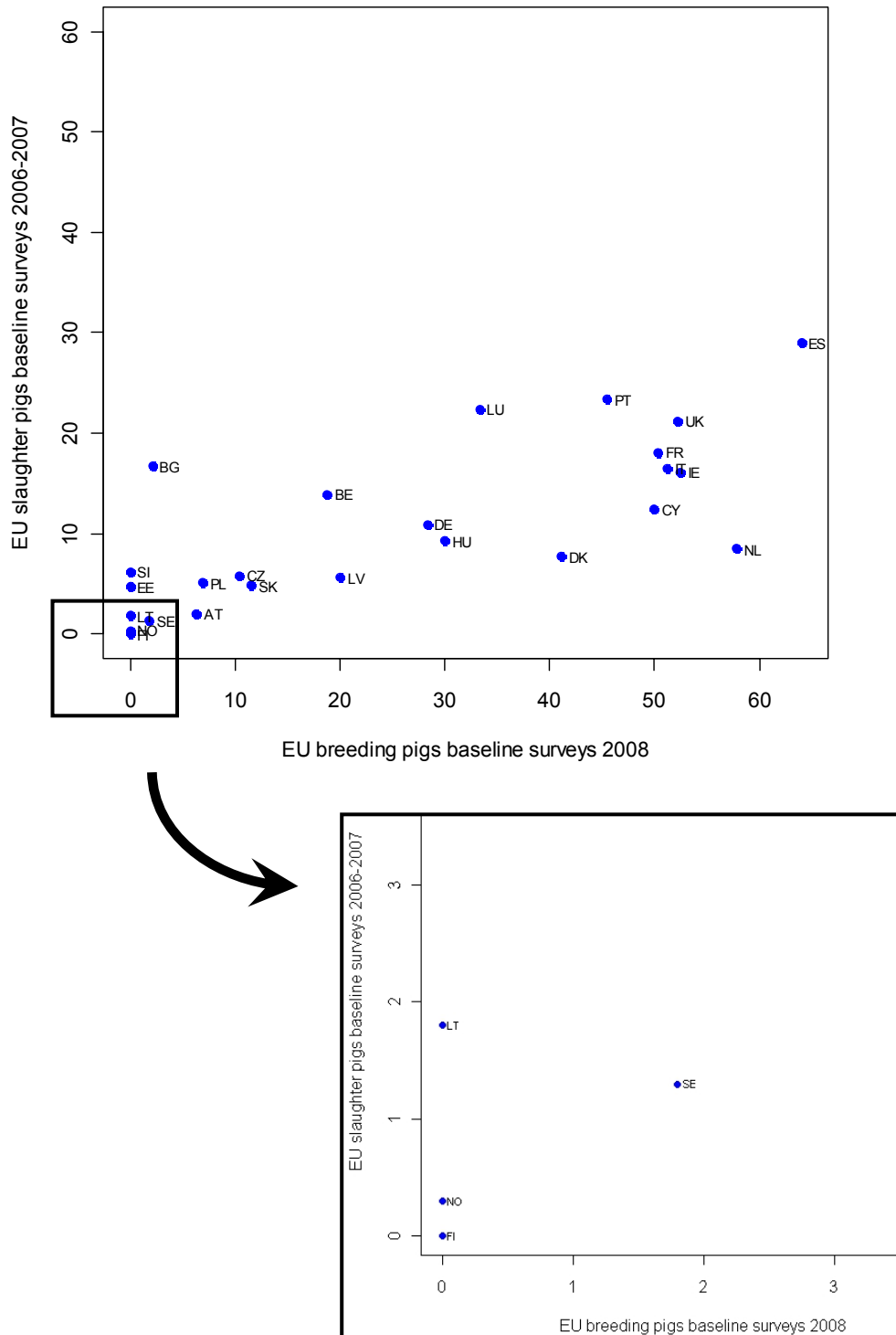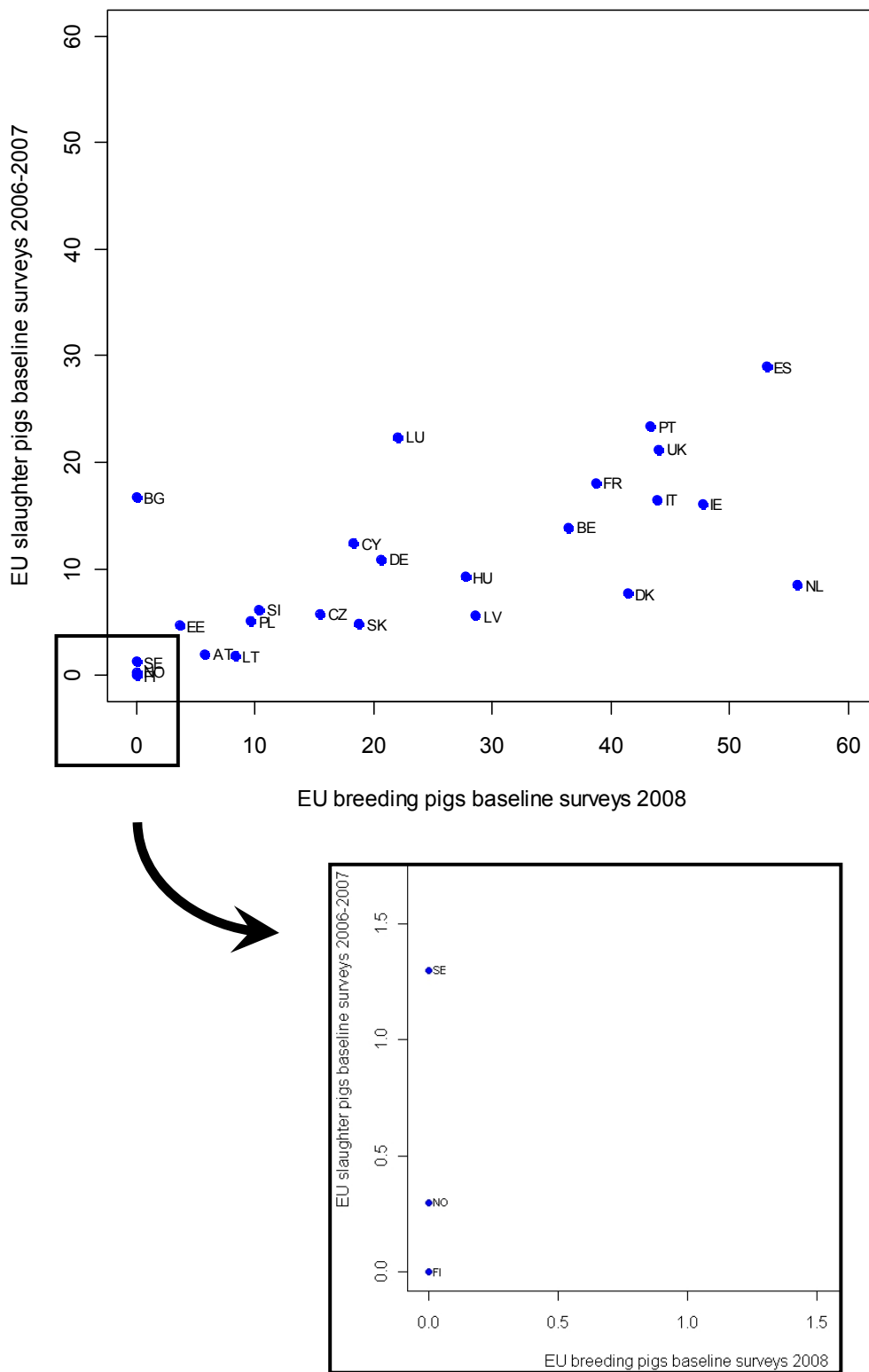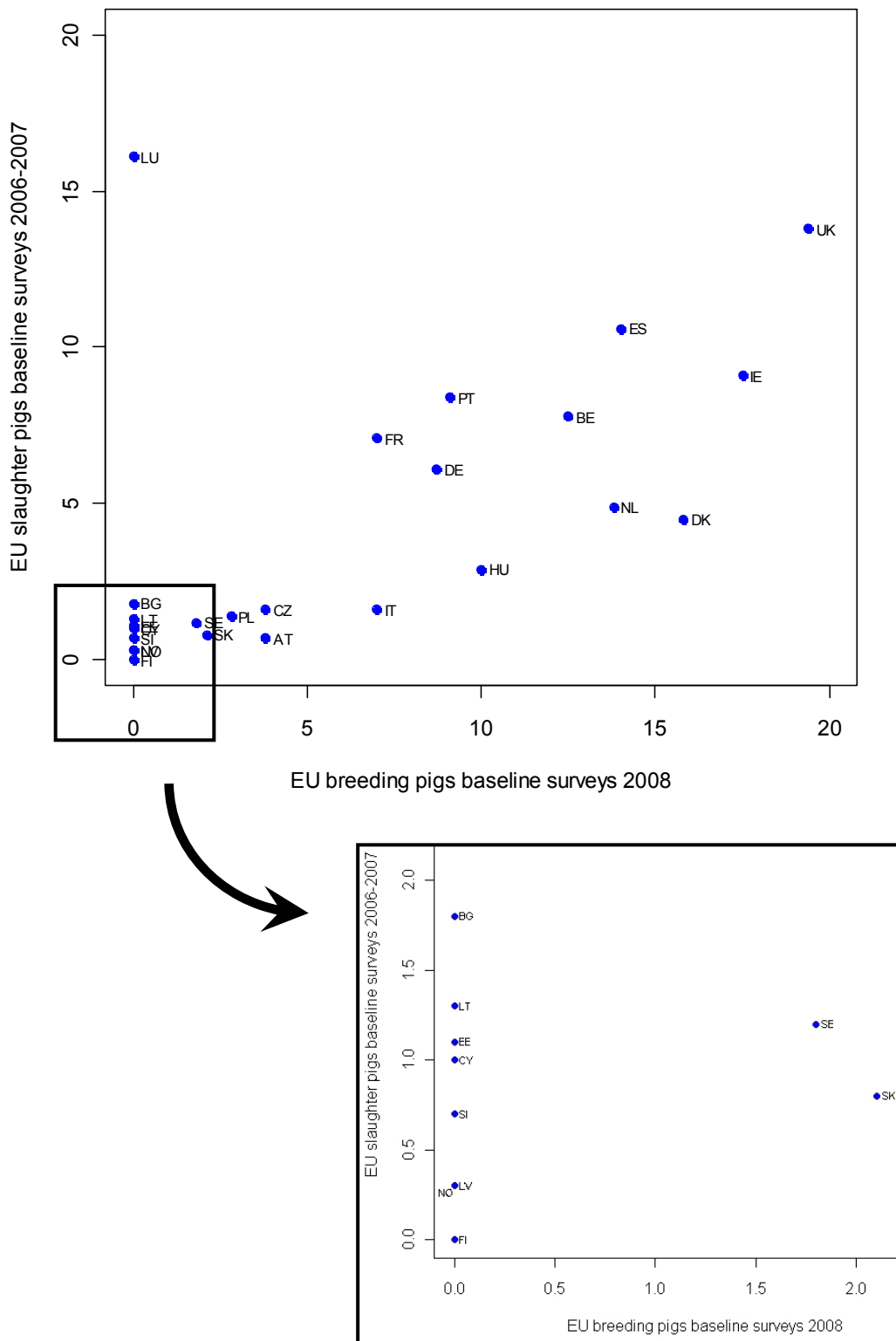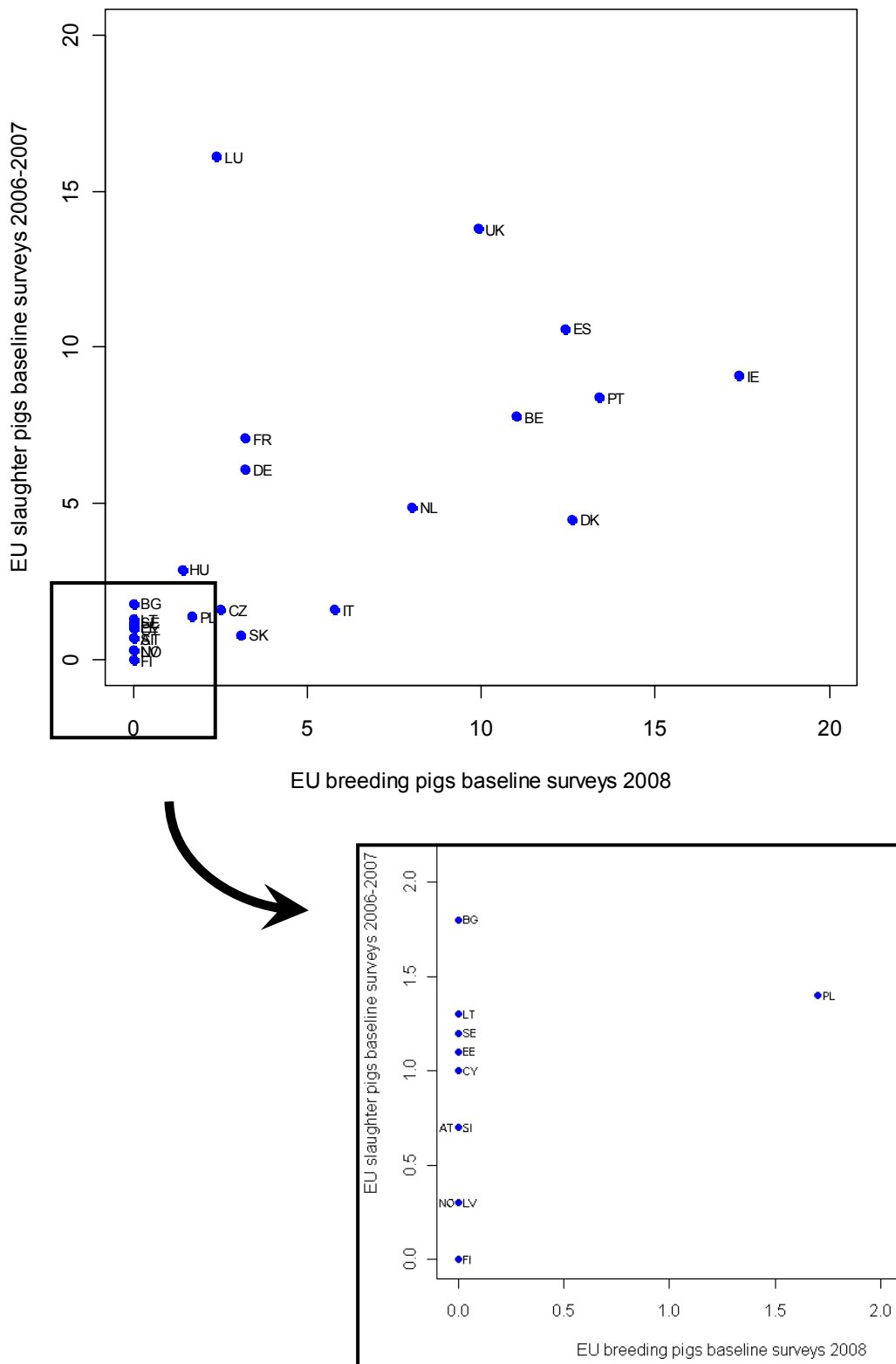
**Figure 59:** Comparison between the prevalence of *S.* Typhimurium-positive lymph nodes of slaughter pigs in the 2006-2007 EU baseline survey and the prevalence of *S.* Typhimurium-positive production holdings observed in the 2008 EU baseline survey

![efsa - European Food Safety Authority]

Analysis of the baseline survey on *Salmonella* in breeding pigs in the EU, 2008
Part B: factors associated with *Salmonella* pen positivity

### N. WITHIN-HOLDING PREVALENCE STUDY

*Bayesian model of within-holding prevalence study data ("first step" model)*

From each pen $i$ within holding $j$ and country $k$, ten individual faecal samples were tested for *Salmonella*, with the number of positive samples, $x_{ijk}$, assumed to be binomially distributed,

$$x_{ijk} \mid \pi_{ijk}, \eta_{ind} \sim \text{Bin}(10, \pi_{ijk}\eta_{ind}),$$

where $\pi_{ijk}$ represents the prevalence of *Salmonella* within holding $j$ and pen $i$, and $\eta_{ind}$ the sensitivity of an individual test in detecting *Salmonella*. From these ten samples, a single artificial pool was created. The binary *Salmonella* status of this artificially pooled sample, $y_{ijk}$, is assumed to follow a Bernoulli distribution,

$$y_{ijk} \mid \eta_{ap} \sim \text{Bernoulli}(\eta_{ap}),$$

where $\eta_{ap}$ denotes the sensitivity of the test on the artificially pooled sample, which will be constructed so that it depends on $\pi_{ijk}$.

A further routine sample was taken from each pen, and the binary test result of this sample, $z_{ijk}$, was also assumed to follow a Bernoulli distribution,

$$z_{ijk} \mid \eta_{routine} \sim \text{Bernoulli}(\eta_{routine}),$$

where $\eta_{routine}$ denotes the sensitivity of the routine test, which will be constructed so that it depends on $\pi_{ijk}$.

*Prevalence estimation*

A previous study (Arnold and Cook, 2009) has shown that the clustering of infection within pens is very important when estimating within-pen and within-holding prevalence of *Salmonella* in pigs. A similar approach to that used by Arnold and Cook (2009) was adopted here, which allows the proportion of positive pens and the degree of variability of the prevalence in affected pens to be included in the analysis. It is assumed that the probability that a pen within a particular holding contained infected pigs, $\tau_{jk}$, was given by

$$\tau_{jk} = \mu_{jk} \exp(\alpha (1 - \mu_{jk}))$$

where $\alpha$ is a parameter that determines the relationship between the within-holding prevalence and the proportion of infected pens, and where $\mu_{jk}$ denotes the within-holding prevalence (i.e. $\mu_{jk}$ is the prevalence of *Salmonella*-infected pigs). This satisfies the necessary conditions that $\tau_{jk} = 0$ if $\mu_{jk} = 0$ (i.e. no pens positive if within-holding prevalence is 0), and $\tau_{jk} = 1$ if $\mu_{jk} = 1$ (i.e. all pens positive if within holding prevalence =1). To ensure that $\tau_{jk}$ could never be greater than 1, $\alpha$ was constrained to be less than or equal to 1.

The within-pen prevalence (i.e. the prevalence of infected pigs within a pen), $\pi_{ijk}$, will naturally depend on the prevalence within the holding, $\mu_{jk}$. The quantity $\pi_{ijk}$ was assumed to follow a beta distribution, with parameters calculated as in Branscum et al. (2004), such that

$$\pi_{ijk} \sim \text{Beta}(a_{jk}, b_{jk}) \text{ with probability } \tau_{jk}\lambda_k;$$

$$\pi_{ijk} = 0 \text{ with probability } (1 - \tau_{jk}\lambda_k),$$

where the parameters $\tau_{jk}$ and $\lambda_k$ allow the pen and holding to be free from *Salmonella*, respectively. Following the methods implemented in (Arnold and Cook, 2009; Branscum et al., 2004), the

parameters $a_{jk}$ and $b_{jk}$ were assumed to be related to the within-holding prevalence, $\mu_{jk}$, and to a measure of variance, $\psi$, such that

$$a_{jk} = \mu_{jk}\psi \,/\, \tau_{jk}$$

$$b_{jk} = (1 - \mu_{jk}\,/\,\tau_{jk})\psi.$$

*Estimation of the sensitivity of faecal sampling for Salmonella.*

For an individual sample of a fixed weight using the culture methods defined for this survey, the sensitivity of faecal culture depends upon the number of *Salmonella* bacteria in the sample. Indeed, these bacteria are not uniformly distributed through the faecal mass but are present in clumps or clusters of bacterial cells. Therefore, individual sample sensitivity depends on the number of clusters of bacteria per gram of faeces.

For the sensitivity of routine and artificially pooled samples, the parametric form discussed in (Arnold et al., 2005; Arnold and Cook, 2009) was employed, linking sensitivity to pen-level prevalence, the weight of the sample (w), and the concentration of *Salmonella* in pig faeces (C),

$$\eta = \eta_{outine} = \eta_{ap} = 1 - \exp(-Cw\pi_{ijk}(1 - \exp(-\rho/w))). \text{ (Eq 1)}$$

Here, $\rho$ is a parameter relating the probability of successful culture to the concentration of *Salmonella* clusters in the sample. Priors for C and $\rho$ were taken from a previous study (Arnold et al., 2005).

These formulae take into account that test sensitivity for artificially pooled and routine samples will vary between pens as $\pi_{ijk}$ varies. It was assumed that the culture method to detect *Salmonella* was 100% specific.

The sensitivities of the artificially pooled and routine samples are treated as though equal. An analysis using separate values for C and rho for each of the artificially pooled and routine sample sensitivity was investigated. However, results showed that the difference between the two was marginal, supported by Table 22 below which shows that only 30 out of 490 pens showed discordant results between the "routine" and the artificial pools. On applying McNemar's nonparametric test, a *P*-value of 0.58 was obtained, which supports the null hypothesis that there was no important difference between the test results for artificial pooled and routine samples. It was therefore deemed appropriate to use the same sensitivity formula for both routine and artificially pooled samples.

**Table 22:** Results of testing artificially pooled samples and routine pooled faecal samples from a study of the sensitivity of pooled sampling for detection of *Salmonella* in holdings of breeding pigs in five MSs, *Salmonella* EU baseline survey, 2008

| Artificial pooled samples | Routine pooled samples | |
|---|---|---|
| | Positive | Negative |
| Positive | 37 (8%) | 17 (3.5%) |
| Negative | 13 (2.5%) | 423 (86%) |

Estimates of all unknown parameters were produced using WinBUGS 3.1, which uses a method known as Markov Chain Monte Carlo (MCMC) to produce random samples of each unknown parameter from the estimated "true" distribution. From these random samples, a credible interval (the Bayesian equivalent of a confidence interval) was derived from the 2.5 and 97.5 percentiles of each parameter. In order for the MCMC method to reach a stable point before parameter estimates were made, 5,000 iterations of the model were performed before using a further 10,000 iterations to derive credible intervals for each parameter. Convergence was checked using Gelman-Rubin convergence statistic applied to multiple chains with varying starting values, as implemented in WinBUGS 3.1, which showed convergence of each of the chains after 5,000 iterations. As is usual with Bayesian models, the median value was used as the best point estimate of each parameter.

*Priors for within-holding prevalence study ("first step" model)*

Priors are listed in Table 23 below. Where applicable, priors were taken from the results of previous studies. Non-informative priors (implemented as uniform distributions via a beta (1,1) prior) were used for pen, holding and MS level prevalence estimates. The between-pen variance of the infection prevalence, Ψ, was investigated in Arnold et al. (2009), and found to follow a gamma distribution with a mean of 2.68, which is consistent with relatively high variability of prevalence within pens. The parameter α, which determines the proportion of pens infected from the within-holding prevalence, was found to be 0.95 in Arnold et al. (2009), which indicates that the proportion of pens with infected pigs is generally higher than the proportion of individual pigs infected e.g. a 50% individual pig prevalence was predicted to result in 75% of pens containing infected pigs. The prior on the sensitivity of an individual 25g faecal sample was taken from a study by Arnold et al. (2005) where this sensitivity was estimated to be 81% i.e. faecal culture was found to give a positive result from an infected pig 81% of the time. The study by Arnold et al. (2005) also estimated values for the two factors that influence the sensitivity of pooled sampling: the *Salmonella* abundance in the pig faeces being tested (mean of 7.3) and the ability of the diagnostic method to detect the *Salmonella* (determine by parameter ρ with value 0.55). While these parameters have a biological interpretation, it is their effect on the sensitivity of pooled sampling that is of primary importance; with C=0.73 and ρ=0.55 the predicted sensitivity of a pooled sample of which 10%, 50% or 100% of samples in the pool were from infected pigs was 33%, 86% and 98% respectively.

The within-holding prevalence study data provided, for each positive pen, the observed number of positive samples, and whether the artificial and/or routine sample was positive i.e. three data points per positive pen. From this the Bayesian model estimates the following unknown parameters: the pen- and within-holding prevalence, the sensitivity of each faecal sample type (via the parameters C, ρ and $\eta_{ind}$).

**Table 23:** Priors used in the "first step" of the Bayesian model to estimate the within-holding prevalence of *Salmonella* in holdings with breeding pigs sampled in five MSs in the framework of the within-holding prevalence study, *Salmonella* EU baseline survey, 2008

| Parameter | Description | Prior[a] | Source |
|---|---|---|---|
| Ψ | Between-pen variance of *Salmonella* prevalence (i.e. how does the prevalence vary between infected pens). | Gamma (134, 50) | Output from model described in Hill et al. (2008) and Arnold et al. (2009). |
| α | Parameter determining the relationship between μ and proportion of positive pens. Given within-herd prevalence, α enables the proportion of infected pens to be predicted. | N (0.95, 0.006) | Arnold et al. (2009) |
| $\eta_{ind}$ | Sensitivity of individual samples | N (0.81, 0.0013) | Arnold et al. (2005) |
| C | *Salmonella* concentration in pig faeces | N (6.7, 1.3) | Arnold et al. (2005) |
| ρ | Parameter determining how test sensitivity of artificially pooled samples varies with C | N (0.59, 0.12) | Arnold et al. (2005) |

[a] Gamma(a,b)=$b^a x^{a-1} e^{-bx} / \Gamma(a)$, where $\Gamma$ denotes the gamma function. N(a,b) denotes the normal distribution with mean a and standard deviation b.

**Table 24:** Additional posterior estimates of the parameters used in the "first step" of the Bayesian model for the within-holding prevalence study, *Salmonella* EU baseline survey, 2008

| Parameter | Description | Median | 2.5 percentile | 97.5 percentile |
|---|---|---|---|---|
| ψ | Between-pen variance of *Salmonella* prevalence | 2.40 | 2.03 | 2.8 |
| α | Determines relationship between within-holding prevalence and proportion of pens infected | 1.0 | 0.91 | 1.0 |

***Bayesian model estimating the true prevalence of Salmonella-positive holdings in 24 MSs and two non-MSs ("second step" model)***

Since the mandatory survey in 24 MSs and two non-MSs only required pooled faecal samples, no individual samples were collected from the selected holdings. Consequently, fewer data were available to estimate within-holding prevalence and the likelihood that the holding was positive. This lack of holding level information was partially offset by exploiting the posterior estimates from the within-holding prevalence study, allowing maximal information from the limited holding level sampling data. Using the estimates of the prevalence of positive samples within pens, together with the estimates of the concentration of *Salmonella* in pig faeces (C) and a term (ρ) describing how test sensitivity of the artificially pooled samples varies with the *Salmonella* concentration in pig faeces, an approximation of the test sensitivity of the routine survey and the artificially pooled samples was made using the equation (Eq 1).

A single routine sample was taken from each of ten pens ($i=1,…,10$), within holding $j$, and tested for *Salmonella.* The test result, $z_{ijk}$, was assumed to follow a Bernoulli distribution,

$$z_{ijk} \mid \eta_{routine} \sim \text{Bernoulli}(\eta_{routine}),$$

where $\eta_{routine}$ denotes the sensitivity of the routine test, and is defined as before. Note that the definition of $\eta_{routine}$ in (Eq 1) depends on the pen-level prevalence, $\pi_{ijk}$.

*Priors for the true prevalence of Salmonella-positive holdings in 24 MSs and two non-MSs*

The priors used for the Bayesian model to estimate the true prevalence of *Salmonella*-positive holdings in 24 MSs and two non-MSs were taken from the posterior estimates of the first part of the analysis for the parameters determining routine pool sensitivity and the clustering of prevalence within-pens. Specifically, the following four priors were used, and a normal distribution was used for each of them: C (mean 5.36, standard deviation 0.85), ρ (mean 0.49, standard deviation 0.088), ψ (mean 2.4, standard deviation 0.20), and α (mean 0.96, standard deviation 0.025).

Non-informative priors (implemented as uniform distributions via beta distribution with both parameters set to 1) were used for within-pen, within-holding and MS level prevalence estimates.

*Comparison of models*

In order to test whether there was any significant difference between the sensitivity of faecal sampling between MSs a more complex model, where C and ρ were permitted to vary between MSs was also fitted to the within-holding prevalence study data. In order to compare these models, the Deviance Information Criterion (DIC) was used (Spiegelhalter et al., 2002), with the convention that the model with the lowest DIC value was 'better'. Since DIC values can be difficult to interpret, the DIC weight method was implemented, as in Spiegelhalter et al. (2002). This gives the probability that a particular model is the best for the available data. Such an analysis showed no important difference in the fit of the model when allowing the parameters C and ρ to vary between member states, and in fact showed

that a model assuming common values of C and ρ between member states was slightly favoured by the DIC (p=0.61), as seen in Table 25 below.

**Table 25:** DIC values and DIC weights for each model fitted to the within-holding prevalence study data, *Salmonella* EU baseline survey, 2008

|  | Deviance | Dhat | DIC | DIC weight |
|---|---|---|---|---|
| C and ρ same for each country | 490.2 | 433.88 | 546.5 | 0.61 |
| C and ρ allowed to vary between countries | 487.8 | 428.24 | 547.4 | 0.39 |

### *True prevalence of Salmonella-positive holdings in 24 MSs and two non-MSs*

For each country, the posterior estimate of the true prevalence of *Salmonella*-positive holdings is given in Table 26. For comparison, the MS 'observed prevalence' column is calculated as the proportion of holdings with at least one sample testing positive for *Salmonella* (from Report A, EFSA, 2009b).

**Table 26:** Posterior estimates of the true prevalence of *Salmonella*-positive holdings with breeding pigs in 24 MSs and two non-MSs, along with credible intervals (CrI) and a comparison with the observed prevalence, *Salmonella* EU baseline survey, 2008

| Country | Number of holdings | MS true prevalence (median) | 95% CrI | | MS observed prevalence[a] |
|---|---|---|---|---|---|
| **Austria** | 252 | 7% | 4% | 11% | 6% |
| **Belgium** | 225 | 41% | 34% | 49% | 35% |
| **Bulgaria** | 72 | 3% | 0.4% | 9% | 1% |
| **Cyprus** | 64 | 25% | 15% | 38% | 20% |
| **Czech Republic** | 267 | 16% | 12% | 21% | 13% |
| **Denmark** | 293 | 49% | 42% | 55% | 41% |
| **Estonia** | 34 | 6% | 0.8% | 18% | 3% |
| **Finland** | 207 | 0.4% | 0.01% | 2% | 0% |
| **France** | 343 | 51% | 45% | 57% | 44% |
| **Germany** | 201 | 27% | 21% | 34% | 22% |
| **Hungary** | 181 | 33% | 26% | 41% | 28% |
| **Ireland** | 189 | 57% | 49% | 66% | 49% |
| **Italy** | 214 | 53% | 46% | 61% | 45% |
| **Latvia** | 33 | 33% | 18% | 56% | 27% |
| **Lithuania** | 82 | 9% | 4% | 18% | 7% |
| **Luxembourg** | 44 | 28% | 15% | 44% | 23% |
| **Netherlands** | 321 | 66% | 60% | 73% | 56% |
| **Poland** | 322 | 10% | 7% | 14% | 8% |
| **Portugal** | 167 | 51% | 43% | 60% | 44% |
| **Slovakia** | 192 | 18% | 13% | 24% | 15% |
| **Slovenia** | 114 | 10% | 5% | 17% | 8% |
| **Spain** | 359 | 68% | 62% | 74% | 58% |
| **Sweden** | 207 | 1% | 0.1% | 3% | 0.5% |
| **United Kingdom** | 258 | 54% | 47% | 62% | 46% |
| **Norway** | 251 | 0.3% | 0.01% | 2% | 0% |
| **Switzerland** | 225 | 15% | 11% | 21% | 13% |

[a] The MS observed prevalence figures were calculated combining the MS *Salmonella* figures (number of positive holdings out of the number of tested holdings) that were presented separately for breeding and production holdings in the Report part A (EFSA, 2009b)

## O. ADDITIONAL RESULTS OF THE WITHIN-HOLDING PREVALENCE STUDY

The results presented in this Appendix are to be considered as intermediate results of within-holding prevalence study. It should be noted that these results are not representative of MS situation since they were obtained using only data from the ten holdings sampled in each of the five countries as part of the within-holding prevalence study.

Table 27 shows the estimated median prevalence of *Salmonella*-positive holdings obtained using the Bayesian model based on the data from the within-holding prevalence study (as shown in Table 8). The estimated prevalence of *Salmonella*-positive holdings ranged from 16% in Sweden to 71% in the UK, and though the 95% credible interval for each MS was wide it was compatible with the results reported in Part A.

**Table 27:** Estimates of the true MS-level prevalence of *Salmonella*-positive holdings for the five Member States that participated in the within-holding prevalence study, *Salmonella* EU baseline survey, 2008

| Country | Median true MS-level prevalence | 95% CrI[a] (%) |
|---|---|---|
| Czech Republic | 37% | (13, 69) |
| Denmark | 61% | (32, 87) |
| Sweden | 16% | (2, 43) |
| Slovenia | 25% | (7, 54) |
| United Kingdom | 71% | (41, 93) |

[a] CrI represents the 95% credible interval from the Bayesian analysis of these data

The full results from the five countries participating in the within-holding prevalence study are given at holding level in Table 28, where the estimated within-holding prevalence for each holding included in the study is also presented.

**Table 28:** Observed holding level *Salmonella* results together with Bayesian estimates of the median within-holding prevalence and its 95% credible interval (CrI), for each holding sampled in the five countries that carried out the within-holding prevalence study, *Salmonella* EU baseline survey, 2008

| Country[a] | Unique holding number | Number of positive individual samples | Number of positive routine samples | Number of positive artificially pooled samples | Number of positive pens | Median within-holding prevalence (%) | 95% CrI | |
|---|---|---|---|---|---|---|---|---|
| CZ | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.8 |
| CZ | 2 | 8 | 1 | 2 | 3 | 15 | 5 | 32 |
| CZ | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CZ | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| CZ | 5 | 2 | 0 | 0 | 1 | 7 | 1 | 21 |
| CZ | 6 | 48 | 6 | 4 | 8 | 53 | 31 | 76 |
| CZ | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0.8 |
| CZ | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| CZ | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| DK | 1 | 19 | 4 | 5 | 5 | 30 | 14 | 50 |
| DK | 2 | 13 | 1 | 2 | 2 | 12 | 3 | 31 |
| DK | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| DK | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| DK | 5 | 6 | 0 | 1 | 1 | 7 | 1 | 22 |

| Country[a] | Unique holding number | Number of positive individual samples | Number of positive routine samples | Number of positive artificially pooled samples | Number of positive pens | Median within-holding prevalence (%) | 95% CrI | |
|---|---|---|---|---|---|---|---|---|
| DK | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| DK | 7 | 37 | 6 | 4 | 7 | 44 | 25 | 65 |
| DK | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| DK | 9 | 5 | 1 | 0 | 2 | 11 | 2 | 26 |
| DK | 10 | 3 | 0 | 2 | 2 | 11 | 3 | 26 |
| SE | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SE | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SE | 3 | 1 | 0 | 0 | 1 | 7 | 1 | 21 |
| SE | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SE | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SE | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SE | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SE | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SE | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SE | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SI | 1 | 9 | 1 | 4 | 4 | 22 | 9 | 41 |
| SI | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SI | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SI | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SI | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SI | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SI | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SI | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SI | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SI | 10 | 1 | 0 | 0 | 1 | 6 | 1 | 20 |
| UK | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| UK | 2 | 29 | 4 | 2 | 6 | 36 | 19 | 57 |
| UK | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| UK | 4 | 59 | 8 | 10 | 10 | 78 | 51 | 99 |
| UK | 5 | 10 | 2 | 2 | 3 | 16 | 5 | 34 |
| UK | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| UK | 7 | 11 | 3 | 2 | 6 | 20 | 7 | 38 |
| UK | 8 | 31 | 4 | 4 | 8 | 40 | 21 | 60 |
| UK | 9 | 31 | 3 | 4 | 4 | 31 | 14 | 54 |
| UK | 10 | 36 | 6 | 6 | 8 | 45 | 25 | 66 |

[a] CZ: Czech Republic; DK: Denmark; SE: Sweden; SI: Slovenia; UK: United Kingdom.

The distribution of the median estimated within-holding prevalence of each holding sampled in the framework of the within-holding prevalence study is illustrated in Figure 60 for each of the five MSs that carried out this study.
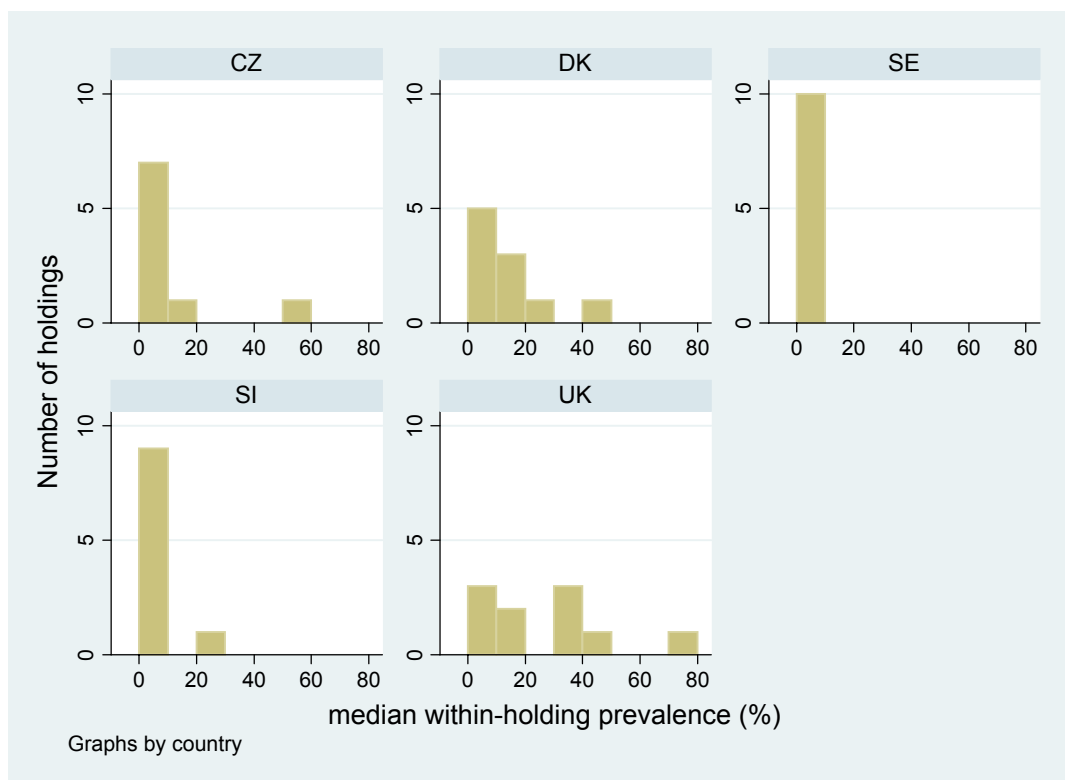
**Figure 60:** Histograms showing the distribution of the median estimated within-holding prevalence by participating MS[a] for those holdings that were sampled during the within-holding prevalence study, *Salmonella* EU baseline survey, 2008

[a]   CZ: Czech Republic; DK: Denmark; SE: Sweden; SI: Slovenia; UK: United Kingdom.

The box-plots in Figure 61 show the variability of the median within-holding prevalence of *Salmonella* for each of the five MS that participated in the within-holding prevalence study. Whiskers denote the range of within-holding prevalences, while dots above the plots represent 'outliers', defined as being greater than the sum of the upper quartile and 1.5 times the inter-quartile range. All Swedish samples were negative, with the exception of one individual faecal sample, accounting for the single positive value for the within-holding prevalence in Sweden.
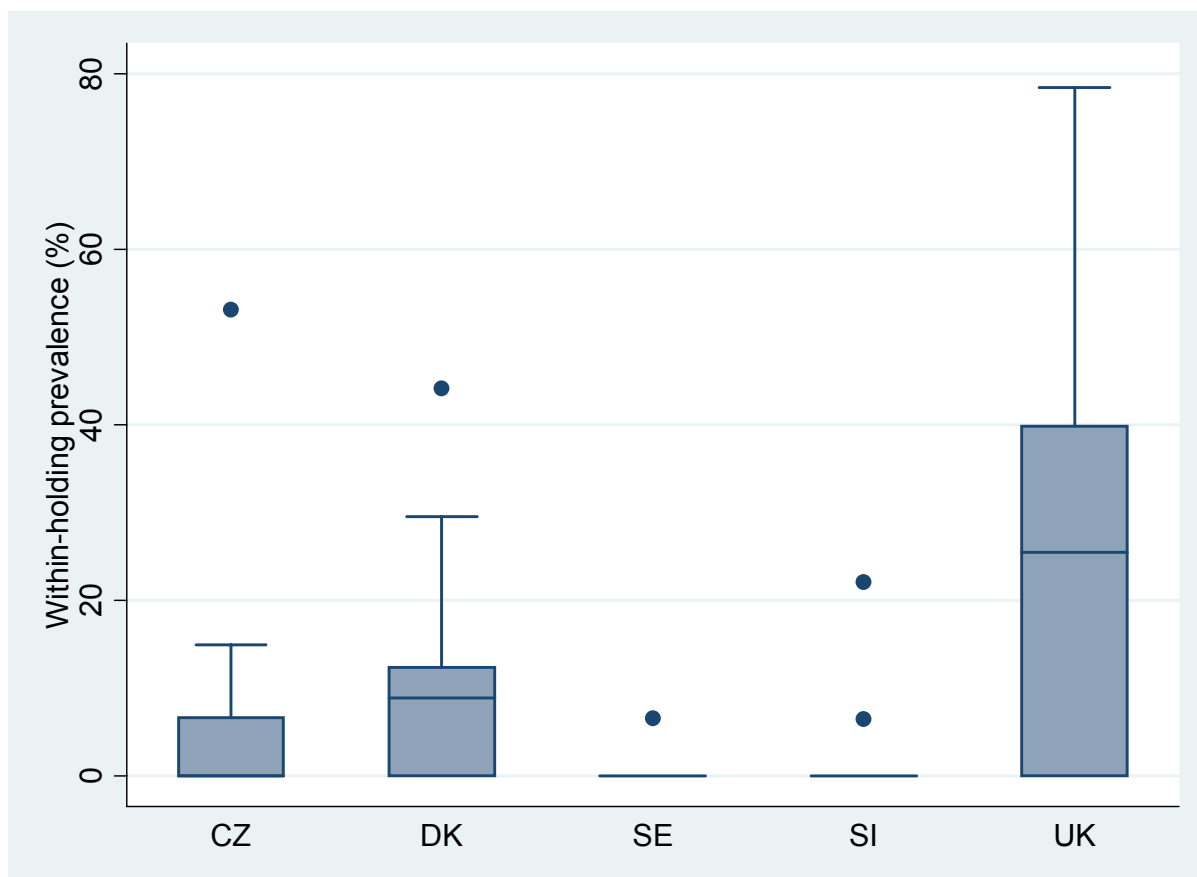
**Figure 61:** Boxplots of the estimated within-holding prevalence of *Salmonella* derived from the output of the Bayesian model, by participating MS[a] for those holdings that were sampled during the within-holding prevalence study, *Salmonella* EU baseline survey, 2008

[a] CZ: Czech Republic; DK: Denmark; SE: Sweden; SI: Slovenia; UK: United Kingdom.

The histograms in Figure 62 represent the estimated distribution of median within-holding prevalence for each of the 24 countries where the within-holding prevalence was greater than zero. No positive samples were received from two countries, namely Finland and Norway, and therefore these are not represented in Figure 62 below.
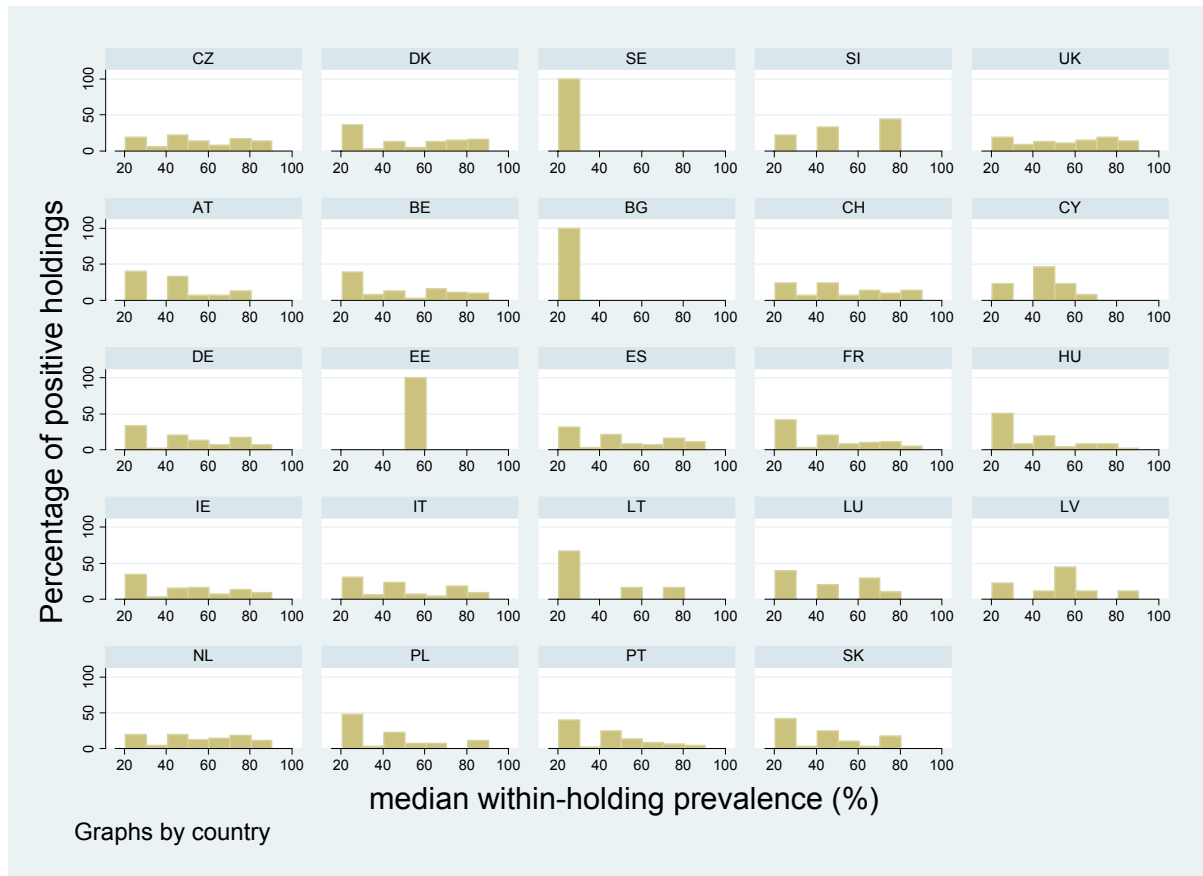
**Figure 62:** Histograms showing the distribution of median within-holding prevalence for each of the 23 MSs[(a)] and Switzerland with at least one positive holding, *Salmonella* EU baseline survey, 2008

[(a)] AT: Austria, BE: Belgium, BG: Bulgaria, CH: Switzerland, CY: Cyprus, CZ: Czech Republic; DE: Germany; DK: Denmark; EE: Estonia, ES: Spain, FI: Finland, FR: France, HU: Hungary, IE: Ireland, IT: Italy, LT: Lithuania, LV: Latvia, LU: Luxembourg, NL: Netherlands, PL: Poland, PT: Portugal, SE: Sweden; SI: Slovenia, SK: Slovakia, UK: United Kingdom.

### *Calculation of the EU true prevalence*

The EU true prevalence was 40.6% (95% CrI: 35.0-46.8). This EU level prevalence was estimated by weighting each MS' true prevalence with the fraction of its total number of holdings housing at least 50 breeding pigs out of the total number of holdings (≥50 breeding pigs) in the EU (Table 29).

**Table 29:** Calculation of EU true prevalence of *Salmonella*-positive holdings, *Salmonella* EU baseline survey, 2008

| Country | Estimate prevalence (median) | 95% CrI | | Total holdings (≥50 breeding pigs) | Prevalence contribution[a] | 95%CrI contribution[a] | |
|---|---|---|---|---|---|---|---|
| Austria | 7.0% | 4.0% | 11.0% | 2856 | 0.3% | 0.2% | 0.5% |
| Belgium | 41.0% | 34.0% | 49.0% | 4,017 | 2.8% | 2.3% | 3.3% |
| Bulgaria | 3.0% | 0.4% | 9.0% | 427 | 0.0% | 0.0% | 0.1% |
| Cyprus | 25.0% | 15.0% | 38.0% | 91 | 0.0% | 0.0% | 0.1% |
| Czech Republic | 16.0% | 12.0% | 21.0% | 2,168 | 0.6% | 0.4% | 0.8% |
| Denmark | 49.0% | 42.0% | 55.0% | 2,593 | 2.2% | 1.8% | 2.4% |
| Estonia | 6.0% | 0.8% | 18.0% | 35 | 0.0% | 0.0% | 0.0% |
| Finland | 0.4% | 0.0% | 2.0% | 601 | 0.0% | 0.0% | 0.0% |
| France | 51.0% | 45.0% | 57.0% | 6,198 | 5.4% | 4.7% | 6.0% |
| Germany | 27.0% | 21.0% | 34.0% | 12,490 | 5.7% | 4.5% | 7.2% |
| Hungary | 33.0% | 26.0% | 41.0% | 524 | 0.3% | 0.2% | 0.4% |
| Ireland | 57.0% | 49.0% | 66.0% | 329 | 0.3% | 0.3% | 0.4% |
| Italy | 53.0% | 46.0% | 61.0% | 1,204 | 1.1% | 0.9% | 1.2% |
| Latvia | 33.0% | 18.0% | 56.0% | 46 | 0.0% | 0.0% | 0.0% |
| Lithuania | 9.0% | 4.0% | 18.0% | 96 | 0.0% | 0.0% | 0.0% |
| Luxembourg | 28.0% | 15.0% | 44.0% | 30 | 0.0% | 0.0% | 0.0% |
| Netherlands | 66.0% | 60.0% | 73.0% | 3,239 | 3.6% | 3.3% | 4.0% |
| Poland | 10.0% | 7.0% | 14.0% | 5,325 | 0.9% | 0.6% | 1.3% |
| Portugal | 51.0% | 43.0% | 60.0% | 875 | 0.8% | 0.6% | 0.9% |
| Slovakia | 18.0% | 13.0% | 24.0% | 300 | 0.1% | 0.1% | 0.1% |
| Slovenia | 10.0% | 5.0% | 17.0% | 70 | 0.0% | 0.0% | 0.0% |
| Spain | 68.0% | 62.0% | 74.0% | 12,864 | 14.9% | 13.5% | 16.2% |
| Sweden | 1.0% | 0.1% | 3.0% | 837 | 0.0% | 0.0% | 0.0% |
| United Kingdom | 54.0% | 47.0% | 62.0% | 1,669 | 1.5% | 1.3% | 1.8% |
| EU total | | | | 58,884 | 40.6%[b] | 35.0[c] | 46.8%[c] |

[a] MS-specific contribution to the EU true prevalence, calculated as: MS estimated true prevalence (or 95%CrI bounds) multiplied by the ratio of the MS total number of holdings housing at least 50 breeding pigs and the EU total number of holdings (≥50 breeding pigs)

[b] EU weighted true prevalence calculated as the sum of the MS prevalence contributions.

[c] Lower and upper bounds of the 95%CrI of the EU weighted true prevalence. These are calculated as the sum of the MS 95%CrI contributions.

## LIST OF ABBREVIATIONS

| | |
|---|---|
| CI | Confidence Interval |
| CrI | Credibility Interval |
| EC | European Commission |
| EFSA | European Food Safety Authority |
| EU | European Union |
| EUSR | European Union Summary Report |
| MS(s) | Member State(s) |
| OR | Odds Ratio |
| PAF | Population Attributable Fraction |
| VIF | Variance Inflation Factor |