Analysis of the baseline survey on the prevalence of Campylobacter in broiler batches and of Campylobacter and Salmonella on broiler carcasses in the EU, 2008, Part A: Campylobacter and Salmonella prevalence estimates

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SCIENTIFIC REPORT OF EFSA

Analysis of the baseline survey on the prevalence of *Campylobacter* in broiler batches and of *Campylobacter* and *Salmonella* on broiler carcasses in the EU, 2008[1]

Part A: *Campylobacter* and *Salmonella* prevalence estimates

European Food Safety Authority[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

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ABSTRACT

A European Union-wide baseline survey on *Campylobacter* in broiler batches and on *Campylobacter* and *Salmonella* on broiler carcasses was carried out in 2008. A total of 10,132 broiler batches were sampled from 561 slaughterhouses in 26 European Union Member States and two countries not belonging to the European Union. From each randomly selected batch the caecal contents of 10 slaughtered broilers were collected, pooled and examined for *Campylobacter*. From the same batch one carcass was collected after chilling and the neck skin together with the breast skin was examined for the presence of *Campylobacter* and *Salmonella*, in addition to the determination of the *Campylobacter* counts. *Campylobacter* was detected in pooled caecal contents of broilers and on broiler carcasses in all participating countries. At Community level the prevalence of *Campylobacter*-colonised broiler batches was 71.2% and that of *Campylobacter*-contaminated broiler carcasses was 75.8%. The Member State prevalence varied from 2.0% to 100.0% and from 4.9% to 100.0%, for caecal contents and carcasses, respectively. The results of the counts of *Campylobacter* on broiler carcasses showed substantial variation among the countries in contamination levels. About two-thirds of the *Campylobacter* isolates from the pooled caecal contents as well as from the broiler carcasses were identified as *Campylobacter jejuni*, while one-third was *Campylobacter coli*. Twenty-two Member States and one non-Member State isolated *Salmonella* on the broiler carcasses, with a Community prevalence of 15.6%. This prevalence varied widely among the Member States, from 0.0% to 26.6%. However, one Member State had an exceptionally high prevalence of 85.6% with the majority of isolates being *S.* Infantis. The Community prevalence of *Salmonella* Enteritidis or *Salmonella* Typhimurium-contaminated broiler carcasses was 3.6%. *Salmonella* Infantis and *Salmonella* Enteritidis were the two most frequently isolated serovars on broiler carcasses in the EU and accounted for about one-third and one-sixth of the *Salmonella* isolates, respectively.

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[4] The figure for prevalence at EU level for *Salmonella*-contaminated broiler carcasses was amended from 15.7% to 15.6% in the abstract, summary and on pages 36, 51 and 55. The corresponding CI was also amended from 13.7% to 13.6% as well as from 18.0% to 17.9% on page 36.

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KEY WORDS

Campylobacter, *Salmonella*, broiler batches, broiler carcasses, chicken, survey, prevalence, EU.

SUMMARY

In the European Union, campylobacteriosis and salmonellosis are the two most frequently reported food-borne illnesses in humans. Broiler meat is considered to be an important food-borne source of both these human diseases.

In order to establish baseline and comparable values for all Member States, a European Union-wide baseline survey was carried out at slaughterhouse level to determine the prevalence of *Campylobacter* in broiler batches and of *Campylobacter* and *Salmonella* on broiler carcasses. The broiler batches and carcasses were randomly selected from the broiler slaughterhouses within each Member State. This was the sixth baseline survey to be conducted in the European Community and it was the first baseline survey directly investigating foodstuffs.

Sampling took place between January and December 2008. A total of 10,132 broiler batches sampled from 561 slaughterhouses in 26 European Union Member States, plus Norway and Switzerland, were included in the survey. From each selected batch the caecal contents of 10 slaughtered broilers were collected, pooled and examined for *Campylobacter*. Furthermore, from the same batch one carcass was collected immediately after chilling and the neck skin together with the breast skin was examined for the presence of *Campylobacter* and *Salmonella*, in addition to the determination of the *Campylobacter* counts. At least one *Campylobacter* isolate was speciated from each positive sample and also at least one isolate serotyped from each *Salmonella*-positive sample.

Campylobacter was detected in pooled caecal contents of broilers and on broiler carcasses in all 26 participating Member States and the two non-Member States. At Community level the prevalence of *Campylobacter*-colonised broiler batches was 71.2% and that of *Campylobacter*-contaminated broiler carcasses was 75.8%. Member State prevalence varied from 2.0% to 100.0% and from 4.9% to 100.0%, for caecal contents and carcasses, respectively. About two-thirds of the *Campylobacter* isolates from the broiler batches as well as those from the broiler carcasses were identified as *Campylobacter jejuni*, while one-third was *Campylobacter coli*. Few were speciated as other *Campylobacter* species.

The counts of *Campylobacter* bacteria on broiler carcasses varied also widely between countries. In general there was a tendency for high counts in countries with high *Campylobacter* prevalence. In the European Union, almost half (47.0%) of the carcasses contained less than 10 *Campylobacter* per g (cfu/g) and 12.2% contained between 10-99 cfu/g. Higher counts were detected as follows: between 100-999 cfu/g on 19.3%, between 1,000-10,000 cfu/g on 15.8% and more than 10,000 cfu/g on 5.8% of carcasses.

Twenty-two of the 26 participating Member States and one non-Member State isolated *Salmonella* from the broiler carcass samples, with a Community prevalence of *Salmonella*-contaminated broiler carcasses of 15.6% at slaughterhouse level. The prevalence of *Salmonella*-contaminated broiler carcasses varied widely among Member States, from 0.0% to 26.6%. However, Hungary had an exceptionally high prevalence of 85.6% with the majority of isolates being *Salmonella* Infantis. Seventeen Member States isolated *Salmonella* Enteritidis or Typhimurium. This resulted in an estimated Community prevalence of *Salmonella* Enteritidis or *Salmonella* Typhimurium-contaminated broiler carcasses of 3.6%, varying from 0.0% to 9.6% within Member States.

At European Union level the four most frequently isolated *Salmonella* serovars on broiler carcasses were respectively, in decreasing order, *Salmonella* Infantis (29.2% of the *Salmonella* positive broiler carcass samples), *Salmonella* Enteritidis (13.6%), *Salmonella* Kentucky (6.2%) and *Salmonella* Typhimurium (4.4%). Out of these *Salmonella* Enteritidis and *Salmonella* Typhimurium are commonly reported in human salmonellosis cases in the European Union, whereas the *Salmonella* Infantis and *Salmonella* Kentucky generally constitute a minor proportion of human infections. Seventy-five percent of the *Salmonella* Infantis-positive samples were reported by Hungary. The serovar distribution varied among Member States, many of them having a specific distribution pattern.

The Member State and European Union level prevalence presented in the report are apparent prevalences, meaning that the prevalence estimates do not account for imperfect test characteristics.

Broiler meat is considered an important food-borne source of both human *Campylobacter* and *Salmonella* infections in the European Union. The risk for human health arises from consumption of under-cooked the meat or cross-contamination of other foods. Safe handling of raw meat, thorough cooking and strict kitchen hygiene should prevent or reduce the risk posed by *Campylobacter* and *Salmonella*-contaminated broiler meat.

The *Campylobacter* and *Salmonella* baseline figures may be used in the future to follow trends and to evaluate the impact of control and monitoring programmes. The figures also provide useful information for setting reduction and performance objectives and possibly for evaluating some potential intervention methods. However, further research on the epidemiology and surveillance methods of *Campylobacter* in the broiler meat production is recommended. In the national *Salmonella* control and surveillance programmes of broiler flocks and broiler meat, Member States may need to address serovars other than *Salmonella* Enteritidis and *Salmonella* Typhimurium.

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BACKGROUND

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.

Upon a request from the European Commission (EC), the European Food Safety Authority (EFSA) adopted a "Report of the Task Force on Zoonoses Data Collection on proposed technical specifications for a coordinated monitoring programme for *Salmonella* and *Campylobacter* in broiler meat in the EU (EFSA, 2007a)".

Previously, a Commission Task Force of scientific experts, in collaboration with EFSA, prepared technical specifications for a baseline study on the harmonised monitoring of *Campylobacter* in broiler flocks.

Based on the EFSA proposal and the Commission technical specifications, the Commission adopted Decision 2007/516/EC of 19 July 2007[6] concerning a financial contribution from the Community towards a survey on the prevalence and antimicrobial resistance of *Campylobacter* spp. in broiler flocks and on the prevalence of *Campylobacter* spp. and *Salmonella* spp. in broiler carcasses to be carried out in Member States (MSs). This large survey consisting of two subsurveys started on 1 January 2008 for a period of 12 months.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

The Commission requested EFSA on 2 April 2008, to analyse the results of the baseline survey on *Campylobacter* spp. in broiler flocks and on *Campylobacter* spp. and *Salmonella* spp. on broiler carcasses, in particular:

EFSA is asked to analyse the results of the baseline survey on *Campylobacter* in broiler flocks and on *Campylobacter* and *Salmonella* on broiler carcasses, in particular:

- to estimate the prevalence of *Campylobacter* spp. in broiler flocks and the prevalence of *Campylobacter* spp. and *Salmonella* spp. on broiler carcasses in MSs and at European Union (EU) level; and
- to assess quantitatively the risk factors for *Campylobacter* spp. in broiler flocks and *Campylobacter* spp. and *Salmonella* spp. on broiler carcasses based on the information collected.

[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, p.1.

[6] Commission Decision 2007/516/EC of 19 July 2007 concerning a financial contribution from the Community towards a survey on the prevalence and antimicrobial resistance of *Campylobacter* spp. in broiler flocks and on the prevalence of *Campylobacter* spp. and *Salmonella* spp. in broiler carcasses to be carried out in Member States. OJ L 190, 21.07.2007, p. 25.

ANALYSIS

1. Introduction

This report (part A) describes the results of a baseline survey carried out in the EU to estimate the prevalence of *Campylobacter* in broiler batches and of *Campylobacter* and *Salmonella* on broiler carcasses at slaughterhouse level. This study was the sixth in a series of baseline surveys carried out within the EU and it was the first baseline survey directly investigating foodstuffs. The objective of the survey has been to obtain comparable data for all MSs through harmonised sampling schemes. According to Article 5 of Directive 2003/99/EC of the European Parliament and of the Council of 17 November 2003 on the monitoring of zoonoses and zoonotic agents[7], such surveys may be established, especially when specific needs are identified, to assess risks and to establish baseline values related to zoonoses and zoonotic agents at MS level. Results of such a survey will provide information on need of a Community-wide intervention.

Two part B reports will be produced regarding this baseline survey. The first one will present the analyses of risk factors associated with the occurrence of *Campylobacter* spp. in broiler batches and with *Campylobacter* spp. on broiler carcasses as well as the analyses of the identified *Campylobacter* species. The second part B report will describe the analyses of risk factors associated with *Salmonella* spp. on broiler carcasses as well as the analyses of the *Salmonella* serovar distributions.

The slaughterhouse survey was carried out over a one-year period, which commenced in January 2008. Examined broiler batches were selected as randomly as possible as regards slaughterhouses, sampling days and batches sampled on a selected sampling day.

The objectives, sampling frame, methods of bacteriological analysis, as well as the collection and reporting of data and the timelines of this baseline survey were specified in Commission Decision 2007/516/EC.

Twenty-six EU MSs participated in the survey whereas Greece did not carry out the survey. In addition, two countries not belonging to the EU, Norway and Switzerland (later 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:

Broiler: a male or female chicken raised specifically for meat production intended to be slaughtered.

Broiler batch: a group (or batch) of broilers which have been raised in the same flock and which are delivered and slaughtered on one single day.

Broiler carcass: the body (or carcass) of a broiler collected after slaughter, dressing (plucking and removal of the offal), and immediately after chilling, but before any further processing such as freezing, cutting or packaging.

***Campylobacter*:** all *Campylobacter* spp. which can be isolated by the prescribed culture techniques.

***Campylobacter*-colonised broiler batch**: a broiler batch from which *Campylobacter* spp. have been isolated from the intestines of at least one broiler. This isolation is based on the detection of *Campylobacter* spp. from a pooled sample composed of the caecal contents from 10 broilers belonging to the batch using the prescribed culture method.

***Campylobacter* and/or *Salmonella*-contaminated carcass:** a broiler carcass from which *Campylobacter* spp. and/or *Salmonella* spp. have been isolated.

[7] Directive 2003/99/EC of the European Parliament and of the Council of 17 November 2003 on the monitoring of zoonoses and zoonotic agents, amending Council Decision 90/424/EC and repealing Council Directive 92/117/EC. OJ L 325, 12.12.2003 p. 31.

3. Objectives

The aim of the survey was to estimate the prevalence of *Campylobacter*-colonised broiler batches and of *Campylobacter* and *Salmonella*-contaminated broiler carcasses, at Community level and for each MS.

The specific objectives for the two subsurveys on the prevalence of these two potentially zoonotic pathogens were:

- to estimate the prevalence of *Campylobacter*-colonised broiler batches, at EU level and per MS;
- to estimate the prevalence of *Campylobacter*-contaminated broiler carcasses, at EU level and per MS;
- to investigate the counts of *Campylobacter* bacteria on broiler carcasses, at EU level and per MS;
- to investigate the *Campylobacter* species distribution and determine the most frequently occurring *Campylobacter* species in broiler batches and on broiler carcasses across the EU;
- to investigate the effects of factors associated with the *Campylobacter*-colonised broiler batches;
- to investigate the effects of factors associated with the *Campylobacter*-contaminated broiler carcasses;
- to estimate the prevalence of *Salmonella*-contaminated broiler carcasses, at EU level and per MS;
- to investigate the *Salmonella* serovar distribution and determine the most frequently occurring *Salmonella* serovars on broiler carcasses across the EU; and
- to investigate the effects of factors associated with *Salmonella*-contaminated broiler carcasses.

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

This part A report includes the analyses of the prevalence of *Campylobacter*-colonised broiler batches, of *Campylobacter*-contaminated broiler carcasses and of *Salmonella*-contaminated broiler carcasses, the analyses of the *Campylobacter* enumeration results on broiler carcasses as well as the analyses of the most frequently identified *Campylobacter* species in broiler batches and *Campylobacter* species and *Salmonella* serovars on broiler carcasses. The analyses of potential risk factors and more in-depth analyses of *Campylobacter* species and *Salmonella* serovar distributions will be provided in the Part B reports, which will be published at a later date.

The results of the antimicrobial susceptibility of the *Campylobacter* and *Salmonella* isolates will be evaluated, in accordance with Article 9 of Directive 2003/99/EC, in the annual report on trends and sources of zoonoses, zoonotic agents and antimicrobial resistance in the EU.

4. Materials and Methods

4.1. Survey design

A detailed description of the design of the baseline survey, sample design, sample sizes and bacteriological analyses may be found in the Commission Decision 2007/516/EC. Aspects of the survey design of particular relevance to data analysis and interpretation are described here.

The survey took place in Europe between January and December 2008 and was conducted at broiler-batch level in slaughterhouses, focusing on birds entering the food chain.[8] In each MS, the number of batches to sample (broiler batch sample size) was estimated based on an expected prevalence (design prevalence) of 50% with an accuracy of 5% and a confidence of 95%. Consequently, each MS had to sample 384 batches of

[8] In Portugal, Malta and Switzerland no sampling was performed for three or more months (only for pooled caecal contents samples).

slaughtered broilers. By way of derogation, Estonia, Latvia and Luxembourg were allowed to sample fewer batches, respectively 96, 120 and 12.

The sampling of broiler batches was based on a random selection of slaughterhouses, sampling days in each month and the batches to be sampled on each sampling day. However, Fridays and days preceding national holidays might have been excluded in several participating countries due to the difficulties in dispatching the samples to laboratories. The randomisation scheme aimed at selecting broiler batches proportionate to the number of broiler flocks, fattened according to the different production types (conventional, free-range, organic), and avoiding the introduction of biases due to the potential knowledge of the status of the holding from where the broiler batch originated. In addition, MSs were asked to stratify sampling to ensure an even spread throughout the study period to investigate seasonal effects on the outcomes.

From each randomly selected batch the intact caecal contents of 10 slaughtered broilers were collected for the detection of *Campylobacter*. Furthermore, from the same batch one whole carcass was collected immediately after chilling but before freezing, cutting or packaging, for the detection and enumeration (determination of counts) of *Campylobacter* and for the detection of *Salmonella*.

Sampling management, laboratory analysis and data submission were carried out by the competent authority of the MS or under its supervision.

4.2. Laboratory analysis

At the laboratory, the caecal contents from the intact caeca from the 10 slaughtered broilers were aseptically removed and pooled to form one composite sample. In the case of the carcass, the neck skin was removed, if present, together with the skin from one side of the carcass (breast skin) avoiding any fat, to make a test portion. When different laboratories were used for *Campylobacter* and *Salmonella* analyses then the laboratory examination for *Campylobacter* should have taken preference in receipt of the sample. Detection and enumeration of *Campylobacter* and the detection of *Salmonella* were performed using the same initial test portion from each sampled carcass.

Isolation and confirmation of *Campylobacter* organisms in caecal contents and on the broiler carcass samples were undertaken as described in ISO 10272-1:2006(E) 'Microbiology of food and animal feeding stuffs — Horizontal method for detection and enumeration of *Campylobacter* spp. Part 1: Detection method'. At least one *Campylobacter* isolate per batch was speciated using phenotypic methods as described in ISO 10272-1:2006(E) or published molecular methods such as Polymerase Chain Reaction (PCR) techniques.

The quantitative analysis of *Campylobacter* in the broiler carcass samples was carried out according to ISO/TS 10272-2:2006 'Microbiology of food and animal feeding stuffs — Horizontal method for detection and enumeration of *Campylobacter* spp. Part 2: Colony-count technique'.

When *Campylobacter* was not detected by the detection method but was detected by the quantitative method, at least one isolate from the quantitative analysis was speciated as above.

The detection of *Salmonella* in the broiler carcass samples was carried out according to ISO 6579-2002(E). 'Microbiology of food and animal feeding stuffs — Horizontal method for the detection of *Salmonella* spp.' At least one isolate from each positive sample was typed by the National Reference Laboratories (NRLs) for *Salmonella*, using the Kaufmann-White scheme.

4.3. Data validation and cleaning

A set of data exclusion criteria (Appendix A) was used by the EC to identify and exclude non-valid and non-plausible information in the dataset submitted by MSs. MSs corrected the excluded data. Nevertheless, a marginal number of samples were finally excluded. The reasons for excluding samples, in accordance with exclusion criteria, could not be exhaustively addressed because relevant information was not fully available in some cases.

The final cleaned, validated dataset of the survey was provided to EFSA by the EC on 4 June 2009. This validated dataset formed the basis for all subsequent analyses.

4.4. Information on the 2008 production of broiler carcasses in the EU

Each MS and non-MS was requested to provide information on the number of broilers slaughtered in their country during 2008.

4.5. Statistical analysis

4.5.1. Descriptive analysis

A comparison among MSs of the survey protocol and the collected samples, in terms of sample size and stratification by month, was made using frequency tables and graphs.

4.5.1.1. *Campylobacter* enumeration results

The *Campylobacter* enumeration results on broiler carcasses were investigated at EU and country-specific level. Results of enumeration for *Campylobacter* were graphically presented as:

- barplots showing positive and negative counts, where counts of < 10 cfu (colony-forming unit)/g were included in the negative (0 cfu/g) counts category;
- barplots showing exclusively the positive counts, *i.e.* ≥ 10 cfu/g;
- cumulative percent distribution functions and boxplots after $\log_{10}$ transformation.

4.5.1.2. Measurement uncertainty of the *Campylobacter* enumeration method

To enable correct comparison and judgement of individual data measurements (for future risk assessment) the measurement uncertainty (MU) of the *Campylobacter* quantitative determination method was estimated for each laboratory, as prescribed by Commission Decision 2007/516/EC, using the technical specification ISO/TS 19036:2006 with the exception that parallel dilutions from the initial suspension were undertaken for estimation of the MU.

The MU is derived from the intra-laboratory standard deviation of reproducibility (S_R) using as the coverage factor k with a value of 2 ($MU = 2 \times S_R$). A total of at least 12 positive samples were examined in duplicate and parallel dilutions were prepared from the initial suspension. Data on MU estimation should have been collected from May to September in order to increase the possibility of testing positive samples. In MSs, where the prevalence of *Campylobacter* was very low, the MU was determined from artificially contaminated samples (spiked samples).

4.5.2. Estimate of prevalence

The first subsurvey analysing pooled caecal contents samples of slaughtered broilers for the detection of *Campylobacter,* served the purpose of estimating a prevalence of *Campylobacter*-colonised broiler batches. The second subsurvey analysing broiler carcass samples served the purpose of estimating a prevalence of *Campylobacter*- or *Salmonella*-contaminated broiler carcasses.

The data analysed originated from a complex survey design and two aspects had to be considered for the prevalence estimation. Firstly, data were collected following a hierarchical approach, in which broilers batches were sampled within slaughterhouses, and slaughterhouses within a country. It is expected that broiler batches processed by a slaughterhouse are more alike than broiler batches processed by different slaughterhouses (clustering issue). Secondly, sample size did not reflect a country's broiler population size thus resulting in disproportionate sampling for the EU estimation of prevalence, necessitating subsequent weighting for the latter analysis.

MS-specific and EU overall prevalence were estimated by logistic regression models using generalised estimating equations (GEE) methodology to empirically correct the standard errors for the possible presence of correlation within clusters (slaughterhouses). Consequently, confidence intervals (CIs) of prevalence estimates were wider than those that would have been obtained by using ordinary logistic regression (OLR) not taking into account within-cluster correlation. An exchangeable working correlation structure was used, a plausible choice assuming that there was no logical ordering of broiler batches or broilers within a slaughterhouse.

When estimating the EU prevalence, in order to account for disproportionate sampling within MSs, proxy-country weights reflecting sampling probabilities were assigned to each country. These weights were obtained by dividing the number of slaughtered broilers in 2008 in the country by the number of sampling units collected in the country. Moreover, weights were standardised in order to avoid inflating the study's sample size. As the MS-specific sizes and numbers of broiler batches were not available, the number of slaughtered birds was agreed as the most appropriate input to weighting. Ideally, disproportionate sampling at slaughterhouse level should also have been considered both when estimating MS and EU prevalence, but the total number of broilers slaughtered per year in the slaughterhouse (i.e. the capacity) was only available as an ordinal variable categorised in rather big ranges and would not have been an appropriate approximation to the weights to attribute to the slaughterhouse capacity.

A detailed description on statistical models and weighting is given in Appendix B.

This report presents estimates for MS level and EU level prevalence, which do not account for test misclassification bias, i.e. imperfect sensitivity or specificity of the used bacteriological survey tests.

4.5.2.1. Prevalence of *Campylobacter*-colonised broiler batches

The prevalence of *Campylobacter*-colonised broiler batches was estimated at EU and country-specific level for the following three outcome variables (based on detection):

- *Campylobacter* spp.;
- *Campylobacter jejuni (C. jejuni)*; and
- *Campylobacter coli (C. coli)*.

Depending on the outcome of interest, a broiler batch was considered positive if *C. jejuni*, *C. coli* or other *Campylobacter* species were detected in the pooled caecal contents sample.

Prevalence was estimated for each country as the proportion of broiler batches colonised with *Campylobacter* out of the total number of broiler batches examined, accounting for slaughterhouse clustering. In addition, for the EU level prevalence estimation, disproportionate sampling, as described above was accounted for by applying country-specific weights. This MS and EU prevalence will be mentioned throughout this report as prevalence of *Campylobacter*-colonised broiler batches.

4.5.2.2. Prevalence of *Campylobacter*-contaminated broiler carcasses

The prevalence of *Campylobacter*-contaminated broiler carcasses was estimated at EU and country-specific level for the following three outcome variables (based on combined detection and enumeration methods):

- *Campylobacter* spp.;
- *Campylobacter jejuni*; and
- *Campylobacter coli*.

A carcass was considered positive if *C. jejuni*, *C. coli* or other *Campylobacter* species were detected by the detection and/or enumeration methods, (i.e. a carcass was regarded as positive when either the detection and/or the enumeration result were positive).

The estimation of the prevalence of *Campylobacter*-contaminated broiler carcasses, at country-specific level, was the proportion of carcasses contaminated with *Campylobacter* out of the total number of carcasses examined, accounting for slaughterhouse clustering. In addition, for the EU level prevalence estimation, disproportionate sampling, as described above, was accounted for by applying country-specific weights. This MS and EU prevalence will be mentioned throughout this report as prevalence of *Campylobacter*-contaminated carcasses.

4.5.2.3. Prevalence of *Salmonella*-contaminated broiler carcasses

The estimation of the prevalence of broiler carcasses contaminated with *Salmonella*, at EU and country-specific level was estimated for the following three outcome variables (based on detection):

- *Salmonella* spp.;
- *Salmonella* Enteritidis (*S.* Enteritidis) and/or Typhimurium (*S.* Typhimurium); and
- serovars other than *Salmonella* Enteritidis or Typhimurium.

Depending on the outcome of interest a carcass was considered positive if *Salmonella* spp., *S.* Enteritidis, *S.* Typhimurium or other *Salmonella* serovars were detected in the carcass sample. It should be noted that the outcome variable serovars other than *Salmonella* Enteritidis or Typhimurium did not include untypeable *Salmonella* or *S.* 4,[5],12:i:- or any other observed incomplete antigenic formula. When several *Salmonella* serovars were isolated from the same broiler carcass, each serovar was considered individually for the purpose of estimation of the prevalence outcomes.

The estimation of the prevalence of *Salmonella*-contaminated broiler carcasses, at country-specific level, was the proportion of carcasses contaminated with *Salmonella* out of the total number of carcasses examined, accounting for slaughterhouse clustering. In addition, for the EU level prevalence estimation, disproportionate sampling, as described above, was accounted for by weighting the country data. This MS and EU prevalence will be mentioned throughout this report as prevalence of *Salmonella*-contaminated carcasses.

4.5.2.3.1 Correlation between the *Salmonella* broiler flock prevalence observed in the EU baseline survey in 2005-2006 and the prevalence of *Salmonella*-contaminated broiler carcasses in the EU baseline survey in 2008

Correlation between the 2005-2006 baseline survey prevalence results of *Salmonella* in broiler flocks (EFSA, 2007b) and the 2008 prevalence results of *Salmonella*-contaminated broiler carcasses in each MS and non-MS was studied graphically via a scatterplot and in a more analytical way using the Spearman rank correlation coefficient.

5. Results

5.1. Overview of the 2008 production of broiler carcasses in the EU

A summary of the production of broiler carcasses in the EU is presented in Table 1 and Figure 1.

All countries provided their best estimates, which in some cases originated from 2007 data (Germany) or total weight of slaughtered broilers during 2008 (Bulgaria, Hungary). It should be noted that some of these figures may be slight overestimates as they also include cockerels, capons, poulardes (France) and cast (spent) hens and other poultry (excluding turkeys) weighing less than 2 kg respectively (United Kingdom).

In the 26 MSs participating in the survey approximately 5,300 million broilers were slaughtered in 2008. The United Kingdom had the highest slaughtered broiler population (about 800 million), followed by France (about 700 million), Spain (about 600 million), and Poland (about 550 million).

These figures were used for the weighting of the MSs' contribution to EU prevalences as previously described in Section 4.5.2. Although this may not have been the ideal weighting factor, it was the best available as neither information regarding the national numbers of broiler batches during 2008, nor regarding the size of the batches, was available.

Table 1. **Total number of slaughtered broilers during 2008 per country, in the EU* and two non-MSs**

Member State	Number of slaughtered broilers during 2008
Austria	63,000,000
Belgium	242,231,046
Bulgaria	35,748,456
Cyprus	11,131,064
Czech Republic	130,294,615
Denmark	101,966,833
Estonia	8,268,180
Finland	55,233,189
France	706,342,387
Germany	438,467,495
Hungary	107,948,558
Ireland	65,398,718
Italy	400,000,000
Latvia	13,906,030
Lithuania	8,228,000
Luxembourg	45,000
Malta	3,118,190
Netherlands	451,544,937
Poland	557,329,015
Portugal	173,068,852
Romania	160,743,265
Slovakia	52,995,538
Slovenia	34,086,375
Spain	594,734,107
Sweden	76,108,463
United Kingdom	816,216,431
Total EU (26 MSs)	**5,308,154,744**
Non-MSs	
Norway	62,234,900
Switzerland	48,535,714
Total (EU - 26 MSs and two non-MSs)	**5,418,925,358**

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

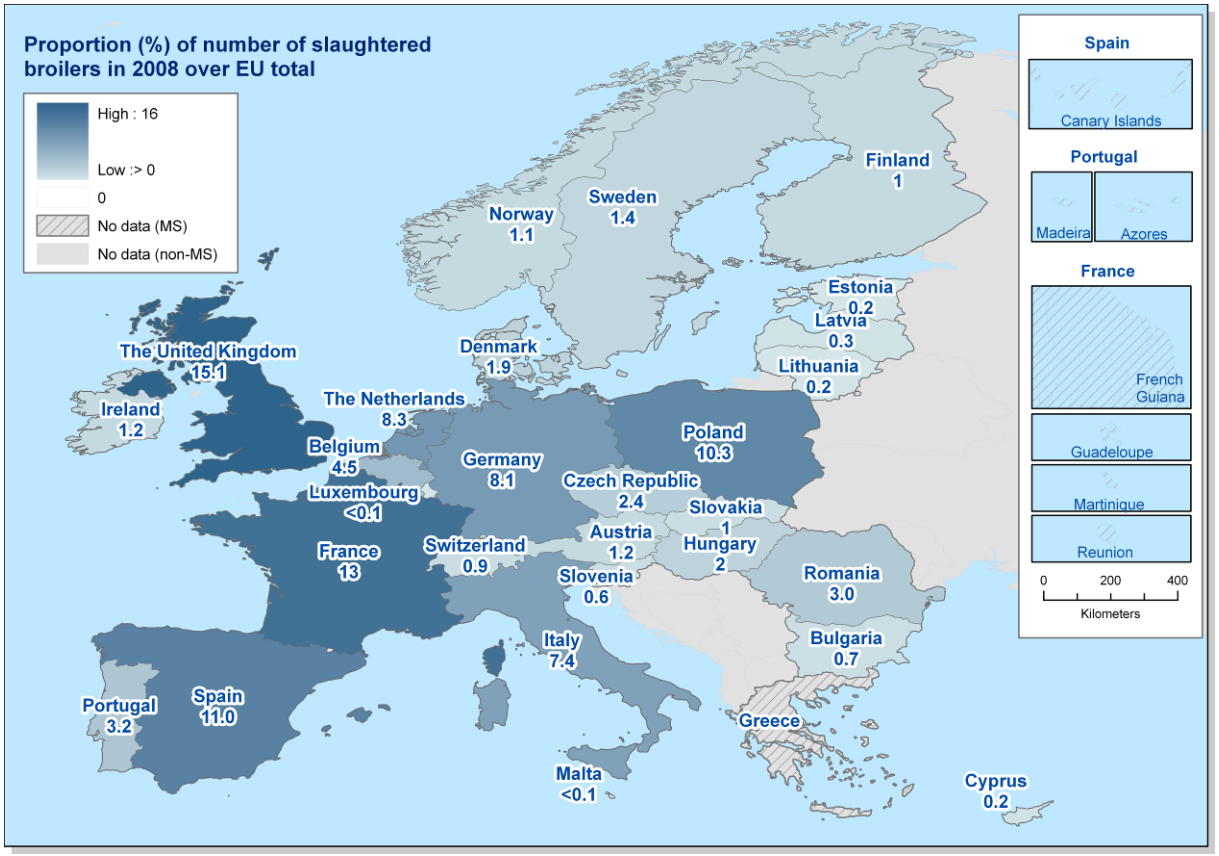

Figure 1. **Proportion of the number of slaughtered broilers in 2008 per country in the EU***

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

5.2. Sample summary statistics and protocol-sample comparison

The cleaned dataset contained data from 10,132 broiler batches sampled from 561 slaughterhouses in 26 MSs and in two non-MSs. Greece did not carry out the survey. This cleaned dataset formed the basis for all subsequent analyses.

The results of the descriptive analysis of this dataset are presented in Appendix C. An overview of the number of sampled broiler batches and slaughterhouses per MS is presented in Table 2. In the EU the total number of sampled slaughterhouses was 551 and varied from 549 for *Campylobacter* detection in caecal contents samples to 551 slaughterhouses for *Salmonella* detection on carcass samples. At national level the number of sampled slaughterhouses ranged from 1 in Estonia to 157 in Poland.

Similarly, the total number of sampled broiler batches in the EU was 9,324 and varied from 9,213 for *Campylobacter* detection/enumeration on carcass samples to 9,249 for *Salmonella* detection on carcass samples. At national level the number of sampled batches ranged from 15 in Luxembourg to 432 in Germany.

The distribution of the total number of analysed broiler batches by month of sampling, by country and in the EU is given in Appendix C (Figure 13). These distributions consider the total number of broiler batches which were sampled for at least one of the following methods: *Campylobacter* detection in pooled caecal contents samples, *Campylobacter* detection/enumeration on carcass samples and *Salmonella* detection on carcass samples. Sampling appears to be evenly distributed over the year for most of the participating countries, even though some MSs (Italy, Latvia, Luxembourg, Malta, Portugal and Romania) did not collect samples during 1 up to 8 months of 2008.

The distribution of the slaughterhouse capacity, i.e. number of slaughtered broilers per year is shown in Appendix C (Table 11) considering six categories by country and in the EU. At EU level, only 8.0% of the enrolled slaughterhouses had a capacity of < 100,000 birds whereas 44.3% slaughterhouses had a capacity of ≥ 5 million broilers slaughtered per year.

Table 2. **Overview of the validated dataset, number of slaughterhouses and samples analysed for *Campylobacter* in broiler batches and *Campylobacter* and *Salmonella* on broiler carcasses baseline survey in the EU*, 2008**

Country	Total		*Campylobacter* spp. broiler batches		*Campylobacter* spp. carcasses		*Salmonella* spp. carcasses	
	Slaughterhouses (N)	Broiler batches (N)	Slaughterhouses (N)	Pooled caecal samples (N)	Slaughterhouses (N)	Carcass samples (N)	Slaughterhouses (N)	Carcass samples (N)
Austria	5	408	5	408	5	408	5	408
Belgium	9	393	9	337	9	380	9	380
Bulgaria	16	316	15	275	15	280	16	316
Cyprus	25	375	25	375	25	357	25	357
Czech Republic	12	422	12	422	12	422	12	422
Denmark	4	396	4	396	4	396	4	396
Estonia	1	102	1	102	1	102	1	102
Finland	3	411	3	411	3	369	3	369
France	58	422	58	422	58	422	58	422
Germany	21	432	21	432	21	432	21	432
Hungary	44	321	44	321	44	321	44	321
Ireland	4	394	4	394	4	394	4	394
Italy	48	393	48	393	48	393	48	393
Latvia	2	122	2	122	2	122	2	122
Lithuania	6	374	6	374	6	374	6	374
Luxembourg	4	15	3	12	4	13	4	13
Malta	4	367	4	367	4	367	4	367
Poland	157	419	157	419	157	419	157	419
Portugal	15	421	15	421	15	421	15	421
Romania	16	357	16	357	16	357	16	357
Slovakia	7	422	7	422	7	422	7	422
Slovenia	3	413	3	413	3	413	3	413
Spain	38	389	38	389	38	389	38	389
Sweden	7	410	7	410	7	410	7	410
Netherlands	17	429	17	429	17	429	17	429
United Kingdom	25	401	25	401	25	401	25	401
EU (26 MS) *	**551**	**9,324**	**549**	**9,224**	**550**	**9,213**	**551**	**9,249**
Norway	5	396	5	396	5	396	5	396
Switzerland	5	412	5	296	5	408	5	390

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

5.3. *Campylobacter* survey results

5.3.1. Prevalence of *Campylobacter*-colonised broiler batches

The prevalence of *Campylobacter*-colonised broiler batches at EU level as well as in each MS and two non-MSs are presented in Table 3.

Campylobacter was detected in broiler batches in all participating MSs and both non-MSs. The EU prevalence was 71.2% (95% CI: 68.5; 73.7). Prevalence of *Campylobacter*-colonised broiler batches (Table 3) in MSs ranged from a minimum of 2.0% (Estonia) to a maximum of 100.0% (Luxembourg). The median of MS prevalence of *Campylobacter*-colonised broiler batches was 57.1% (Figure 2). Figure 3 displays the geographic distribution of this prevalence.

C. jejuni was detected in broiler batches in all participating MSs and both non-MSs (Table 15 in Appendix D). The EU prevalence was 40.6% (95% CI: 38.3; 42.9). The MS-specific prevalence in the EU ranged from a minimum of 2.0% (Estonia) to a maximum of 56.4% (Slovakia). The median of the MS prevalence of *C. jejuni* colonised broiler batches was 30.7% (Figure 14 in Appendix D).

C. coli was detected in broiler batches in most MSs with the exception of Estonia, Finland and Sweden and of the non-MS Norway (Table 16 in Appendix D). The EU prevalence was 31.9% (95% CI: 29.2; 34.8). The MS-specific prevalence in the EU ranged from a minimum of 0% (Estonia, Finland and Sweden) to a maximum of 91.9% (Luxembourg). The median of the MS prevalence of *C. coli*-colonised broiler batches was 20.7% (Figure 15 in Appendix D).

By way of derogation, Estonia, Latvia and Luxembourg were allowed to sample less batches and this translated in a comparatively wider 95% CI for these MSs.

In Appendix C the proportions (%) of *Campylobacter*-positive broiler batches, meaning the number of *Campylobacter*-positive broiler batches out of the total number of collected batches, for each of the *Campylobacter* outcomes, are presented at both national and EU levels. These proportions do not take account of any analytical strategies to correct for design aspects, such as clustering, mentioned in section 4.5.2. The unweighted EU level proportion of batches positive to *Campylobacter*, *C. jejuni* and *C. coli* were lower than the weighted estimates of the EU level *Campylobacter*, *C. jejuni* and *C. coli* prevalence. These differences were due to the weights that were assigned to broiler batches from MSs with higher slaughter populations combined with a relatively high prevalence of infection in broiler batches in these MSs.

Table 3. **Prevalence of *Campylobacter*-colonised broiler batches, by country and in the EU*, 2008**

Country	N (No of broiler batches)	% prevalence[3]	95% CI[3]
Austria	408	47.8[4]	41.5[4] - 54.2[4]
Belgium	337	31.0	23.6 - 39.4
Bulgaria	275	29.6	21.9 - 38.6
Cyprus	375	30.6	25.7 - 36.0
Czech Republic	422	61.3	56.1 - 66.3
Denmark	396	19.0	15.9 - 22.6
Estonia	102	2.0[1]	0.5[1] - 7.5[1]
Finland	411	3.9	3.8 - 4.0
France	422	76.1	70.4 - 81.0
Germany	432	48.9	40.3 - 57.7
Hungary	321	50.1	44.5 - 55.7
Ireland	394	83.1	75.2 - 88.8
Italy	393	63.3	54.5 - 71.3
Latvia	122	41.0	17.0 - 70.2
Lithuania	374	41.5	40.7 - 42.2
Luxembourg	12	100	73.5[2] - 100[2]
Malta	367	96.8	95.0 - 98.0
Netherlands	429	24.4	20.3 - 29.0
Poland	419	78.9	74.1 - 83.0
Portugal	421	82.0	76.3 - 86.6
Romania	357	77.0	63.9 - 86.4
Slovakia	422	73.6	63.6 - 81.6
Slovenia	413	78.2	78.1 - 78.2
Spain	389	88.0	84.0 - 91.2
Sweden	410	13.2	8.0 - 21.0
United Kingdom	401	75.3	69.9 - 80.1
EU (26 MS)*	**9,224**	**71.2**	**68.5 - 73.7**
Norway	396	3.2	2.1 - 4.8
Switzerland	296	59.0	55.0 - 62.9

[1] As one slaughterhouse contributed to the entire survey, point estimate and 95% CI are based on logistic regression.

[2] Exact binomial CI, the clustering of data is not taken into account.

[3] Prevalence estimates and CIs at national as well as at EU level were obtained taking into account correlation among observations within the same slaughterhouse. In addition, at EU level, prevalence estimates and CIs were weighted for the national numbers of slaughtered broilers during 2008.

[4] Results assuming independent covariance structure.

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

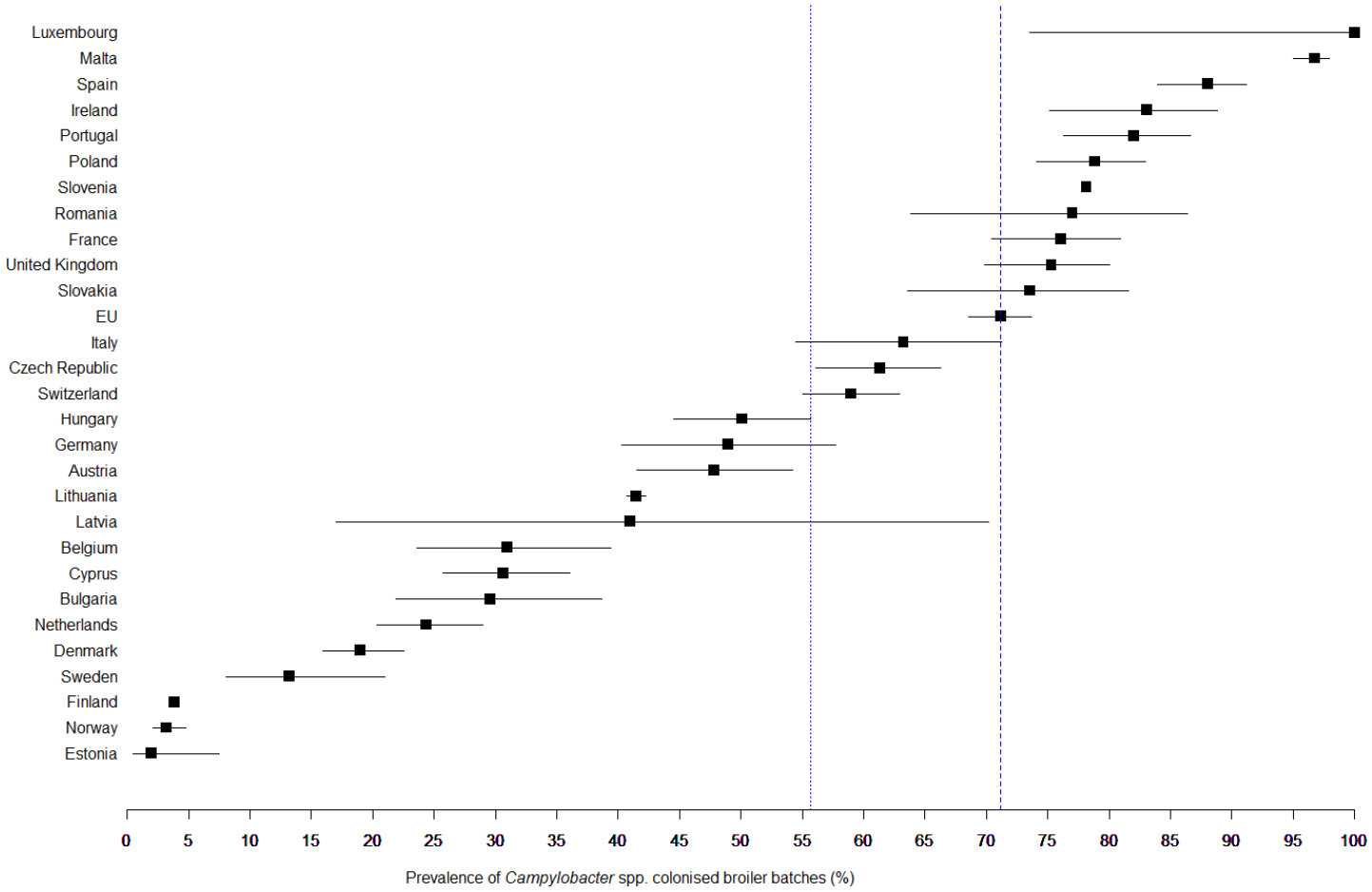

Figure 2. **Prevalence of *Campylobacter*-colonised broiler batches by country and at EU* level (dashed line), 2008. The dotted line indicates the median prevalence of 26 participating MSs. Horizontal lines indicate 95% CIs of prevalence**

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

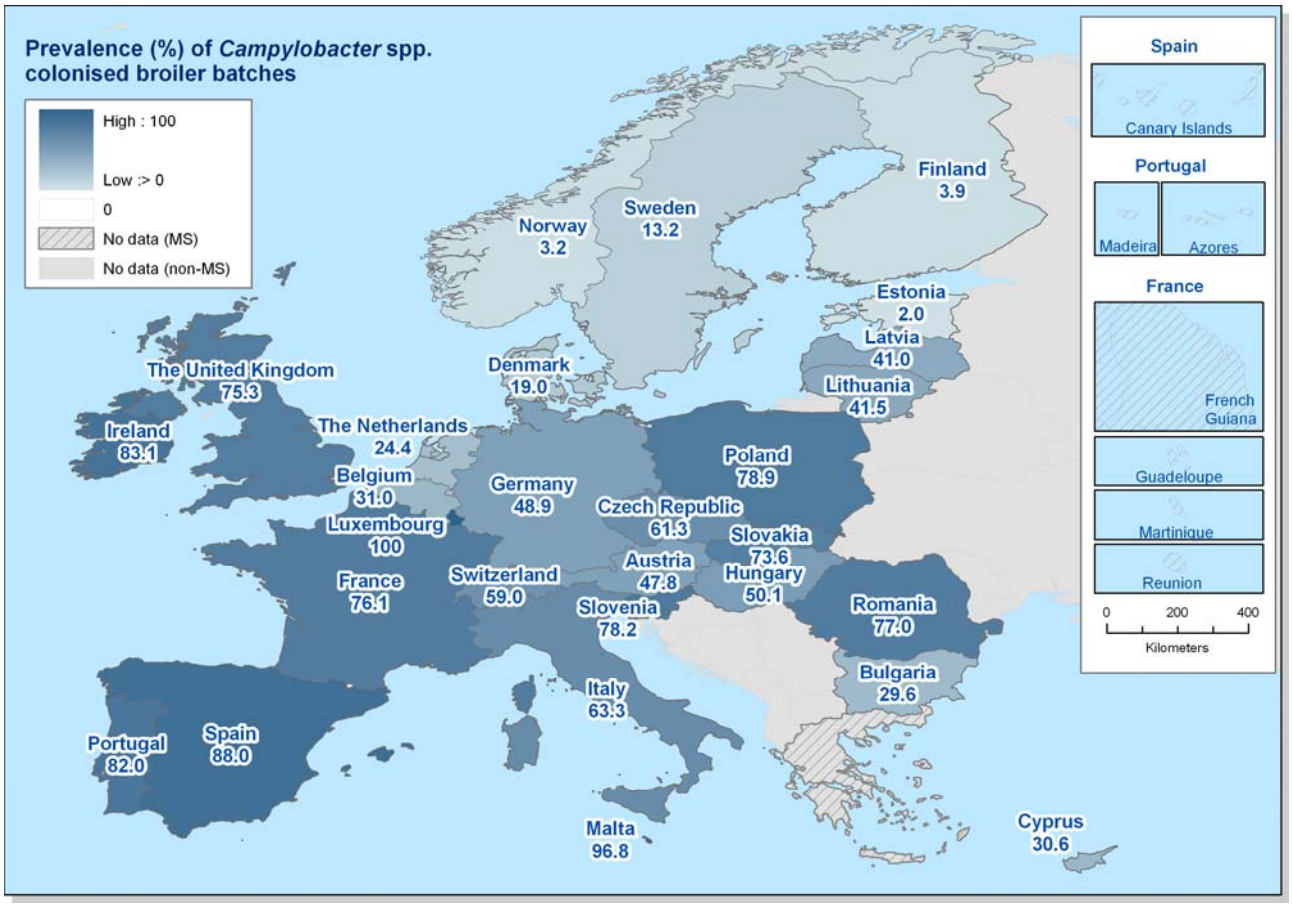

Figure 3. **Prevalence of *Campylobacter*-colonised broiler batches in the EU*, 2008**

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

5.3.2. Prevalence of Campylobacter-contaminated broiler carcasses

The prevalence of *Campylobacter*-contaminated broiler carcasses at EU level, as well as in each MS and both non-MSs, based upon any detected *Campylobacter* by either the detection method or the enumeration method, are presented in Table 4.

Campylobacter was detected on broiler carcasses in all participating MSs and both non-MSs. The EU prevalence was 75.8% (95% CI: 74.3; 79.4). MS prevalence ranged from a minimum of 4.9% (Estonia) to a maximum of 100.0% (Luxembourg) (Table 4). The median of MS prevalence of *Campylobacter*-contaminated broiler carcasses was 62.5% (Figure 4). Figure 5 displays the geographic distribution of these prevalences.

C. jejuni was detected on broiler carcasses in all participating MSs and both non-MSs. The EU prevalence, based on the combined results of the detection and enumeration method, was 51.0% (95% CI: 48.3; 53.7). MS prevalence ranged from a minimum of 4.9% (Estonia) to a maximum of 72.0% (France) (Table 17 in Appendix E). The median of the MS prevalence of *C. jejuni*-contaminated broiler carcasses was 39.7% (Figure 16 in Appendix E).

C. coli was detected on broiler carcasses in most MSs with the exception of Estonia, Finland and Sweden and of the non-MS, Norway. The EU prevalence was 35.5% (95% CI: 32.6; 38.5). MS prevalence ranged from a minimum of 0.0% (Estonia, Finland and Sweden) to a maximum of 75.0% (Luxembourg) (Table 18 in Appendix E). The median was the MS prevalence of *C. coli*-contaminated broiler carcasses was 21.6% (Figure 17 in Appendix E).

By way of derogation, Estonia, Latvia and Luxembourg were allowed to sample less carcasses and this translated into a wider 95% CI for these.

In Appendix C, the proportions (%) of *Campylobacter*-positive carcasses, meaning the number of *Campylobacter*-positive carcasses out of the total number of collected carcasses, for each of the *Campylobacter* outcomes, are presented at both national and EU levels. These proportions do not take account of any analytical strategies to correct for design aspects, such as clustering, mentioned in section 4.5.2. This unweighted EU level proportion of carcasses positive to the *Campylobacter* outcomes was lower than the estimates of the EU level prevalence of those outcomes. These differences were due to the weights that were assigned to broiler carcasses from MSs with higher slaughter populations combined with a relatively high prevalence of carcass contamination in these MSs.

Table 4. **Prevalence of *Campylobacter*-contaminated broiler carcasses, based on the combined results of the detection and enumeration method, by country and in the EU*, 2008**

Country	N (No of broiler batches)	% prevalence[3]	95% CI[3]
Austria	408	80.6	76.7 - 83.9
Belgium	380	52.7	44.8 - 60.5
Bulgaria	280	45.2	38.9 - 51.7
Cyprus	357	14.1	14.0 - 14.2
Czech Republic	422	68.6	65.5 - 71.5
Denmark	396	31.4	26.1 - 37.2
Estonia	102	4.9[1]	2.1[1] - 11.2[1]
Finland	369	5.5	5.4 - 5.5
France	422	88.7	84.3 - 91.9
Germany	432	60.8	53.6 - 67.7
Hungary	321	55.3	48.9 - 61.6
Ireland	394	98.3	98.0 - 98.5
Italy	393	49.6	39.5 - 59.7
Latvia	122	33.6	11.3 - 66.7
Lithuania	374	45.8	42.0 - 49.6
Luxembourg[2]	13	100	75.3[3] - 100[3]
Malta	367	94.3	93.6 - 95.0
Netherlands	429	37.6	31.8 - 43.7
Poland	419	80.4	75.8 - 84.3
Portugal	421	70.2	58.7 - 79.7
Romania	357	64.2	51.9 - 75.0
Slovakia	422	79.1	68.8 - 86.7
Slovenia	413	77.8	70.7 - 83.6
Spain	389	92.6	89.8 - 94.7
Sweden	410	14.6	8.4 - 24.2
United Kingdom	401	86.3	79.6 - 91.0
EU (26 MS)*	**9,213**	**75.8**	**73.2 - 78.3**
Norway	396	5.1	3.1 - 8.3
Switzerland	408	71.7	63.8 - 78.5

[1] As one slaughterhouse contributed to the entire survey, point estimate and 95% CI are based on logistic regression.

[2] Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples.

[3] Prevalence estimates and CIs at national as well as at EU level were obtained taking into account correlation among observations within the same slaughterhouse. In addition, at EU level, prevalence estimates and CIs were weighted for the national numbers of slaughtered broilers during 2008.

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

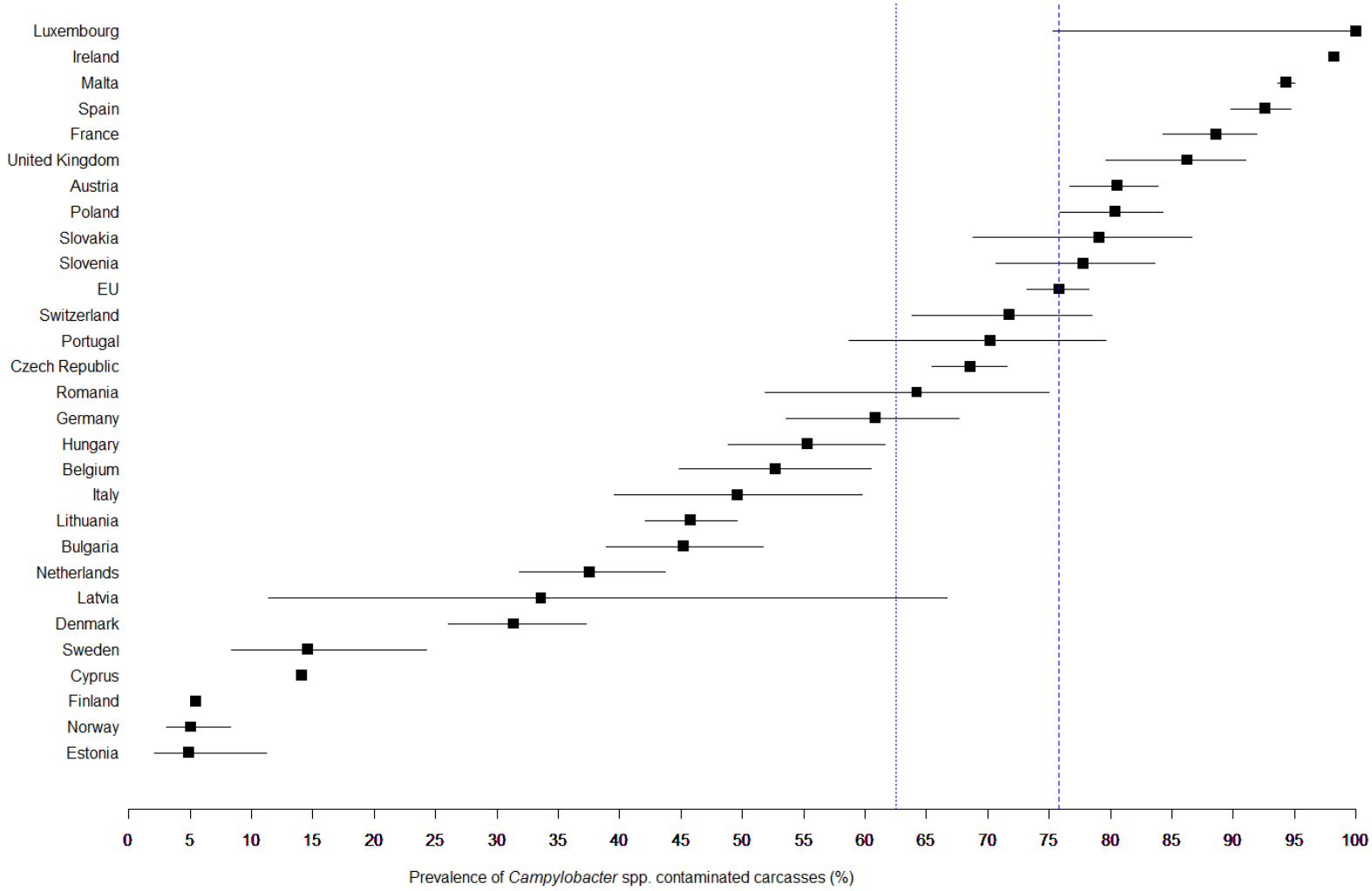

Figure 4. **Prevalence of *Campylobacter*-contaminated broiler carcasses, based on the combined detection and enumeration method, by country and at the EU* level (dashed line), 2008. The dotted line indicates the median prevalence of 26 participating MSs. Horizontal lines indicate 95% CIs of prevalence. Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples**

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

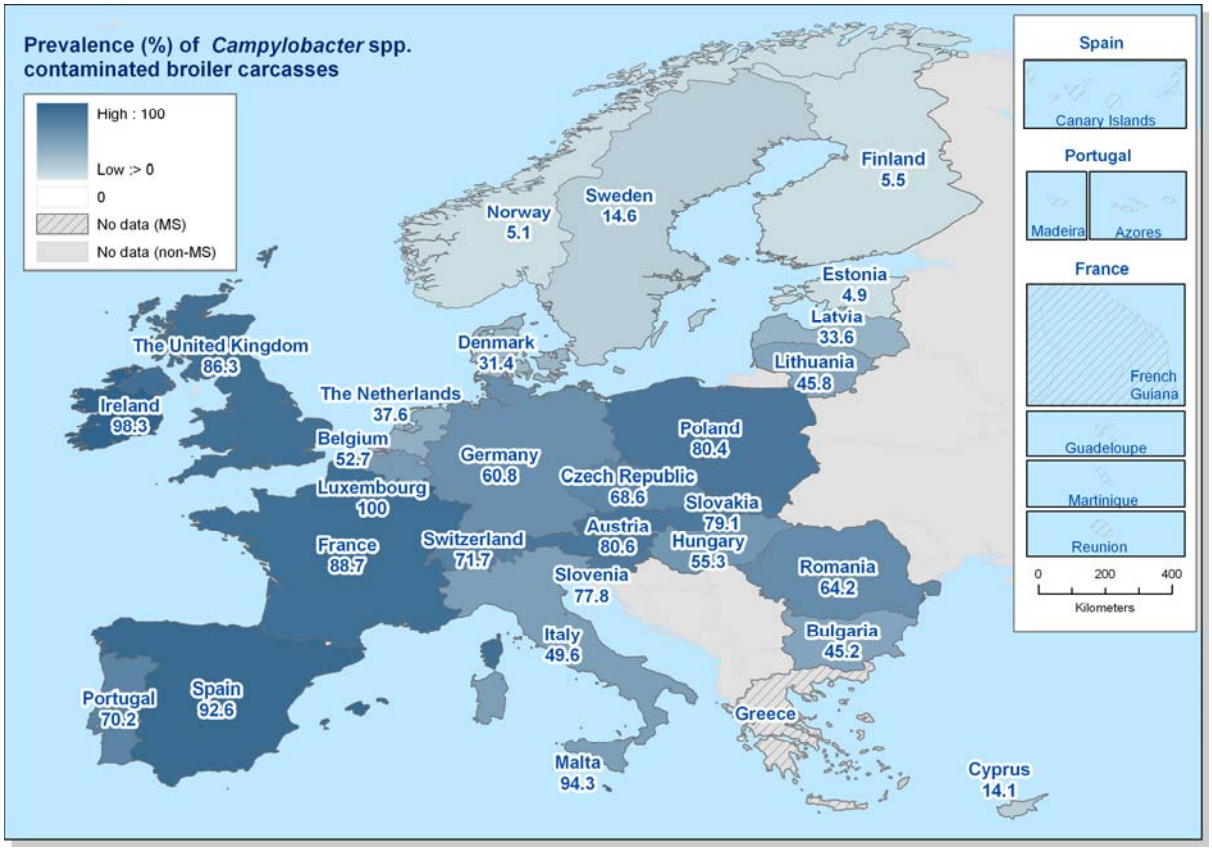

Figure 5. **Prevalence of *Campylobacter*-contaminated broiler carcasses, based on the combined results of the detection and enumeration method in the EU*, 2008**

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

5.3.3. *Campylobacter* enumeration results on broiler carcasses

As an exception in this baseline survey, Luxembourg did not perform *Campylobacter* enumeration on carcass samples.

The results of the *Campylobacter* enumeration on broiler carcasses were categorised as follows: < 10 cfu/g; 10-39 cfu/g; 40-99 cfu/g; 100-1,000 cfu/g; 1,000-10,000 cfu/g and > 10,000 cfu/g. *Campylobacter* counts < 10 cfu/g of neck skin together with breast skin correspond to the absence of *Campylobacter* detection in the enumeration method, *i.e.* less than one *Campylobacter* colony detected in the initial carcass samples suspension. The reason for grouping counts between 10 and 39 cfu/g into one separate category were that counts below 40 are considered of too low a precision and are normally reported as 'presence of *Campylobacter*', in agreement with ISO 7218: 2007.

At Community level, the percentages of broiler carcass samples with enumeration results (cfu/g of neck skin together with breast skin) below 10, between 10-99, between 100-999, between 1,000-10,000 and above 10,000 were 46.6%, 12.5%, 19.3%, 15.8% and 5.8%, respectively.

The *Campylobacter* enumeration results on broiler carcasses showed a huge variation at country-specific level (Table 5). All countries apart from Norway counted *Campylobacter* between 1,000-10,000 cfu/g of neck skin together with breast skin in some samples and all but six countries (Cyprus, Estonia, Finland, Latvia, Sweden and Norway) counted >10,000 cfu/g of neck skin together with breast skin. The proportion of samples with enumeration results below 10 cfu/g varied from 3.8% in Ireland to 98.7% in Norway,

whereas the proportion of samples with enumeration results above 10,000 cfu/g varied from 0% in Cyprus, Estonia, Finland, Latvia, Sweden and Norway to 31.9% in Malta.

Some countries (Ireland, Norway, the Netherlands, Poland, Portugal and the United Kingdom) used a modification of the ISO standard for the *Campylobacter* enumeration with a higher analytical sensitivity allowing values below 10 cfu/g to be detected. It was decided that positive results obtained by this adapted enumeration method were considered positive for the purpose of the estimation of the prevalence of *Campylobacter*-contaminated carcasses. On the contrary, in the descriptive barplot of the *Campylobacter* enumeration results showing the dichotomised positive counts and negative (zero) counts (Figure 6), these positive results were included in the negative (zero) counts category. The bars corresponding to individual countries were ranked according to increasing proportion of *Campylobacter* positive enumeration results.

When comparing MS-specific figures for the prevalence of *Campylobacter*-colonised broiler batches (Table 3 and Figure 2), and *Campylobacter*-contaminated broiler carcasses (Table 4 and Figure 4) with *Campylobacter* enumeration results (Figure 7), a tendency can be observed for countries having a higher *Campylobacter* prevalence in both slaughter batches and carcasses, to have higher quantitative loads on carcasses.

Figure 7 shows exclusively the barplots of the positive counts, *i.e.* ≥ 10 cfu/g.

The cumulative percent distribution functions of the $\log_{10}$ transformed *Campylobacter* counts on broiler carcasses at EU as well as at national levels are presented in Appendix F, Figure 18.

The boxplot in Figure 19 of Appendix F shows the $\log_{10}$ transformed *Campylobacter* counts on broiler carcasses at EU level as well as the national level ranked according to the prevalence estimates.

Table 5. **Categorised *Campylobacter* counts present on broiler carcasses, in the EU*, 2008**

Country	*Campylobacter* enumeration						Total
	<10 cfu/g	10-39 cfu/g	40-99 cfu/g	100-999 cfu/g	1,000-10,000 cfu/g	>10,000 cfu/g	
Austria	146	37	45	86	63	31	408
	35.8	*9.1*	*11.0*	*21.1*	*15.4*	*7.6*	*100*
Belgium	188	20	19	74	66	13	380
	49.5	*5.3*	*5.0*	*19.5*	*17.4*	*3.4*	*100*
Bulgaria	163	1	15	52	28	21	280
	58.2	*0.4*	*5.4*	*18.6*	*10.0*	*7.5*	*100*
Cyprus	352	0	1	2	2	0	357
	98.6	*0*	*0.3*	*0.6*	*0.6*	*0*	*100*
Czech Republic	205	4	8	92	78	35	422
	48.6	*1.0*	*1.9*	*21.8*	*18.5*	*8.3*	*100*
Denmark	302	10	11	38	29	6	396
	76.3	*2.5*	*2.8*	*9.6*	*7.3*	*1.5*	*100*
Estonia	100	0	1	0	1	0	102
	98.0	*0*	*1.0*	*0*	*1.0*	*0*	*100*
Finland	361	4	2	1	1	0	369
	97.8	*1.1*	*0.5*	*0.3*	*0.3*	*0*	*100*
France	102	54	47	154	54	11	422
	24.2	*12.8*	*11.1*	*36.5*	*12.8*	*2.6*	*100*
Germany	246	27	19	73	50	17	432
	56.9	*6.3*	*4.4*	*16.9*	*11.6*	*3.9*	*100*
Hungary	161	37	18	65	25	15	321
	50.2	*11.5*	*5.6*	*20.3*	*7.8*	*4.7*	*100*
Ireland	15	60	27	127	130	35	394
	3.8	*15.2*	*6.9*	*32.2*	*33.0*	*8.9*	*100*
Italy	246	23	13	62	34	15	393
	62.6	*5.9*	*3.3*	*15.8*	*8.7*	*3.8*	*100*
Latvia	81	14	5	17	5	0	122
	66.4	*11.5*	*4.1*	*13.9*	*4.1*	*0*	*100*
Lithuania	202	74	18	60	18	2	374
	54.0	*19.8*	*4.8*	*16.0*	*4.8*	*0.5*	*100*
Malta	20	1	5	49	175	117	367
	5.5	*0.3*	*1.4*	*13.4*	*47.7*	*31.9*	*100*
Netherlands	290	21	10	63	35	10	429
	67.6	*4.9*	*2.3*	*14.7*	*8.2*	*2.3*	*100*
Poland	98	15	16	135	122	33	419
	23.4	*3.6*	*3.8*	*32.2*	*29.1*	*7.9*	*100*
Portugal	164	32	19	104	84	18	421
	39.0	*7.6*	*4.5*	*24.7*	*20.0*	*4.3*	*100*
Romania	132	4	8	43	119	51	357
	37.0	*1.1*	*2.2*	*12.0*	*33.3*	*14.3*	*100*
Slovakia	132	20	33	108	107	22	422
	31.3	*4.7*	*7.8*	*25.6*	*25.4*	*5.2*	*100*
Slovenia	80	161	51	97	23	1	413
	19.4	*39.0*	*12.4*	*23.5*	*5.6*	*0.2*	*100*
Spain	29	42	16	130	110	62	389
	7.5	*10.8*	*4.1*	*33.4*	*28.3*	*15.9*	*100*
Sweden	373	9	9	15	4	0	410
	91.0	*2.2*	*2.2*	*3.7*	*1.0*	*0*	*100*
United Kingdom	132	15	20	125	90	19	401
	32.9	*3.7*	*5.0*	*31.2*	*22.4*	*4.7*	*100*
EU Total (25 MSs)*	4,320	685	436	1,772	1,453	534	9,200
	47.0	*7.5*	*4.7*	*19.3*	*15.8*	*5.8*	*100*
Norway	391	2	1	2	0	0	396
	98.7	*0.5*	*0.3*	*0.5*	*0*	*0*	*100*
Switzerland	196	21	19	89	70	13	408
	48.0	*5.2*	*4.7*	*21.8*	*17.2*	*3.2*	*100*

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

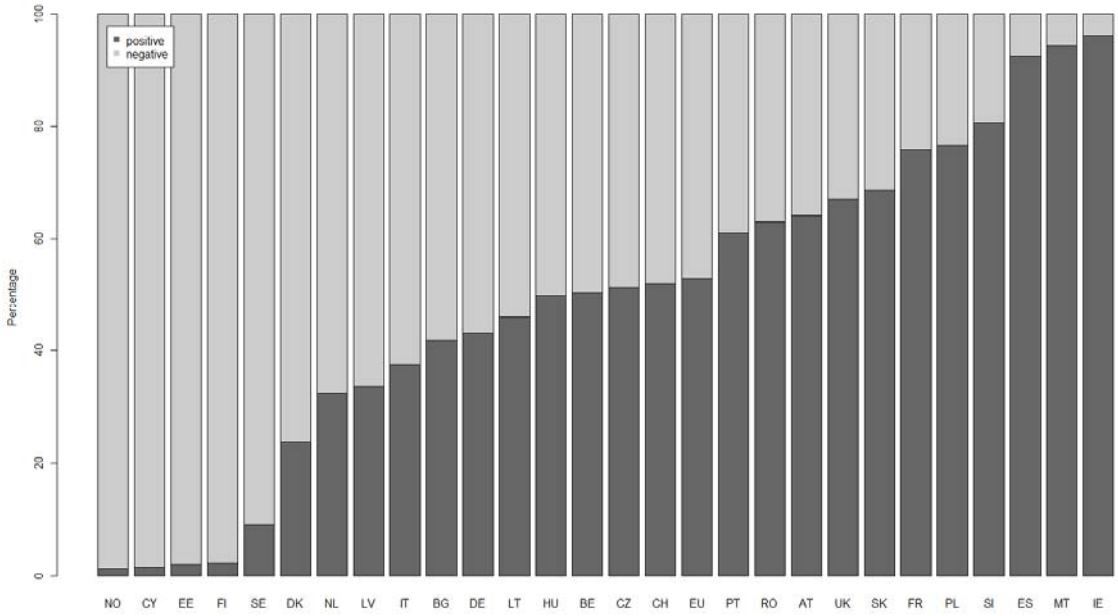

Figure 6. **Barplot of the *Campylobacter* enumeration results in broiler carcasses showing two categories: negative (<10 cfu/g of neck skin together with breast skin) and positive (≥10 cfu/g of neck skin together with breast skin), by country and in the EU*, 2008**

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

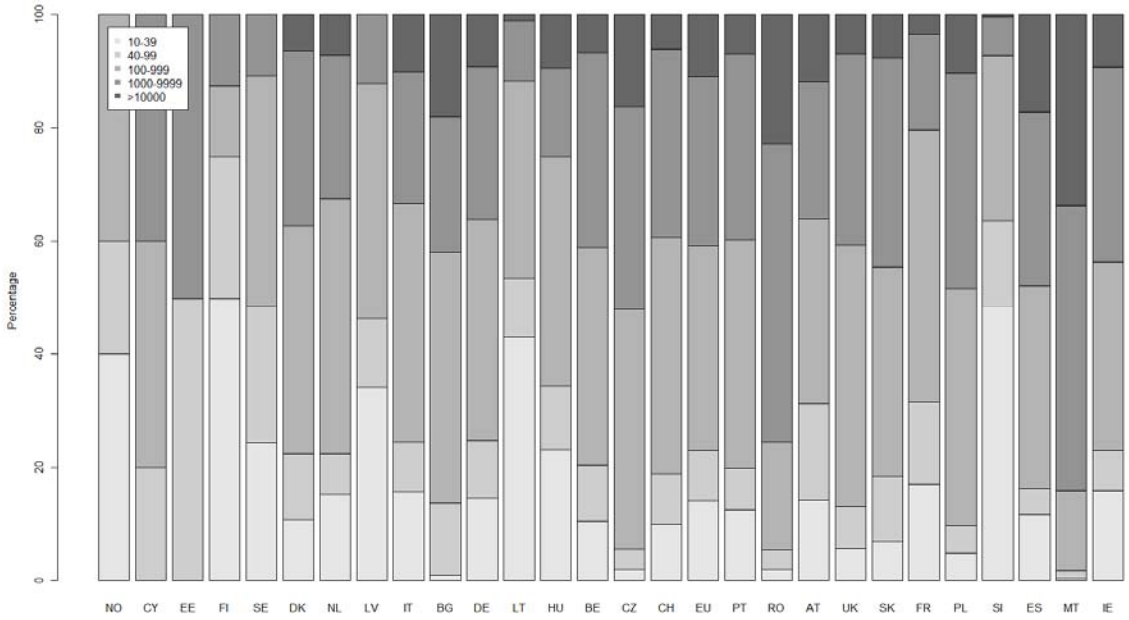

Figure 7. **Barplot of the *Campylobacter* enumeration results distributions in broiler carcasses showing five categories (10-39; 40-99; 100-999; 1,000-9999; >10,000 cfu/g of neck skin together with breast skin) and excluding counts <10 cfu/g of neck skin together with breast skin, by country and in the EU*, 2008**

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

5.3.4. Measurement uncertainty of the *Campylobacter* enumeration

A summary of the raw data on the laboratory-specific MU estimation of the *Campylobacter* enumeration results (counts of *Campylobacter*) on broiler carcass samples is included in Appendix G (Table 19).

No MU was estimated in Luxembourg, as it did not perform *Campylobacter* enumeration. Most of the MSs (20 out of 25) and both non-MSs performing *Campylobacter* enumeration generated one MU estimate. The remaining five MSs submitted two to eight MU estimates according to the number of national laboratories performing *Campylobacter* enumeration. In total 41 MU estimates were submitted among the participating countries.

- Most of the countries used naturally contaminated samples from this baseline survey for the MU estimations, except for Estonia, Finland, Sweden and Norway which also used spiked (artificially contaminated) samples in addition to some naturally contaminated samples.
- For 28 out of 41 MU estimations, data were collected from May to September as recommended to increase the chance of obtaining positive samples. For the remaining 13 MU estimations, data were collected at different periods throughout 2008.

The MU estimated throughout laboratories in all countries participating in this baseline survey ranged from 0.06 $\log_{10}$ cfu/g to 0.70 $\log_{10}$ cfu/g.

5.3.5. Frequency distribution of *Campylobacter* species

Analyses of frequency distributions at European and country-specific level were made with the contribution of Norwegian and Swiss isolates.

5.3.5.1. Frequency distribution of *Campylobacter* species in pooled caecal contents of broilers (based on detection)

The frequency distribution of isolated *Campylobacter* species in the pooled caecal contents of broilers in the EU and two non-MSs is listed in Table 6.

In total 5,457 isolates were reported from 5,255 positive pooled caecal content samples (positive broiler batches). *C. jejuni* was found in 60.8% positive batches, *C. coli* and *C. lari* were detected in 41.5% and 0.2%, respectively, and other *Campylobacter*. spp were isolated in 1.4% of positive broiler batches.

Table 6. **Frequency distributions of *Campylobacter* species obtained by the detection method in colonised broiler batches, in the EU*, 2008**

EU (26 MSs) and two non-MSs			
***Campylobacter* species in broiler batches**	**No of batches**	**% of batches with species[b] (N=5,255[a])**	**No of countries with species**
C. jejuni	3,193	*60.8*	28
C. coli	2,180	*41.5*	24
Other *C.* spp.**	72	*1.4*	8
C. lari	12	*0.2*	5

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

** Other *Campylobacter* spp. = unidentified.

[a] The total number of broiler batchesincludes all batches where at least one *Campylobacter* species was isolated.

[b] Percentage of broiler batches that were positive for each *Campylobacter* species.

MS-specific overviews of the frequency distribution of *Campylobacter* species in broiler batches are shown in Appendix H (Table 20). This table shows that *C. jejuni* was the most commonly reported species in 19 MSs and two non-MSs with up to 100% of this species identified among isolates in Estonia, Finland, Sweden and Norway. In seven MSs (Bulgaria, Hungary, Italy, Luxembourg, Malta, Portugal and Spain) *C. coli* was the most commonly isolated species in broiler batches, with up to 76.1% and 91.7% of this species identified among batches in Malta and Luxembourg, respectively.

5.3.5.2. Frequency distribution of *Campylobacter* species on broiler carcasses (based on detection)

The frequency distribution of isolated *Campylobacter* species on broiler carcasses in the EU and two non-MSs based on detection testing is listed in Table 7.

In total 6,030 *Campylobacter* isolates were identified from the 5,558 positive broiler carcasses, *C. jejuni* was detected in 67.9% positive samples, *C. coli* and *C. lari* were isolated in 39.4% and 0.3% of positive carcass samples respectively, while other *Campylobacter* spp. were detected in 0.9 % positive samples.

Table 7. **Frequency distributions of *Campylobacter* species obtained by the detection method on contaminated broiler carcasses in the EU*, 2008**

EU (26 MSs) and two non-MSs			
***Campylobacter* species on broiler carcasses (detection)**	**No of carcasses**	**% of carcasses with species[b] (N=5,558[a])**	**No of countries with species**
C. jejuni	3,775	*67.9*	28
C. coli	2,191	*39.4*	24
Other *C.* spp.**	49	*0.9*	9
C. lari	15	*0.3*	7

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

** Other *Campylobacter* spp. = unidentified.

[a] The total number of broiler carcasses includes all carcasses where at least one *Campylobacter* species was isolated.

[b] Percentage of broiler carcasses that were positive for each *Campylobacter* species.

MS-specific overviews of the frequency distribution of *Campylobacter* species on contaminated broiler carcasses (based on detection) are shown in Table 21 in Appendix I. The appendix shows that *C. jejuni* was the most commonly reported species in 20 MSs and two non-MSs with up to 100% of this species identified among isolates in Estonia, Finland, Sweden and Norway. In six MSs (Bulgaria, Ireland, Italy, Luxembourg, Malta and Spain), *C. coli* was the most commonly isolated species on broiler carcasses based on detection with up to 72.8% and 76.9% of this species identified among carcasses in Spain and Luxembourg, respectively.

5.3.5.3. Frequency distribution of *Campylobacter* species on broiler carcasses (based on enumeration)

The frequency distribution of isolated *Campylobacter* species on broiler carcasses (based on enumeration) in the EU and two non-MSs is listed in Table 8.

In total, 1,802 *Campylobacter* isolates were identified from the 1,712 positive broiler carcasses. *C. jejuni* was found in 62.6% of positive samples, *C. coli* and *C. lari* in 32.7%, and 0.4%, respectively, while in 4.1% of positive samples "other *C.* spp." were identified. Up to 5.5% of isolates were not speciated.

Table 8. **Frequency distributions of *Campylobacter* species obtained by the enumeration method on contaminated broiler carcasses in the EU*, 2008**

EU (26 MSs) and two non-MSs			
***Campylobacter* species on broiler carcasses (enumeration)**	**No of carcasses**	**% of carcasses with species[b] (N=1,712[a])**	**No of countries with species**
C. jejuni	1,072	*62.6*	19
C. coli	560	*32.7*	14
Not done ***	94	*5.5*	3
Other *C.* spp.**	70	*4.1*	5
C. lari	8	*0.5*	4

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

** Other *Campylobacter* spp. = unidentified.

*** Speciation of *Campylobacter* isolates recovered by the enumeration method was only mandatory if the result of the detection method from the same broiler carcass was negative.

[a] The total number of broiler carcasses includes all carcasses where at least one *Campylobacter* species was isolated.

[b] Percentage of broiler carcasses that were positive for each *Campylobacter* species.

MS-specific overviews of the frequency distribution of *Campylobacter* species on broiler carcasses (based on enumeration) are shown in Table 22 of Appendix I. This table shows that, for the 11 MSs that speciated at least 25 isolates, *C. jejuni* was the most commonly reported species in 10 MSs whereas in Malta *C. coli* was more frequently reported, based on the speciation by the enumeration test. Five MSs reported 'Other *Campylobacter* species'. This means in most cases that the species was unknown or unidentifiable. In Spain all species were categorised as 'other *Campylobacter* spp.'. Denmark did not speciate the isolates recovered by this method.

In some MSs (Ireland, Italy, Slovakia and Spain) the results of the *Campylobacter* speciation based on detection as compared to enumeration on broiler carcasses differed considerably. However, the usefulness of this comparison is very limited because the speciation of *Campylobacter* isolates obtained through the enumeration method was only mandatory when negative results of the *Campylobacter* detection were observed in the same samples. Indeed, Appendix I shows that 14 out of 22 countries with positive enumeration results speciated a low number of *Campylobacter* isolates from this test, from 1 to 44.

5.3.6. Overview of the quality-control of the *Campylobacter* analysis

As described in Commission Decision 2007/516/EC Annex I, a proportion of *Campylobacter* isolates, i.e. a maximum of eight isolates from caecal contents samples and eight isolates from carcass samples, were to be submitted to the Community Reference Laboratory (CRL)-*Campylobacter* for confirmation and speciation.

A total of 456 isolates from 26 MSs and two non-MS were submitted to the CRL *Campylobacter* for confirmation and species identification. Twenty-two of the submissions (4.8%) could not be analysed by the CRL as the isolates were either dead/non-viable or heavily contaminated. The remaining 434 isolates were analysed by phenotyping and PCR methods. For the majority of isolates (91.7%) the identifications made by the NRLs and CRL corresponded. For 36 isolates, the identifications made by the NRLs and the CRL did not correspond or the NRLs were not able to obtain a conclusive species identification. The most common diverging result was due to the identification of *C. coli* as *C. jejuni* or *C. jejuni* as *C. coli* (17 isolates). Five submitted "isolates" consisting of a mixture of *C. jejuni* and *C. coli* and three isolates were not *Campylobacter* species but belonged to the closely related genera *Arcobacter* and *Helicobacter*.

5.4. *Salmonella* survey results

5.4.1. Prevalence of *Salmonella*-contaminated broiler carcasses

In Appendix C the proportions (%) of *Salmonella*-positive carcasses, meaning the number of *Salmonella*-positive carcasses out of the total number of collected carcasses, for each of the *Salmonella* outcomes, are presented at both national and EU levels. These proportions do not take account of any design aspect mentioned in section 4.5.2.

The prevalence of *Salmonella*-contaminated broiler carcasses at EU level as well as in each MS and both non-MSs are presented in Table 9.

Salmonella was detected on broiler carcasses in all participating countries with the exception of Denmark, Estonia, Finland and Luxembourg and of the non-MS Norway. The EU prevalence was 15.6% (95% CI: 13.6; 17.9). MS prevalence ranged from a minimum of 0% to a maximum of 85.6% (Hungary). Figure 8 shows that seven MSs have a prevalence higher than the EU prevalence. Figure 9 displays the geographic distribution of MS prevalence of *Salmonella*-contaminated broiler carcasses.

Salmonella Enteritidis and/or *Salmonella* Typhimurium were detected on broiler carcasses in 17 MSs and in one non-MS. The EU prevalence was 3.6% (95% CI: 2.8; 4.6) (Table 9). Prevalence in the EU ranged from a minimum of 0% (Cyprus, Denmark, Estonia, Finland, Ireland, Luxembourg, Malta, Sweden and the United Kingdom) to a maximum of 9.6% (Poland). Figure 10 shows that seven MSs had a national prevalence higher than the EU prevalence.

Serovars other than *Salmonella* Enteritidis and/or *Salmonella* Typhimurium were detected on broiler carcasses in 21 MSs and in one non-MS. The EU prevalence was 11.2% (95% CI: 9.5; 13.0). Prevalence in the EU ranged from a minimum of 0% (Denmark, Estonia, Finland, Latvia and Luxembourg) to a maximum of 83.7% (Hungary) (Table 9). Figure 11 shows that seven MSs had a national prevalence higher than the EU prevalence.

An additional median line to facilitate the description of the *Salmonella* prevalence at national level was deemed unnecessary, as the *Salmonella* prevalence values were lower and more homogeneous among countries, even though there was the outlying result of Hungary (Figures 8, 10 and 11).

By way of derogation, Estonia, Latvia and Luxembourg were allowed to sample less carcasses and this translated into some wider 95% CIs for these countries.

In Appendix C the proportions (%) of *Salmonella*-positive carcasses, meaning the number of *Salmonella*-positive carcasses out of the total number of sampled carcasses, for each of the *Salmonella* outcomes, are presented at both national and EU levels (Tables 12 and 14). These proportions do not take account of any design aspect such as clustering and/or weighting mentioned in section 4.5.2. The EU level proportion of carcasses positive to the *Salmonella* outcomes were lower than the estimates of the EU level prevalence of those *Salmonella* outcomes. As an example, the *Salmonella* EU prevalence was 15.6% whereas the raw proportion of *Salmonella* positive results was 13.1%. These differences were due to the weights that were assigned to broiler carcasses from MSs with higher slaughter populations combined with a relatively high prevalence of carcass contamination in these MSs.

Table 9. **Prevalence of *Salmonella*-contaminated broiler carcasses, by country and in the EU*, 2008**

Country	*Salmonella* spp.-contaminated broiler carcasses			*Salmonella* Enteritidis and Typhimurium-contaminated broiler carcasses			Other than *Salmonella* Enteritidis and Typhimurium-contaminated broiler carcasses		
	N (No of broiler batches)	% prevalence[2]	95% CI[2]	N (No of broiler batches)	% prevalence[2]	95% CI[2]	N (No of broiler batches)	% prevalence[2]	95% CI[2]
Austria	408	2.7	1.3 - 5.5	408	0.6	0.3 - 1.3	408	1.9	0.6 - 6.0
Belgium	380	18.7	10.2 - 31.9	380	3.2	1.0 - 10.0	380	11.9	6.1 - 21.9
Bulgaria	316	26.6	20.1 - 34.3	316	6.6	3.0 - 13.6	316	15.6	10.5 - 22.6
Cyprus	357	10.5	7.5 - 14.6	357	0	0[1] - 1.0[1]	357	10.5	7.5 - 14.6
Czech Republic	422	4.9	2.4 - 9.9	422	0.9	0.4 - 2.1	422	3.8	1.5 - 9.4
Denmark	396	0	0[1] - 0.9[1]	396	0	0[1] - 0.9[1]	396	0	0[1] - 0.9[1]
Estonia	102	0	0[1] - 3.6[1]	102	0	0[1] - 3.6[1]	102	0	0[1] - 3.6[1]
Finland	369	0	0[1] - 1.0[1]	369	0	0[1] - 1.0[1]	369	0	0[1] - 1.0[1]
France	422	7.4	3.8 - 13.7	422	0.2	0 - 1.7	422	6.7	3.4 - 13.1
Germany	432	14.5	6.8 - 28.4	432	2.7	0.4 - 16.5	432	9.0	4.5 - 17.2
Hungary	321	85.6	79.5 - 90.1	321	4.6	2.6 - 8.1	321	83.7	76.8 - 88.8
Ireland	394	11.2	3.4 - 31.4	394	0	0[1] - 0.9[1]	394	11.2	3.4 - 31.4
Italy	393	17.4	12.1 - 24.3	393	0.3	0 - 1.8	393	13.4	9.3 - 19.0
Latvia	122	4.9	1.2 - 18.2	122	4.9	1.2 - 18.2	122	0	0[1] - 3.0[1]
Lithuania	374	5.4	2.2 - 12.4	374	0.3	0 - 1.4	374	1.9	0.9 - 3.8
Luxembourg	13	0	0[1] - 24.7[1]	13	0	0[1] - 24.7[1]	13	0	0[1] - 24.7[1]
Malta	367	19.3	12.2 - 29.2	367	0	0[1] - 1.0[1]	367	13.0	6.4 - 24.4
Netherlands	429	10.1	6.2 - 16.1	429	0.2	0 - 1.5	429	9.4	5.9 - 14.6
Poland	419	25.4	20.9 - 30.5	419	9.6	7.0 - 12.9	419	16.0	12.2 - 20.7
Portugal	421	10.4	6.7 - 15.7	421	8.3	5.1 - 13.1	421	1.9	0.8 - 4.5
Romania	357	4.9	2.6 - 9.0	357	0.8	0.2 - 2.9	357	4.1	2.0 - 8.5
Slovakia	422	22.8	7.8 - 50.7	422	5.6	2.6 - 11.7	422	17.2	4.7 - 46.3
Slovenia	413	2.0	0.9 - 4.5	413	0.4	0.3 - 0.5	413	1.4	0.5 - 3.8
Spain	389	14.4	10.1 - 20.2	389	6.8	4.4 - 10.4	389	7.5	4.6 - 11.9
Sweden	410	0.3	0.1 - 1.3	410	0	0[1] - 0.9[1]	410	0.3	0.1 - 1.3
United Kingdom	401	3.6	1.7 - 7.2	401	0	0[1] - 0.9[1]	401	3.4	1.6 - 7.1
EU (26 MS)*	**9,249**	**15.6**	**13.6 - 17.9**	**9,249**	**3.6**	**2.8 - 4.6**	**9,249**	**11.1**	**9.5 - 13.0**
Norway	396	0	0[1] - 0.9[1]	396	0	0[1] - 0.9[1]	396	0	0[1] - 0.9[1]
Switzerland	390	2.3	2.3 - 2.4	390	0.8	0.3 - 1.9	390	1.5	1.0 - 2.4

[1] Exact binomial CI, the clustering of data is not taken into account.

[2] Prevalence estimates and CIs at national as well as at EU level were obtained taking into account correlation among observations within the same slaughterhouse. In addition, at EU level, prevalence estimates and CIs were weighted for the national numbers of slaughtered broilers during 2008.

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

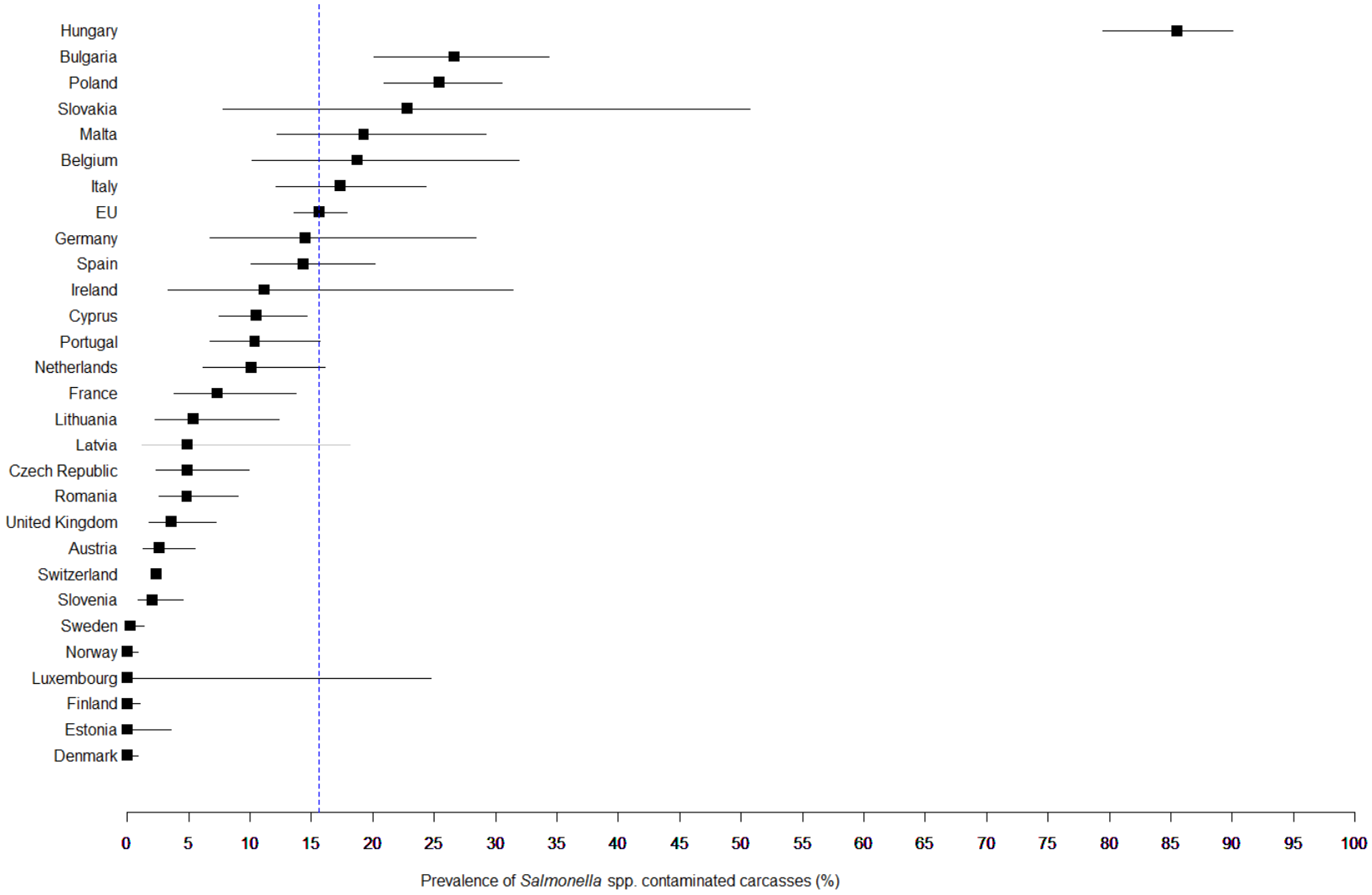

Figure 8. **Prevalence of *Salmonella*-contaminated broiler carcasses by country and at EU* level (dashed line), 2008. Horizontal lines indicate 95% CIs of prevalence**

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

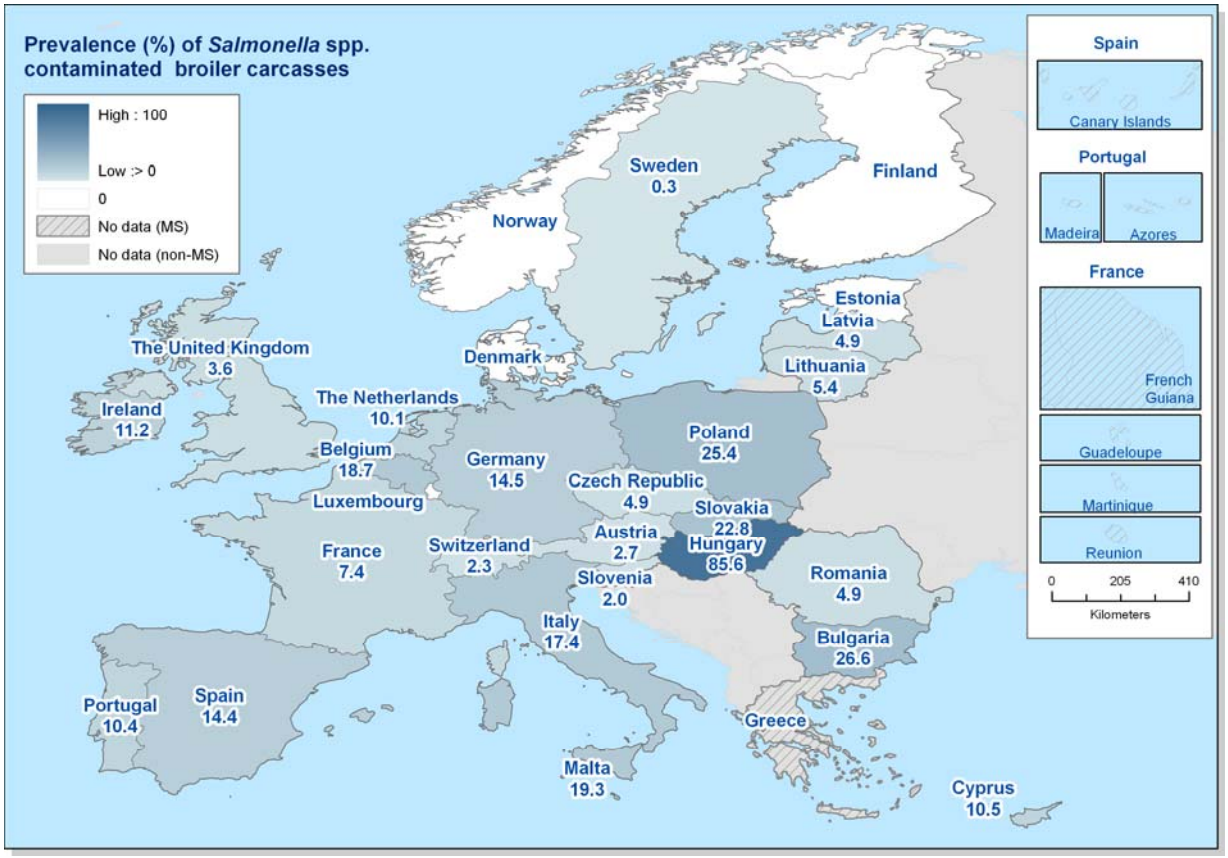

Figure 9. **Prevalence of *Salmonella*-contaminated broiler carcasses in the EU*, 2008**

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

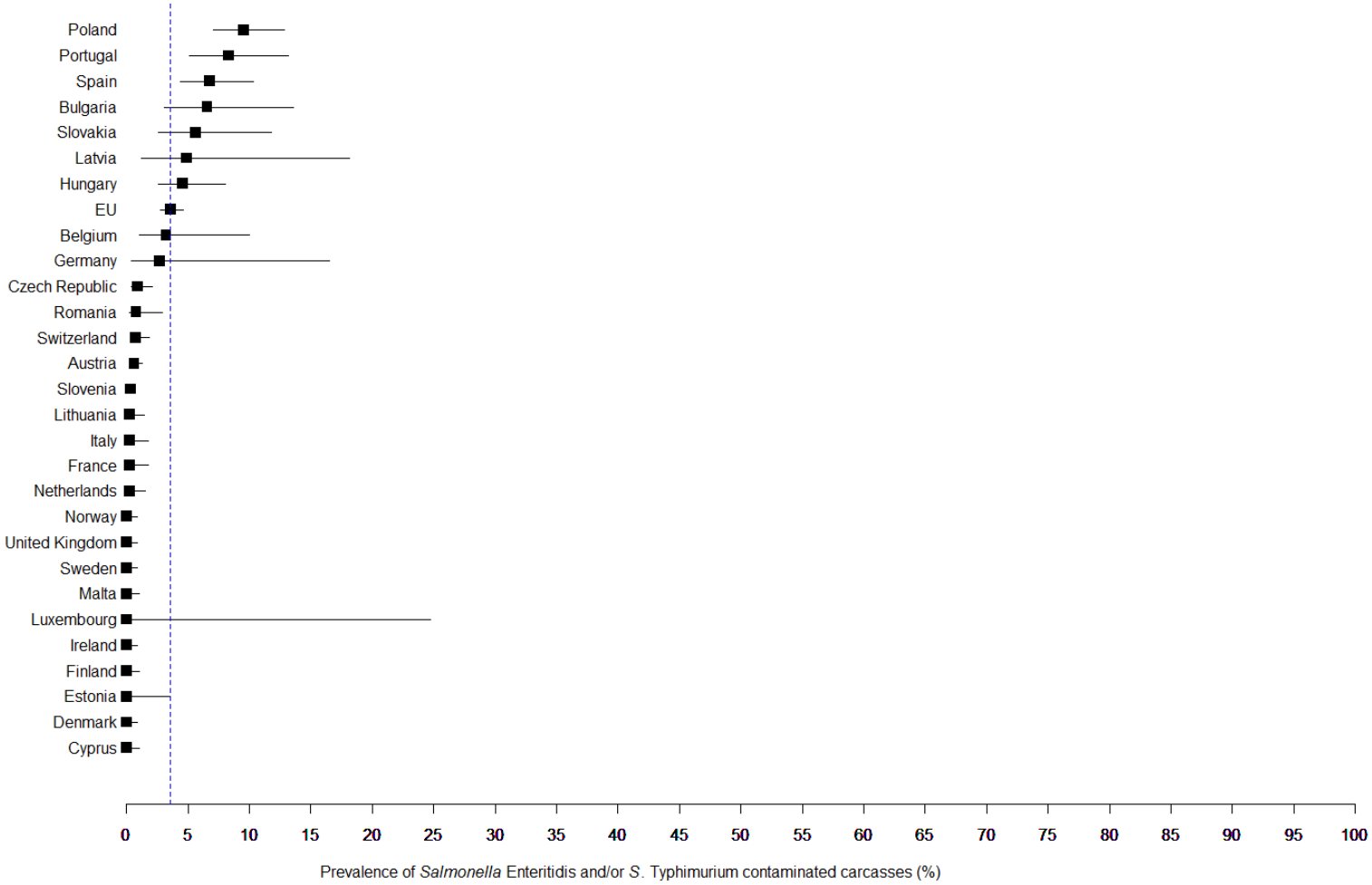

Figure 10. **Prevalence of *S.* Enteritidis and *S.* Typhimurium-contaminated broiler carcasses by country and at EU* level (dashed line), 2008. Horizontal lines indicate 95% CIs of prevalence**

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

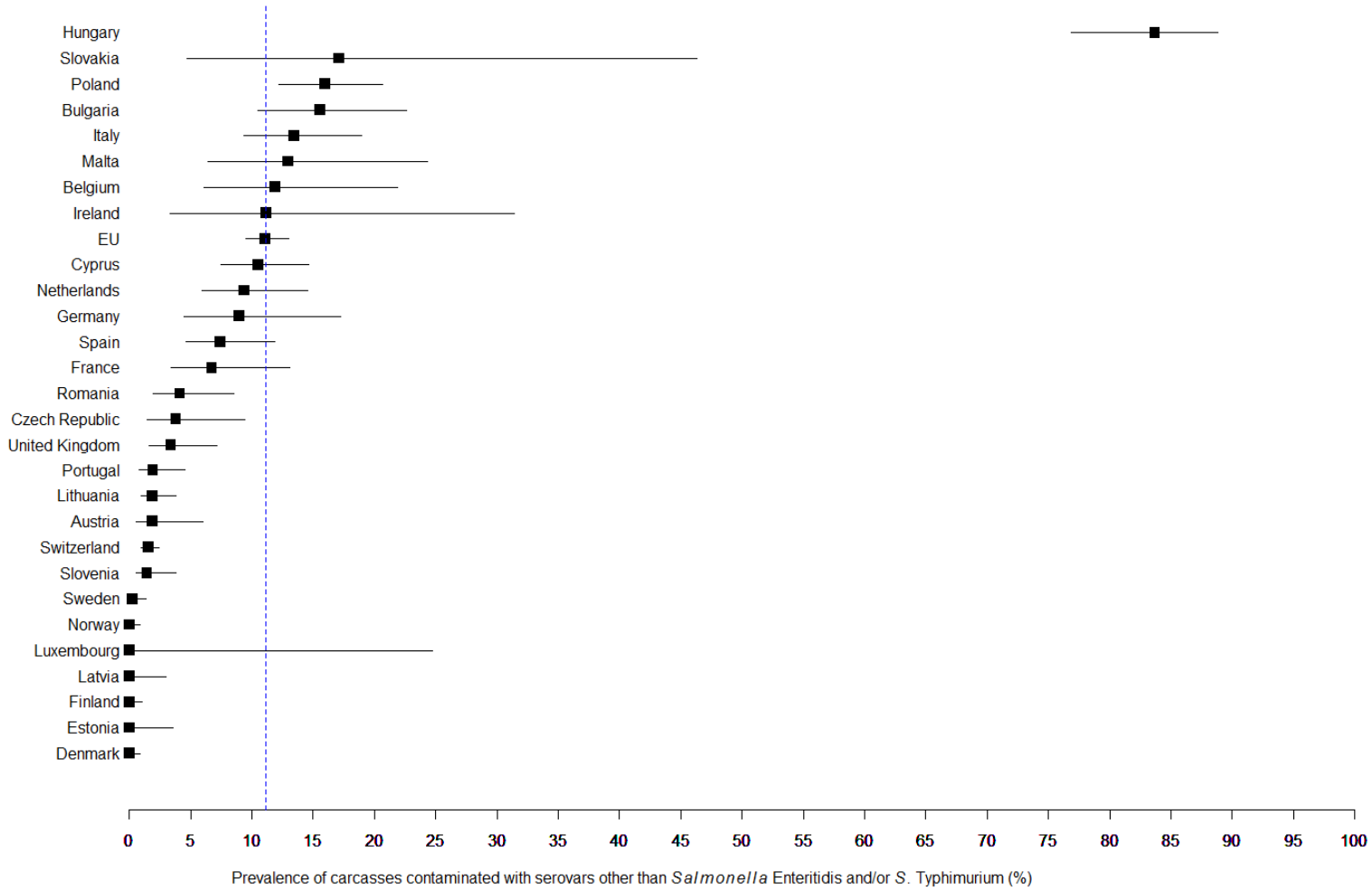

Figure 11. **Prevalence of broiler carcasses contaminated with serovars other than *S.* Enteritidis and *S.* Typhimurium, by country and at EU* level (dashed line), 2008. Horizontal lines indicate 95% CIs of prevalence**

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

5.4.2. Frequency distribution of *Salmonella* serovars on broiler carcasses

The serotyping of *Salmonella* isolates was mandatory according to the technical specifications of the survey. At least one isolate from each positive sample was to be typed according to the Kaufmann-White Scheme. Together there were 1,225 *Salmonella*-positive carcasses out of the 10,035 carcasses sampled. Two different *Salmonella* serovars were isolated from 29 *Salmonella*-positive carcasses and from one carcass three different serovars were reported.

The frequency distributions of isolated *Salmonella* serovars on contaminated broiler carcasses in the EU and two non-MSs are listed in decreasing order in Table 10. The serovar frequency distribution, overall as well as for each MS, was based on the serovar-specific number of typed isolates per total number of *Salmonella*-contaminated carcasses, including untypeable isolates. MS-specific overviews of the frequency distribution of serovars are shown in Table 23 of Appendix J.

Overall there were 56 different *Salmonella* serovars identified in the survey. *S.* Infantis was the most frequently reported serovar on broiler carcasses in the EU with 29.2% of the *Salmonella*-contaminated carcasses. The two next most frequently isolated serovars were *S.* Enteritidis and *S.* Kentucky (13.6% and 6.2%, respectively). *S.* Typhimurium was ranking fourth followed closely by *S.* Bredeney (4.3%) and *S.* Virchow (4.1%). A total of 4.4% was reported as untypeable *Salmonella*.

Serovar distribution varied substantially among MSs. Despite being the most frequently isolated serovar in the EU, *S.* Infantis was the dominant serovar in only two of the 22 MSs reporting *Salmonella* findings (Hungary and Slovenia, 97.8% and 57.1% of isolates, respectively) and in Switzerland (40% of the isolates). *S.* Enteritidis was the most commonly detected serovar in five MSs (Latvia, Poland, Portugal, Slovakia and Spain) and *S.* Kentucky in two MSs (Ireland and the United Kingdom). *S.* Typhimurium was not reported as the most commonly detected serovar in any country.

Table 10. **Frequency distributions of *Salmonella* serovars detected on contaminated broiler carcasses in the EU*, 2008**

EU (26 MSs)* and two non-MSs			
***Salmonella* serovar**	**No of carcasses**	**% of carcasses with serovar[b] (N=1,225)[a]**	**No of countries**
S. Infantis	358	29.2	15
S. Enteritidis	166	13.6	14
S. Kentucky	76	6.2	6
S. Typhimurium	54	4.4	10
S. Bredeney	53	4.3	7
S. Virchow	50	4.1	6
S. Hadar	47	3.8	9
S. Paratyphi B var. Java	46	3.8	3
S. Agona	37	3.0	10
S. Indiana	35	2.9	6
S. Montevideo	32	2.6	7
S. Mbandaka	30	2.4	10
S. Blockley	22	1.8	5
S. 4,12:d:-	21	1.7	1
S. Thompson	21	1.7	5
S. 4,[5],12:i:-	15	1.2	4
S. Livingstone	12	1.0	4
S. 6,7:-:-	11	0.9	2
S. Ohio	11	0.9	5
S. Derby	10	0.8	3
S. Kottbus	9	0.7	3
S. Anatum	8	0.7	4
S. Bareilly	7	0.6	2
S. Newport	7	0.6	3
S. Haifa	5	0.4	1
S. Isangi	5	0.4	1
S. Havana	4	0.3	2
S. Kiambu	4	0.3	1
S. Menden	4	0.3	1
S. Senftenberg	4	0.3	3
S. Braenderup	3	0.2	2
S. Tennessee	3	0.2	1
S. Brandenburg	3	0.2	1
S. 6,7:z10:-	2	0.2	1
S. 8,20:-:-	2	0.2	1
S. Berkeley	2	0.2	1
S. Corvallis	2	0.2	2
S. Emek	2	0.2	1
S. Heidelberg	2	0.2	2
S. Saintpaul	2	0.2	2
S. 3,15:-:-	1	0.1	1
S. 6,8:-:1,5	1	0.1	1

Table 10 (*contd.*) **Frequency distributions of *Salmonella* serovars detected in contaminated broiler carcasses, in the EU*, 2008**

	EU (26 MSs)* and two non-MSs		
***Salmonella* serovar**	**No of carcasses**	**% of carcasses with serovar[b] (N=1,225)[a]**	**No of countries**
S. O-rough:r:1,2	1	0.1	1
S. Bonariensis	1	0.1	1
S. Carnac	1	0.1	1
S. Coeln	1	0.1	1
S. Concord	1	0.1	1
S. Djugu	1	0.1	1
S. Irumu	1	0.1	1
S. Kedougou	1	0.1	1
S. Lexington	1	0.1	1
S. Oakey	1	0.1	1
S. Parkroyal	1	0.1	1
S. Redba	1	0.1	1
S. Schwarzengrund	1	0.1	1
Salmonella untypeable	55	4.5	6

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

[a] The total number of broiler carcasses includes all carcasses where at least one *Salmonella* serovar was isolated.

[b] Percentage of broiler carcasses that were positive for each *Salmonella* serovar.

5.4.3. Correlation between the *Salmonella* broiler flock prevalence observed in the EU baseline survey in 2005 to 2006 and the prevalence of *Salmonella*-contaminated broiler carcasses in the EU baseline survey in 2008

Correlation between the 2005 to 2006 baseline survey prevalence results of *Salmonella* in broiler flocks (EFSA, 2007b) with the 2008 prevalence results of *Salmonella*-contaminated broiler carcasses in each MS and non-MS was studied formally using the Spearman rank correlation coefficient, ρ, a non-parametric rank correlation procedure which can be used when few data pairs (23, i.e. the pairwise results from MSs that have conducted both surveys) are available. It seemed that there was a good correlation because the Spearman rank correlation coefficient was 0.81 (the coefficient was 0.78 when not considering the Hungarian data) (Figure 12). The p-value from testing the null hypothesis of no association between the prevalence estimates in the two surveys was significant ($p < 0.001$) (also the same significance level when not considering the Hungarian data). Figure 12 further indicates that the *Salmonella* flock prevalence in most MSs was higher compared to their prevalence of *Salmonella*-contaminated carasses, i.e. most MS datapoints are situated beneath the displayed dashed diagonal line. Some MSs have the reverse situation.

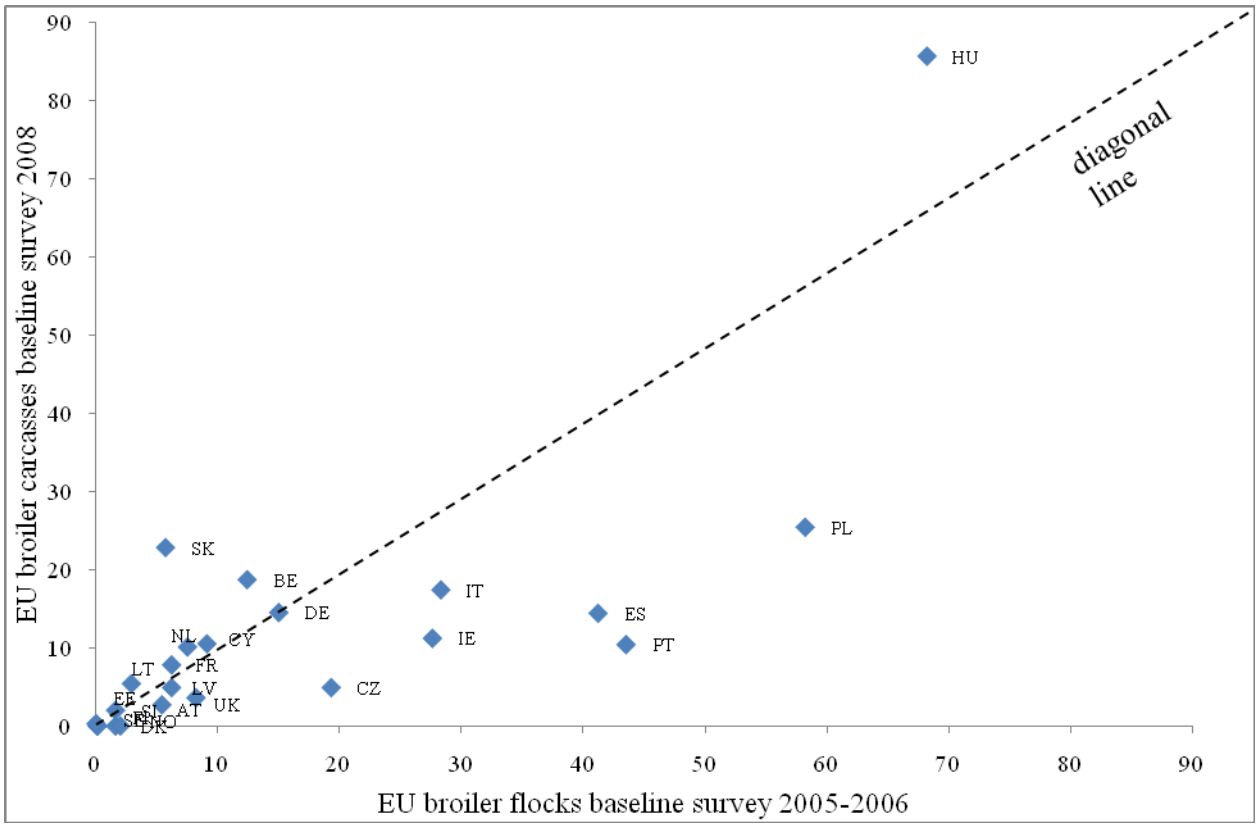

Figure 12. **Comparison of the *Salmonella* broiler flock prevalence observed in the EU baseline survey in 2005 to 2006 and the prevalence of *Salmonella*-contaminated broiler carcasses in the EU baseline survey in 2008.**

5.4.4. Overview of the quality-control of the *Salmonella* analysis

According to the Commission Decision 2007/516/EC, a proportion of the non-typeable *Salmonella* isolates, i.e. a maximum of 16 isolates from carcass samples, should be submitted to the *Salmonella* CRL for confirmation and serotyping.

A total of 45 *Salmonella* non-typeable isolates were sent to the *Salmonella* CRL by six of the 27 *Salmonella* NRLs from MSs and one of the two non-MSs.

The *Salmonella* CRL was able to identify a further 38 of these 45 non-typeable isolates. However, for the purpose of analysis in this report these isolates were considered as non-typeable, as no information was available allowing the recognition (traceability) of the broiler batch identification from which these strains were isolated.

6. Discussion

6.1. General discussion on context and strength of the survey

This baseline survey was conducted by 26 MSs, Switzerland and Norway and consisted of two subsurveys. The first subsurvey analysing pooled caecal contents samples of slaughtered broilers for the detection of *Campylobacter* served the purpose of estimating a prevalence of *Campylobacter*-colonised broiler batches as an indicator of the situation in broiler flocks. The caecal contents of 10 slaughtered broilers were collected from every randomly selected slaughter batch, pooled and examined for *Campylobacter*. The second subsurvey analysing the broiler carcass samples served the purpose of estimating a prevalence of *Campylobacter*- or *Salmonella*-contaminated broiler carcasses. One carcass produced from the same slaughter batch was collected immediately after chilling and the neck skin (if present) together with the breast skin was examined for the presence of *Campylobacter* and *Salmonella*, in addition to the determination of the *Campylobacter* counts. This was the sixth baseline survey to be conducted in the European Community and it was the first baseline survey directly investigating foodstuffs.

Overall there was good compliance with the survey and very few samples were excluded from the analyses. However, Greece did not carry out the survey.

This slaughterhouse survey was to collect information on the counts of *Campylobacter* on the neck skin together with the breast skin from the sampled carcasses. The need for quantitative data as counts (loads) of *Campylobacter* in broiler meat has increased in the context of continued progress towards quantitative microbial risk assessment for food-borne pathogens. Therefore, a major strength of this survey was the collection of *Campylobacter* quantitative data on broiler carcasses. This type of data can potentially contribute to the improvement of the models for risk assessment and provide more accurate estimates of risk as well as provide evidence for any consideration of establishing quantitative targets (EFSA, 2009a). Another strength of this survey was the opportunity to have a wide collection of laboratory-specific estimates of MUs. Quantitative microbial analyses have inherent limitations. Knowledge of the uncertainty of bacterial counts is essential to adequately interpret microbiological counts, especially to define whether the enumeration results are in accordance with given specifications (Corry et al., 2007; Augustin and Carlier, 2006). Taking into account the uncertainty allows, for example, to determine if differences between results obtained from the same samples are in the acceptable range of the experimental variability. Ideally each measurement (enumeration result) should be quoted with an indication of the uncertainty, often as a figure, so that decisions based on the measurement are fully informed (Lombard, 2006).

The survey scheme was not appropriate to estimate the prevalence of *Campylobacter*-positive broiler flocks, at farm level, because although each broiler slaughter batch came from a unique flock, each flock might generate multiple slaughter batches, for example due to thinning. Broiler batches may be colonised with *Campylobacter* either on the farm or during catching or transport to the slaughterhouse. Broiler batches can also be composed of broilers raised in different flocks, but these were specifically excluded from the survey. Another weakness of the survey was that counts of *Campylobacter* were not determined in individual caecal contents samples. If they had been, it would have been possible to estimate the relationship between the counts of *Campylobacter* in the caeca and the within-batch prevalence to the presence and counts of *Campylobacter* on the carcasses of that batch, which is also very important information for risk assessments. Moreover, only one carcass per broiler batch was collected for bacteriological analysis. Due to possible variability in contamination of carcasses from a broiler batch this was not optimal.

6.2. *Campylobacter* survey results

This is the first time a survey of broiler slaughter batches and carcasses has been carried out at EU level and so a direct comparison with previous data cannot be made although information on prevalence at MS level is available for some MSs (EFSA, 2009b).

Due to the weighting of MS-specific results by the national production figures, the prevalence estimates at EU level were substantially influenced by the results from MSs with the highest numbers of slaughtered broilers during 2008. In general, these were also the MSs which had the highest prevalence of *Campylobacter*.

6.2.1. Prevalence of *Campylobacter*-colonised broiler batches

The *Campylobacter* detection analysis in a (pooled) sample of the contents of intact caeca detects *Campylobacter* colonisation of batches of broiler birds that have been raised in the same house or paddock/field or that have become colonised with *Campylobacter* during catching or transport to the slaughterhouse. This *Campylobacter* detection test reflected the colonisation at the time the batch was slaughtered. Analysis of contents of a portion of the intestines, the caecum, obtained post-mortem, is a sensitive method at individual bird level; and by pooling 10 samples from individual birds a relatively sensitive method to detect batch colonisation. Pooling of 10 individual samples into one sample increases the epidemiological sensitivity of detection (i.e. increases the chance of detecting a positive broiler batch) compared to the analysis of one caecal content per broiler batch, if *Campylobacter*-negative caecal content samples occur among the 10 caecal content samples taken per batch. The present data provided an estimation of the prevalence of *Campylobacter*-colonised broiler batches, which were processed in slaughterhouses in the EU. While not an entirely accurate surrogate for the prevalence of colonisation in broiler flocks, it is a useful indicator of the extent of this issue in the pre-harvest phase of chicken production.

The EU level *Campylobacter* prevalence was 71.2% meaning that on average seven out of 10 broiler batches at EU level were colonised with *Campylobacter*. The EU level *C. jejuni* and *C. coli* prevalence were 40.6% and 31.9%, respectively. The observed prevalence of *Campylobacter* was high at EU level, but varied widely among MSs. Prevalence was lowest in the Nordic countries and Estonia. *Campylobacter* prevalence was higher than at EU level in 11 MSs, among them the four MSs that slaughtered most broilers (France, Poland, Spain and the United Kingdom).

Campylobacter is a known common inhabitant of the caeca of broilers and high prevalence has been reported in other surveys. Broilers can become colonised by *Campylobacter* following exposure to viable bacteria from the environment and presence of *Campylobacter* in the caeca can be at a detectable level after a few hours (Bull et al, 2006) and colonisation of most in-contact birds may take place within a few days of exposure.

More factors affect the *Campylobacter* transmission to and among broilers than for *Salmonella*. *Campylobacter* is widespread in wild and domestic animals and therefore common in the environment, although they cannot normally grow nor reproduce outside the gut of warm-blooded animals. Wide variation between prevalences among MSs may be partly explained by climatic conditions, which affect the reservoirs or vectors of *Campylobacter* in the environment such as, for example, insects and arachnids in the broiler production environment. In the Nordic countries, the cold winters probably decrease the environmental load of *Campylobacter*, and therefore *Campylobacter*-positive broiler flocks occur mostly in summer (Jore et al., 2009; Meremäe et al, 2010). Moist climates of more temperate EU MSs provide conditions favouring environmental *Campylobacter* survival. In colder climates the broiler houses need to be thermally insulated, which also prevents the access of wild birds or rodents to the houses from outside. Also, countries that have actively implemented a target strategy to control *Campylobacter* in broilers (for example Denmark, Sweden and Norway) have seen a reduction in the prevalence of *Campylobacter* in broiler flocks and broiler meat (Rosenquist et al, 2009). Analyses of factors that might explain differences in the prevalence of *Campylobacter*-colonised broiler batches among MSs will be explored in the Part B report that will be published at a later stage.

6.2.2. Prevalence of *Campylobacter*-contaminated broiler carcasses

Presence of *Campylobacter* on a sample of neck skin together with breast skin from a carcass reflects the surface contamination that can occur from faecal contamination of the skin during primary production and the transport phase as well as contamination during slaughter and dressing, particularly at the plucking and the evisceration phase, and chilling (Berrang and Dickens 2000, Berrang et al. 2001, Rosenquist et al. 2006). For comparability purposes a common point for sampling in the slaughterhouse was decided. Due to the variation in packing, processing and freezing methods in use in the processing plants, 'after chilling but before any further processing' was chosen as the best point to sample (EFSA, 2007a).

The culture method to detect the presence of *Campylobacter* on carcasses (detection method) included an enrichment step that attempted to encourage the growth and proliferation of any *Campylobacter* compared to other background flora that are present in the sample and hence be detected. This explains why the detection method should be more sensitive than the enumeration method, which determined the counts of *Campylobacter*. Moreover, the amount (grams) of specimen (test portion) used was 10 times higher in the detection test.

The EU level *Campylobacter* prevalence was 75.8% meaning that on average about eight out of 10 broiler carcasses at EU level were contaminated with *Campylobacter*. The EU level *C. jejuni* and *C. coli* prevalence were 51.0% and 35.5%, respectively. The observed prevalence of *Campylobacter* was high at EU level, but varied widely among MSs.

The prevalence of *Campylobacter*-contaminated broiler carcasses was slightly higher than the prevalence of *Campylobacter*-colonised broiler slaughter batches in most countries (18 out of 26 MSs and two non-MSs). This can be explained by cross contamination from positive batches to negative batches during slaughter and associated carcass preparation (Johannessen et al. 2007; Jørgensen et al. 2002) through contamination of the slaughterhouse environment (Johnsen et al 2006). Differences between the prevalence of *Campylobacter*-colonised broiler batches and of *Campylobacter*-contaminated broiler carcasses and possible explanations will be explored further in the Part B report.

6.2.3. *Campylobacter* enumeration results on broiler carcasses

This enumeration method provided both a detection result when any *Campylobacter* were present on the selective media agar plates and an estimation of the counts of *Campylobacter*.

The results of the counts of *Campylobacter* on broiler carcasses showed substantial variation among countries in the contamination levels. The proportion of samples considered negative by the enumeration test, meaning below the threshold of 10 cfu/g, varied from 3.8% to 98.6% among countries, whereas the proportion of samples with very high counts above 10,000 cfu/g varied from 0% to 31.9% among countries.

As explained above, the enumeration method was less sensitive than the detection method. However, in some instances *Campylobacter* was detected by the enumeration method but not by the detection method. Thus it can be concluded that the detection method result yielded false negative results indicating that the *Campylobacter* present in the sample had not been able to grow sufficiently in the enrichment media possibly due to growth of other background flora (Habib et al, 2008b, Jasson et al, 2009). When this was observed the overall result for the sample was deemed positive for the presence of *Campylobacter*, for the purposes of this survey analysis. The use of this parallel testing of broiler carcasses by both detection and enumeration methods to determine prevalence has resulted in an increased probability of obtaining positive test results for *Campylobacter* in the broiler carcasses than single examination by either method would have done.

Low *Campylobacter* numbers on broiler carcasses may reflect effective pre-harvest production procedures, good slaughter hygiene, low within-flock prevalence or low cross-contamination of carcasses of a *Campylobacter*-negative batch from a previous positive batch (Johannessen et al. 2007). In the present survey, the trend was that countries with higher *Campylobacter* prevalences in both broiler batch

colonisation and carcass contamination had higher counts (contamination levels) on the carcasses. That trend would be consistent with the greater potential for contamination of skin at pre-harvest or during slaughter and dressing, by the increased number of birds and/or carcasses carrying the organism. Some studies have also concluded that higher counts of *Campylobacter* in caecal samples also correlate with higher numbers on carcasses (Allen at al., 2007). The Part B report will present a more in-depth analysis of the characteristics of the broiler carcass sample *Campylobacter* detection and enumeration tests used.

6.2.3.1. Measurement uncertainty of the *Campylobacter* enumeration method.

Assessing and reporting MU is very important in quality control and this baseline survey collected valuable data to this end. MU values are quantitative indications of the analytical variability of a result. Estimated MU values by a laboratory are unique for that laboratory and demonstrate how much variation would exist in that laboratory's outcome indicating the value of the quantity being measured in the test portion. This information is important in the consideration of individual results and provides a CI within which the true value of an individual result would be expected to fall. In the current baseline survey, the MU values estimated by the laboratories who undertook the *Campylobacter* enumeration tests, varied from 0.06 to 0.70 $\log_{10}$ cfu/g of neck skin together with breast skin. These MU values are generally consistent with best obtainable international practice. The quantitative results may therefore be compared across MSs with reasonable confidence. With harmonised protocols such a method would seem to provide information on which risk assessors and risk managers can depend. More background information on the evaluation of uncertainty in food microbiology is provided in Appendix G.

6.2.4. Frequency distribution of *Campylobacter* species

At EU level about two-thirds of the *Campylobacter* isolates from the broiler batches as well as those from the broiler carcasses were identified as *C. jejuni*, while approximately one-third was *C. coli*. Few were speciated as other *Campylobacter* species. This is consistent with previous studies that reported the vast majority of *Campylobacter* isolates to be *C. jejuni* and *C. coli* (Jørgensen et al, 2002). Still, while *C. jejuni* was more dominant than *C. coli* in most of the countries, also the reverse situation was reported, notably seven MSs reported dominance of *C. coli* isolates, whether in broiler batches or broiler carcasses.

The majority of testing laboratories performed very well with species determination of the *Campylobacter* isolates irrespective of the method used for species identification, although PCR-based methods tended to give more reliable results.

It should be noted that the results from *Campylobacter* speciations may not be robust for samples containing both *C. jejuni* and *C. coli* because only one isolate per sample was mostly speciated and because the enrichment of samples in the detection test may favour the outgrowth of certain *Campylobacter* species such as *C. coli.* More generally it must be considered that the *Campylobacter* detection and enumeration methods used in this survey did not allow for a robust interpretation of the *Campylobacter* speciation results, because different selective media and different incubation methods were used among MSs and laboratories. Another reason for possible interpretational difficulties regarding the *Campylobacter* speciation results on broiler carcasses was that isolates from the enumeration method were only to be speciated, on a mandatory basis, when *Campylobacter* was not detected from the same sample by the detection method and indeed 14 out of 22 countries with positive enumeration results speciated a low number of *Campylobacter* isolates from this test, from 1 to 44.

Correlations between the prevalence of *Campylobacter* and the occurrence of certain species in broiler batches, on broiler carcasses and in other animal species as well as in human campylobacteriosis cases will be studied further in the Part B report. Also spatial differences in the reported *Campylobacter* species in the EU will be explored in the Part B report.

6.2.5. Relevance of the findings to human health

For several years campylobacteriosis has been the most frequently notified human zoonotic disease in the EU (EFSA, 2009b).

Results of the present EU wide baseline survey revealed that the prevalence of broiler batches colonised with *Campylobacter* is very high. This is alarming, as on average eight out of 10 broiler carcasses presented in the EU market (with notable exceptions of the Nordic countries, Cyprus and Estonia) were contaminated with *Campylobacter*. Such high prevalence indicates that broiler meat is a significant vehicle for exposure of the European consumer to *Campylobacter*. The data provided in this report contribute to the evidence from molecular subtyping and epidemiological studies identifying poultry meat as an important source of food-borne transmission of human campylobacteriosis. Numerous molecular typing studies reported an overlap between genotypes of *Campylobacter* from humans and broiler meat origins (Hänninen et al., 2000; Wilson et al., 2008). In addition, markers of virulence traits associated with human diarrhoeal illness and neurological syndromes have been characterised in *Campylobacter jejuni* isolated from retail broiler meat (Zheng et al., 2006; Habib et al., 2009).

The EFSA Panel on Biological Hazards estimated in its recent scientific opinion on the quantification of the risk posed by broiler meat to human campylobacteriosis cases (EFSA, 2010) that the handling, preparation and consumption of broiler meat may account for 20% to 30% of human campylobacteriosis cases, while 50% to 80% may be attributed to the chicken (broiler) reservoir as a whole. Strains from the chicken reservoir may reach humans via routes other than food (e.g. by the environment or by direct contact).

Aside from generating a prevalence estimate, the present EU-wide survey provides novel data on counts of *Campylobacter* on broiler carcasses. This quantitative data obtained in the survey indicate that broiler carcasses may be contaminated with high numbers of *Campylobacter*. Such carcasses represent a potential health risk for consumers. It has been shown that once broiler meat harbouring *Campylobacter* is introduced into the kitchen, it can serve as a source for cross-contamination to other foodstuffs and surfaces during meal preparation (for example hands of food handlers, utensils and food contact surfaces). Adding to that, laboratory models of cross-contamination scenarios indicated that the number of *Campylobacter* cells transferred depends on the number of the bacteria on the broiler meat causing cross-contamination (Verhoeff-Bakkenes et al., 2008).

Scientific consensuses indicate that reducing numbers of *Campylobacter* on broiler meat could effectively reduce the number of cases of human campylobacteriosis (Nauta et al., 2009; Bronzwaer et al., 2009). Several *Campylobacter* risk assessments have been undertaken estimating human campylobacteriosis cases via consumption of poultry meat or the chicken reservoir and evaluation efficacy of potential intervention strategies (Hartnett et al. 2001, WHO/FAO 2002, Nauta et al. 2006, Rosenquist et al. 2003). The overall conclusion is that reducing the load of *Campylobacter* presented to the consumer will result in a reduction of human campylobacteriosis cases. Nevertheless, data gaps are still identified in the elaboration of risk assessments, among which the disposal of quantitative datasets. Hence, data generated in this survey could be useful for every MS in order to develop or update their national *Campylobacter* risk assessment plan. This will allow better estimation of the public health risk imposed by *Campylobacter* through contaminated broiler meat. In addition, both prevalence and data on counts of the bacteria provided in the present survey would allow better assessment of the effectiveness of *Campylobacter* control plans.

The data provided by this survey, gathered in all EU countries using a similar and representative nationwide experimental set-up, will be useful for risk assessments at European level and may also contribute to more precise estimations of the health risk for consumers due to consumption of broiler meat in the various EU MSs. Part B of this report will attempt to interpret further the findings in a wider food safety context.

6.3. *Salmonella* survey results

6.3.1. Prevalence of *Salmonella*-contaminated broiler carcasses

The presence of *Salmonella* on broiler carcasses reflects both surface contamination from faeces and cross-contamination from the processing equipment and the processing environment at the slaughterhouse (Corry et al., 2002; Rasschaert et al., 2008). Following slaughter of a *Salmonella*-positive broiler batch, unless effective cleaning is undertaken, *Salmonella* can persist in the slaughterhouse environment and contaminate subsequent slaughter batches.

Salmonella was less frequently detected from broiler carcasses in this survey than *Campylobacter*. This was the case in all participating countries except one MS, Hungary.

The EU level prevalence of 3.6% as regards *S.* Enteritidis and/or *S.* Typhimurium can be regarded as favourable (3.6%), except for some MSs such as Poland and Portugal where about one in 10 carcasses was contaminated with at least one of these serovars. The low prevalences of broiler carcasses contaminated with *S.* Enteritidis and/or Typhimurium in many countries suggest that the *Salmonella* control programmes, foreseen by Community legislation No 1003/2005[9] on breeding flocks of *Gallus gallus*, for those particular serovars, are working well. These data are consistent with, and provide further assurance of the conclusions from the previously published EFSA baseline survey on *Salmonella* in broiler flocks carried out in 2005 to 2006 (EFSA, 2007b). Allowing for some progress by MSs since that survey, the potential for cross-contamination at slaughterhouses with these serovars would appear to be minimised by the low prevalence in birds at pre-harvest.

The prevalence of other serovars than *S.* Enteritidis and/or Typhimurium was 11.2% at EU level in the current survey, i.e. about one in 10 carcasses, and remarkably higher in some MSs. Together with the *S.* Enteritidis and/or *S.* Typhimurium-contamination of carcasses this lead to EU level prevalence of *Salmonella*-contaminated broiler carcasses of 15.6%. Some serovars such as *S.* Infantis and *S.* Kentucky would seem to have established potential for contamination of this food chain in some specific MSs.

Comparison of the 2005 to 2006 baseline survey prevalence results of *Salmonella* in broiler flocks (EFSA, 2007b) with the 2008 prevalence results of *Salmonella*-contaminated broiler carcasses is not without difficulties. The results of the former survey might not represent the actual flock prevalence situation in 2008 and the surveys differed in the type of prevalence parameters studied. The broiler flock survey estimated the *Salmonella* flock prevalence while the present survey estimated a prevalence at individual bird level, i.e. *Salmonella*-contaminated carcasses. A prevalence estimation at flock level would very likely tend to be higher than the one at individual bird level, because infections like *Salmonella* cluster at group or flock level wherein it persists. Also, the designs of the surveys were at different points in the food chain. The flock survey was at primary production level whereas the carcass survey was at slaughterhouse level. This implies that some carcasses sampled could have originated from non-domestic broilers, jeopardising a meaningful comparison between both survey results. Moreover, the flock survey was based on environmental samples (boot swabs) while the carcass survey was based on neck skin together with breast skin samples. Nevertheless, the descriptive comparison made between the *Salmonella* MS prevalence figures of both surveys disclosed a significant correlation. This is consistent with the hypothesis of an epidemiological association between the flock and carcass levels within the same MS. This correlation also indicates that lower broiler flock *Salmonella* prevalence translate into lower prevalence of *Salmonella*-contaminated carcasses.

[9] Commission Regulation (EC) No 1003/2005 of 30 June 2005 implementing Regulation (EC) No 2160/2003 as regards a Community target for the reduction of the prevalence of certain *Salmonella* serotypes in breeding flocks of *Gallus gallus* and amending regulation (EC) No 2160/2003. OJL 170, 1.7.2005, p.12.

6.3.2. Frequency distribution of *Salmonella* serovars on broiler carcasses

Overall there were 56 different *Salmonella* serovars identified in the survey. The four most frequently isolated *Salmonella* serovars on broiler carcasses were respectively, in decreasing order, *S.* Infantis, *S.* Enteritidis, S. Kentucky and *S.* Typhimurium, followed by 'untypeable *Salmonella*'. The distribution of the serovars varied substantially among MSs. Despite being the most frequently isolated serovar in the EU, *S.* Infantis was the dominant serovar in only two of the 22 MSs reporting *Salmonella* findings, *S.* Enteritidis was the most commonly detected serovar in five MSs and *S.* Kentucky in two MSs. *S.* Typhimurium was not reported as the most commonly detected serovar in any country.

Overall the frequency of commonly isolated serovars in the broiler carcass survey was consistent with the frequency of isolated serovars, at flock level, from the previously published EFSA baseline survey on *Salmonella* in broiler flocks (EFSA, 2007b). Six of the 10 most commonly isolated serovars were common in both surveys, notably *S.* Infantis, *S.* Enteritidis, *S.* Kentucky, *S.* Typhimurium, *S.* Virtchow and *S.* Hadar. The first two serovars *S.* Infantis and *S.* Enteritidis, were clearly predominant in both surveys, in terms of frequency of isolation as well as in terms of countries reporting the serovar. *S.* Enteritidis accounted for 13.6% of the isolates in this carcass survey whereas it accounted for approximately one third of the positive flocks in the broiler flock survey. Moreover, overall in both surveys the frequent isolation of *S.* Infantis, 29.2% and 20.4% respectively in the broiler carcass and broiler flock surveys, was due to a special prevalence situation in Hungary that accounted for the major part of the *S.* Infantis isolates, in both surveys. For the other four serovars, which all accounted for approximately 3% to 6% of the isolates in both surveys, *S.* Typhimurium was the one which was reported by at least 10 countries in both surveys. More generally, the serovar diversity varied between MSs.

Isolates belonging to monophasic group B *Salmonella, S.* 4,[5],12:i:-, were reported by several MSs from broiler carcasses. This type of *Salmonella* is most likely to be a variant of *S.* Typhimurium. Such isolates have been associated predominantly to *S.* Typhimurium DT193. These strains have been increasing notably in the EU since 2006 and have also been found in the USA and Canada (PHAC, 2006; CDC, 2007a, 2007b; Switt et al. 2009). Monophasic *S.* Typhimurium strains have been reported from pigs, cattle, poultry and humans (de la Torre et al. 2003; Sorensen et al., 2002; Zamperini et al. 2007). There have been food-borne outbreaks involving this strain in humans in MSs and non-European countries (Agasan et al. 2002; Tavechio et al. 2004; Amavisit et al. 2005; Mossong et al. 2007). The strain was also commonly reported in the EU-wide baseline surveys of slaughter and breeding pigs that were carried out in 2006 until 2008 (EFSA, 2008; EFSA 2009c).

A risk factor analysis, a more in depth analysis of the *Salmonella* serovars on the broiler carcasses including the phage types, as well as the investigations of the associations between the occurrence of *Salmonella* serovars on the broiler carcasses and in the broiler flocks, and in other animal species as well as in human salmonellosis cases will be presented in the Part B report.

6.3.3. Relevance of the findings to human health

Salmonellosis has been the second most frequently reported human zoonotic disease for many years in the EU. However, among the reported food-borne outbreaks, *Salmonella* was the most common causative agent, accounting for 1,888 outbreaks in the EU in 2008. Broiler meat and products thereof were reported to be the fifth most frequent cause of these outbreaks, following eggs and egg products, bakery products, pig meat and products thereof and mixed or buffet meals (EFSA, 2009b).

The results of this survey indicate that in many MSs contaminated broiler meat may be an important food-borne source of human *Salmonella* infections, notably of *S.* Enteritidis that is the most commonly reported serovar in human salmonellosis cases but also of *S.* Typhimurium and *S.* Infantis that are also commonly reported in human *Salmonella* infections in the EU (EFSA, 2009b). In addition, the relatively frequent findings of other serovars of public health importance, such as *S.* Hadar, *S.* Virchow, and *S.* Kentucky on broiler meat indicate that broilers are a relevant reservoir for these serovars as well and constitute a potential

food-borne source for human infections. As prevalence and serovar distribution greatly varied between the MSs, the importance of broiler meat as a source of human *Salmonella* infections is likely to be MS specific. For example, *S.* Infantis was the dominant serovar in two MSs reporting *Salmonella* findings (Hungary and Slovenia). In Hungary, broilers have been reported to serve as a reservoir for a *S.* Infantis clone causing human infections (Nógrády et al, 2007; Nógrády et al, 2008).

In contrast to *Campylobacter,* which cannot multiple at temperatures below 30°C, *Salmonella* is able to grow on meat at temperatures above 10°C. Consequently, temperature abuses in the broiler meat chain and by the consumer (during transport and storage of broiler meat) may lead to an increase of the number of *Salmonella* in contaminated broiler meat, making such products more risky for the consumer. However, thorough cooking destroys *Salmonella* bacteria present in meat. Broiler meat is often heat-treated before consumption and properly prepared broiler meats do not pose a health risk for consumers. The *Salmonella* infection risk arises from undercooking broiler meat or from cross-contamination from raw broiler meat to other food during preparation in the kitchen (for example via food handlers, utensils or food contact surfaces). Good kitchen hygiene and thorough cooking of broiler meat will reduce the risk. More generally, consumer education campaigns, good hygienic practice and procedures based on HACCP principles implemented by catering establishments and restaurants would further contribute to the reduction of the risk. Control programmes in primary production also reduce the number of broilers colonised with *Salmonella* thus reducing the likelihood of carcass contamination.

CONCLUSIONS

This survey was the first EU-wide survey on the prevalence of *Campylobacter* in broiler batches and of *Campylobacter* and *Salmonella* on broiler carcasses. It was a slaughterhouse survey and the first food survey in a series of baseline surveys in the EU. It provides comparable estimates of the prevalence of *Campylobacter*-colonised broiler batches, the prevalence of and counts in *Campylobacter*-contaminated broiler carcasses and the prevalence of *Salmonella*-contaminated broiler carcasses. Moreover, the distribution of the most frequently occurring *Campylobacter* species in broiler batches and on broiler carcasses, and of the most frequently occurring *Salmonella* serovars on broiler carcasses have been determined across the EU. The baseline figures may be used in the future to follow trends and to evaluate the impact of possible interventions.

Campylobacter survey

- The survey demonstrated that *Campylobacter* was detected in pooled caecal contents of broilers and on broiler carcasses in all participating 26 MSs and in both participating non-MSs.
- In the EU, approximately seven in 10 broiler batches (71.2%) was estimated to be colonised by *Campylobacter* at the slaughterhouse confirming that broilers are commonly colonised by *Campylobacter*. The prevalence of *Campylobacter*-colonised broiler batches varied widely among the MSs from as low as 2% up to 100%. A prevalence of <20% was observed in four MSs, mainly in Nordic countries, whereas a prevalence of >75% were detected in 10 MS, among them the four MSs that slaughtered most broilers.
- At EU level approximately eight in 10 broiler carcasses (75.8%) were estimated to be contaminated by *Campylobacter*. The prevalence of *Campylobacter*-contaminated carcasses varied widely among MSs from as low as 4.9% up to 100%.
- Overall at EU level *Campylobacter* were present at enumerable levels (≥ 10cfu/g) on 53.4% of the sampled carcasses, but this proportion also varied widely among MSs, from 1.4% to 100%. At EU level, together 12.2% of the carcasses contained *Campylobacter* of between 10-99 cfu/g and higher counts were detected as follows: between 100-999 cfu/g on 19.3%, between 1,000-10,000 cfu/g on 15.8% and more than 10,000 cfu/g on 5.8% of the carcasses. In general there was a tendency for high counts in countries with high *Campylobacter* prevalence. All MSs counted results between 1,000-10,000 cfu/g on some carcasses, and for 18 MS in at least 1% of the carcasses counts of > 10,000 cfu/g occurred. This indicates that elevated levels of *Campylobacter* can be recovered from the broiler carcasses and transmitted in the food chain during further processing and preparation by cross-contamination.
- The use of parallel testing of broiler carcasses by both detection and enumeration methods to determine prevalence has resulted in an increased probability of obtaining positive test results for *Campylobacter* in the broiler carcasses than single examination by either method would have done.
- About two-thirds of the *Campylobacter* isolates from the broiler batches as well as those from the broiler carcasses were identified as *Campylobacter jejuni*, while one-third was *Campylobacter coli*.
- The results of the survey support the view that broiler meat is an important food-borne source of human campylobacteriosis in the EU. The infection may result from undercooking meat or cross-contamination of other foods by raw poultry meat. Thorough cooking of broiler meat and strict kitchen hygiene would prevent or reduce the risk posed by *Campylobacter*-contaminated broiler meat.

***Salmonella* survey**

- In this survey *Salmonella* was less frequently detected on broiler carcasses compared to *Campylobacter*.
- Twenty-two of the 26 participating MSs and one non-MS isolated *Salmonella* on broiler carcasses. At EU level approximately one in six broiler carcasses (15.6%) was estimated to be contaminated by *Salmonella*. The prevalence of *Salmonella*-contaminated broiler carcasses varied widely between MSs, from 0% to 26.6%. Hungary had an exceptionally high prevalence of 85.6 % with the majority of isolates being *S.* Infantis. A *Salmonella* prevalence of less than 5% was noted in 11 MSs.
- Seventeen MSs isolated *Salmonella* Enteritidis or Typhimurium on the broiler carcasses resulting in an EU prevalence of *S.* Enteritidis or *S.* Typhimurium-contaminated broiler carcasses of 3.6% varying from 0% to 9.6% among MSs. The EU prevalence of broiler carcasses contaminated with one or more serovars other than *S.* Enteritidis and/or *S.* Typhimurium was 11.2%. The variation in prevalence of these serovars between MSs was also considerable.
- In this survey, the four most frequently isolated *Salmonella* serovars on broiler carcasses were *S.* Infantis (29.2% of the contaminated broiler carcasses), *S.* Enteritidis (13.6%), *S.* Kentucky (6.2%) and *S.* Typhimurium (4.4%), while untypeable *Salmonella* accounted for 4.4% of the isolates. Out of these, *S.* Enteritidis, *S.* Typhimurium and *S.* Infantis are the most commonly reported serovars in human *Salmonella* infections in the EU.
- Serovar distribution varied among MSs, many of them having a specific distribution pattern of their own. Often, for a specific *Salmonella* serovar, a few MSs accounted for the majority of the positive carcasses.
- The results of the survey support the view that broiler meat is one of the important food-borne sources of human salmonellosis in the EU along with other sources such as eggs and pig meat. The results are also in line with the notion that lower *Salmonella* prevalence in broiler flocks translate to lower levels of *Salmonella* contaminated carcasses.

RECOMMENDATIONS

- Detailed research on the epidemiology and, in particular, effective surveillance methods (i.e. monitoring and control) of *Campylobacter* in the broiler meat production is recommended.
- The variation in the *Campylobacter* and *Salmonella* prevalence among MSs in this survey and the provision of the quantitative dataset of *Campylobacter* in broiler carcasses are useful information to serve as input for quantitative risk assessment and could be utilised for setting reduction and performance objectives and evaluating the most effective intervention methods.
- MSs may need to address serovars other than *S.* Enteritidis and *S.* Typhimurium in their national *Salmonella* control and surveillance programmes of broiler flocks and broiler meat also when these other serovars are of public health importance in their country.

REFERENCES

Agasan A, Kornblum J and Williams G, 2002. Profile of *Salmonella* enterica subsp. enterica (subspecies I) serotype 4,5,12:i:- strains causing food-borne infections in New York City. Journal of Clinical Microbiology, 40, 1924-9.

Allen VM, Bull SA, Corry JE, Domingue G, Jorgensen F, Frost JA, Whyte R, Gonzalez A, Elviss N and Humphrey TJ, 2007. *Campylobacter* spp. contamination of chicken carcasses during processing in relation to flock colonisation. International Journal of Food Microbiology, 113(1), 54-61.

Amavisit P, Boonyawiwat W and Bangtrakulnont A, 2005. Characterization of *Salmonella enterica* serovar Typhimurium and monophasic *Salmonella* serovar 1,4,[5],12:i:- isolates in Thailand. Journal of Clinical Microbiology, 43, 2736-40.

Augustin JC and Carlier V, 2006. Lessons from the organization of a proficiency testing program in food microbiology by interlaboratory comparison: analytical methods in use, impact of methods on bacterial counts and measurement uncertainty of bacterial counts. Food Microbiology, 23, 1-38.

Berrang ME and Dickens JA, 2000. Presence and level of *Campylobacter* spp. on broiler carcasses throughout the processing plant. Journal of Applied Poultry Research, 9, 43-47.

Berrang ME, Buhr RJ, Cason JA and Dickens JA, 2001. Broiler carcass contamination with *Campylobacter* from feces during defeathering. Journal of Food Protection, 64, 2063-2066.

Bronzwaer S, Hugas M, Collins J, Newell D, Robinson T, Mäkela P and Havelaar A, 2009. EFSA's 12th Scientific Colloquium--assessing health benefits of controlling *Campylobacter* in the food chain. International Journal of Food Microbiology, 131, 284-285.

Bull SA, Allen VM, Domingue G, Jorgensen F, Frost JA, Ure R, Whyte R, Tinker D, Corry JEL, Gillard-King J and Humphrey TJ, 2006. Sources of *Campylobacter* spp. colonizing housed broiler flocks during rearing. Applied and Environmental Microbiology, 72(1), 645-652.

CDC (Centers for Disease Control and Prevention), 2007a. Turtle associated Salmonellosis in humans - United States, 2006-2007. Morbidity and Morality Weekly Report, 57, 649-652.

CDC, (Centers for Disease Control and Prevention)2007b. Investigation of Outbreak of Human Infections Caused by *Salmonella* I 4,[5],12:i:-. Available at: http://www.cdc.gov/Salmonella/4512eyeminus.html

Corry JEL, VM Allen, Hudson WR, Breslin MF and Davies RH, 2002. Sources of *Salmonella* on broiler carcasses during transportation and processing: modes of contamination and methods of control. Journal of Applied Microbiology 92, 424-432.

Corry JE, Jarvis B, Passmore S and Hedges A, 2007. A critical review of measurement uncertainty in the enumeration of food micro-organisms. Food Microbiology 24, 230-253.

de la Torre E, Zapata D, Tello M, Mejia W, Frias N, Garcia Pena FJ, Mateu EM and Torre E, 2003. Several *Salmonella* enterica subsp. enterica serotype 4,5,12:i:- phage types isolated from swine samples originate from serotype Typhimurium DT U302. Journal of Clinical Microbiology 41, 2395-400.

EFSA (European Food Safety Authority), 2007a. Report of Task Force on Zoonoses Data Collection on proposed technical specifications for a coordinated monitoring programme for *Salmonella* and *Campylobacter* in broiler meat in the EU. The EFSA Journal (2006) 92, 1-33.

EFSA (European Food Safety Authority), 2007b. Report of the Task Force on Zoonoses Data Collection on the analysis of the baseline survey on the prevalence of *Salmonella* in broiler flocks of *Gallus gallus*, in the EU, 2005-2006, Part A: *Salmonella* prevalence estimates. The EFSA Journal (2007) 98, 1-85.

EFSA (European Food Safety Authority), 2008. Report of the Task Force on Zoonoses Data Collection on the analysis of the baseline survey on the prevalence of *Salmonella* in slaughter pigs, in the EU, 2006-2007, Part A: *Salmonella* prevalence estimates. The EFSA Journal (2008) 135, 1-111.

EFSA (European Food Safety Authority), 2009a. Assessing health benefits of controlling *Campylobacter* in the food chain. EFSA Scientific Colloquium Summary Report 12. 4-5 December 2008, Rome, Italy.

EFSA (European Food Safety Authority), 2009b. The community summary report on trends and sources of zoonoses and zoonotic agents in the European Union in 2007. The EFSA Journal, 223.

EFSA (European Food Safety Authority), 2009c. Analysis of the baseline survey on the prevalence of *Salmonella* in holdings with breeding pigs, in the EU, 2008, Part A: *Salmonella* prevalence estimates. The EFSA Journal, 7 (12), 1-93.

EFSA (European Food Safety Authority), 2010. Scientific opinion on quantification of the risk posed by broiler meat to human campylobacteriosis in the EU. The EFSA Journal, 8(1), 1-89.

Habib I, Sampers I, Uyttendaele M, Berkvens D and De Zutter L, 2008a. Performance characteristics and estimation of measurement uncertainty of three plating procedures for *Campylobacter* enumeration in chicken meat. Food Microbiology 25(1), 65-74

Habib I, Sampers I, Uyttendaele M, De Zutter L and Berkvens D, 2008b. A Bayesian modelling framework to estimate *Campylobacter* prevalence and culture methods sensitivity: application to a chicken meat survey in Belgium. Journal of Applied Microbiology 105, 2002-2008.

Habib I, Louwen R, Uyttendaele M, Houf K, Vandenberg O, Nieuwenhuis E, Miller W, van Belkum A and De Zutter L, 2009. Correlation between genotypic diversity, lipooligosaccharide gene locus class variation, and Caco-2 cell invasion potential of *Campylobacter jejuni* isolates from chicken meat and humans: contribution to virulotyping. Applied and Environmental Microbiology, 75, 4277-4288.

Hänninen M, Perko-Mäkelä P, Pitkälä A and Rautelin H, 2000. A three-year study of *Campylobacter jejuni* genotypes in humans with domestically acquired infections and in chicken samples from the Helsinki area. Journal of Clinical Microbiology, 38, 1998-2000.

Hartnett E, Kelly L, Newell D, Wooldridge M and Gettinby G, 2001. A quantitative risk assessment for the occurrence of *Campylobacter* in chickens at the point of slaughter. Epidemiology and Infection, 127, 195-206.

ISO (International Organization for Standardization), 2002. Microbiology of food and animal feeding stuffs - Horizontal method for the detection of *Salmonella* spp.. ISO 6579:2002.

ISO (International Organization for Standardization), 2006. Microbiology of food and animal feeding stuffs - Horizontal method for detection and enumeration of *Campylobacter* spp. - Part 1: Detection method. ISO 10272-1:2006.

ISO (International Organization for Standardization), 2006. Microbiology of food and animal feeding stuffs - Horizontal method for detection and enumeration of *Campylobacter* spp. - Part 2: Colony-count technique. ISO/TS 10272-2:2006.

ISO (International Organization for Standardization), 2006. Measurement uncertainty for low counts. ISO/TS 19036:2006.

ISO (International Organization for Standardization), 2007. Microbiology of food and animal feeding stuffs - General requirements and guidance for microbiological examinations. ISO 7218:2007.

Jasson V, Sampers I, Botteldoorn N, López-Gálvez F, Baert L, Denayer S, Rajkovic, A, Habib I, De Zutter L, Debevere J. and Uyttendaele, M. 2009. Characterization of *Escherichia coli* from raw poultry in Belgium and impact on the detection of *Campylobacter jejuni* using Bolton broth. International Journal of Food Microbiology 135, 248-253.

Johannessen GS, Johnsen G, Økland M, Cudjoe KS and Hofshagen M, 2007. Enumeration of thermotolerant *Campylobacter* spp. from poultry carcasses at the end of the slaughter-line. Letters in Applied Microbiology, 44, 92-97.

Johnsen G, Kruse H and Hofshagen M, 2006. Genotyping of *Campylobacter jejuni* from broiler carcasses and slaughterhouse environment by amplified fragment length polymorphism. Poultry Science, 85, 2278-2284.

Jørgensen F, Bailey R, Williams S, Henderson P, Wareing DRA, Bolton FJ, Frost JA, Ward L and Humphrey TJ, 2002. Prevalence and numbers of *Salmonella* and *Campylobacter* spp. on raw, whole chickens in relation to sampling methods. International Journal of Food Microbiology, 76, 151-164.

Jore S, Viljugrein H, Heier BT, Borch B, Ethelberg S, Hakkinen M, Kuusi M, Reiersen J, Hansson I, Olsson E, Løfdahl M, Wagenaar J, Van Pelt W. and Hofshagen M, 2009. Trends in *Campylobacter* incidence in broilers and humans in six European countries, 1997-2007. Preventive Veterinary Medicine, 93, 33-41.

Meremäe K, Elias P, Tamme T, Kramarenko T, Lillenberg M, Karus A, Hänninen M. and Roasto M, 2010. The occurrence of *Campylobacter* spp. in Estonian broiler chicken production in 2002-2007. Food Control 21, 272-275.

Liang K and Zeger SL, 1986. Longitudinal data analysis unsing generalized linear models, Biometrika 73, 13-22.

Lombard B, 2006. Estimation of measurement uncertainty in food microbiology: the ISO approach. Accreditation and Quality Assurance, 17, 94-100.

Molenberghs G and Verbeke G, 2005. Models for discrete longitudinal data. Springer, New York.

Mossong J, Marques P, Ragimbeau, C Huberty-Krau, P Losch, S Meyer, G Moris, G Strottner, C Rabsch, W Schneider F, 2007. Outbreaks of monophasic *Salmonella* enterica serovar 4,[5],12:i:- in Luxembourg, 2006. Euro Surveillance 12(6), E11-2.

Nauta MJ, Jacobs-Reitsma WF and Havelaar AH, 2006. A Risk Assessment Model for *Campylobacter* in Broiler Meat. Risk Analysis, 26(6), 1-17.

Nauta M, Hill A, Rosenquist H, Brynestad S, Fetsch A, van der Logt P, Fazil A, Christensen B, Katsma E, Borck B. and Havelaar A, 2009. A comparison of risk assessments on *Campylobacter* in broiler meat. International Journal of Food Microbiology, 129, 107-123.

Niemelä SI, 2003. Uncertainty of quantitative determinations derived by cultivation of microorganisms, Centre for metrology and accreditation, Helsinki, Finland, Publication J4/2003.

Nógrády N, Tóth A, Kostyák A, Pászti J and Nagy B, 2007. Emergence of multidrug-resistant clones of *Salmonella* Infantis in broiler chickens and humans in Hungary. Journal of Antimicrobial Chemotherapy, 60, 645-648.

Nógrády N, Kardos G, Bistyák A, Turcsányi I, Mészáros J, Galántai zs, Juhász A, Samu P, Kaszanyitzky JÉ, Pászti J. and Kiss I, 2008. Prevalence and characterization of *Salmonella* Infantis isolates originating from different points of the broiler chicken-human food chain in Hungary. International Journal of Food Microbiology, 127, 162-167.

PHAC (Public Health Agency of Canada), 2006. Government of Canada, National Integrated Enteric Pathogen Surveillance Program (Centernet) 2005-2006. Guelph, ON: Public Health Agency of Canada, 2006.

Rasschaert G, Houf K, Godard C, Wildemauwe C, Pastuszczak-Frak M and De Zutter L. 2008. Contamination of carcasses with *Salmonella* during poultry slaughter. Journal of Food Protection 7, 146-152.

Rosenquist H, Nielsen NL, Sommer HM, Norrung B and Christensen BB, 2003. Quantitative risk assessment of human campylobacteriosis associated with thermophilic *Campylobacter* species in chickens. International Journal of Food Microbiology, 83, 87-103.

Rosenquist H, Sommer HM, Nielsen NL and Christensen BB, 2006. The effect of slaughter operations on the contamination of chicken carcasses with thermotolerant *Campylobacter*. International Journal of Food Microbiology, 108, 226-232.

Rosenquist H, Boysen L, Galliano C, Nordentoft S, Ethelberg S and Borck B, 2009. Danish strategies to control *Campylobacter* in broilers and broiler meat: facts and effects. Epiedmiology and Infection, 137: 1742-1750.

Sorensen O, Van Donkersgoed J, McFall M, Manninen K, Gensler G and Ollis G, 2002. *Salmonella* spp. shedding by Alberta beef cattle and the detection of *Salmonella* spp. in ground beef. Journal of Food Protection, Vol. 65, N. 3, 484-491(8).

Switt AIM, Soyer Y, Warnick LD and Wiedmann M, 2009. Emergence, distribution, and molecular and phenotypic characteristics of *Salmonella* enterica Serotype 4,5,12:i:-. Foodborne Pathogens and Disease 6(4), 407-415.

Tavechio AT, Ghilardi AC, and Fernandesm SA, 2004. "Multiplex PCR" identification of the atypical and monophasic *Salmonella* enterica subsp. enterica serotype 1,4,[5],12:i:- in São Paulo State, Brazil: frequency and antibiotic resistance patterns. Rev Inst Med Trop São Paulo. 46, 115-7.

Verhoeff-Bakkenes L, Beumer R, de Jonge R, van Leusden F and de Jong A, 2008. Quantification of *Campylobacter jejuni* cross-contamination via hands, cutlery, and cutting board during preparation of a chicken fruit salad. Journal of Food Protection, 71, 1018-1022.

WHO/FAO, (World Health Organization/Food and Agriculture Organization), 2002. Risk assessments of *Salmonella* in eggs and broiler chickens. World Health Organisation, Food and Agriculture Organization of the United Nations. Geneva, Switzerland.

Wilson D, Gabriel E, Leatherbarrow A, Cheesbrough J, Gee S, Bolton E, Fox A, Fearnhead P, Hart C and Diggle P, 2008. Tracing the source of campylobacteriosis. PLoS Genet. 4: e1000203.

Zamperini K, Soni V, Waltman D, Sanchez S, Theriault EC, Bray J, Maurer JJ, 2007. Molecular characterization reveals *Salmonella* enterica serovar 4,[5],12:i:- from poultry is a variant Typhimurium serovar. Avian Diseases 51(4): pp. 958-64.

Zeger SL and Liang K, 1986. Longitudinal data analysis for discrete and continuous outcomes. Biometrics, 42, 121-130.

Zheng J, Meng J, Zhao S, Singh R and Song W, 2006. Adherence to and invasion of human intestinal epithelial cells by *Campylobacter jejuni* and *Campylobacter coli* isolates from retail meat products. Journal of Food Protection, 69, 768-774.

LIST OF APPENDICES

APPENDICES

APPENDIX A. List of criteria used to identify non-valid and non-plausible information in the baseline survey on the prevalence of *Campylobacter*-colonised broiler batches and of *Campylobacter* and *Salmonella*-contaminated broiler carcasses in the EU, 2008

The variables are uniquely identified using the 'item integer' mentioned in the *ad hoc* data dictionary.

Criterion No	Criterion	Rationale for the criterion
1	017 Date of sampling: < 15 December 2007.	This criterion excludes all records containing a date of sampling before 15 December 2007.
2	017 Date of sampling: > 15 January 2009.	This criterion excludes all records containing a date of sampling after 15 January 2009.
3	014 *Salmonella* serovar in flock: IS NULL (EMPTY) and 013 *Salmonella* test result in flock is 'positive'.	This criterion excludes all records containing positive test results with no information of the isolate.
4	014 *Salmonella* serovar in flock: IS NOT NULL (NOT EMPTY) and 013 *Salmonella* test result in flock is not 'positive'.	This criterion excludes all records containing no positive test result with information of the isolate.
5	016 *Campylobacter* species in flock: IS NULL (EMPTY) and 015 *Campylobacter* test result in flock is 'positive'.	This criterion excludes all records containing positive test results with no information of the isolate.
6	016 *Campylobacter* species in flock: IS NOT NULL (NOT EMPTY) and 015 *Campylobacter* test result is not 'positive'	This criterion excludes all records containing no positive test results with information of the isolate.
7	021 Transport protocol = 'No'.	This criterion excludes all records where the correct transport protocol was not respected.
8	025 Time between sampling and testing = '> 80 hours'.	This criterion excludes all records if testing started more than 80 hours after sampling.
9	030 *Campylobacter* species: IS NULL (EMPTY) and 027 *Campylobacter* test result is 'positive'	This criterion excludes all records containing positive test results with no information of the isolate.
10	030 *Campylobacter* species: IS NOT NULL (NOT EMPTY) and 027 *Campylobacter* test result is 'negative'.	This criterion excludes all records containing negative test results with information of the isolate.

APPENDIX A (*contd.*) List of criteria used to identify non-valid and non-plausible information in the baseline survey on the prevalence of *Campylobacter*-colonised broiler batches and of *Campylobacter* and *Salmonella*-contaminated broiler carcasses in the EU, 2008

Criterion No	Criterion	Rationale for the criterion
11	031 Transport protocol = 'No'.	This criterion excludes all records where the correct transport protocol was not respected.
12	035 Time between sampling and testing = '> 80 hours'.	This criterion excludes all records if testing started more than 80 hours after sampling.
13	040 *Campylobacter* species of detection testing: IS NULL (EMPTY) and 037 *Campylobacter* detection result is 'positive'.	This criterion excludes all records containing positive detection results with no information of the isolate.
14	040 *Campylobacter* species of detection testing: IS NOT NULL (NOT EMPTY) and 037 *Campylobacter* detection result is 'negative'.	This criterion excludes all records containing negative detection results with information of the isolate.
15	041 *Campylobacter* quantification result: IS AN INTEGER WITH A SPACE, COMMA, DOT OR ANY OTHER ALPHANUMERICAL CHARACTER.	This criterion excludes all records containing an integer written with a space, comma or dot between figures or any other alphanumerical character.
16	041bis *Campylobacter* species of quantification result: IS NULL (EMPTY) and 037 *Campylobacter* detection result is 'negative' and 041 *Campylobacter* quantification result is not '0'.	This criterion excludes all records containing negative detection results but *Campylobacter* in the quantification with no information of the isolate.
17	042 Transport protocol = 'No'.	This criterion excludes all records where the correct transport protocol was not respected.
18	046 Time between sampling and testing = '> 80 hours'.	This criterion excludes all records if testing started more than 80 hours after sampling.
19	051 *Salmonella* serovar: IS NULL (EMPTY) and 047 *Salmonella* detection result is 'positive'.	This criterion excludes all records containing positive detection results with no information of the isolate.
20	051 *Salmonella* serovar: IS NOT NULL (NOT EMPTY) and 047 *Salmonella* detection result is 'negative'.	This criterion excludes all records containing negative detection results with information of the isolate.

APPENDIX B. Statistical methodology used in the "Analysis of the baseline survey on the prevalence of *Campylobacter* in broiler batches and of *Campylobacter* and *Salmonella* on broiler carcasses in the EU, 2008"

Methodology and tools for the prevalence estimation

The hierarchical structure in the data can essentially be expressed as follows: slaughter broilers within a slaughterhouse, and slaughterhouses within a country. Interest goes to broiler level prevalence for the carcass samples and to batch level prevalence for the pooled caecal content samples. Therefore, let π_i be the probability for a sample (carcass sample or pooled caecal content sample) to be positive, let n_{ij} be the number of samples (carcass samples or pooled caecal content samples) in slaughterhouse *j* from country *i*. The starting point for inference on the 'broiler level prevalence' of the different outcome variables is the binomial distribution for the number of positive broilers y_{ij} in slaughterhouse *j* from country *i*:

$$y_{ij} \sim Bin(n_{ij}, \pi_i). \quad (1)$$

In a fully random sample these numbers y_{ij} could be combined in a straightforward way to estimate the prevalence for country *i*. The main complications here are:

- the assumptions on the binomial distribution are violated,
- the sample is not drawn at random (but essentially stratified).

Indeed,

violation of independence: outcomes from the same slaughterhouse are expected to be more alike (correlated) as compared to outcomes from a different slaughterhouse (hierarchical correlation structure),

violation of constant probability: samples, even from the same slaughterhouse, might have different probabilities to be infected (heterogeneity of probability).

Clustering

To account for the possibility of samples from the same slaughterhouse being more alike than from different slaughterhouses, there exist, broadly, the following three approaches.

Ignore the correlation. While this typically leaves the consistency of point estimation intact, the same is not true for measures of precision. In case of a "positive" correlation (i.e. samples within a slaughterhouse are more alike than between slaughterhouses), then ignoring this aspect of the data, just as ignoring overdispersion, overestimates precision and hence underestimates standard errors and widths of CIs.

Account for correlation. The existence of correlation is recognised but considered as a nuisance characteristic. A crude way of correcting for clustering is done by computing a so-called *design effect*. Roughly, the design effect is a factor comparing the precision under simple random sampling with the precision of the actual design. Standard errors, computed as if the design had been simple random sampling, can then be artificially inflated using the design effect.

Model correlation. In contrast to the previous view-point, one can have a genuine scientific interest in the correlation itself. The intra-class correlation should be addressed in order to obtain valid statistical inferences, and specialised methods which model the correlation should be used.

Obviously the third method is much broader. Hence, analysis strategies consistent with an interest in the intra-cluster dependence can be applied. There exist two important families of models which can be used for this purpose: random-effects models and marginal models.

Given that the objective of the analysis in this report is to obtain a prevalence estimate of *Campylobacter* and *Salmonella* in the EU and for each MS and two non-MS countries separately, the *marginal* or *population-averaged approach* is the obvious path to follow. Indeed, the marginal model can be used to evaluate the overall prevalence (i.e. averaged over all slaughterhouses in the EU and in the MS and two non-MS countries). We will fit a logistic intercept model, which will provide us with an estimate for the prevalence of *Campylobacter* and *Salmonella*, while correcting the estimated standard errors for clustering. The association structure is typically captured using a set of association parameters, such as correlations or odds ratios. Often, generalised estimating equations (GEE) (Zeger and Liang, 1986; Liang and Zeger, 1986) are used to account for the clustering of outcomes. In this approach, instead of specifying the full distribution for the correlated binary response, assumptions are made about the mean, variance and correlation.

For example, let y_{ijk} represent the response of broiler *k* of slaughterhouse *j* in country *i.* There are a variety of possible working correlation structures. Some of the more popular choices are:

Independence: The simplest choice is the independence working model, i.e.,

$$\text{Corr}(Y_{ijk}, Y_{ij\ell}) = 0.$$

Exchangeable: When there is no logical ordering for the observations within a cluster, an exchangeable correlation structure may be more appropriate:

$$\text{Corr}(Y_{ijk}, Y_{ij\ell}) = \alpha.$$

Autoregressive: When repeated samples are taken at the same slaughterhouse, an autoregressive correlation structure might be of interest, assuming that the correlation between samples depends on the time lag between samples:

$$\text{Corr}(Y_{ijk}, Y_{ij\ell}) = \alpha^{|t_k - t_\ell|}.$$

Unstructured: A totally unspecified correlation matrix is given by

$$\text{Corr}(Y_{ijk}, Y_{ij\ell}) = \alpha_{k\ell}.$$

Any of these choices are justified since estimation using the GEE method is robust against misspecification of the working correlation structure. However, misspecification of the correlation structure can come at the cost of efficiency of the parameter estimates (Molenberghs and Verbeke, 2005).

As was mentioned before, in this report prevalence estimates for *Campylobacter* and *Salmonella* in slaughter broilers, are obtained starting from (1), and considering the logit link function such that

$$\log\left(\frac{\pi_i}{1-\pi_i}\right) = \beta_0. \qquad (2)$$

Observe that in this model, e^{β_0} represents the odds of success. Using the GEE methodology, an estimate can be obtained for β_0 together with a 95% CI. This interval is based on the robust or empirical standard errors from assuming an exchangeable working correlation structure, a plausible choice given that there is no logical ordering of broiler batches or broilers within a slaughterhouse. Independence is chosen only when problems occur while trying to fit the exchangeable structure. Note that independence in itself would also be a good option, however this assumption could decrease the efficiency of the prevalence estimates when an exchangeable working correlation structure is more appropriate.

From (2) a direct expression for π_i can be derived, given by

$$\pi_i = \frac{e^{\beta_0}}{1+e^{\beta_0}},$$

which provides us with an estimate for the prevalence π_i, as well as the corresponding 95% CI. Observe that in this report the models are used only to obtain prevalence estimates. Since no model building is performed in this analysis, no model diagnostic or remedial measures are required to study the goodness-of-fit.

Weighting

Most statistical procedures analyse the data as if they were collected as a simple random sample. As a result, these procedures may lead to biased estimates and may underestimate the variability present in the data, when the data actually arise from complex surveys. Assigning weights to the observations is one possible approach to correct for the differences between the complex survey design and simple random sampling. In general, weights are used in an attempt to 'reconstruct the total population', in order to avoid that certain strata or subpopulations are over- or under-represented. Below the weighting scheme for pooled caecal content samples and for broiler carcasses samples is described.

Ideally, in order to calculate the weights, two pieces of information should be taken into account, first the probability of selection of a slaughterhouse within a country, and second, given that a slaughterhouse is selected, the probability of selecting a specific sample (pooled caecal content sample or broiler carcass) within a slaughterhouse.

For the first probability, the total number of slaughtered broilers within the country and the number of slaughtered broilers in the slaughterhouses included in the survey could be considered. To calculate the second probability, the number of slaughtered broilers per year in each slaughterhouse could be used. However, the capacity of the selected slaughterhouses is given in the survey as an ordinal variable categorized in big ranges (for instance, 1,000,000-4,999,999, 5,000,0000-9,999,999 or ≥10,000,000). Hence, the second probability would not give us a good approximation to the weights and the first probability could be taken into account to calculate the weights for broiler carcass samples and pooled caecal content samples.

Hence, weights are only used at country level to calculate the estimated prevalence at European level. For these weights, the total number of sampled broilers per slaughterhouse and the total number of slaughtered broilers within a country are used. The same procedure is performed for the pooled caecal content samples.

In this report, two weighting schemes are considered for the prevalence estimation:

No weights: this takes into account each observation *as it is*. This would disregard the (possible) disproportionate sampling at country level and within the slaughterhouses. This scheme is used to obtain the estimates at country level.

Proxy - country weights: for each country, the number of slaughtered broilers in the year is divided by the number of samples. This scheme is used to obtain the estimate at EU level.

Therefore, an estimated prevalence of broiler carcass and pooled caecal content samples for *Campylobacter* and broiler carcasses for *Salmonella* takes into account the slaughterhouse as a cluster and the weighting at EU level.

Finally, it should be observed that the sum of these weights gives an indication of the total number of slaughtered broilers *N* in the EU. To avoid overemphasising the importance of the broilers used in the sample, the standardisation of calculated weights is therefore need so that they sum up to N_s, i.e., the sample size. In general, this implies that, for broiler *k*, in slaughterhouse *j*, in country *i*:

$$\text{If } \sum_{ikc} w_{ijk} = N \text{ then } \sum_{ijk}(N_s/N)w_{ijk} = N_s.$$

Therefore, the standardised weights $w^*_{ijk} = (N_s/N)w_{ijk}$ are used.

APPENDIX C. Results of the descriptive analysis of the sample data of the baseline survey on the prevalence of *Campylobacter* in broiler batches and of *Campylobacter* and *Salmonella* on broiler carcasses in the EU, 2008

Table 11. **Number and percentage of the slaughterhouses by capacity, by country and in the EU*, 2008**

Country	Capacity of the slaughterhouse												No of slaughterhouses
	<100,000		100,000-499,999		500,000-999,999		1,000,000-4,999,999		5,000,000-9,999,999		>10,000,000		
	N	%	N	%	N	%	N	%	N	%	N	%	
Austria	0	0	0	0	0	0	2	40.0	0	0	3	60.0	5
Belgium	0	0	0	0	0	0	0	0	0	0	9	100	9
Bulgaria	5	31.3	2	12.5	3	18.8	3	18.8	0	0	3	18.8	16
Cyprus	14	56.0	7	28.0	0	0	4.0	16.0	0	0	0	0	25
Czech Republic	0	0	0	0	0	0	5	41.7	3	25	4	33.3	12
Denmark	0	0	0	0	0	0	0	0	0	0	4	100	4
Estonia	0	0	0	0	0	0	0	0	1	100	0	0	1
Finland	0	0	0	0	0	0	0	0	1	33.3	2	66.7	3
France	2	3.5	3	5.2	6	10.3	15	25.9	7	12.1	25	43.1	58
Germany	3	14.3	3	14.3	1	4.8	2	9.5	2	9.5	10	47.6	21
Hungary	3	6.8	9	20.5	6	13.6	18	40.9	6	13.6	2	4.6	44
Ireland	0	0	0	0	0	0	0	0	2	50.0	2	50.0	4
Italy	3	6.3	9	18.8	7	14.6	11	22.9	5	10.4	13	27.1	48
Latvia	0	0	0	0	0	0	1	50	1	50	0	0	2
Lithuania	0	0	1	16.7	0	0	2	33.3	1	16.7	2	33.3	6
Luxembourg	4	100	0	0	0	0	0	0	0	0	0	0	4
Malta	0	0	1	25.0	2	50.0	0	0	1	25.0	0	0	4
Netherlands	0	0	1	5.9	0	0	1	5.9	0	0	15	88.2	17
Poland	10	6.4	45	28.7	20	12.7	52	33.1	11	7.0	19	12.1	157
Portugal	0	0	0	0	0	0	2	13.3	8	53.3	5	33.3	15
Romania	0	0	0	0	0	0	5	31.3	9	56.3	2	12.5	16
Slovakia	0	0	0	0	0	0	4	57.1	1	14.3	2	28.6	7
Slovenia	0	0	0	0	0	0	1	33.3	1	33.3	1	33.3	3
Spain	0	0	0	0	0	0	5	13.2	15	39.5	18	47.4	38
Sweden	0	0	1	14.3	1	14.3			1	14.3	4	57.1	7
United Kingdom	0	0	0	0	0	0	2	8.0	5	20.0	18	72.0	25
EU Total (26 MSs)	**44**	**8.0**	**82**	**14.9**	**46**	**8.4**	**135**	**24.5**	**81**	**14.7**	**163**	**29.6**	**551**
Norway	0	0	0	0	0	0	1	20.0	2	40.0	2	40.0	5
Switzerland	0	0	0	0	0	0	1	20.0	2	40.0	2	40.0	5

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

Table 12. **Number and percentage of positive broiler batches for *Campylobacter* detection, positive carcasses for combined *Campylobacter* detection and enumeration and for *Salmonella* detection, by country and in the EU*, 2008**

Country	Total samples	*Campylobacter* in broiler batches		Total samples	*Campylobacter* on carcasses		Total samples	*Salmonella* on carcasses	
		Positive	%		Positive	%		Positive	%
Austria	408	195	47.8	408	329	80.6	408	10	2.5
Belgium	337	102	30.3	380	198	52.1	380	77	20.3
Bulgaria	275	91	33.1	280	126	45.0	316	85	26.9
Cyprus	375	119	31.7	357	46	12.9	357	38	10.6
Czech Republic	422	258	61.1	422	295	69.9	422	23	5.5
Denmark	396	76	19.2	396	123	31.1	396	0	0
Estonia	102	2	2.0	102	5	4.9	102	0	0
Finland	411	17	4.1	369	21	5.7	369	0	0
France	422	317	75.1	422	370	87.7	422	32	7.6
Germany	432	210	48.6	432	268	62.0	432	76	17.6
Hungary	321	162	50.5	321	180	56.1	321	275	85.7
Ireland	394	318	80.7	394	386	98.0	394	39	9.9
Italy	393	251	63.9	393	205	52.2	393	66	16.8
Latvia	122	50	41.0	122	41	33.6	122	6	4.9
Lithuania	374	157	42.0	374	172	46.0	374	26	7.0
Luxembourg	12	12	100	13	13	100	13	0	0
Malta	367	356	97.0	367	348	94.8	367	77	21.0
Netherlands	429	104	24.2	429	162	37.8	429	43	10.0
Poland	419	332	79.2	419	339	80.9	419	107	25.5
Portugal	421	349	82.9	421	312	74.1	421	47	11.2
Romania	357	273	76.5	357	227	63.6	357	17	4.8
Slovakia	422	298	70.6	422	315	74.6	422	91	21.6
Slovenia	413	321	77.7	413	333	80.6	413	7	1.7
Spain	389	341	87.7	389	360	92.5	389	58	14.9
Sweden	410	51	12.4	410	55	13.4	410	1	0.2
United Kingdom	401	304	75.8	401	350	87.3	401	14	3.5
EU Total (26 MSs)	**9,224**	**5,066**	**54.9**	**9,213**	**5,579**	**60.6**	**9,249**	**1,215**	**13.1**
Norway	396	13	3.3	396	20	5.1	396	0	0
Switzerland	296	176	59.5	408	288	70.6	390	10	2.6

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

Table 13. **Number and percentage of positive broiler batches for *Campylobacter jeuni* and *C. coli* detection and positive carcasses for combined *Campylobacter jeuni* and *C. coli* detection and enumeration, by country and in the EU*, 2008**

Country	*Campylobacter jejuni* in broiler batches			*Campylobacter coli* in broiler batches			*Campylobacter jejuni* on broiler carcasses			*Campylobacter coli* on broiler carcasses		
	Total samples	Positive	%	Total samples	Positive	%	Total samples	Positive	%	Total samples	Positive	%
Austria	408	127	31.1	408	65	15.9	408	245	60.1	408	112	27.5
Belgium	337	67	19.9	337	28	8.3	380	146	38.5	380	43	11.4
Bulgaria	275	30	10.9	275	61	22.2	280	47	16.8	280	78	27.9
Cyprus	375	78	20.8	375	41	10.9	357	31	8.7	357	15	4.2
Czech Republic	422	217	51.4	422	59	14.0	422	251	59.5	422	69	16.4
Denmark	396	69	17.4	396	7	1.8	396	112	28.3	396	11	2.8
Estonia	102	2	2.0	102	0	0	102	5	4.9	102	0	0
Finland	411	17	4.1	411	0	0	369	21	5.7	369	0	0
France	422	180	42.7	422	163	38.6	422	304	72.0	422	226	53.6
Germany	432	163	37.7	432	47	10.9	432	213	49.3	432	50	11.6
Hungary	321	73	22.7	321	85	26.5	321	108	33.6	321	64	19.9
Ireland	394	219	55.6	394	103	26.1	394	212	53.9	394	213	54.2
Italy	393	121	30.8	393	127	32.3	393	89	22.7	393	112	28.5
Latvia	122	42	34.4	122	8	6.6	122	38	31.2	122	3	2.5
Lithuania	374	124	33.2	374	33	8.8	374	137	36.6	374	33	8.8
Luxembourg	12	2	16.7	12	11	91.7	13	2	15.4	13	10	76.9
Malta	367	80	21.8	367	271	73.8	367	150	40.9	367	184	50.1
Netherlands	429	82	19.1	429	19	4.4	429	137	31.9	429	28	6.5
Poland	419	203	48.5	419	129	30.8	419	226	53.9	419	127	30.3
Portugal	421	99	23.5	421	215	51.1	421	232	55.1	421	177	42.0
Romania	357	199	55.7	357	103	28.9	357	144	40.3	357	79	22.1
Slovakia	422	233	55.2	422	85	20.1	422	258	61.1	422	70	16.6
Slovenia	413	203	49.2	413	146	35.4	413	218	52.8	413	149	36.1
Spain	389	154	39.6	389	239	61.4	389	183	47.0	389	254	65.3
Sweden	410	51	12.4	410	0	0	410	55	13.4	410	0	0
United Kingdom	401	225	56.1	401	79	19.7	401	266	66.3	401	103	25.7
EU (26 MSs)*	**9,224**	**3,060**	**33.2**	**9,224**	**2,124**	**23.0**	**9,213**	**3,830**	**41.6**	**9,213**	**2,210**	**24.0**
Norway	396	13	3.3	396	0	0	396	20	5.1	396	0	0
Switzerland	296	120	40.5	296	56	18.9	408	216	52.9	408	92	22.6

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

Table 14. **Number and percentage of positive carcasses for *Salmonella* Enteritidis and Typhimurium and *Salmonella* serovars other than Enteritidis and Typhimurium , by country and in the EU*, 2008**

Country	*Salmonella* Enteritidis and Typhimurium on carcasses			Other than *Salmonella* Enteritidis and Typhimurium on carcasses		
	Total samples	Positive	%	Total samples	Positive	%
Austria	408	3	0.7	408	7	1.7
Belgium	380	11	2.9	380	51	13.4
Bulgaria	316	19	6.0	316	52	16.5
Cyprus	357	0	0	357	38	10.6
Czech Republic	422	4	1.0	422	19	4.5
Denmark	396	0	0	396	0	0
Estonia	102	0	0	102	0	0
Finland	369	0	0	369	0	0
France	422	1	0.2	422	31	7.3
Germany	432	20	4.6	432	45	10.4
Hungary	321	14	4.4	321	270	84.1
Ireland	394	0	0	394	39	9.9
Italy	393	1	0.3	393	52	13.2
Latvia	122	6	4.9	122	0	0
Lithuania	374	1	0.3	374	7	1.9
Luxembourg	13	0	0	13	0	0
Malta	367	0	0	367	55	15.0
Netherlands	429	1	0.2	429	40	9.3
Poland	419	40	9.6	419	67	16.0
Portugal	421	38	9.0	421	9	2.1
Romania	357	3	0.8	357	14	3.9
Slovakia	422	27	6.4	422	64	15.2
Slovenia	413	2	0.5	413	5	1.2
Spain	389	26	6.7	389	32	8.2
Sweden	410	0	0	410	1	0.2
United Kingdom	401	0	0	401	13	3.2
EU (26 MSs)*	**9,249**	**217**	**2.3**	**9,249**	**911**	**9.8**
Norway	396	0	0	396	0	0
Switzerland	390	3	0.8	390	6	1.5

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

Figure 13. **Distribution of the total number of tested broiler batches by month of sampling, by country and in the EU*, 2008**

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

APPENDIX D. Prevalence of *Campylobacter jejuni* and *Campylobacter coli*-colonised broiler batches

Table 15. **Prevalence of *Campylobacter jejuni-colonised* broiler batches, by country and in the EU*, 2008**

Country	N (No of broiler batches)	% prevalence[2]	95% CI[2]
Austria	408	30.8	27.0 - 34.8
Belgium	337	20.0	17.9 - 22.3
Bulgaria	275	8.8	5.5 - 13.8
Cyprus	375	23.8	23.5 - 24.0
Czech Republic	422	51.9	45.8 - 57.8
Denmark	396	17.0	15.0 - 19.2
Estonia	102	2.0[1]	0.5[1] - 7.5[1]
Finland	411	3.9	3.8 - 4.0
France	422	42.9	38.7 - 47.3
Germany	432	38.0	29.8 - 46.9
Hungary	321	22.7	18.5 - 27.6
Ireland	394	56.1	49.8 - 62.2
Italy	393	30.6	25.3 - 36.4
Latvia	122	34.4	8.7 - 74.4
Lithuania	374	33.4	29.9 - 37.1
Luxembourg	12	19.5	16.9 - 22.4
Malta	367	21.7	15.8 - 29.2
Netherlands	429	19.1	15.7 - 23.1
Poland	419	48.2	43.2 - 53.3
Portugal	421	18.8	12.0 - 28.2
Romania	357	54.6	43.2 - 65.5
Slovakia	422	56.4	45.8 - 66.5
Slovenia	413	48.7	46.2 - 51.2
Spain	389	38.3	34.3 - 42.4
Sweden	410	13.2	8.0 - 21.0
United Kingdom	401	55.8	49.6 - 61.8
EU (26 MSs)*	**9,224**	**40.6**	**38.3 - 42.9**
Norway	396	3.2	2.1 - 4.8
Switzerland	296	40.1	39.0 - 41.3

[1] As one slaughterhouse contributed to the entire survey, point estimate and 95% CI are based on logistic regression.

[2] Prevalence estimates and CIs at national as well as at EU level were obtained taking into account correlation among observations within the same slaughterhouse. In addition, at EU level, prevalence estimates and CIs were weighted for the national numbers of slaughtered broilers during 2008.

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

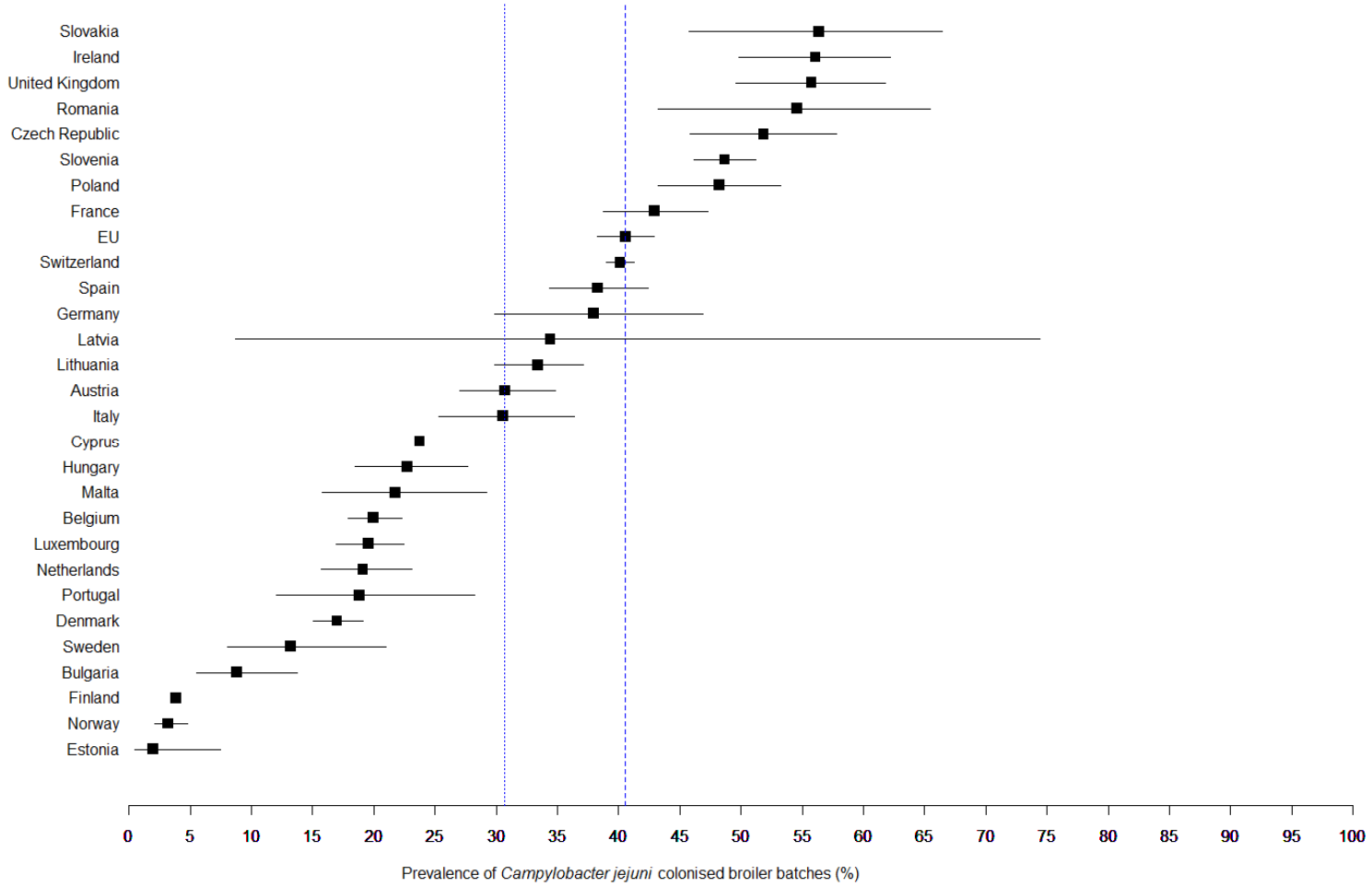

Figure 14. **Prevalence of *Campylobacter jejuni*-colonised broiler batches by country and at EU* level (dashed line), 2008. The dotted line indicates the median prevalence of 26 participating MSs. Horizontal lines indicate 95% CIs of prevalence**

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

Table 16. **Prevalence of *Campylobacter coli-colonised* broiler batches, by country and in the EU*, 2008**

Country	N (No of broiler batches)	% prevalence[3]	95% CI[3]
Austria	408	15.2	12.6 - 18.2
Belgium	337	9.2	5.4 - 15.5
Bulgaria	275	21.8	16.7 - 28.0
Cyprus	375	10.7	7.7 - 14.7
Czech Republic	422	14.7	9.5 - 21.9
Denmark	396	1.8	0.8 - 3.7
Estonia	102	0	0[2] - 3.6[2]
Finland	411	0	0[2] - 0.9[2]
France	422	42.4	35.0 - 50.1
Germany	432	10.9	8.3 - 14.1
Hungary	321	26.0	21.2 - 31.5
Ireland	394	26.1	22.1 - 30.6
Italy	393	31.6	25.1 - 38.9
Latvia	122	6.6	1.6 - 23.6
Lithuania	374	8.9	6.3 - 12.4
Luxembourg	12	91.9	65.2 - 98.6
Malta	367	74.2	65.8 - 81.1
Netherlands	429	4.4	2.8 - 6.8
Poland	419	30.9	26.3 - 35.9
Portugal	421	53.1	44.2 - 61.8
Romania	357	30.3	23.3 - 38.3
Slovakia	422	23.7	16.6 - 32.8
Slovenia	413	35.9	35.2 - 36.7
Spain	389	61.4	57.3 - 65.4
Sweden	410	0	0[2] - 0.9[2]
United Kingdom	401	19.5	14.8 - 25.1
EU (26 MSs)*	**9,224**	**31.9**	**29.2 - 34.8**
Norway	396	0	0[2] - 0.9[2]
Switzerland	296	18.9[1]	16.7[1] - 21.3[1]

[1] Results assuming independent covariance structure.

[2] Exact binomial CI, it does not take into account the clustering of data.

[3] Prevalence estimates and CIs at national as well as at EU level were obtained taking into account correlation among observations within the same slaughterhouse. In addition, at EU level, prevalence estimates and CIs were weighted for the national numbers of slaughtered broilers during 2008.

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

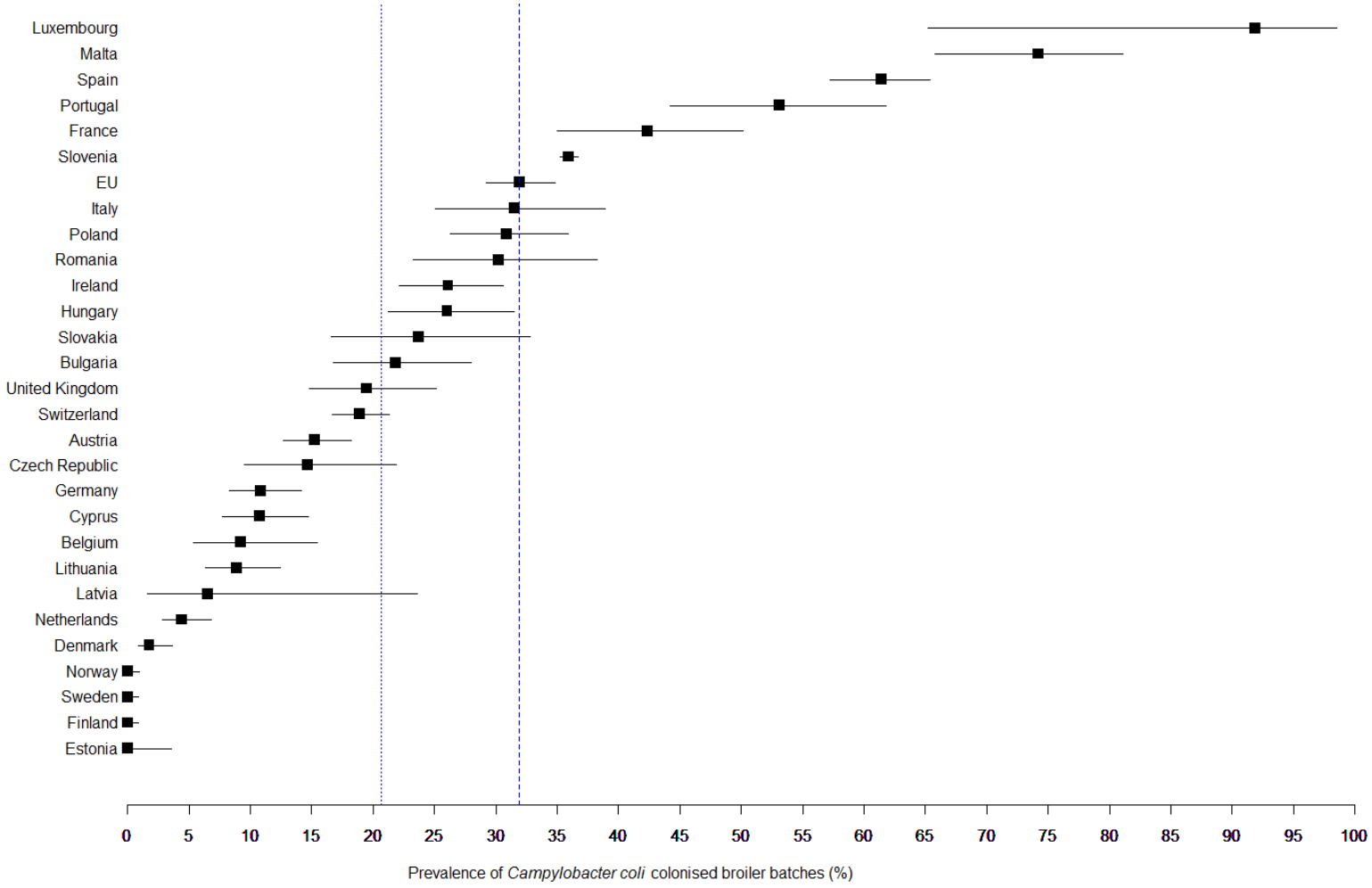

Figure 15. **Prevalence of *Campylobacter coli*-colonised broiler batches by country and at EU* level (dashed line), 2008. The dotted line indicates the median prevalence of 26 participating MSs. Horizontal lines indicate 95% CIs of prevalence**

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

APPENDIX E. Prevalence of *Campylobacter jejuni* and *Campylobacter coli-contaminated* broiler carcasses

Table 17. **Prevalence of *Campylobacter jejuni-contaminated* broiler carcasses, based on the combined detection and enumeration method, by country and in the EU*, 2008**

Country	N (No of broiler batches)	% prevalence[3]	95% CI[3]
Austria	408	60.1	55.1 - 64.8
Belgium	380	38.7[2]	32.5[2] - 45.3[2]
Bulgaria	280	17.0	13.0 - 21.9
Cyprus	357	10.4	10.2 - 10.5
Czech Republic	422	59.7	53.6 - 65.5
Denmark	396	28.4	23.8 - 33.5
Estonia	102	4.9[1]	2.1[1] - 11.2[1]
Finland	369	5.5	5.4 - 5.5
France	422	72.0	67.6 - 76.1
Germany	432	48.7	41.6 - 55.9
Hungary	321	32.4	26.3 - 39.2
Ireland	394	54.0[2]	46.0[2] - 61.8[2]
Italy	393	22.3	16.6 - 29.4
Latvia	122	31.1	8.5 - 68.9
Lithuania	374	37.1	29.7 - 45.2
Luxembourg	13	16.2	6.9 - 33.4
Malta	367	41.4	32.6 - 50.8
Netherlands	429	31.3	26.0 - 37.1
Poland	419	53.5	48.3 - 58.7
Portugal	421	49.3	36.8 - 61.8
Romania	357	40.8	31.7 - 50.5
Slovakia	422	62.3	53.2 - 70.7
Slovenia	413	53.7	53.6 - 53.8
Spain	389	47.0	42.0 -52.1
Sweden	410	14.6	8.4 - 24.2
United Kingdom	401	65.0	57.7 - 71.7
EU (26 MSs)	**9,213**	**51.0**	**48.3 - 53.7**
Norway	396	5.1	3.1 - 8.3
Switzerland	408	52.2	43.3 - 61.1

[1] As one slaughterhouse contributed to the entire survey, point estimate and 95% CI are based on logistic regression.

[2] To estimate this prevalence, two slaughter batches have been excluded, because the species of *Campylobacter* was not determined in the enumeration test.

[3] Prevalence estimates and CIs at national as well as at EU level were obtained taking into account correlation among observations within the same slaughterhouse. In addition, at EU level, prevalence estimates and CIs were weighted for the national numbers of slaughtered broilers during 2008.

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

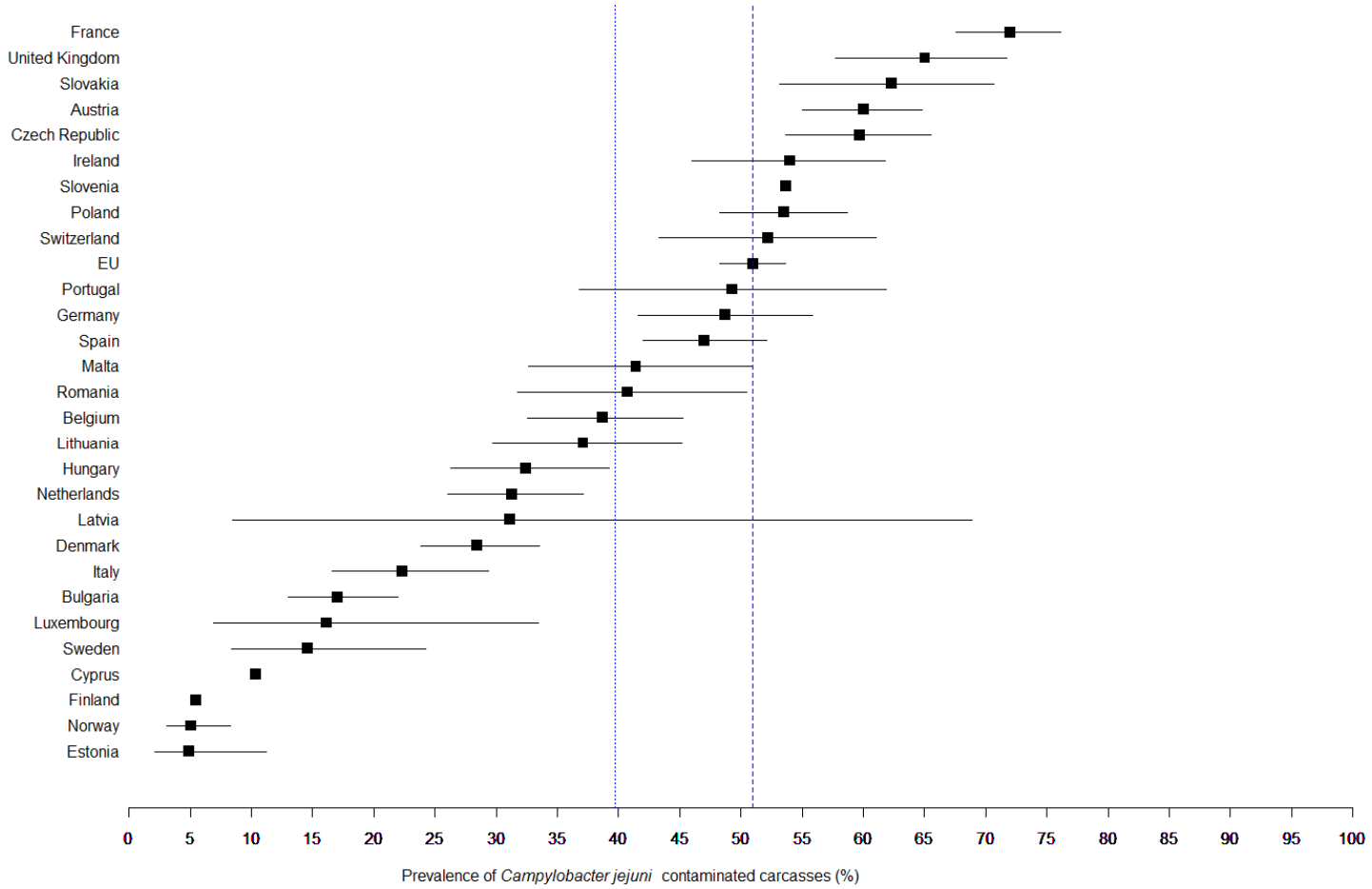

Figure 16. **Prevalence of *Campylobacter jejuni*-contaminated broiler carcasses, based on the combined detection and enumeration method, by country and at EU* level (dashed line), 2008. The dotted line indicates the median prevalence of 26 participating MSs. Horizontal lines indicate 95% CIs of prevalence**

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

Table 18. **Prevalence of *Campylobacter coli-contaminated* broiler carcasses, based on the combined detection and enumeration method, by country and in the EU*, 2008**

Country	N (No of broiler batches)	% prevalence	95% CI
Austria	408	26.2	23.4 - 29.2
Belgium	380	11.2[2]	8.9[2] - 13.9[2]
Bulgaria	280	28.6	23.1 - 34.8
Cyprus	357	3.8	3.6 - 4.0
Czech Republic	422	17.0	11.3 - 24.7
Denmark	396	2.6	1.8 - 3.7
Estonia	102	0	0[3] - 3.6[3]
Finland	369	0	0[3] - 1.0[3]
France	422	57.5	51.0 - 63.6
Germany	432	11.5	8.7 - 15.1
Hungary	321	20.7	17.2 - 24.8
Ireland	394	53.5[1]	44.2[1] - 62.5[1]
Italy	393	26.3	19.2 - 34.9
Latvia	122	2.5	0.6 - 9.5
Lithuania	374	8.9	6.3 - 12.5
Luxembourg	13	75.0	44.2[3] - 94.0[3]
Malta	367	49.9	41.0 - 58.7
Netherlands	429	5.3	3.9 - 7.1
Poland	419	30.2	25.7 - 35.2
Portugal	421	41.8	35.0 - 48.9
Romania	357	22.4	17.1 - 28.9
Slovakia	422	20.1	14.0 - 28.0
Slovenia	413	32.3	24.8 - 41.0
Spain	389	65.2	60.0 - 70.0
Sweden	410	0	0[3] - 0.9[3]
United Kingdom	401	26.0	20.6 - 32.2
EU (26 MSs)*	**9213**	**35.5[4]**	**32.6[4] - 38.5[4]**
Norway	396	0	0[3] - 0.9[3]
Switzerland	408	22.2	19.6 - 24.9

[1] To estimate this prevalence, two slaughter batches have been excluded, because the species of *Campylobacter* was not determined in the enumeration test.

[2] Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples.

[3] Exact binomial CI, it does not take into account the clustering of data.

[4]Prevalence and CIs at EU level were weighted for the national numbers of slaughtered broilers during 2008.

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

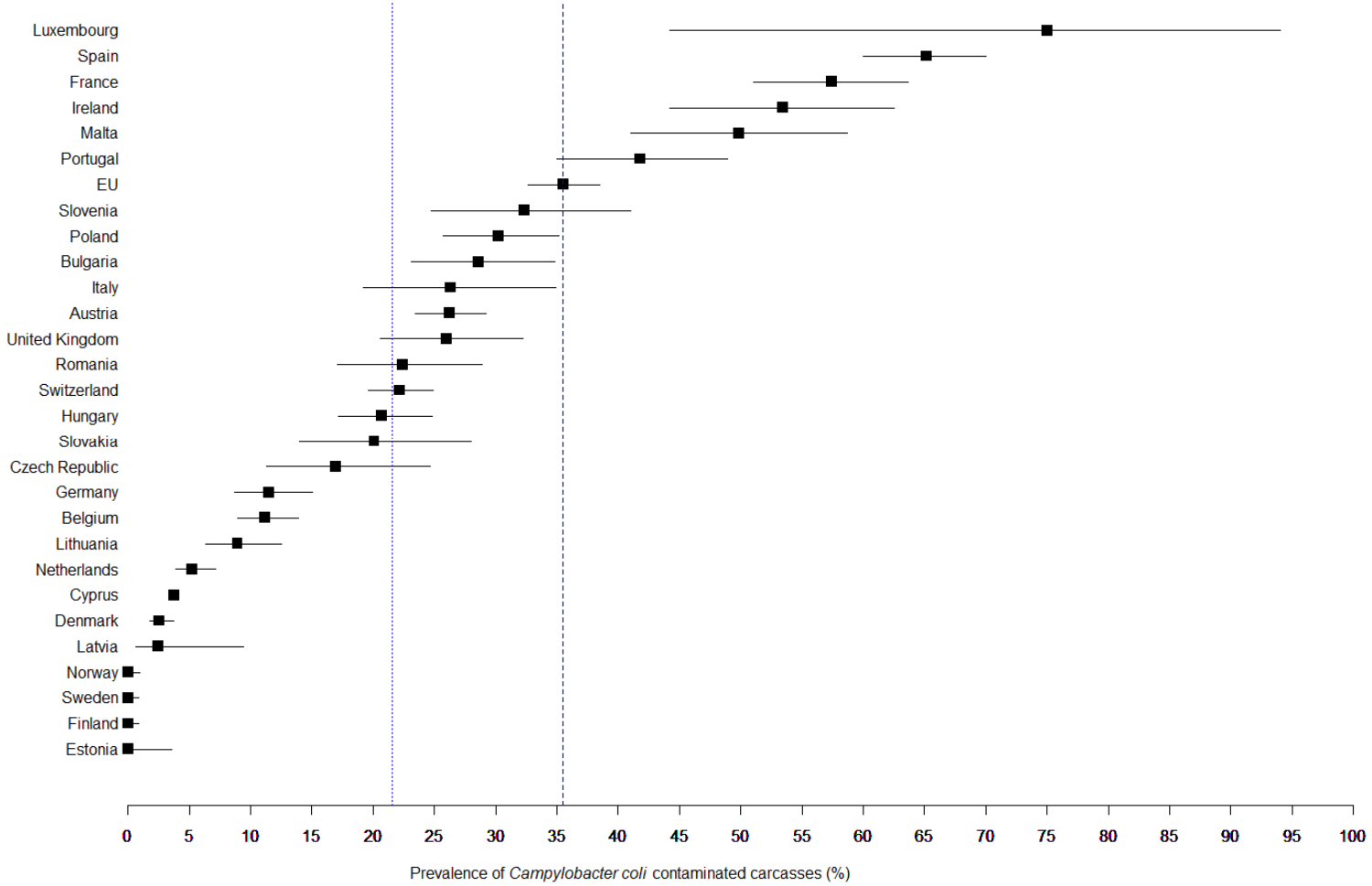

Figure 17. **Prevalence of *Campylobacter coli-contaminated* broiler carcasses, based on the combined detection and enumeration method, by country and at EU* level (dashed line), 2008. The dotted line indicates the median prevalence of 26 participating MSs. Horizontal lines indicate 95% CIs of prevalence**

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated

APPENDIX F. *Campylobacter* enumeration tests results on broiler carcasses

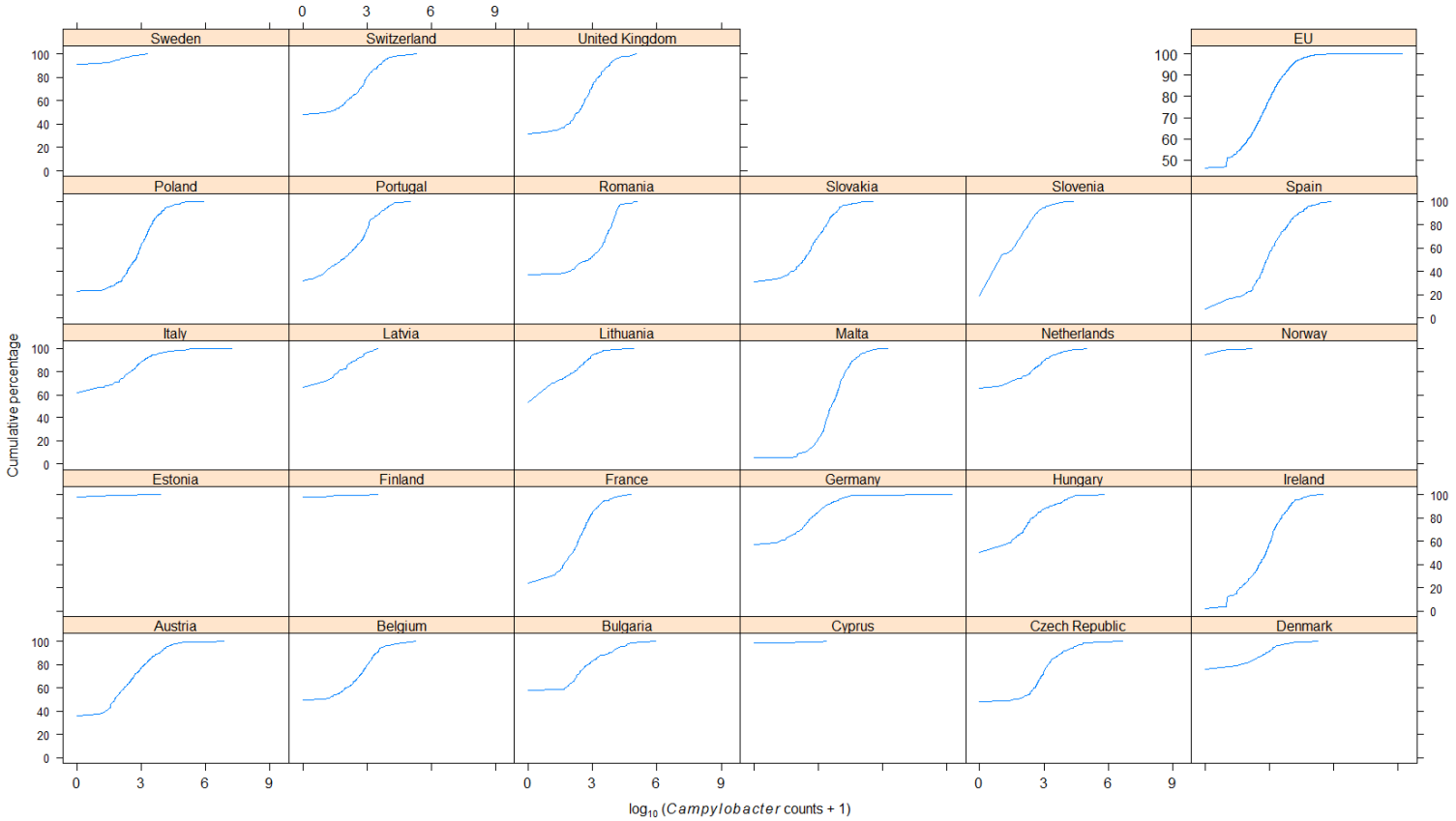

Figure 18. **Cumulative distribution functions of the $\log_{10}$ (*Campylobacter* counts + 1) in broiler carcasses, by country and in the EU*, 2008**

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated. *Campylobacter* counts were added to one previous to $\log_{10}$ transformation in order to allow for inclusion of negative counts (< 10 cfu/g) in these representations.

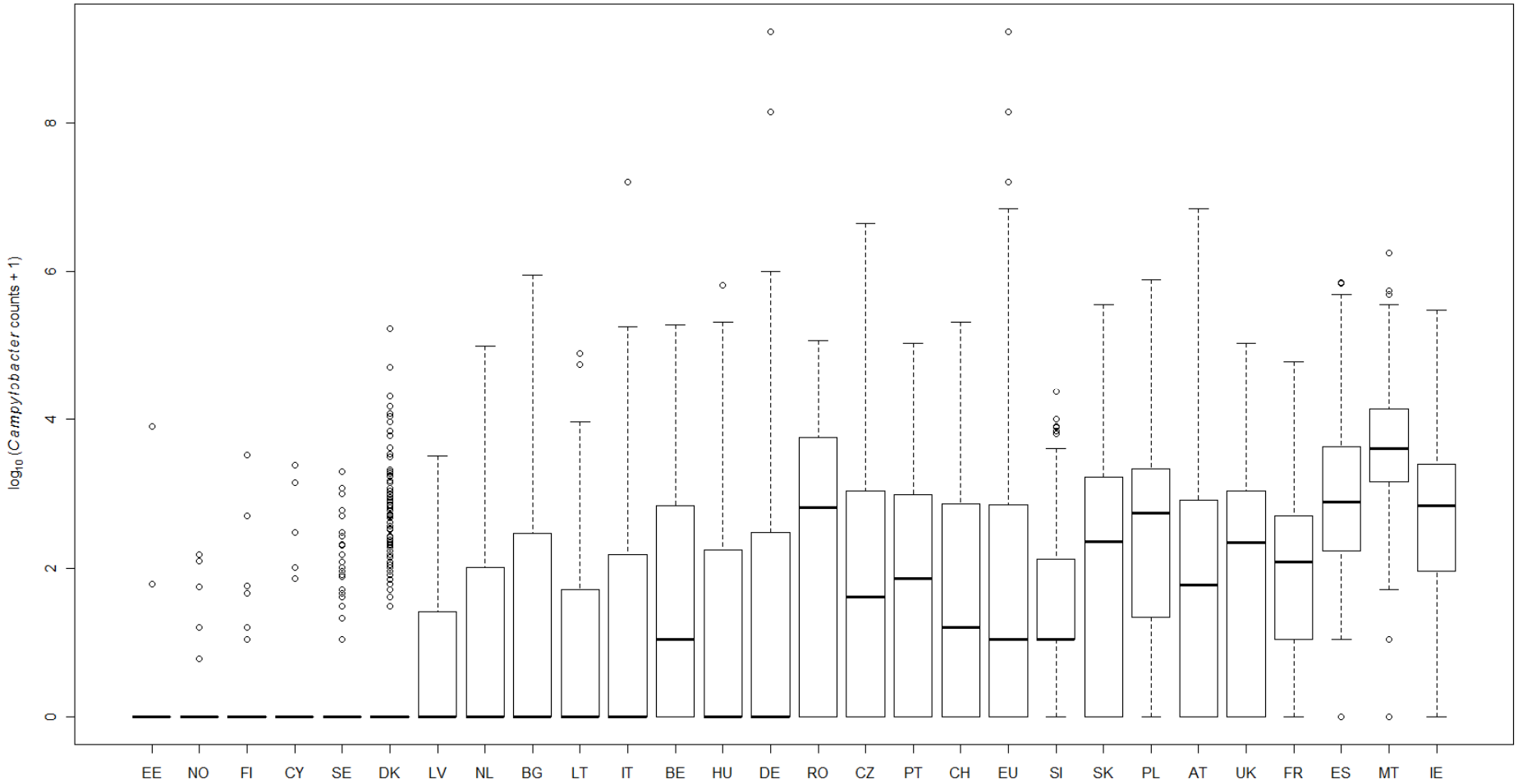

Figure 19. **Boxplot of the $\log_{10}$ (*Campylobacter* counts on broiler carcasses + 1), by country and in the EU*, 2008**

Note: In the boxplots, the bottom of the box represents the first quartile of the distribution and the top of the box the third quartile, whereas the bar inside the box represents the median. Small circular symbols indicate extreme values, differing from the box > 1.5 times the difference between the third and the first quartile (interquartile range).

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated. *Campylobacter* counts were added to one previous to log10 transformation in order to allow for the inclusion of negative counts (< 10 cfu/g) in these representations.

APPENDIX G. Estimations of the measurement uncertainties for *Campylobacter* enumeration in broiler carcass samples

Assessing and reporting MU is very important in quality control and this baseline survey collected valuable data to this end. MU values are quantitative indications of the analytical variability of a result. Estimated MU-values by a laboratory are unique for that laboratory and demonstrate how much variation would exist in that laboratory's outcome indicating the value of the quantity being measured in the test portion. This information is important in the consideration of individual results and provides a CI within which the true value of an individual result would be expected to fall. In the current baseline survey, the MU values estimated by the laboratories who undertook the survey varied from 0.06 to 0.70 $\log_{10}$ cfu/g of neck skin together with breast skin.

International consensus supports the use of reproducibility (R) data in the evaluation of uncertainty in food microbiology (Lombard, 2006; Corry et al., 2007). Reproducibility is the precision of the results obtained on identical test items with the same method under different conditions, for example different operators and equipments (Augustin and Carlier, 2006). The precision of a measurement means the closeness of agreement between independent test results. Reproducibility data can be generated using inter-laboratory study, inter-laboratory proficiency trial, and intra-laboratory study. Using data based on the intralaboratory standard deviation of reproducibility (S_R) is the first option for the estimation of MU associated with quantitative microbiological methods (Lombard, 2006).

Whilst for many years, food microbiologists have estimated the reliability of their quantitative methods to be at best 0.5 $\log_{10}$ cfu, the task now is to refine such a statement to provide a reliable and objective estimate for uncertainty of results obtained by microbiological methods (Corry et al., 2007). In a Belgian study, a general MU value for the combination of all poultry meat matrices was estimated to be 0.24 $\log_{10}$ cfu/g for spread plating on mCCDA (Habib et al. 2008a).

The MU values obtained in the present study provide some insight into the potential variation inherent to the *Campylobacter* enumeration methods. The values obtained are in general consistent with best obtainable international practice. The quantitative results may therefore be compared across MSs with reasonable confidence. With harmonised protocols such a method would seem to provide information on which risk assessors and risk mangers can depend.

Table 19. **Estimations of the measurement uncertainties (MUs) for *Campylobacter* enumeration in broiler carcass samples for all participating laboratories in the EU*, 2008**

Country - Laboratory	Reproducibility standard deviation S_R (log cfu/g)	Expanded uncertainty $MU=2*S_R$ (log cfu/g)	Type of samples [a]	Period of analysis
Austria	0.09	0.18	Naturally contaminated	June - September
Belgium - Lab 1	0.13	0.25	Naturally contaminated	June - September
- Lab 2	0.08	0.16		May - June
Bulgaria	0.09	0.18	Naturally contaminated	May - July
Cyprus	0.13	0.26	Naturally contaminated	January
Czech Republic - Lab 1	0.10	0.20	Naturally contaminated	May - September
- Lab 2	0.12	0.24		May - August
- Lab 3	0.18	0.36		April - October
Denmark	0.04	0.08	Naturally contaminated	July - September
Estonia	0.10	0.20	1 naturally contaminated and 12 spiked	July - November
Finland	0.13	0.25	10 Spiked and 2 CRL ring-trial	May
France	0.14	0.28	Naturally contaminated	June - October
Germany	0.24	0.48	Naturally contaminated	July - August
Hungary	0.13	0.26	Naturally contaminated	June - August
Ireland	0.35	0.70	Naturally contaminated	June - August
Italy - Lab 1[b]	0.08	0.15	Naturally contaminated	July - December
- Lab 2[b]	0.10	0.20		October - November
- Lab 3	0.07	0.14		March - December
- Lab 4[c]	0.05	0.10		-
Latvia	0.06	0.12	Naturally contaminated	May - September
Lithuania	0.13	0.26	Naturally contaminated	May - July
Luxembourg [d]	-	-	-	-
Malta [e]	0.26	0.53	Naturally contaminated	July - August
Netherlands	0.06	0.12	Naturally contaminated	September - October
Poland - Lab 1	0.05	0.10	Naturally contaminated	January - September
- Lab 2	0.12	0.25		
- Lab 3	0.10	0.20		
- Lab 4	0.21	0.42		
- Lab 5	0.07	0.14		
- Lab 6	0.15	0.30		
- Lab 7	0.4	0.09		
- Lab 8	0.05	0.10		
Portugal - Lab 1	0.03	0.06	Naturally contaminated	May - December
- Lab 2	0.08	0.17		
Romania	0.10	0.20	Naturally contaminated	May - September
Slovakia	0.05	0.10	Naturally contaminated	May - July
Slovenia	0.17	0.34	Naturally contaminated	May - August
Spain	0.07	0.13	Naturally contaminated	May - July
Sweden	0.18	0.35	1 naturally contaminated and 11 spiked	September - November
United Kingdom	0.16	0.31	Naturally contaminated	July - September

Table 19 (*contd.*): **Estimations of the measurement uncertainties (MUs) for *Campylobacter* enumeration in broiler carcass samples for all participating laboratories in the EU*, 2008**

Country - Laboratory	Reproducibility standard deviation SR (log cfu/g)	Expanded uncertainty MU=2*SR (log cfu/g)	Type of samples a	Period of analysis
Non-Member States				
Norway	0.15	0.30	7 Naturally contaminated and 5 spiked	June - November
Switzerland	0.08	0.16	Naturally contaminated	April - October

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

[a] Naturally contaminated samples were the samples collected in the scope of this baseline survey.

[b] Exceptionally MU estimation was based on the examination of 10 samples instead of 12 as specified in Commssion Decision 2007/516/EC.

[c] Exceptionally, MU estimation was based on interlaboratory testing instead of analysis of 12 samples as specified in Commssion Decision 2007/516/EC.

[d] Luxembourg did not perform *Campylobacter* enumeration on broiler carcass samples.

[e] Malta performed *Campylobacter* MU estimation according to Niemelä, S.I. (2003). Uncertainty of quantitative determinations derived by cultivation of microorganisms, Centre for metrology and accreditation, Helsinki, Finland, Publication J4/2003.

APPENDIX H. Frequency distributions of *Campylobacter* species in colonised broiler batches, by country

Table 20. **Frequency distributions of *Campylobacter* species obtained from the detection method in colonised broiler batches, by country*, 2008**

Country / *Campylobacter* species	No of batches	% of broiler batches with species[b] (N)[a]
Austria		**(N=195)**
C. jejuni	127	65.1
C. coli	65	33.3
Other *C.* spp.**	3	1.5
Belgium		**(N=102)**
C. jejuni	67	65.7
C. coli	28	27.5
Other *C.* spp.**	7	6.9
Bulgaria		**(N=91)**
C. coli	61	67.0
C. jejuni	30	33.0
Cyprus		**(N=119)**
C. jejuni	78	65.6
C. coli	41	34.5
Czech Republic		**(N=258)**
C. jejuni	217	84.1
C. coli	59	22.9
Denmark		**(N=76)**
C. jejuni	69	90.8
C. coli	7	9.2
Estonia		**(N=2)**
C. jejuni	2	100
Finland		**(N=17)**
C. jejuni	17	100
France		**(N=317)**
C. jejuni	180	56.8
C. coli	163	51.4
Germany		**(N=210)**
C. jejuni	163	77.6
C. coli	47	22.4
Hungary		**(N=162)**
C. coli	85	52.5
C. jejuni	73	45.1
Other *C.* spp.**	4	2.5
Ireland		**(N=318)**
C. jejuni	219	68.9
C. coli	103	32.4
C. lari	2	0.6

Table 20 (*contd.*): **Frequency distributions of *Campylobacter* species obtained from the detection method in colonised broiler batches, by country, 2008**

Country / *Campylobacter* species	No of batches	% of broiler batches with species[b] (N)[a]
Italy		**(N=251)**
C. coli	127	50.6
C. jejuni	121	48.2
Other *C.* spp.**	12	4.8
C. lari	3	1.2
Latvia		**(N=50)**
C. jejuni	42	84.0
C. coli	8	16.0
Lithuania		**(N=157)**
C. jejuni	124	79.0
C. coli	33	21.0
Luxembourg		**(N=12)**
C. coli	11	91.7
C. jejuni	2	16.7
Malta		**(N=356)**
C. coli	271	76.1
C. jejuni	80	22.5
C. lari	3	0.8
Other *C.* spp.**	2	0.6
Netherlands		**(N=104)**
C. jejuni	82	78.9
C. coli	19	18.3
Other *C.* spp.**	3	2.9
Poland		**(N=332)**
C. jejuni	203	61.1
C. coli	129	38.9
Portugal		**(N=349)**
C. coli	215	61.6
C. jejuni	99	28.4
Other *C.* spp.**	39	11.2
Romania		**(N=273)**
C. jejuni	199	72.9
C. coli	103	37.7
Slovakia		**(N=298)**
C. jejuni	233	78.2
C. coli	85	28.5
Slovenia		**(N=321)**
C. jejuni	203	63.2
C. coli	146	45.5
C. lari	3	0.9

Table 20 (*contd.*): **Frequency distributions of *Campylobacter* species obtained from the detection method in colonised broiler batches, by country, 2008**

Country / *Campylobacter* species	No of batches	% of broiler batches with species[b] (N)[a]
Spain		**(N=341)**
C. coli	239	70.1
C. jejuni	154	45.2
Other *C.* spp.**	2	0.6
C. lari	1	0.3
Sweden		**(N=51)**
C. jejuni	51	100
United Kingdom		**(N=304)**
C. jejuni	225	74.0
C. coli	79	26.0
Norway		**(N=13)**
C. jejuni	13	100
Switzerland		**(N=176)**
C. jejuni	120	68.2
C. coli	56	31.8

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

** Other *Campylobacter* spp. = unidentified.

[a] The total number of broiler batches includes all batches where at least one *Campylobacter* species was isolated.

[b] Percentage of broiler batches that were positive for each *Campylobacter* species.

APPENDIX I. Frequency distributions of *Campylobacter* species on contaminated broiler carcasses by country

Table 21. **Frequency distributions of *Campylobacter* species obtained from the detection method on contaminated broiler carcasses, by country, 2008***

Country / *Campylobacter* species	No of carcasses	% of carcasses with species[b] (N)[a]
Austria		**(N=320)**
C. jejuni	217	67.8
C. coli	98	30.6
Other *C.* spp.**	5	1.6
Belgium		**(N=64)**
C. jejuni	46	71.9
C. coli	16	25.0
C. lari	1	1.6
Other *C.* spp.**	1	1.6
Bulgaria		**(N=126)**
C. coli	78	61.9
C. jejuni	47	37.3
C. lari	1	0.8
Cyprus		**(N=46)**
C. jejuni	31	67.4
C. coli	15	32.6
Czech Republic		**(N=295)**
C. jejuni	251	85.1
C. coli	69	23.4
Denmark		**(N=123)**
C. jejuni	112	91.1
C. coli	11	8.9
Estonia		**(N=5)**
C. jejuni	5	100
Finland		**(N=21)**
C. jejuni	21	100
France		**(N=370)**
C. jejuni	304	82.2
C. coli	226	61.1
C. lari	1	0.3
Germany		**(N=237)**
C. jejuni	189	79.8
C. coli	42	17.7
Other *C.* spp.**	7	3.0
Hungary		**(N=180)**
C. jejuni	108	60.0
C. coli	64	35.6
Other *C.* spp.**	6	3.3
C. lari	2	1.1

Table 21 (*contd.*): **Frequency distributions of *Campylobacter* species obtained from the detection method on contaminated broiler carcasses, by country, 2008**

Country / *Campylobacter* species	No of carcasses	% of carcasses with species[b] (N)[a]
Ireland		**(N=378)**
C. coli	213	56.4
C. jejuni	205	54.2
Italy		**(N=182)**
C. coli	105	57.7
C. jejuni	74	40.7
Other *C.* spp.**	9	5.0
Latvia		**(N=41)**
C. jejuni	38	92.7
C. coli	3	7.3
Lithuania		**(N=170)**
C. jejuni	135	79.4
C. coli	33	19.4
C. lari	2	1.2
Luxembourg		**(N=13)**
C. coli	10	76.9
C. jejuni	2	15.4
Other *C.* spp.**	1	7.7
Malta		**(N=348)**
C. coli	184	52.9
C. jejuni	150	43.1
Other *C.* spp.**	10	2.9
C. lari	4	1.2
Netherlands		**(N=110)**
C. jejuni	93	84.6
C. coli	17	15.5
Poland		**(N=339)**
C. jejuni	218	64.3
C. coli	121	35.7
Portugal		**(N=262)**
C. jejuni	176	67.2
C. coli	141	53.8
Other *C.* spp.**	9	3.4
Romania		**(N=227)**
C. jejuni	144	63.4
C. coli	79	34.8
C. lari	4	1.8
Slovakia		**(N=315)**
C. jejuni	258	81.9
C. coli	70	22.2
Slovenia		**(N=333)**
C. jejuni	218	65.5
C. coli	149	44.7

Table 21 (*contd*.): **Frequency distributions of *Campylobacter* species obtained from the detection method on contaminated broiler carcasses, by country, 2008**

Country / *Campylobacter* species	No of carcasses	% of carcasses with species[b] (N)[a]
Spain		**(N=349)**
C. coli	254	72.8
C. jejuni	183	52.4
Other *C.* spp.**	1	0.3
Sweden		**(N=55)**
C. jejuni	55	100
United Kingdom		**(N=343)**
C. jejuni	261	76.1
C. coli	101	29.4
Norway		**(N=20)**
C. jejuni	20	100
Switzerland		**(N=286)**
C. jejuni	214	74.8
C. coli	92	32.2

***** Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

[a] The total number of broiler carcasses includes all carcasses where at least one *Campylobacter* species was isolated.

[b] Percentage of broiler carcasses that were positive for each *Campylobacter* species.

Table 22. **Frequency distributions of *Campylobacter* species obtained from the enumeration method on contaminated broiler carcasses, by country*, 2008**

Country / *Campylobacter* species	No of carcasses	% of carcasses with species[b] (N)[a]
Austria		**(N=262)**
C. jejuni	189	72.1
C. coli	68	26.0
Other *C.* spp.**	5	1.9
Belgium		**(N=134)**
C. jejuni	100	74.6
C. coli	27	20.2
Other *C.* spp.**	6	4.5
Not done	1	0.8
Bulgaria		**(N=5)**
C. coli	4	80.0
C. jejuni	1	20.0
Denmark		**(N=92)**
Not done	92	100
Estonia		**(N=2)**
C. jejuni	2	100
Finland		**(N=1)**
C. jejuni	1	100
Germany		**(N=31)**
C. jejuni	24	77.4
C. coli	8	25.8
Hungary		**(N=1)**
C. jejuni	1	100
Ireland		**(N=8)**
C. jejuni	7	87.5
Not done	1	12.5
Italy		**(N=23)**
C. jejuni	15	65.2
C. coli	7	30.4
C. lari	1	4.4
Latvia		**(N=41)**
C. jejuni	38	92.7
C. coli	3	7.3
Lithuania		**(N=141)**
C. jejuni	114	80.9
C. coli	26	18.4
C. lari	1	0.7
Malta		**(N=348)**
C. coli	184	52.9
C. jejuni	150	43.1
Other *C.* spp.**	10	2.9
C. lari	4	1.2

Table 22 (*contd*.): **Frequency distributions of *Campylobacter* species obtained from the enumeration method on contaminated broiler carcasses, by country, 2008**

Country / *Campylobacter* species	No of carcasses	% of carcasses with species[b] (N)[a]
Netherlands		**(N=146)**
C. jejuni	121	82.9
C. coli	25	17.1
Poland		**(N=95)**
C. jejuni	55	57.9
C. coli	40	42.1
Portugal		**(N=287)**
C. jejuni	215	74.9
C. coli	152	53.0
Other *C.* spp.**	9	3.1
C. lari	2	0.7
Romania		**(N=44)**
C. jejuni	31	70.5
C. coli	13	29.6
Slovakia		**(N=1)**
C. coli	1	100
Spain		**(N=11)**
Other *C.* spp.**	11	100
United Kingdom		**(N=7)**
C. jejuni	5	71.4
C. coli	2	28.6
Norway		**(N=1)**
C. jejuni	1	100
Switzerland		**(N=2)**
C. jejuni	2	100

* Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples, Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

** Other *Campylobacter* spp. = unidentified.

[a] The total number of broiler carcasses includes all carcasses where at least one *Campylobacter* species was isolated.

[b] Percentage of broiler carcasses that were positive for each *Campylobacter* species.

APPENDIX J. Frequency distributions of *Salmonella* serovars detected on contaminated broiler carcasses, by country

Table 23. **Frequency distributions of *Salmonella* serovars detected on contaminated broiler carcasses, by country*, 2008**

Country / *Salmonella* serovar	No of carcasses	% of carcasses with serovar[b] (N)[a]
Austria		**(N=10)**
S. Montevideo	4	*40.0*
S. Enteritidis	2	*20.0*
S. Infantis	1	*10.0*
S. Kentucky	1	*10.0*
S. Senftenberg	1	*10.0*
S. Typhimurium	1	*10.0*
Belgium		**(N=77)**
S. Virchow	18	*23.4*
Salmonella untypeable	15	*19.5*
S. Typhimurium	11	*14.3*
S. Infantis	7	*9.1*
S. Paratyphi B var. Java	7	*9.1*
S. Agona	5	*6.5*
S. Anatum	3	*3.9*
S. Blockley	3	*3.9*
S. Livingstone	3	*3.9*
S. Montevideo	2	*2.6*
S. Hadar	1	*1.3*
S. Heidelberg	1	*1.3*
S. Indiana	1	*1.3*
Bulgaria		**(N=85)**
S. Montevideo	21	*24.7*
S. Enteritidis	18	*21.2*
S. Infantis	13	*15.3*
S. 6,7:-:-	10	*11.8*
S. Virchow	5	*5.9*
S. Menden	4	*4.7*
S. Thompson	3	*3.5*
S. 8,20:-:-	2	*2.4*
S. Kottbus	2	*2.4*
S. 3,15:-:-	1	*1.2*
S. 6,8:-:1,5	1	*1.2*
S. Bonariensis	1	*1.2*
S. Concord	1	*1.2*
S. Irumu	1	*1.2*
S. Parkroyal	1	*1.2*
S. Typhimurium	1	*1.2*

Table 23 (*contd.*): **Frequency distributions of *Salmonella* serovars detected on contaminated broiler carcasses, by country*, 2008**

Country / *Salmonella* serovar	No of carcasses	% of carcasses with serovar[b] (N)[a]
Cyprus		**(N=38)**
S. Bredeney	11	*29.0*
S. Blockley	9	*23.7*
S. Hadar	9	*23.7*
S. Infantis	3	*7.9*
S. Braenderup	2	*5.3*
S. Emek	2	*5.3*
S. Derby	1	*2.6*
S. Newport	1	*2.6*
Czech Republic		**(N=23)**
S. Agona	12	*52.2*
S. Enteritidis	4	*17.4*
S. Kentucky	2	*8.7*
S. Ohio	2	*8.7*
S. Infantis	1	*4.4*
S. Montevideo	1	*4.4*
S. Newport	1	*4.4*
France		**(N=32)**
S. Indiana	12	*37.5*
S. Kottbus	5	*15.6*
S. Derby	4	*12.5*
S. Brandenburg	3	*9.4*
S. Montevideo	2	*6.3*
S. Agona	2	*6.3*
S. Anatum	2	*6.3*
S. Bareilly	1	*3.1*
S. Enteritidis	1	*3.1*
S. Hadar	1	*3.1*
S. Livingstone	1	*3.1*
S. Mbandaka	1	*3.1*
S. Thompson	1	*3.1*
Germany		**(N=76)**
S. 4,12:d:-	21	*27.6*
S. Typhimurium	20	*26.3*
S. Paratyphi B var. Java	9	*11.8*
S. Bredeney	8	*10.5*
S. Infantis	6	*7.9*
S. Isangi	5	*6.6*
S. Kiambu	4	*5.3*
S. Ohio	4	*5.3*
S. Indiana	4	*5.3*
S. Blockley	4	*5.3*
S. Anatum	2	*2.6*

Table 23 (*contd.*): **Frequency distributions of *Salmonella* serovars detected on contaminated broiler carcasses, by country*, 2008**

Country / *Salmonella* serovar	No of carcasses	% of carcasses with serovar[b] (N)[a]
Germany *(contd.)*		**(N=76)**
S. 4,[5],12:i:-	1	*1.3*
S. Hadar	1	*1.3*
S. Mbandaka	1	*1.3*
Hungary		**(N=275)**
S. Infantis	269	*97.8*
S. Enteritidis	13	*4.7*
S. Thompson	4	*1.5*
S. Indiana	2	*0.7*
S. Typhimurium	1	*0.4*
Ireland		**(N=39)**
S. Kentucky	39	*100*
Italy		**(N=66)**
S. Hadar	18	*27.3*
Salmonella untypeable	13	*19.7*
S. Thompson	12	*18.2*
S. Livingstone	7	*10.6*
S. Derby	5	*7.6*
S. Mbandaka	3	*4.6*
S. Blockley	1	*1.5*
S. Bredeney	1	*1.5*
S. Coeln	1	*1.5*
S. Corvallis	1	*1.5*
S. Enteritidis	1	*1.5*
S. Infantis	1	*1.5*
S. Montevideo	1	*1.5*
S. Virchow	1	*1.5*
Latvia		**(N=6)**
S. Enteritidis	6	*100*
Lithuania		**(N=26)**
Salmonella untypeable	15	*57.7*
S. Agona	3	*11.5*
S. 6,7:z10:-	2	*7.7*
S. 6,7:-:-	1	*3.9*
S. Djugu	1	*3.9*
S. Enteritidis	1	*3.9*
S. Mbandaka	1	*3.9*
S. Oakey	1	*3.9*
S. Redba	1	*3.9*

Table 23 (*contd.*): **Frequency distributions of *Salmonella* serovars detected on contaminated broiler carcasses, by country*, 2008**

Country / *Salmonella* serovar	No of carcasses	% of carcasses with serovar[b] (N)[a]
Malta		**(N=77)**
S. Bredeney	28	*36.4*
S. Kentucky	15	*19.5*
S. 4,[5],12:i:-	12	*15.6*
Salmonella untypeable	10	*13.0*
S. Haifa	5	*6.5*
S. Infantis	3	*3.9*
S. Hadar	2	*2.6*
S. Kottbus	2	*2.6*
Netherlands		**(N=43)**
S. Paratyphi B var. Java	30	*69.8*
S. Infantis	3	*7.0*
S. Ohio	3	*7.0*
S. 4,5,12:i:-	1	*2.3*
S. Agona	1	*2.3*
S. Hadar	1	*2.3*
S. Indiana	1	*2.3*
S. Mbandaka	1	*2.3*
S. Typhimurium	1	*2.3*
Salmonella untypeable	1	*2.3*
Poland		**(N=107)**
S. Enteritidis	30	*28.0*
S. Infantis	26	*24.3*
S. Virchow	11	*10.3*
S. Mbandaka	10	*9.4*
S. Typhimurium	10	*9.4*
S. Hadar	8	*7.5*
S. Newport	5	*4.7*
S. Agona	4	*3.7*
S. Indiana	1	*0.9*
S. Montevideo	1	*0.9*
Poland		**(N=107)**
S. Saintpaul	1	*0.9*
Portugal		**(N=47)**
S. Enteritidis	38	*80.9*
S. Mbandaka	6	*12.8*
S. Heidelberg	1	*2.1*
S. Senftenberg	1	*2.1*
Salmonella untypeable	1	*2.1*

Table 23 (*contd.*): **Frequency distributions of *Salmonella* serovars detected on contaminated broiler carcasses, by country*, 2008**

Country / *Salmonella* serovar	No of carcasses	% of carcasses with serovar[b] (N)[a]
Romania		**(N=17)**
S. Virchow	8	*47.1*
S. Bredeney	3	*17.7*
S. Berkeley	2	*11.8*
S. Enteritidis	2	*11.8*
S. Lexington	1	*5.9*
S. Typhimurium	1	*5.9*
Slovakia		**(N=91)**
S. Enteritidis	27	*29.7*
S. Infantis	15	*16.5*
S. Indiana	14	*15.4*
S. Kentucky	14	*15.4*
S. Agona	7	*7.7*
S. Bareilly	6	*6.6*
S. Havana	3	*3.3*
S. Tennessee	3	*3.3*
S. Mbandaka	1	*1.1*
S. Schwarzengrund	1	*1.1*
Slovenia		**(N=7)**
S. Infantis	4	*57.1*
S. Enteritidis	2	*28.6*
S. Saintpaul	1	*14.3*
Spain		**(N=58)**
S. Enteritidis	21	*36.2*
S. Virchow	7	*12.1*
S. Hadar	6	*10.3*
S. Blockley	5	*8.6*
Spain		**(N=58)**
S. Typhimurium	5	*8.6*
S. Mbandaka	4	*6.9*
S. Infantis	2	*3.5*
S. Senftenberg	2	*3.5*
S. Anatum	1	*1.7*
S. Bredeney	1	*1.7*
S. Carnac	1	*1.7*
S. Corvallis	1	*1.7*
S. Ohio	1	*1.7*
S. Thompson	1	*1.7*
Sweden		**(N=1)**
S. Agona	1	*100*

Table 23 (*contd.*): **Frequency distributions of *Salmonella* serovars detected on contaminated broiler carcasses, by country*, 2008**

Country / *Salmonella* serovar	No of carcasses	% of carcasses with serovar[b] (N)[a]
United Kingdom		**(N=14)**
S. Kentucky	5	*35.7*
S. Mbandaka	2	*14.3*
S. O-rough:r:1,2	1	*7.1*
S. Agona	1	*7.1*
S. Bredeney	1	*7.1*
S. Havana	1	*7.1*
S. Kedougou	1	*7.1*
S. Livingstone	1	*7.1*
S. Ohio	1	*7.1*
Switzerland		**(N=10)**
S. Infantis	4	*40.0*
S. Typhimurium	3	*30.0*
S. 4,[5],12:i:-	1	*10.0*
S. Agona	1	*10.0*
S. Braenderup	1	*10.0*

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

[a] The total number of broiler carcasses includes all carcasses where at least one *Salmonella* serovar was isolated.

[b] Percentage of broiler carcasses that were positive for each *Salmonella* serovar.

ABBREVIATIONS

CDC	Centers for Disease Control and Prevention
cfu	Colony forming units
CI	Confidence interval
CRL	Community reference laboratory
CRL	Community reference laboratory
EC	European Commission
EFSA	European Food Safety Authority
EU	European Union
FAO	Food and Agriculture Organization
GEE	Generalized estimating equations
ISO	International Organization for Standardization
MSs	Member State(s)
MU	Measurement uncertainty
NRL	National Reference Laboratory
OLR	Ordinary logistic regression
PCR	Polymerase chain reaction
PHAC	Public Health Agency of Canada
WHO	World Health Organization