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## SCIENTIFIC REPORT OF EFSA AND ECDC

# The European Union Summary Report on antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food in 2010[1]

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

**European Centre for Disease Prevention and Control**[2,3]

## ABSTRACT

The antimicrobial resistance data on zoonotic and indicator bacteria in 2010, submitted by 26 European Union Member States, were jointly analysed by the European Food Safety Authority and the European Centre for Disease Prevention and Control. Data covered resistance in zoonotic *Salmonella* and *Campylobacter* from humans, food and animals, and in indicator *Escherichia coli* and enterococci from animals and food. Some data on meticillin-resistant *Staphylococcus aureus* in animals and food were also included. In isolates from humans, resistance was mainly interpreted using clinical breakpoints, whereas in animal and food isolates, microbiological resistance was defined using epidemiological cut-off values. No major changes in resistance in monitored bacteria were observed compared with previous years. Resistance was commonly found in isolates from humans, animals and food, although disparities in resistance were frequently observed between Member States. High resistance levels were recorded to ampicillin, tetracyclines and sulfonamides in *Salmonella* isolates from humans, whereas resistance to third-generation cephalosporins and fluoroquinolones remained low. In *Salmonella* and indicator *E. coli* isolates from fowl, pigs, cattle and meat thereof, resistance to tetracyclines, ampicillin and sulfonamides was also commonly detected, whereas resistance to third-generation cephalosporins was low. Moderate to high levels of ciprofloxacin (a fluoroquinolone) resistance were observed in *Salmonella* isolates from turkeys, fowl and broiler meat. In *Campylobacter* isolates from human cases, resistance to ampicillin, ciprofloxacin, nalidixic acid and tetracyclines was high, while resistance to erythromycin was recorded at low to moderate levels. High resistance to ciprofloxacin, nalidixic acid and tetracyclines was also observed in *Campylobacter* isolates from fowl, broiler meat, pigs and cattle, whereas much lower levels were observed for erythromycin and gentamicin. Among the indicator enterococci isolates from animals and food, resistance to tetracyclines and erythromycin was commonly detected. Meticillin-resistant *Staphylococcus aureus* was detected in some animal species and food of animal origin.



## KEY WORDS

Zoonoses, antimicrobial resistance, surveillance, monitoring, *Salmonella*, *Campylobacter*, indicator *Escherichia coli*, indicator enterococci, MRSA

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# EUROPEAN UNION SUMMARY REPORT

# Antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food in the European Union in 2010

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## About EFSA

The European Food Safety Authority (EFSA), located in Parma, Italy, was established and funded by the European Union (EU) as an independent agency in 2002 following a series of food scares that caused the European public to voice concerns about food safety and the ability of regulatory authorities to protect consumers. EFSA provides objective scientific advice on all matters, in close collaboration with national authorities and in open consultation with its stakeholders, with a direct or indirect impact on food and feed safety, including animal health and welfare and plant protection. EFSA is also consulted on nutrition in relation to EU legislation. EFSA's work falls into two areas: risk assessment and risk communication. In particular, EFSA's risk assessments provide risk managers (EU institutions with political accountability, i.e. the European Commission, the European Parliament and the Council) with a sound scientific basis for defining policy-driven legislative or regulatory measures required to ensure a high level of consumer protection with regard to food and feed safety. EFSA communicates to the public in an open and transparent way on all matters within its remit. Collection and analysis of scientific data, identification of emerging risks and scientific support to the Commission, particularly in the case of a food crisis, are also part of EFSA's mandate, as laid down in the founding Regulation (EC) No 178/2002[4] of 28 January 2002.

## About ECDC

The European Centre for Disease Prevention and Control (ECDC), an EU agency based in Stockholm, Sweden, was established in 2005. The objective of ECDC is to strengthen Europe's defences against infectious diseases. According to Article 3 of the founding Regulation (EC) No 851/2004[5] of 21 April 2004, ECDC's mission is to identify, assess and communicate current and emerging threats to human health posed by infectious diseases. In order to achieve this mission, ECDC works in partnership with national public health bodies across Europe to strengthen and develop EU-wide disease surveillance and early warning systems. By working with experts throughout Europe, ECDC pools Europe's knowledge in health so as to develop authoritative scientific opinions about the risks posed by current and emerging infectious diseases.

## About the report

Based on Article 33 in the Regulation (EC) 178/2002, EFSA's Zoonoses Unit is responsible for examining data on zoonoses, antimicrobial resistance and food-borne outbreaks collected from the Member States in accordance with Directive 2003/99/EC[6] and for preparing the EU Summary Report from the results. Regarding antimicrobial resistance data from 2010, this EU Summary Report was produced in collaboration with ECDC and the Animal Health and Veterinary Laboratories Agency (AHVLA), United Kingdom, contracted by EFSA.

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[4] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. OJ L 31, 1.2.2002, p. 1–24.

[5] Regulation (EC) No 851/2004 of the European Parliament and of the Council of 21 April 2004 establishing a European Centre for Disease Prevention and Control. OJ L 142, 30.4.2004, p. 1–11.

[6] 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/EEC and repealing Council Directive 92/117/EEC. OJ L 325, 12.12.2003, p. 31–40.

## Summary

Zoonoses are infections and diseases that are transmissible between animals and humans. Infection can be acquired directly from animals, or through the ingestion of contaminated foodstuffs or other indirect contact. The severity of these infections in humans can vary from mild and asymptomatic to serious and even life-threatening. Zoonotic bacteria which develop resistance to antimicrobials are of special concern since they might compromise the effective treatment of infections in humans. In order to follow the occurrence of antimicrobial resistance in zoonotic bacteria isolated from animals and food, information is collected and analysed from all EU Member States.

In 2010, 26 Member States submitted information on the occurrence of antimicrobial resistance in zoonotic bacteria to the European Commission, the European Food Safety Authority and the European Centre for Disease Prevention and Control. In addition, three other European countries provided information. Assisted by its contractor, the Animal Health and Veterinary Laboratories Agency in the United Kingdom, the European Food Safety Authority and the European Centre for Disease Prevention and Control analysed the data, and the results of this analysis are published in this EU Summary Report. Information on antimicrobial resistance was reported regarding *Salmonella* and *Campylobacter* isolates from human cases, food and animals, whereas data on indicator *Escherichia coli* and indicator enterococci isolates derived only from animals and food. Some information was also reported on the occurrence of meticillin-resistant *Staphylococcus aureus* (MRSA). Data on antimicrobial resistance in isolates from human cases were mainly interpreted by using clinical breakpoints, while the quantitative data on antimicrobial resistance in isolates from food and animals were interpreted using harmonised epidemiological cut-off values defining the microbiologically resistant isolates. The epidemiological cut-off values discriminate between the wild-type (susceptible) bacterial population and the non-wild type populations which have a decreased susceptibility towards a given antimicrobial. This enables the early detection of developing resistance. However, the use of different thresholds, clinical breakpoints and epidemiological cut-off values, means that resistance data in isolates from humans and in isolates from animals and food are, in most cases, not directly comparable.

In the EU, among *Salmonella* isolates from salmonellosis cases in humans, the level of resistance to ampicillin, tetracyclines and sulfonamides was high, whereas resistance to the critically important antimicrobials for human medicine, cefotaxime (a third-generation cephalosporin) and ciprofloxacin (fluoroquinolones), was relatively low. Reported levels of resistance to these antimicrobials were higher in countries where epidemiological cut-off values were used. There was a high level of resistance to ampicillin, ciprofloxacin, nalidixic acid and tetracyclines among *Campylobacter* isolates from human cases, while relatively low resistance was recorded to the clinically most important antimicrobial, erythromycin.

Resistance to antimicrobials was commonly found in isolates of *Salmonella*, *Campylobacter* and indicator *E. coli* and enterococci from animals and food in the EU. The high proportions of *Salmonella, Campylobacter* and indicator *E. coli* isolates exhibiting resistance to ciprofloxacin are of concern. In food and animal isolates, the highest occurrence of resistance to ciprofloxacin was noted in *Salmonella* from turkeys, with 28 % of isolates being found resistant according to the group of reporting Member States, while levels were 24 % in fowl (*Gallus gallus*) and broiler meat. Among the indicator *E. coli* isolates, high levels of ciprofloxacin resistance were observed in isolates from *Gallus gallus* (29 %) and low levels were reported in pigs (2 %). Furthermore, high resistance to ciprofloxacin was commonly observed in *Campylobacter* isolates from *Gallus gallus*, as well as from pigs and cattle, at levels ranging from 37 % to 84 %.

Resistance to third-generation cephalosporins was observed in *Salmonella* and indicator *E. coli* isolates from *Gallus gallus*, pigs and cattle and in *Salmonella* from meat derived from broilers and pigs, at very low or low levels varying from 0.2 % to 7 %. Resistance to erythromycin was detected in *Campylobacter* isolates from *Gallus gallus,* poultry meat and pigs at levels of 0.5 % to 25 %.

Among *Salmonella* isolates from meat and animals, resistance to ampicillin, sulfonamides and tetracyclines was reported at levels of 13 % to 75 %, and was higher in isolates from turkeys, pigs and cattle than in isolates from *Gallus gallus*. Resistance to ciprofloxacin and nalidixic acid was higher in *Salmonella* isolates from turkeys, *Gallus gallus* and broiler meat.

Among isolates of *Campylobacter* from meat and animals, resistance to ciprofloxacin, nalidixic acid and tetracyclines was commonly detected at levels of 21 % to 84 %, whereas in general much lower levels of resistance to erythromycin and gentamicin were reported.

Among indicator *E. coli* from animals, resistance to ampicillin, sulfonamides and tetracyclines was commonly reported at levels ranging from 21 % to 48 %. Resistance to ciprofloxacin and nalidixic acid was highest for isolates from *Gallus gallus*. Considering indicator enterococci, resistance to erythromycin and tetracyclines was common in isolates from *Gallus gallus*, pigs and cattle at levels of 13 % to 71 %, the level of resistance being lowest for isolates from cattle. Resistance to vancomycin continued to be detected, albeit at low to very low levels, at 0.3 % to 0.9 %, in enterococcal isolates from animals.

Information on the occurrence of MRSA in food and animals was reported in 2010 at levels varying from 0 to 79 %, most commonly found in turkeys or turkey meat. The MRSA isolates were of *spa* types that mainly belonged to clonal complex 398, previously detected in the EU-wide baseline survey of breeding pigs.

In food and animal isolates, the resistance situation remained mainly relatively stable over the years 2005–2010, even though some statistically significant increasing and decreasing trends in the resistance were observed at national level.

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# 1. INTRODUCTION

## 1.1 Antimicrobial resistance monitoring and reporting at EU level

According to Directive 2003/99/EC on the monitoring of zoonoses and zoonotic agents, EU Member States (MSs) are obliged to monitor and report antimicrobial resistance in *Salmonella* and *Campylobacter* isolates from animals and food. In addition, Commission Decision 2007/407/EC lays down detailed requirements on the harmonised monitoring and reporting of antimicrobial resistance in *Salmonella* isolates from poultry populations and pigs sampled under the National *Salmonella* Control Programmes. Since 1 January 2010, turkeys have been also subject to legislation and inclusion in national *Salmonella* control programmes (as specified in Regulations 2160/2003/EC and 584/2008/EC) and, as a consequence, the antimicrobial resistance data in turkeys reported by MSs have been, for the first time, analysed and included in the EU Summary Report. The monitoring and reporting of antimicrobial resistance data from the indicator organisms *Escherichia coli* and enterococci is voluntary.

Decision 2119/98/EC[7] on setting up a network for the epidemiological surveillance and control of communicable diseases in the EU, as complemented by Decision 2000/96/EC[8] with amendment 2003/542/EC[9] on the diseases to be progressively covered by the network, established the basis for data collection on human diseases from MSs. The decisions foresee that data from the networks shall be used in the EU Summary Reports. Consequently, the European Centre for Disease Prevention and Control (ECDC) has provided data on zoonotic infections in humans, as well as their analyses, for the Community Summary Reports since 2005. Starting in 2007, data on human cases have been reported from The European Surveillance System (TESSy), maintained by ECDC.

This EU Summary Report 2010 includes data related to the occurrence of antimicrobial resistance both in isolates from animals and foodstuffs, collected in the framework of Directive 2003/99/EC, and in isolates from human cases, derived from the networks under Decision 2119/98/EC. This report is a joint collaboration between the European Food Safety Authority (EFSA) and ECDC with the assistance of EFSA's contractor, the Animal Health and Veterinary Laboratories Agency (AHVLA) in the United Kingdom. MSs, other reporting countries, the European Commission and the relevant EU Reference Laboratories (EURLs) were consulted during the preparation of this report. The efforts made by MSs, the reporting non-MSs as well as by the EC in the reporting of zoonoses data and in the preparation of this report are gratefully acknowledged.

The antimicrobial agents used in food-producing animals in Europe frequently belong to the same classes as those used in human medicine; many antimicrobials are used in both humans and animals. Antimicrobial resistance usually both develops and increases as a consequence of antimicrobial use in both humans and animals as a result of the selection of resistant bacterial clones, whether these be pathogenic, commensal or even environmental bacteria. The methods of use of antimicrobials frequently differ between humans and food-producing animals in terms of modes of administration, the degree of prophylactic and metaphylactic use and quantities administered; there are also important variations in patterns of use between and within food-producing animal species, as well as between countries.

Bacterial resistance to antimicrobials occurring in food-producing animals can spread to people via food-borne routes but also by environmental routes such as through water and by direct animal contact. *Campylobacter*, *Salmonella* and some strains of *E. coli* are examples of zoonotic bacteria which can infect people by the food-borne route. Infections with bacteria which are resistant to antimicrobials may result in treatment failures or necessitate the use of second-line antimicrobials for therapy. The commensal bacterial flora can also form a reservoir of resistance genes which may transfer between bacterial species, including transfer to organisms capable of causing disease in both humans and animals (EFSA, 2008a).

EFSA, at the request of the EC, has prepared detailed specifications for the harmonised monitoring of antimicrobial resistance in food-producing animals. These were developed by an expert working group, established under the Task Force on Zoonoses Data Collection, which recommended guidelines for the

[7] Decision 2119/98/EC of the European Parliament and of the Council of 24 September 1998 setting up a network for the epidemiological surveillance and control of communicable diseases in the Community. OJ L 268, 3.10.1998, p. 1.
[8] Decision 2000/96/EC on communicable diseases to be progressively covered by the Community network under Decision No 2119/98/EC of the European Parliament and of the Council. OJ L 180, 11.7.2009, p. 22–23.
[9] Decision 2003/542/EC Commission Decision of 17 July 2003 amending Decision 2000/96/EC as regards the operation of dedicated surveillance networks. OJ L 185, 24.7.2003, p. 55–58.

monitoring of antimicrobial resistance in *Salmonella* and *Campylobacter* (EFSA 2007) and also in indicator *E. coli* and enterococci[10] (EFSA 2008b). These specifications include detailed protocols on sampling strategies, the method of susceptibility testing, the antimicrobials to be tested and the criteria for categorising isolates as susceptible or resistant, as well as recommendations on quality control and reporting. The specifications have been developed for use in all 27 EU MSs and have been progressively implemented. All reporting MSs followed the recommended susceptibility testing method for *Campylobacter* and enterococci from animals and food in 2010.

The main difficulties encountered when comparing antimicrobial resistance data between different countries in the past have been the use of different methods and different interpretative criteria used in different countries; these issues have been addressed by the development of EFSA's guidelines. The resistance monitoring performed in accordance with these guidelines utilises epidemiological cut-off values which separate the naive, susceptible wild-type bacterial population from bacterial isolates that have developed reduced susceptibility to a given antimicrobial agent (Kahlmeter et al., 2003). The epidemiological cut-off values may differ from breakpoints used for clinical purposes, which are defined against a background of clinically relevant data, including therapeutic indication, clinical response data and dosing schedules, as well as pharmacokinetic and pharmacodynamic properties.

In the Community Summary Reports on Antimicrobial Resistance from 2004 to 2007, 2008 and 2009, epidemiological cut-off values were applied to minimum inhibitory concentration (MIC) data to define resistant *Salmonella*, *Campylobacter*, *E. coli* and enterococci isolates from animals and food. The use of harmonised methods and epidemiological cut-off values ensured the comparability of data over time at country level and also facilitated the comparison of the occurrence of resistance between MSs. The same methods and principles have been applied in this report covering 2010.

The antimicrobial resistance data reported to EFSA for the year 2010 for *Campylobacter*, *Salmonella*, *E. coli* and enterococcal isolates from animals and food were analysed and all quantitative MIC data were interpreted using epidemiological cut-off values. The 2010 Summary Report on Antimicrobial Resistance includes the results of phenotypic monitoring of resistance caused by extended-spectrum beta-lactamases in *Salmonella* and indicator *E. coli*, conferring resistance to third-generation cephalosporins. A number of MSs also submitted results relating to the monitoring of animals and food for MRSA, and these results are also included in the report. The majority of antimicrobial resistance data reported to EFSA by MSs comprised data collected in accordance with EFSA's monitoring specifications; quantitative disc diffusion data constituted only a small percentage of the total data and were analysed in the report as qualitative data for *Salmonella* only. This has circumvented the problem that epidemiological cut-off values are not available for the different disc diffusion methods used by MSs. The report also includes, for only the second time, resistance in *Salmonella* and *Campylobacter* isolates from human cases of salmonellosis and campylobacteriosis, respectively. These data were reported as qualitative data, mostly interpreted using clinical breakpoints, by MSs to TESSy.

An important consideration when interpreting the data included in this report is that human data are largely based on susceptibility testing of clinical isolates, whereas animal data are based mainly on the testing of isolates from healthy animals, where testing has been performed in accordance with EFSA's recommendations. Furthermore, the data on zoonotic bacteria from humans have largely been collated and collected using clinical breakpoints. Such data are therefore not always directly comparable with data from animals and food, which have been analysed using epidemiological cut-off values. Indeed, the use of epidemiological cut-off values in animal and food isolates generally conveys a picture of 'microbiological resistance' levels in these isolates that is higher than 'clinical resistance' levels recorded in human isolates where clinical breakpoints have been used. These issues are discussed further where relevant in the chapters on *Campylobacter* and *Salmonella*. Universal adoption and understanding of the distinction between clinical breakpoints and epidemiological cut-off values would enable clinicians to choose the appropriate treatment based on information relevant to the individual patient, yet would recognise that epidemiologists need to be aware of small changes in bacterial susceptibility, which may indicate emerging

[10] *E. coli* and enterococci (i.e. *Enterococcus (E.) faecium* and *E. faecalis*) can be used as indicator organisms of, respectively, the gram-negative and gram-positive commensal intestinal flora. These three bacterial species are commonly isolated from animal faeces, and most resistance phenotypes present in the animal populations are present in these species. In addition, the effects of use patterns of antibiotics in a given country and animal species, as well as trends in the occurrence of resistance, can be studied more accurately in indicator organisms than in food-borne pathogens because all food animals generally carry these indicator bacteria.

resistance and allow for appropriate control measures to be considered. The concepts of epidemiological cut-off values and clinical breakpoints are presented in detail below.

## 1.2 Epidemiological cut-off values and clinical breakpoints

The European Committee on Antimicrobial Susceptibility Testing (EUCAST) has defined clinical breakpoints and epidemiological cut-off values. A microorganism is defined as clinically resistant when the degree of resistance shown is associated with a high likelihood of therapeutic failure. The microorganism is categorised as resistant by applying the appropriate clinical breakpoint in a defined phenotypic test system, and this breakpoint may alter with legitimate changes in circumstances (e.g. alterations in dosing regime, drug formulation, patient factors).

A microorganism is defined as wild type for a bacterial species when no acquired or mutational mechanisms of resistance to the antimicrobial in question are present. A microorganism is categorised as wild type for a given bacterial species by applying the appropriate epidemiological cut-off value in a defined phenotypic test system. This cut-off value will not be altered by changing circumstances (such as alterations in frequency of antimicrobial administration). Wild-type microorganisms may or may not respond clinically to antimicrobial treatment. A microorganism is defined as non-wild type for a given bacterial species by the presence of an acquired or mutational mechanism of resistance to the antimicrobial in question. A microorganism is categorised as non-wild type for a given bacterial species by applying the appropriate epidemiological cut-off value in a defined phenotypic test system; non-wild-type organisms are considered to show ‘microbiological resistance’ (as opposed to ‘clinical resistance’). Clinical breakpoints and epidemiological cut-off values may be the same, although it is often the case that the epidemiological cut-off value is lower than the clinical breakpoint.

The advantages and disadvantages of the use of clinical breakpoints compared with epidemiological cut-off values (see box below) have been taken into account in the detailed specifications for harmonised monitoring schemes on antimicrobial resistance in animals and food devised by EFSA. These specifications have been published (EFSA, 2007; EFSA, 2008b) and the terminology used is that devised by EUCAST (Kahlmeter et al., 2003). As far as possible, epidemiological cut-off values have been used in this report, as recommended in the guidelines, to determine non-wild-type organisms also termed ‘microbiologically resistant’ organisms, and to ensure that results from different MSs are comparable. Hereafter in this report, ‘microbiologically antimicrobial resistant’ organisms are referred to as ‘resistant’ for brevity.

### CLINICAL BREAKPOINTS (CLINICAL RESISTANCE)

*The clinician, or veterinarian, choosing an antimicrobial agent to treat humans or animals with a bacterial infection requires information that the chosen antimicrobial will be effective against the bacterial pathogen. Such information will be used, in conjunction with clinical details such as the site of infection, ability of the antimicrobial to reach the site of infection, formulations available and dosage regimen, to determine an appropriate therapeutic course of action. The in vitro susceptibility of the bacterial pathogen can be determined and clinical breakpoints used to ascertain whether the organism is likely to respond to treatment. Clinical breakpoints will take into account the clinical behaviour of the drug following administration, and a susceptible result implies that a clinical response will be achieved if the drug is given as recommended and there are no other adverse factors that affect the outcome. Conversely, if the clinical breakpoint indicates resistance, then it is likely that treatment will be unsuccessful. Frequency of dosing is one factor that can affect the antimicrobial concentration achieved at the site of infection. Therefore, different dosing regimes can lead to the development of different clinical breakpoints, as occurs in some countries for certain antimicrobials where different therapeutic regimes are in place. Although the rationale for the selection of different clinical breakpoints may be clear, their use makes the interpretation of results from different countries in reports of this type problematic, as the results are not directly comparable between those different countries.*

### EPIDEMIOLOGICAL CUT-OFF VALUES (MICROBIOLOGICAL RESISTANCE)

*For a given bacterial species, the pattern of the MIC distribution or the inhibition zone diameter distribution (i.e. the frequency of occurrence of each given MIC or zone diameter plotted against the MIC value or zone diameter obtained) can usually enable the separation of the wild-type population of microorganisms from those populations which show antimicrobial resistance. The wild-type susceptible population is assumed to have no acquired or mutational resistance and commonly shows a normal distribution.*

*When bacteria acquire resistance by a clearly defined and efficacious mechanism, such as the acquisition of a plasmid bearing a gene which produces an enzyme capable of destroying the antimicrobial, then the MIC or zone diameter distribution commonly shows two major subpopulations, one a fully susceptible normal distribution of isolates and the other a fully resistant population which has acquired the resistance mechanism. Resistance may be achieved by a series of small steps, such as changes in the permeability of the bacterial cell wall to the antimicrobial or other mechanisms which confer a degree of resistance. In this case, subpopulations of organisms lying between the fully susceptible population and more resistant populations may occur. The epidemiological cut-off value indicates the MIC or zone diameter above which the pathogen has some detectable reduction in susceptibility. Epidemiological cut-off values are derived by testing an adequate number of isolates to ensure that the wild-type population can be confidently identified for a given antimicrobial. The clinical breakpoint, which is set to determine the therapeutic effectiveness of the antimicrobial, may fail to detect emergent resistance. Conversely, the epidemiological cut-off value detects any deviation in susceptibility from the wild-type population, but it may not be appropriate for determining the likelihood of success or failure for clinical treatment.*

# 2. MAIN FINDINGS

## 2.1 Main findings of the EU Summary Report on antimicrobial resistance 2010

- In 2010, Member States (MSs) reported qualitative data on antimicrobial resistance in *Salmonella* and *Campylobacter* isolates from human cases mostly by using clinical breakpoints to define the resistant isolates. In contrast, quantitative data (minimum inhibitory concentrations (MIC) and/or inhibition zone diameter (IZD) results) on antimicrobial resistance in isolates from food and animals were interpreted by using epidemiological cut-off values. Epidemiological cut-off values are in most cases lower than clinical breakpoints, and this can result in more isolates being classified as resistant, depending on the MIC distribution.
- Further harmonisation is still required to enable better comparisons of the levels of antimicrobial resistance occurring in different MSs in humans and also differences in levels of resistance between humans, animals and food. The results presented in this report should therefore be interpreted with caution.
- In the EU, among *Salmonella* isolates from human salmonellosis cases resistance to tetracyclines[11], ampicillin and sulfonamides was high. In contrast, resistance to the critically important antimicrobials, ciprofloxacin and cefotaxime, was relatively low. Higher resistance rates for these antimicrobials were reported by the few countries using epidemiological cut-off values.
- Among *Campylobacter* isolates from human cases, resistance to ampicillin, ciprofloxacin, nalidixic acid and tetracyclines was high to very high. Low to moderate resistance to the critically important antimicrobial, erythromycin, was recorded.
- Microbiological resistance to antimicrobials was regularly observed in isolates of *Salmonella*, *Campylobacter* and indicator (commensal) *E. coli* and enterococci from animals and food in the EU. In the case of many of the antimicrobials, there were large differences in the level of resistance in different MSs.
- Fluoroquinolones, such as ciprofloxacin, are critically important antimicrobials in human medicine. In food and animal isolates, the highest level of of resistance to ciprofloxacin was recorded in *Salmonella* isolates from turkeys, followed by fowl (*Gallus gallus*) and broiler meat. In pigs, cattle and pig meat, low resistance rates were observed. Furthermore, extremely high resistance to fluoroquinolones was commonly observed in *Campylobacter* isolates from broilers (*Gallus gallus*) and broiler meat, as well as in isolates from pigs and cattle. Important disparities were observed between animal species and MSs.
- Third-generation cephalosporins, such as cefotaxime, are also considered critically important antimicrobials in human medicine. Resistance to third-generation cephalosporins was observed in *Salmonella* isolates from *Gallus gallus*, pigs, turkeys and cattle, and in the meat derived from broilers and pigs, but at low or very low levels when all reporting MSs are considered. However, even low levels of resistance to these critically important antimicrobials are important. Variability in third-generation cephalosporin resistance was observed between animal species and MSs.
- Resistance to erythromycin, another critically important antimicrobial in human medicine, was detected in *Campylobacter* isolates from broilers (*Gallus gallus*) and poultry meat, although at much lower levels than those reported for fluoroquinolones. The highest level of resistance to erythromycin was in *C. coli* isolates from pigs, whereas the level of erythromycin resistance in isolates of *C. jejuni* from cattle was very low.
- Among *Salmonella* isolates from meat and animals, resistance to tetracyclines, ampicillin and sulfonamides was frequently reported, and it was higher in isolates from pigs and cattle than in isolates from *Gallus gallus*. The highest occurrence of resistance to ciprofloxacin was recorded in *Salmonella* isolates from turkeys, which was analysed by reporting at EU level for the first time in 2010.
- Among *Campylobacter* isolates from meat and animals, resistance to ciprofloxacin, nalidixic acid and tetracyclines was common, whereas much lower levels of resistance to erythromycin and gentamicin were observed.

[11] The term tetracyclines in this report refers to the following substances: tetracycline, chlortetracycline and oxytetracycline.

- Among indicator (commensal) *E. coli* isolates from meat and animals, resistance to tetracyclines, ampicillin and sulfonamides was commonly reported. Resistance to ciprofloxacin and nalidixic acid was highest for *E. coli* isolates from broilers (*Gallus gallus*), whereas resistance to sulfonamides and tetracyclines was highest in isolates from pigs.
- Among indicator (commensal) enterococci, resistance to tetracyclines and erythromycin was common in isolates from broilers (*Gallus gallus*), pigs and cattle, the level of resistance being lowest for cattle. Resistance to vancomycin continued to be detected, albeit at very low levels, in enterococcal isolates from animals.
- The number of MSs reporting results for indicator (commensal) *E. coli* for a number of categories declined in 2010 in comparison with 2009.
- Meticillin-resistant *Staphylococcus aureus* (MRSA) was detected by some MSs in a number of different animal species, including pigs, *Gallus gallus*, turkeys, cattle, dogs and solipeds, as well as in some food of animal origin. The MRSA *spa* types reported included those previously detected in the EU-wide baseline survey of breeding pigs.
- No major changes in the general occurrence of antimicrobial resistance in *Salmonella*, *Campylobacter* and indicator *E. coli* from animals and food and indicator enterococci from animals and food were observed in 2010 compared with the results in 2005–2009. However, some increasing and decreasing trends over the years 2005–2010 were detected among the MSs. In general, countries that reported a high level of resistance for a given combination of microorganism and antimicrobial also tended to have a comparatively high level of resistance for that antimicrobial in the other microorganisms considered in this report. This may suggest that an important factor accounting for this resistance could be antimicrobial usage.

## 2.2 Zoonotic and indicator agent-specific summaries

### *Salmonella*

In this report, data for *Salmonella* spp. comprise the amalgamated results for all reported *Salmonella* serovars and therefore represent the overall occurrence of antimicrobial resistance in *Salmonella* in the different animal or food categories. Some of the differences in the levels of antimicrobial resistance may be due to differences in the distribution and prevalence of particular serovars and phage types of *Salmonella* in different countries and in different animal species. This is because certain *Salmonella* serovars, or phage types within serovars, may have a particular and characteristic pattern of antimicrobial resistance to certain antimicrobials. The degree of spread of certain *Salmonella* serovars (clonal spread) can therefore explain some of the differences in the level of resistance observed. The selective pressure exerted by the use of antimicrobials in both human and animal populations can contribute both to the spread of particularly resistant clones of *Salmonella* and also to the occurrence of resistance genes within those clones. The spread of clones of *Salmonella* can also be influenced by factors independent of antimicrobial usage, such as foreign travel in humans, as well as by the pyramidal structure of some animal primary productions, animal movements, and by farming systems and hygienic practices on farms.

In addition, resistance data for the most important *Salmonella* serovars for public health, *S*. Enteritidis and *S*. Typhimurium, were analysed separately.

#### In humans

In 2010, 19 MSs and one non-MS provided information on antimicrobial resistance in *Salmonella* isolates from cases of salmonellosis in humans that occurred in that year. The reported data represent 25.9 % of confirmed salmonellosis cases reported in the EU in 2010. Resistance in human *Salmonella* isolates, especially *S*. Typhimurium, was very high for ampicillin, tetracyclines and sulfonamides and high for streptomycin. Resistance to these antimicrobials in isolates from monophasic *S*. Typhimurium was extremely high. Resistance to the clinically important antimicrobials ciprofloxacin and cefotaxime was relatively low among the isolates, albeit resistance to ciprofloxacin was significantly higher in countries using epidemiological cut-off values or similar values for interpretation of the resistance results than in those countries using clinical breakpoints. Resistance to quinolones (ciprofloxacin and nalidixic acid) was generally higher in *S*. Enteritidis isolates than in *S*. Typhimurium isolates.

### In animals and food

In 2010, information on antimicrobial resistance in *Salmonella* isolates from animals and food was reported by 21 MSs and two non-MSs.

Among *Salmonella* spp. isolates from turkeys, the level of resistance to tetracyclines, ampicillin and sulfonamides in all reporting MSs was 75 %, 51 % and 64 %, respectively. The level of resistance to ciprofloxacin and nalidixic acid was 28 % and 25 %, respectively, for all reporting MSs. There were commonly large variations in the levels of resistance to these antimicrobials among the different reporting MSs. The occurrence of resistance to cefotaxime in all reporting MSs was 0.3 %.

Among *Salmonella* spp. isolates from *Gallus gallus*, the resistance level to tetracyclines, ampicillin and sulfonamides in all reporting MSs was 20 %, 13 % and 22 %, respectively. Resistance to ciprofloxacin and nalidixic acid was 24 % and 23 %, respectively, for all reporting MSs. In general, as in turkeys, there were large variations in the levels of resistance to these antimicrobials between different reporting MSs. The occurrence of resistance to cefotaxime in all reporting MSs was 1 %.

Some MSs showed statistically significant increasing trends in resistance among *Salmonella* spp. isolates from *Gallus gallus* over the years 2005–2010, whereas other MSs exhibited decreasing trends. In particular, in the case of ciprofloxacin and nalidixic acid resistance, three MSs demonstrated a significant increasing trend and one a decreasing trend. Resistance in *S.* Enteritidis was generally lower than in *Salmonella* spp. isolates from *Gallus gallus*. In *S.* Enteritidis the occurrence of resistance for all reporting MSs was 6 % for tetracyclines, 4 % for ampicillin and 7 % for sulfonamides, whereas ciprofloxacin and nalidixic acid resistance was 25 % and 23 %, respectively.

In *Salmonella* spp. isolates from broiler meat, resistance levels for all reporting MSs for tetracyclines, ampicillin and sulfonamides were 20 %, 21 % and 27 %, respectively. Resistance to ciprofloxacin and nalidixic acid resistance was also common, with overall resistance levels for both of 24 %. The resistance level for cefotaxime was low, at 4 %.

For *Salmonella* isolates from pigs, resistance levels in the reporting group of MSs were 57 % for tetracyclines, 55 % for ampicillin and 59 % for sulfonamides. Ciprofloxacin and nalidixic acid resistance levels were low, at 3 % and 2 % respectively, and the level of resistance to cefotaxime was very low, at 0.8 %. Resistance to tetracyclines, ampicillin and sulfonamides was common in *Salmonella* spp. from pig meat, 50 %, 47 % and 52 %, respectively, considering all reporting MSs. Resistance to ciprofloxacin and nalidixic acid was 5 % and 4 %, respectively, and cefotaxime resistance equalled 0.2 %. Mostly relatively stable situations in resistance were observed in *Salmonella* spp. isolates from pigs over the years 2005–2010. Among the few observed statistically significant national trends, some were decreasing trends, whereas others were increasing ones.

Among *Salmonella* isolates from cattle, the occurrence of resistance to tetracyclines, ampicillin and sulfonamides in all reporting MSs was 39 %, 36 % and 45 %, respectively. The level of resistance to both ciprofloxacin and nalidixic acid resistance was 2 % for all reporting MSs, while cefotaxime resistance was overall very low, at 0.3 %; only one MS reported such resistance. Some MSs showed statistically significant decreasing trends in resistance among *Salmonella* spp. from cattle over the past 5 years.

Resistance data reported on some *Salmonella* serovars of public health significance were specifically addressed in this report. Quantitative dilution data on antimicrobial resistance in *S.* Typhimurium from various animal and food categories were provided by 20 MSs and two non-MSs, and similar data on *S.* Enteritidis isolates were provided by 18 MSs and one non-MS. Where sufficient data were available for inclusion in the report, the observed levels of resistance to ampicillin, chloramphenicol, streptomycin, sulfonamides and tetracyclines were much higher in *S*. Typhimurium than in *S.* Enteritidis isolates.

Eight MSs provided data on antimicrobial resistance in monophasic *S.* Typhimurium isolates from pigs and pig meat, *Gallus gallus* and cattle. Most of the isolates were resistant to ampicillin, sulfonamides and tetracyclines, whereas resistance to cefotaxime, ciprofloxacin and nalidixic acid was mostly reported as absent or at low levels. Resistance in *S*. Java[12] isolates from *Gallus gallus* was reported by five MSs. These

[12] Also known as *S*. Paratyphi B var. Java.

isolates showed low to high levels of resistance to ampicillin, streptomycin and tetracyclines. In addition, they exhibited very high to extremely high levels of resistance to (fluoro)quinolones.

Antimicrobial resistance in *S*. Saintpaul isolates from turkeys was reported by eight MSs. These isolates showed high levels of resistance to ampicillin, sulfonamides and tetracyclines, and 40 % were resistant to ciprofloxacin.

Resistance data from *S*. Kentucky isolates from *Gallus gallus* and turkeys were provided by seven MSs. The isolates from turkeys were highly resistant to ampicillin, sulfonamides and tetracyclines, and all isolates were resistant to (fluoro)quinolones. *S*. Kentucky isolates from *Gallus gallus* showed a much lower level of resistance.

## ***Campylobacter***

### In humans

Overall, 13 MSs and one non-MS provided information on antimicrobial resistance in isolates from campylobacteriosis cases in humans for the year 2010. Data from antimicrobial susceptibility testing represented 16.4 % of the total confirmed campylobacteriosis cases reported in the EU in 2010. Fewer countries reported results for *Campylobacter* than for *Salmonella.* The variety of methods and interpretative criteria being used by MSs in antimicrobial susceptibility testing for *Campylobacter* was large, reflecting the need for harmonisation and convergence of international guidelines to cover relevant antimicrobials and methods. The resistance levels in human *Campylobacter* isolates were high to extremely high for ampicillin, ciprofloxacin, nalidixic acid and tetracyclines. Resistance to the clinically important antimicrobial erythromycin was overall low, but moderately high in *C. coli*, although the number of tested isolates for this species was small.

### In animals and food

In 2010, information on antimicrobial resistance in *Campylobacter* isolates from animals and food was reported by 14 MSs and two non-MSs. All quantitative *Campylobacter* data were reported as MIC values. Most of the data were derived from broilers, pigs and cattle, or from meat from broilers.

Resistance was in general more frequent in *C. coli* than in *C. jejuni* isolates. For many antimicrobials, including tetracyclines, ciprofloxacin, nalidixic acid and gentamicin, there were differences in the occurrence of resistance in different MSs.

For *C. jejuni* isolates from *Gallus gallus*, the occurrence of tetracycline, ciprofloxacin and nalidixic acid resistance among reporting MSs was high, at 32 %, 47 % and 43 %, respectively. The level of resistance was very low for erythromycin, at 0.5 %, and for gentamicin, at 0.8 %. In *C. coli* isolates from *Gallus gallus*, resistance to ciprofloxacin, nalidixic acid and tetracyclines was extremely high, at 84 %, 76 % and 73 %, respectively. Erythromycin resistance at MS reporting level was 15 % and gentamicin resistance 8 % among *C. coli* isolates. Some MSs showed statistically significant increasing trends in resistance, particularly against ciprofloxacin and nalidixic acid, in *Campylobacter* isolates from broilers (*Gallus gallus*) over the 2005–2010 period.

In *C. coli* isolates from pigs, tetracyclines, ciprofloxacin and nalidixic acid resistance was 60 %, 40 % and 40 %, respectively. Erythromycin resistance was high at 25 %. The resistance situation was mostly stable over the years 2005–2010.

Among *C. jejuni* isolates from cattle, resistance levels for tetracyclines, ciprofloxacin and nalidixic acid were 34 %, 37 % and 38 %, respectively; the occurrence of resistance to erythromycin was very low, at 0.2 %.

## Indicator (commensal) *Escherichia coli*

In 2010, information on antimicrobial resistance in indicator *E. coli* isolates from animals and food was reported by eight MSs and two non-MSs. The information related to broilers, pigs and cattle.

In *E. coli* isolates from broilers (*Gallus gallus*), the occurrence of resistance to tetracyclines, ampicillin and sulfonamides for all reporting MSs was 31 %, 35 % and 34 %, respectively. Similarly, the level of resistance to ciprofloxacin was 29 %, to nalidixic acid 26 % and to cefotaxime 5 %. There were wide variations in the level of resistance to these antimicrobials among different MSs. Mostly relatively stable situations in the resistance were observed in *E. coli* isolates from *Gallus gallus* over the years 2005–2010. However, among the observed statistically significant national trends, more were increasing than decreasing ones.

Among *E. coli* isolates from pigs, resistance levels in the reporting group of MSs were 48 % for tetracyclines, 21 % for ampicillin and 37 % for sulfonamides. The level of resistance to both ciprofloxacin and nalidixic acid was 2 %. Cefotaxime resistance was 1 % and varied from 0 % to 5 %. As in broilers, there were differences in the occurrence of resistance to each of these antimicrobials in different MSs, with the exception of cefotaxime resistance, which was recorded by all reporting MSs as low, very low or not detectable. Mostly stable resistance was observed in *E. coli* isolates from pigs over the years 2005–2010.

In indicator *E. coli* isolates from cattle, resistance levels in the reporting group of MSs were 38 % for tetracyclines, 28 % for ampicillin and 34 % for sulfonamides. Resistance to ciprofloxacin and nalidixic acid was 15 % and 13 % respectively, while the level of resistance to cefotaxime was 3 %. As in broilers and pigs, the occurrence of resistance was variable for all antimicrobials except cefotaxime, the level of resistance to which was low, very low or not detectable. Some MSs showed statistically significant decreasing national trends in resistance to some antimicrobials in the 2005–2010 period.

### Indicator (commensal) enterococci

In 2010, information on antimicrobial resistance in enterococcal isolates from animals and food was reported by seven MSs and one non-MS. Most of the data related to isolates from broilers (*Gallus gallus*), pigs and cattle; only two MSs reported results from meat derived from those species. In general, wide variation in the level of resistance in different MSs was observed.

Among *E. faecium* and *E. faecalis* isolates from broilers (*Gallus gallus*), the level of resistance to tetracyclines and erythromycin was 56 % and 47 %, respectively, in *E. faecium* and 60 % and 56 %, respectively, in *E. faecalis*. In isolates from pigs, tetracycline and erythromycin resistance levels were 53 % and 35 %, respectively, in *E. faecium* and 71 % and 38 %, respectively, in *E. faecalis*. In the case of *E. faecium* isolates from cattle, tetracycline and erythromycin resistance levels were 21 % and 20 %, respectively, while in *E. faecalis* isolates from cattle resistance levels were 26 % for tetracyclines and 13 % for erythromycin.

Since there is cross-resistance between avoparcin and the human antimicrobial vancomycin, the use of avoparcin as an antimicrobial growth promoter was banned in the EU in 1997. In 2010 vancomycin-resistant *E. faecium* was reported in poultry and pigs; the level of resistance in these species was 0.3 % in poultry and 0.9 % in pigs. In the case of *E. faecalis*, the occurrence of vancomycin resistance in *Gallus gallus* was 0.7 % and in cattle was 0.6 %. No vancomycin resistance was detected in isolates from pigs.

### Meticillin-resistant *Staphylococcus aureus*

Seven MSs and one non-MS reported data on the occurrence of MRSA in animals and two MSs reported data on the occurrence of MRSA in food in 2010. One of the reporting MSs reported MRSA finding from turkey meat at levels of 32 % to 65 %. The *spa* types reported included those previously detected in the EU-wide baseline survey of breeding pigs. MRSA was detected in a number of different animal species, including pigs, *Gallus gallus*, turkeys, cattle, dogs and solipeds, at levels ranging from 0 % to 79 %. The observed prevalence varied greatly among the animal species and the reporting MSs.

### Farm-to-fork analyses

The association between the observed resistance to certain antimicrobials in *Campylobacter* isolates from humans, food and animals was analysed by using the same clinical breakpoints to determine resistance. It appeared that when erythromycin and ciprofloxacin resistance was observed in the human isolates within the country, resistant isolates were also found from animals and food, mostly at the same levels.

# 3. ANTIMICROBIAL RESISTANCE IN *SALMONELLA*

## 3.1 Introduction

*Salmonella* is an important zoonotic pathogen of public health relevance in both humans and animals. The genus *Salmonella* is divided into two species: *S. enterica* and *S. bongori*. There are six subspecies of *S. enterica* and most *Salmonella* belong to the subspecies *S. enterica* subsp. *enterica*. *Salmonella* are further subdivided into serovars based on the serological reactions of their somatic O-antigens and flagellar H-antigens. Different serovars have often been named based on the location where the serovar was first isolated. In this report, the organisms are identified by genus followed by serovar, e.g. *S.* Typhimurium. More than 2 500 serovars of zoonotic *Salmonella* have been recognised, and the prevalence of these different serovars can change over time. Within a given serovar, further subdivision of the isolates can be done e.g. using bacteriophages (bacterial viruses). The pattern of lysis obtained with a standard panel of *Salmonella* bacteriophages (the phage type) can be used to assign different phage types to a given serovar.

Human salmonellosis is usually characterised by the acute onset of fever, abdominal pain, nausea and sometimes vomiting. The majority of *Salmonella* infections result in mild, self-limiting, gastrointestinal illness and usually do not require antimicrobial treatment. Invasive disease, such as *Salmonella* bacteraemia or meningitis, can occur in a smaller subset of patients, with a higher risk in patients who are immuno-compromised. Commonly, these infections do not require antimicrobial treatment. In some patients the infection may be more serious and the associated dehydration can be life-threatening. The infection may on rare occasions be invasive. In cases of severe enteric disease, or when *Salmonella* invades and causes a bloodstream infection, effective antimicrobials are essential for treatment and can be life-saving. The treatment of choice for *Salmonella* infection is fluoroquinolones for adults and third-generation cephalosporins for children. Emerging resistance in *Salmonella* to these first-line treatments, resulting in infections with antimicrobial-resistant strains, may result in ineffective treatment, which in turn can lead to more severe outcomes in patients. Salmonellosis has also been associated with some long-term and sometimes chronic sequelae, e.g. reactive arthritis. The common reservoir of non-typhoidal *Salmonella* strains is the intestinal tract of a wide range of domestic and wild animals. This can result in a wide variety of foodstuffs, including foodstuffs of both animal and plant origin, becoming contaminated and acting as a source of infection for humans. Transmission usually occurs when organisms are introduced into food preparation areas or are allowed to multiply in food (for example because of inadequate storage temperature, inadequate cooking or cross-contamination of ready-to-eat food and uncooked food). *Salmonella* may also be transmitted through direct contact with infected animals or humans, or by contact with contaminated environments.

Overall, considering all *Salmonella* infections in the EU, *S.* Enteritidis and *S.* Typhimurium are the serovars most frequently associated with human illness. *S.* Enteritidis cases in humans are most commonly associated with the consumption of contaminated eggs and poultry meat, whereas *S.* Typhimurium cases are mostly associated with the consumption of contaminated pig, poultry and bovine meat.

In animals, particularly of certain species, subclinical infections can be common. The organism may spread rapidly and easily between animals in a herd or flock without the animals showing any clinical signs in some cases, and animals may become intermittent or persistent carriers. In other species, clinical disease may occur following *Salmonella* infection and, in particular, cattle may succumb to fever, diarrhoea and abortion following infection, particularly with some serovars. In calves, *Salmonella* can cause outbreaks of diarrhoea with high mortality. Fever and diarrhoea are less common in pigs than in cattle and sheep, and poultry may also show no signs of infection.

## 3.2 Antimicrobial resistance in *Salmonella* isolates from humans

Nineteen MSs and Iceland submitted antimicrobial resistance data from human non-typhoidal *Salmonella* isolates to ECDC for 2010. In total, 25 525 isolates were tested for resistance to one or several antimicrobials, representing 25.9 % (N = 98 735) of the confirmed human salmonellosis cases reported in 2010 (EFSA and ECDC, 2012).

The method of testing for antimicrobial susceptibility and the selection of the isolates to be tested varied markedly between the countries. In several countries, the reference laboratories subject only a fraction of the available isolates to susceptibility testing. The remainder may be subjected to susceptibility testing by hospitals or local laboratories and the methods used by these may not be reported. The methods and breakpoints used for *Salmonella* antimicrobial susceptibility testing (AST) differed somewhat between MSs (for detailed information, see Materials and Methods, Table MM1). Most countries used clinical breakpoints as provided by the Clinical and Laboratory Standards Institute (CLSI) for the interpretation of test results, but a few countries used other criteria, such as epidemiological cut-off values provided by the European Committee on Antimicrobial Susceptibility Testing (EUCAST). For chloramphenicol, nalidixic acid, sulfonamide and tetracycline, the CLSI and EUCAST breakpoints/cut-offs are equivalent, whereas for the remaining antimicrobials they might differ markedly. The results must therefore be interpreted with caution and no direct comparison between countries should be made. Where countries have used the same method over the time period covered by the report, the trends in occurrence of resistance are likely to be valid, although sensitivity may vary depending on the specific breakpoint used.

The highest level of resistance in all *Salmonella* from 2010 was observed for tetracyclines, 28.4 %, closely followed by ampicillin, 28.0 % (Table SA1). However, as in previous years, there was wide variability in percentages of resistance to different antimicrobials among reporting countries. *Salmonella* Enteritidis and *S.* Typhimurium were, in 2010 as in previous years, the two most commonly reported *Salmonella* serovars, accounting for 45.0 % and 22.4 %, respectively, of all reported confirmed human cases in 2010 (EFSA and ECDC, 2012). Furthermore, harmonisation of reporting of monophasic *Salmonella* Typhimurium 1,4,[5],12:i:- in 2010 revealed that this serotype rose to be the fourth most commonly reported serovar accounting for 1.5 % of all confirmed reported cases in 2010. The AST results are presented separately for these three serovars.

### 3.2.1 Antimicrobial resistance in *S.* Enteritidis

The highest levels of resistance among *S.* Enteritidis isolates from 2010 were observed for nalidixic acid, 18.7 % (N = 6 904), and ciprofloxacin, 9.3 % (N = 7 949) (Table SA2). Both of these antimicrobials belong to the quinolones, a family of synthetic broad-spectrum antimicrobials. While nalidixic acid is a first generation quinolone (and normally not used for the treatment of salmonellosis), ciprofloxacin belongs to the second generation of fluoroquinolones and is today the antimicrobial of choice for treatment of severe or invasive *Salmonella* infections in humans. As in 2009, the highest resistance to ciprofloxacin was found in the United Kingdom (19.0 %, N = 2 784) and Denmark (19.0 %, N = 364), followed by the Netherlands (9.7 %, N = 452). However, the level of resistance to ciprofloxacin in the United Kingdom decreased by 10 % in 2010 compared with 2009. For the country-specific 4-year trends for ciprofloxacin resistance over the 2007 to 2010 period, the countries were presented individually owing to wide diversity of AST methods and breakpoints/cut-off values used for interpretation of the results (Figure SA1). Among countries using EUCAST epidemiological cut-off values (ECOFFs) or similar, trends in resistance over the period 2007–2010 have fluctuated in the United Kingdom and Denmark. In the United Kingdom a marked decrease in the ciprofloxacin resistance of *S.* Enteritidis, from 30.5 % (N = 4 288) to 19.0 % (N = 2 874), occurred between 2009 and 2010, while in Denmark, in contrast, a marked increase in the resistance of *S.* Enteritidis to ciprofloxacin, from 11.0 % (N = 355) to 19.0 % (N = 364), was observed. Most of the countries using CLSI breakpoints reported very low levels of resistance.

The second most clinically important group of antimicrobials for the treatment of human salmonellosis are the cephalosporins, especially for treatment of severe infections in children. In the panel of antimicrobials tested, this group of antimicrobials is represented by cefotaxime, a third-generation cephalosporin. As in previous years, resistance to cefotaxime was generally low in the reporting MSs, 0.4 % (N = 7 731) in 2010. The highest resistance was observed in Estonia (4.0 %, N = 226) followed by Italy (2.3 %, N = 175). The 4-year 2007–2010 trends in cefotaxime resistance were generally at very low level in reporting MSs (Figure SA2).

Other noteworthy observations are the high resistance to gentamicin in *S.* Enteritidis in Slovakia (92.8 %, N = 111) and Italy (52.3 %, N = 153). A very high resistance to nalidixic acid in *S.* Enteritidis was also observed in Hungary (71.9 %, N = 32), Spain (57.6 %, N = 375), Ireland (40.0 %, N = 70) and the United Kingdom (23.2 %, N = 2 777).

### 3.2.2 Antimicrobial resistance in *S.* Typhimurium

Antimicrobial resistance in *S.* Typhimurium isolates reported for 2010 differed compared with *S.* Enteritidis. The highest resistance in *S.* Typhimurium was to ampicillin (64 %, N = 6 466), tetracycline (58.5 %, N = 5 180), sulfonamide (57.1 %, N = 4 383) and streptomycin (44.1 %, N = 5 485) (Table SA3). The percentage of resistance increased considerably for sulfonamides, from 46.4 % (N = 4 130) in 2009 to 57.1 % (N = 4 383) in 2010. The occurrence of resistance to these antimicrobials was generally high to extremely high in the majority of reporting MSs. In 2010, observed resistance in *S.* Typhimurium isolates to the two clinically most important antimicrobials was 4.7 % (N = 6 412) for ciprofloxacin and 1.1 % (N = 6 146) for cefotaxime. Resistance to the former antimicrobial in the Netherlands increased from 4.9 %, N = 268 in 2009 to 20.1%, N = 388 in 2010. The highest level of resistance to cefotaxime was observed in France (6.3 %, N = 96), Italy (3.1 %, N = 639) and Ireland (1.8 %, N = 113). This is the first year that France has reported data on antimicrobial resistance for human cases of salmonellosis.

The 4-year trend (2007–2010) in resistance to ciprofloxacin by country showed that most reporting countries using CLSI breakpoints (Estonia, Italy, Slovenia, Spain) reported low levels of resistance to ciprofloxacin. Countries using ECOFFs or interpretative criteria nearing ECOFFs (Denmark, the Netherlands and the United Kingdom) reported the highest level of resistance (ranging from 7 % to 20.1 %) (Figure SA3). For the 4-year trends for cefotaxime resistance over 2007–2010, resistance was overall low in reporting MSs independent of the breakpoints used. The highest resistance (13.8 %, N = 87) was observed in Romania in 2007, followed by a considerable decline in 2010 (0.9 %, N = 109).

Other noteworthy observations were the high resistance in *S.* Typhimurium to gentamicin in Italy (44.4 %, n = 604) and extremely high resistance in Slovakia (95.8 %, N = 24).

### 3.2.3 Antimicrobial resistance in monophasic *S.* Typhimurium 1.4.[5].12.I:-

This is the first year that a separate section on this *Salmonella* serovar has been included in the report. In 2010, Austria, France, Hungary, Ireland and Luxembourg were the only MSs that reported antimicrobial resistance data for this serovar. The highest resistance in monophasic *S* Typhimurium was observed for tetracyclines (92.5 %), ampicillin (90.1 %), sulfonamides (86.5 %) and streptomycin (85.3 %) (Table SA4). This was in accordance with the highest resistance observed for generic *S.* Typhimurium isolates described above. The occurrence of resistance to these antimicrobials was generally high to extremely high in the majority of reporting MSs, although the number of isolates tested was low (N = 252). The resistance observed in monophasic *S.* Typhimurium isolates to the two most important antimicrobials for treatment of clinical human cases was 2.4 % for cefotaxime and 1.2 % for ciprofloxacin.

***Table SA1. Antimicrobial resistance in* Salmonella *spp. (all non-typhoidal serovars) from humans by Member State in 2010, TESSy data***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Kanamycin | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 2,179 | 13.8 | 2,179 | 0.4 | 2,179 | 2.8 | 2,179 | 0.9 | 2,179 | 1.2 | 2,179 | 0.7 |
| Cyprus | 6 | NA | - | - | - | - | 1 | NA | 1 | NA | - | - |
| Denmark | 1,514 | 30.8 | 1,513 | 0.5 | 1,514 | 5.5 | 1,514 | 13.7 | 1,514 | 2.6 | 1,512 | 1.1 |
| Estonia | 335 | 11.6 | 293 | 3.1 | 215 | 3.7 | 334 | 2.1 | 214 | 0 | 193 | 2.1 |
| France | 1,088 | 33.5 | 1,088 | 4.3 | 1,088 | 10.1 | 1,088 | 15.3 | 1,088 | 13.6 | 1,088 | 4.0 |
| Germany | 1,585 | 41.3 | 1,586 | 0.9 | - | - | 1,585 | 2.0 | 1,585 | 2.1 | 1,586 | 1.6 |
| Hungary | 964 | 58.5 | 964 | 0.1 | 963 | 12.8 | 964 | 0.2 | 963 | 0.1 | 963 | 1.2 |
| Ireland | 350 | 29.7 | 350 | 3.1 | 350 | 14.9 | 350 | 0.6 | 350 | 4.0 | 350 | 2.3 |
| Italy | 2,261 | 57.9 | 1,849 | 2.1 | 855 | 9.7 | 2,206 | 1.3 | 1,678 | 50.7 | 310 | 4.5 |
| Latvia | 12 | NA | - | - | - | - | 12 | NA | - | - | - | - |
| Lithuania | 1,950 | 19.0 | 1,595 | 0.8 | 933 | 1.2 | 1,566 | 6.7 | 850 | 0.1 | 695 | 0.3 |
| Luxembourg | 211 | 38.4 | 211 | 0.5 | 211 | 21.3 | 211 | 6.2 | 211 | 0.9 | 211 | 1.9 |
| Malta | 156 | 14.1 | - | - | - | - | 158 | 1.9 | 159 | 1.3 | - | - |
| Netherlands | 1,277 | 32.7 | 1,277 | 0.3 | 1,277 | 9.6 | 1,277 | 14.6 | 1,277 | 1.7 | - | - |
| Romania | 344 | 38.1 | 344 | 0.6 | 344 | 3.8 | 344 | 0 | 344 | 0.3 | 344 | 0.3 |
| Slovakia | 411 | 11.8 | 214 | 1.9 | 72 | 1.4 | 191 | 1.0 | 169 | 94.1 | | |
| Slovenia | 363 | 11.8 | 363 | 0.3 | 363 | 3.6 | 363 | 0 | 363 | 0.6 | 363 | 0.8 |
| Spain | 991 | 40.4 | 991 | 0.8 | 990 | 12.3 | 991 | 0.3 | 984 | 0.8 | 991 | 0.9 |
| United Kingdom | 9,528 | 19.4 | 9,434 | 0.7 | 9,520 | 5.9 | 9,588 | 14.3 | 9,518 | 2.7 | 9,503 | 2.1 |
| **Total (19 MSs)** | **25,525** | **28.0** | **24,251** | **1.0** | **20,874** | **6.7** | **24,927** | **8.6** | **23,447** | **6.7** | **20,288** | **1.7** |
| Iceland | 34 | 23.5 | 2 | NA | 34 | 2.9 | 34 | 0 | 2 | NA | - | - |

Note: NA = not applicable: Whenever there are fewer than 20 isolates tested, resistance levels are not calculated.

***Table SA1 (continued). Antimicrobial resistance in* Salmonella *spp.* (all serovars) *from humans by Member State in 2010, TESSy data***

| Country | Nalidixic acid | | Streptomycin | | Sulfonamides | | Tetracyclines | | Trimethoprim | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 2,179 | 10.2 | 2,179 | 12.2 | 2,179 | 13.4 | 2,179 | 14.8 | 2,179 | 3.4 |
| Cyprus | - | - | - | - | - | - | - | - | 1 | NA |
| Denmark | 1,514 | 11.4 | 1,514 | 30.9 | 1,514 | 32.9 | 1,514 | 23.5 | 1,514 | 5.8 |
| Estonia | 210 | 8.6 | 192 | 10.4 | 198 | 11.6 | 193 | 9.8 | 313 | 4.2 |
| France | 1,088 | 26.6 | 1,088 | 37.3 | 1,088 | 41.5 | 1,088 | 42.6 | 1,088 | 10.6 |
| Germany | 1,586 | 11.5 | 1,586 | 43.3 | - | - | - | - | 1,585 | 7.3 |
| Hungary | 964 | 25.8 | 963 | 57.8 | 963 | 59.8 | 964 | 59.2 | 964 | 8.7 |
| Ireland | 350 | 14.6 | 350 | 30.3 | 350 | 30.0 | 350 | 31.1 | 350 | 9.4 |
| Italy | 713 | 7.4 | 306 | 60.5 | 309 | 64.7 | 1,108 | 60.2 | 2,134 | 10.3 |
| Latvia | - | - | - | - | - | - | - | - | 12 | NA |
| Lithuania | 776 | 13.0 | 768 | 7.2 | 766 | 7.2 | 770 | 7.4 | 1,927 | 8.8 |
| Luxembourg | 211 | 6.6 | 210 | 34.8 | 211 | 40.3 | 211 | 46.0 | 211 | 9.5 |
| Malta | - | - | - | - | - | - | - | - | 156 | 5.1 |
| Netherlands | 1,277 | 13.3 | 1,277 | 25.5 | - | - | 1,277 | 35.4 | - | - |
| Romania | 344 | 11.0 | 344 | 19.5 | 344 | 34.0 | 344 | 22.4 | 344 | 4.4 |
| Slovakia | - | - | 9 | 22.2 | 31 | 16.1 | 267 | 18.4 | - | - |
| Slovenia | 363 | 8.0 | 363 | 9.1 | 362 | 12.4 | 363 | 11.6 | 363 | 2.2 |
| Spain | 991 | 28.7 | 990 | 30.0 | 992 | 34.8 | 991 | 34.4 | 973 | 6.0 |
| United Kingdom | 9,551 | 15.9 | 9,503 | 7.9 | 9,467 | 20.8 | 9,467 | 25.0 | 9,607 | 9.8 |
| **Total (19 MSs)** | **22,117** | **15.3** | **21,642** | **19.8** | **18,774** | **25.4** | **21,086** | **28.4** | **23,726** | **8.3** |
| Iceland | 33 | 9.1 | - | - | - | - | - | - | 34 | 5.9 |

Note: NA = not applicable: Whenever there are fewer than 20 isolates tested, resistance levels are not calculated.

***Table SA2. Antimicrobial resistance in* Salmonella *Enteritidis from humans by Member State in 2010, TESSy data***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Kanamycin | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 1,212 | 3.5 | 1,212 | 0.1 | 1,212 | 0.1 | 1,212 | 0 | 1,212 | 0 | 1,212 | 0 |
| Denmark | 364 | 6.0 | 364 | 0 | 364 | 0.8 | 364 | 19.0 | 364 | 0.3 | 364 | 0 |
| Estonia | 253 | 5.5 | 226 | 4.0 | 162 | 1.2 | 250 | 1.6 | 161 | 0 | 147 | 2.7 |
| France | 97 | 6.2 | 97 | 1.0 | 97 | 0 | 97 | 0 | 97 | 0 | 97 | 0 |
| Germany | 194 | 5.7 | 194 | 0.5 | - | - | 194 | 0.5 | 194 | 0 | 194 | 0.5 |
| Hungary | 32 | 12.5 | 32 | 0 | 32 | 9.4 | 32 | 0 | 32 | 0 | 32 | 0 |
| Ireland | 70 | 5.7 | 70 | 1.4 | 70 | 0 | 70 | 0 | 70 | 1.4 | 70 | 1.4 |
| Italy | 216 | 7.9 | 175 | 2.3 | 72 | 1.4 | 207 | 1.4 | 153 | 52.3 | 16 | 0 |
| Latvia | 10 | NA | - | - | - | - | 10 | NA | - | - | - | - |
| Lithuania | 1,481 | 13.3 | 1,210 | 0.5 | 740 | 0.3 | 1,274 | 6.7 | 724 | 0.1 | 603 | 0.3 |
| Luxembourg | 71 | 4.2 | 71 | 0 | 71 | 0 | 71 | 6.0 | 71 | 0 | 71 | 0 |
| Malta | 71 | 1.4 | - | - | - | - | 72 | 0 | 72 | 0 | - | - |
| Netherlands | 452 | 2.9 | 452 | 0 | 452 | 0.2 | 452 | 9.7 | 452 | 0.2 | - | - |
| Romania | 188 | 35.1 | 188 | 0 | 188 | 0 | 188 | 0 | 188 | 0 | 188 | 0 |
| Slovakia | 272 | 6.6 | 134 | 2.2 | 53 | 1.9 | 114 | 1.8 | 111 | 92.8 | - | - |
| Slovenia | 183 | 2.7 | 183 | 0 | 183 | 0 | 183 | 0 | 183 | 0 | 183 | 0.5 |
| Spain | 375 | 15.2 | 375 | 0.3 | 374 | 1.3 | 375 | 0 | 374 | 0.3 | 375 | 0 |
| United Kingdom | 2,773 | 4.4 | 2,748 | 0.2 | 2,761 | 0.8 | 2,784 | 19.0 | 2,760 | 0.1 | 2,758 | 0.1 |
| **Total (18 MSs)** | **8,314** | **7.2** | **7,731** | **0.4** | **6,829** | **0.6** | **7,949** | **9.3** | **7,218** | **2.7** | **6,310** | **0.2** |
| Iceland | 7 | NA | - | - | 7 | NA | 7 | NA | - | - | - | - |

Note: NA = not applicable: Whenever there are fewer than 20 isolates tested, resistance levels are not calculated.

***Table SA2 (continued). Antimicrobial resistance* in Salmonella *Enteritidis from humans by Member State in 2010, TESSy data***

| Country | Nalidixic acid | | Streptomycin | | Sulfonamide | | Tetracycline | | Trimethoprim | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 1,212 | 8.2 | 1,212 | 0.3 | 1,212 | 0.3 | 1,212 | 2.5 | 1,212 | 0.2 |
| Denmark | 364 | 18.1 | 364 | 1.6 | 364 | 1.9 | 364 | 4.4 | 364 | 1.9 |
| Estonia | 158 | 9.5 | 144 | 3.5 | 148 | 4.1 | 145 | 2.8 | 233 | 2.1 |
| France | 97 | 20.6 | 97 | 1.0 | 97 | 1.0 | 97 | 1.0 | 97 | 0 |
| Germany | 194 | 5.2 | 194 | 0 | - | - | - | - | 194 | 1.0 |
| Hungary | 32 | 71.9 | 32 | 15.6 | 32 | 15.6 | 32 | 15.6 | 32 | 0 |
| Ireland | 70 | 40.0 | 70 | 2.9 | 70 | 1.4 | 70 | 2.9 | 70 | 1.4 |
| Italy | 61 | 6.6 | 17 | NA | 16 | NA | 97 | 6.2 | 196 | 2.0 |
| Latvia | - | - | - | - | - | - | - | - | 10 | NA |
| Lithuania | 670 | 12.1 | 664 | 0.5 | 660 | 0.6 | 663 | 1.1 | 1,473 | 9.0 |
| Luxembourg | 71 | 5.6 | 71 | 0 | 71 | 1.4 | 71 | 5.6 | 71 | 1.4 |
| Malta | - | - | - | - | - | - | - | - | 69 | 2.9 |
| Netherlands | 452 | 10.0 | 452 | 0.4 | - | - | 452 | 1.1 | - | - |
| Romania | 188 | 13.8 | 188 | 0.5 | 188 | 12.8 | 188 | 0 | 188 | 0.5 |
| Slovakia | - | - | 5 | NA | 22 | 13.6 | 176 | 10.2 | - | - |
| Slovenia | 183 | 7.7 | 183 | 1.1 | 182 | 3.3 | 183 | 1.6 | 183 | 0 |
| Spain | 375 | 57.6 | 375 | 2.9 | 375 | 3.7 | 375 | 5.3 | 372 | 1.3 |
| United Kingdom | 2,777 | 23.2 | 2,758 | 1.1 | 2,745 | 2.7 | 2,745 | 4.7 | 2,788 | 2.9 |
| **Total (18 MSs)** | **6,904** | **18.7** | **6,826** | **1.1** | **6,182** | **2.4** | **6,870** | **3.6** | **7,552** | **3.2** |
| Iceland | 7 | NA | - | - | - | - | - | - | 7 | NA |

Note: NA = not applicable: Whenever there are fewer than 20 isolates tested, resistance levels are not calculated.

**Table SA3.** ***Antimicrobial resistance in*** **Salmonella** ***Typhimurium from humans by Member State in 2010, TESSy data***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Kanamycin | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 248 | 51.6 | 248 | 0.8 | 248 | 18.5 | 248 | 0 | 248 | 0.4 | 248 | 2.0 |
| Cyprus | 4 | NA | - | - | - | - | 4 | NA | 1 | NA | | |
| Denmark | 513 | 53.8 | 512 | 0.2 | 513 | 9.4 | 513 | 7.0 | 513 | 0.6 | 512 | 0 |
| Estonia | 47 | 34.0 | 40 | 0 | 29 | 17.2 | 48 | 2.1 | 29 | 0 | 22 | 0 |
| France | 96 | 69.8 | 96 | 6.3 | 96 | 53.1 | 96 | 0 | 96 | 4.2 | 96 | 4.2 |
| Germany | 714 | 77.6 | 714 | 1.3 | - | - | 714 | 0.4 | 713 | 0.8 | 714 | 2.2 |
| Hungary | 514 | 72.8 | 514 | 0.2 | 514 | 20.2 | 514 | 0.4 | 514 | 0 | 514 | 1.4 |
| Ireland | 113 | 54.0 | 113 | 1.8 | 113 | 35.4 | 113 | 0 | 113 | 2.7 | 113 | 2.7 |
| Italy | 845 | 81.1 | 639 | 3.1 | 326 | 20.9 | 824 | 0.8 | 604 | 44.4 | 83 | 7.2 |
| Lithuania | 135 | 85.2 | 120 | 0.8 | 61 | 14.8 | 122 | 8.2 | 59 | 0 | 54 | 0 |
| Luxembourg | 66 | 62.1 | 66 | 0 | 66 | 56.1 | 66 | 4.5 | 66 | 0 | 66 | 6.1 |
| Malta | 35 | 40.0 | - | - | - | - | 37 | 0 | 37 | 0 | - | - |
| Netherlands | 388 | 66.2 | 388 | 0.3 | 388 | 26.3 | 388 | 20.1 | 388 | 0.3 | - | - |
| Romania | 109 | 53.2 | 109 | 0.9 | 109 | 11.9 | 109 | 0 | 109 | 0 | 109 | 0 |
| Slovakia | 54 | 44.4 | 31 | 0 | 9 | NA | 24 | 0 | 24 | 95.8 | - | - |
| Slovenia | 49 | 36.7 | 49 | 0 | 49 | 22.4 | 49 | 0 | 49 | 0 | 49 | 0 |
| Spain | 356 | 81.7 | 356 | 1.1 | 356 | 30.3 | 356 | 0 | 355 | 0.8 | 356 | 2.0 |
| United Kingdom | 2,180 | 53.0 | 2,151 | 0.9 | 2,164 | 17.3 | 2,187 | 7.4 | 2,163 | 1.8 | 2,160 | 3.3 |
| **Total (18 MSs)** | **6,466** | **64.0** | **6,146** | **1.1** | **5,041** | **20.2** | **6,412** | **4.7** | **6,080** | **5.8** | **5,096** | **2.6** |
| Iceland | 8 | NA | 1 | NA | 8 | NA | 8 | NA | 1 | NA | - | - |

Note: NA = not applicable: Whenever there are fewer than 20 isolates tested, resistance levels are not calculated.

*Table SA3 (continued). Antimicrobial resistance in* **Salmonella** *Typhimurium from humans by Member State in 2010, TESSy data*

| Country | Nalidixic acid | | Streptomycin | | Sulfonamide | | Tetracycline | | Trimethoprim | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 248 | 6.5 | 248 | 42.7 | 248 | 5.2 | 248 | 47.6 | 248 | 13.7 |
| Cyprus | - | - | - | - | - | - | - | - | 4 | NA |
| Denmark | 513 | 6.0 | 513 | 57.5 | 513 | 59.6 | 513 | 25.5 | 513 | 4.3 |
| Estonia | 28 | 3.6 | 22 | 45.5 | 23 | 43.5 | 23 | 43.5 | 47 | 10.6 |
| France | 96 | 24.0 | 96 | 70.8 | 96 | 70.8 | 96 | 74.0 | 96 | 10.4 |
| Germany | 714 | 13.0 | 714 | 77.6 | - | - | - | - | 714 | 7.1 |
| Hungary | 514 | 5.3 | 514 | 47.9 | 514 | 51.8 | 514 | 49.4 | 514 | 12.3 |
| Ireland | 113 | 5.3 | 113 | 57.5 | 113 | 58.4 | 113 | 54.9 | 113 | 11.5 |
| Italy | 312 | 8.3 | 79 | 78.5 | 82 | 57.5 | 455 | 78.9 | 800 | 12.4 |
| Lithuania | 56 | 17.9 | 57 | 87.7 | 57 | 80.7 | 57 | 78.9 | 134 | 11.2 |
| Luxembourg | 66 | 4.5 | 65 | 60.0 | 66 | 63.6 | 66 | 78.8 | 66 | 22.7 |
| Malta | - | - | - | - | - | - | - | - | 36 | 8.3 |
| Netherlands | 388 | 19.3 | 388 | 38.7 | - | - | 388 | 72.2 | - | - |
| Romania | 109 | 3.7 | 109 | 48.6 | 109 | 70.6 | 109 | 56.0 | 109 | 9.2 |
| Slovakia | - | - | 3 | NA | 4 | NA | 41 | 34.1 | - | - |
| Slovenia | 49 | 10.2 | 49 | 32.7 | 49 | 38.8 | 49 | 36.7 | 49 | 6.1 |
| Spain | 356 | 11.2 | 355 | 67.9 | 357 | 78.2 | 356 | 13.5 | 346 | 9.8 |
| United Kingdom | 2,172 | 6.9 | 2,160 | 21.4 | 2,152 | 52.4 | 2,152 | 60.9 | 2,192 | 15.1 |
| **Total (18 MSs)** | **5,734** | **8.9** | **5,485** | **44.1** | **4,383** | **57.2** | **5,180** | **58.5** | **5,981** | **11.8** |
| Iceland | - | - | - | - | 8 | NA | - | - | - | - |

Note: NA = not applicable: Whenever there are fewer than 20 isolates tested, resistance levels are not calculated.

*Table SA4. Antimicrobial resistance in monophasic* **Salmonella** *Typhimurium 1.4.[5].12:I:- from humans by Member State in 2010, TESSy data*

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Kanamycin | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 65 | 93.8 | 65 | 1.5 | 65 | 3.1 | 65 | 0 | 65 | 1.6 | 65 | 1.5 |
| France | 101 | 89.1 | 101 | 3.0 | 101 | 8.9 | 101 | 1.0 | 101 | 6.9 | 101 | 4.6 |
| Hungary | 54 | 88.9 | 54 | 0 | 54 | 3.7 | 54 | 0 | 54 | 0 | 54 | 0 |
| Ireland | 19 | 84.2 | 19 | 5.3 | 19 | 5.3 | 19 | 0 | 19 | 0 | 19 | 0 |
| Luxembourg | 13 | 92.3 | 13 | 7.7 | 13 | 23.1 | 13 | 15.4 | 13 | 0 | 13 | 0 |
| **Total (5 MSs)** | **252** | **90.1** | **252** | **2.4** | **252** | **6.7** | **252** | **1.2** | **252** | **3.2** | **252** | **1.6** |

| Country | Nalidixic acid | | Streptomycin | | Sulfonamides | | Tetracyclines | | Trimethoprim | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 65 | 3.1 | 65 | 84.6 | 65 | 84.6 | 65 | 92.3 | 65 | 4.6 |
| France | 101 | 1.0 | 101 | 84.2 | 101 | 87.1 | 101 | 93.1 | 101 | 18.8 |
| Hungary | 54 | 3.7 | 54 | 88.9 | 54 | 87.0 | 54 | 88.9 | 54 | 1.9 |
| Ireland | 19 | 0 | 19 | 78.9 | 19 | 78.9 | 19 | 94.7 | 19 | 5.3 |
| Luxembourg | 13 | 7.7 | 13 | 92.3 | 13 | 100 | 13 | 100 | 13 | 15.4 |
| **Total (5 MSs)** | **252** | **2.4** | **252** | **85.3** | **252** | **86.5** | **252** | **92.5** | **252** | **10.3** |

Note: Even though data based on fewer than 10 isolates tested are not shown in these tables, they are included in totals. Hence, totals will sometimes exceed the sum of isolates from the reporting MS.

***Figure SA1. Resistance to ciprofloxacin in* Salmonella *Enteritidis in humans in reporting Member States, 2007–2010***

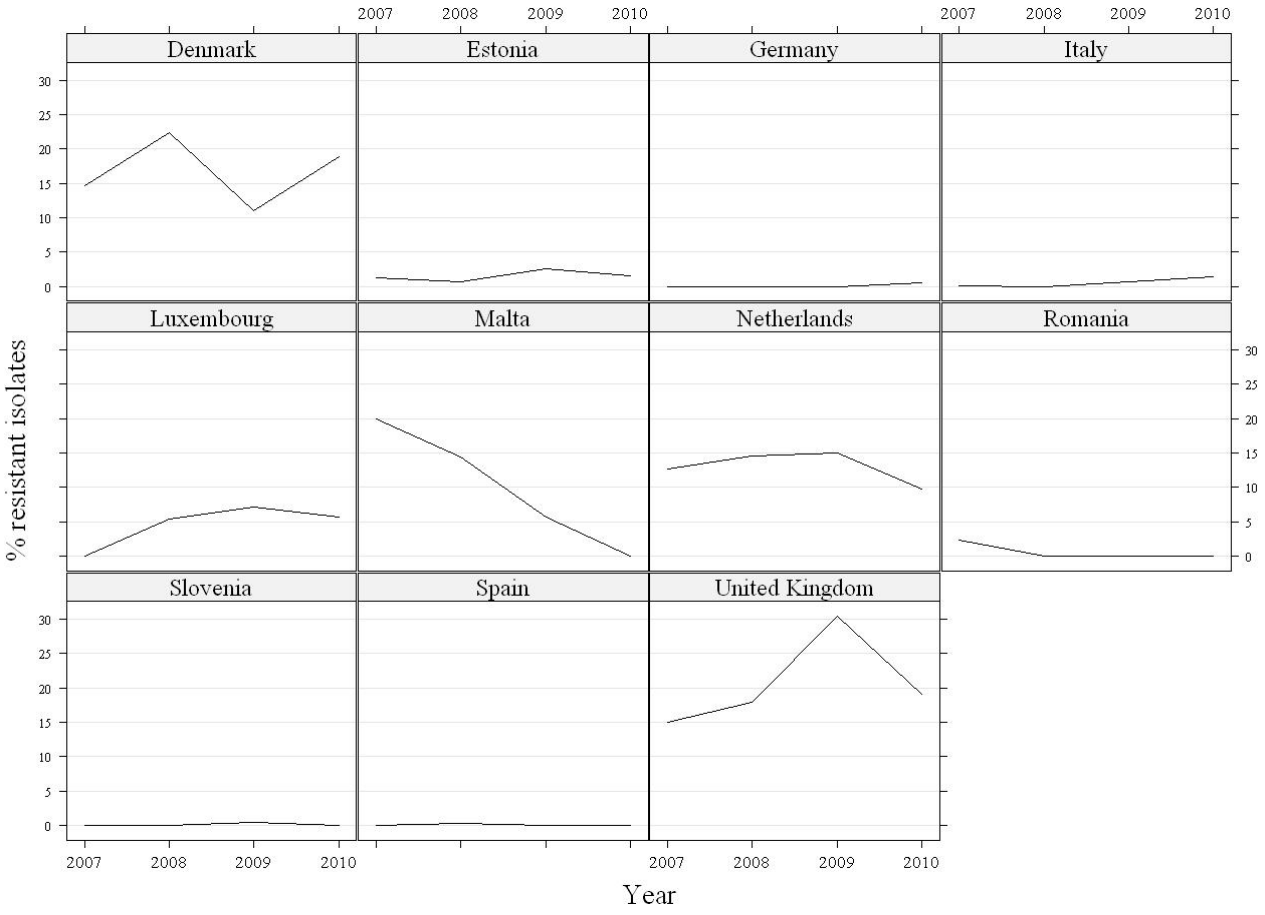


***Figure SA2. Resistance to cefotaxime in* Salmonella *Enteritidis in humans in reporting Member States, 2007–2010***

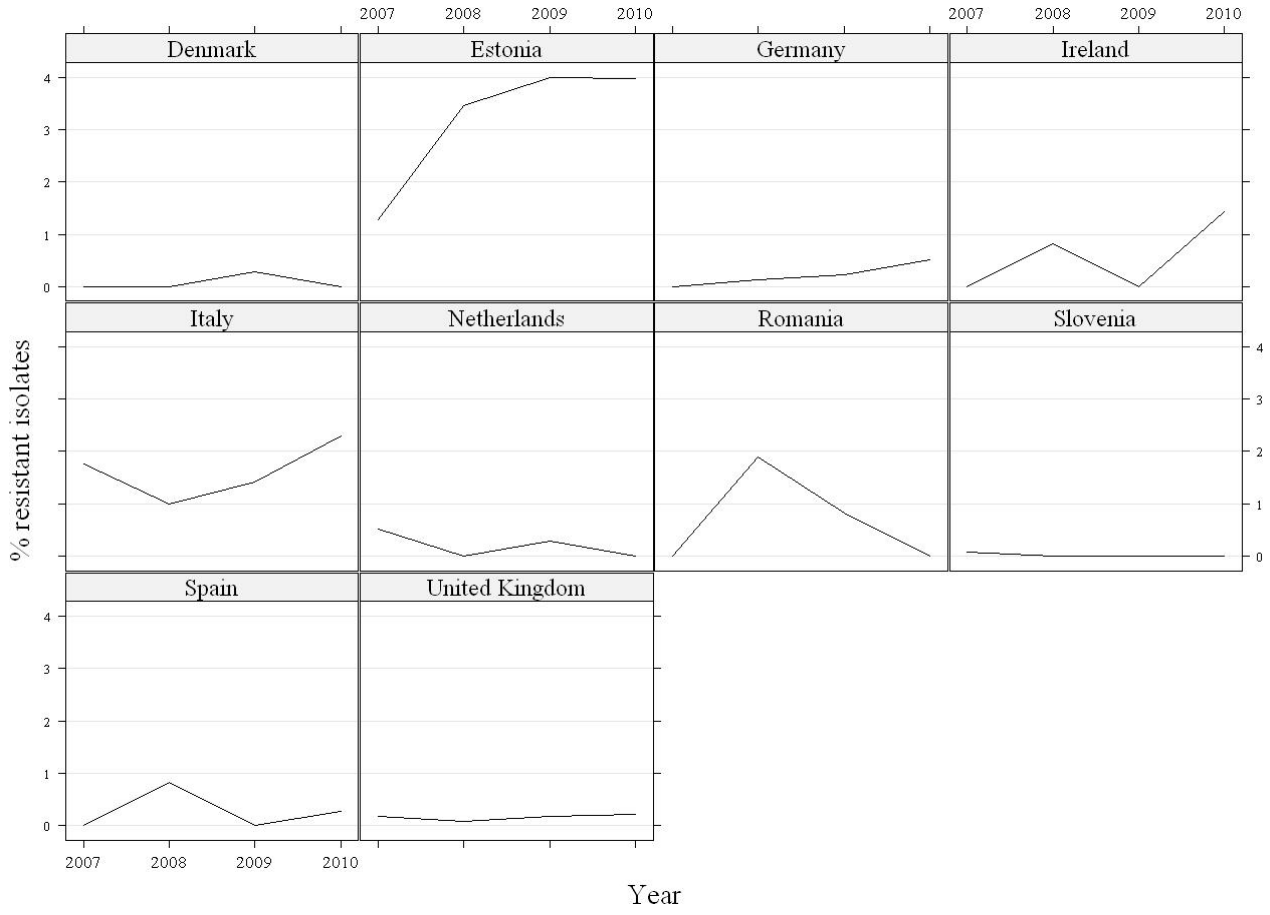


***Figure SA3. Resistance to ciprofloxacin in* Salmonella *Typhimurium in humans in reporting Member States, 2007–2010***

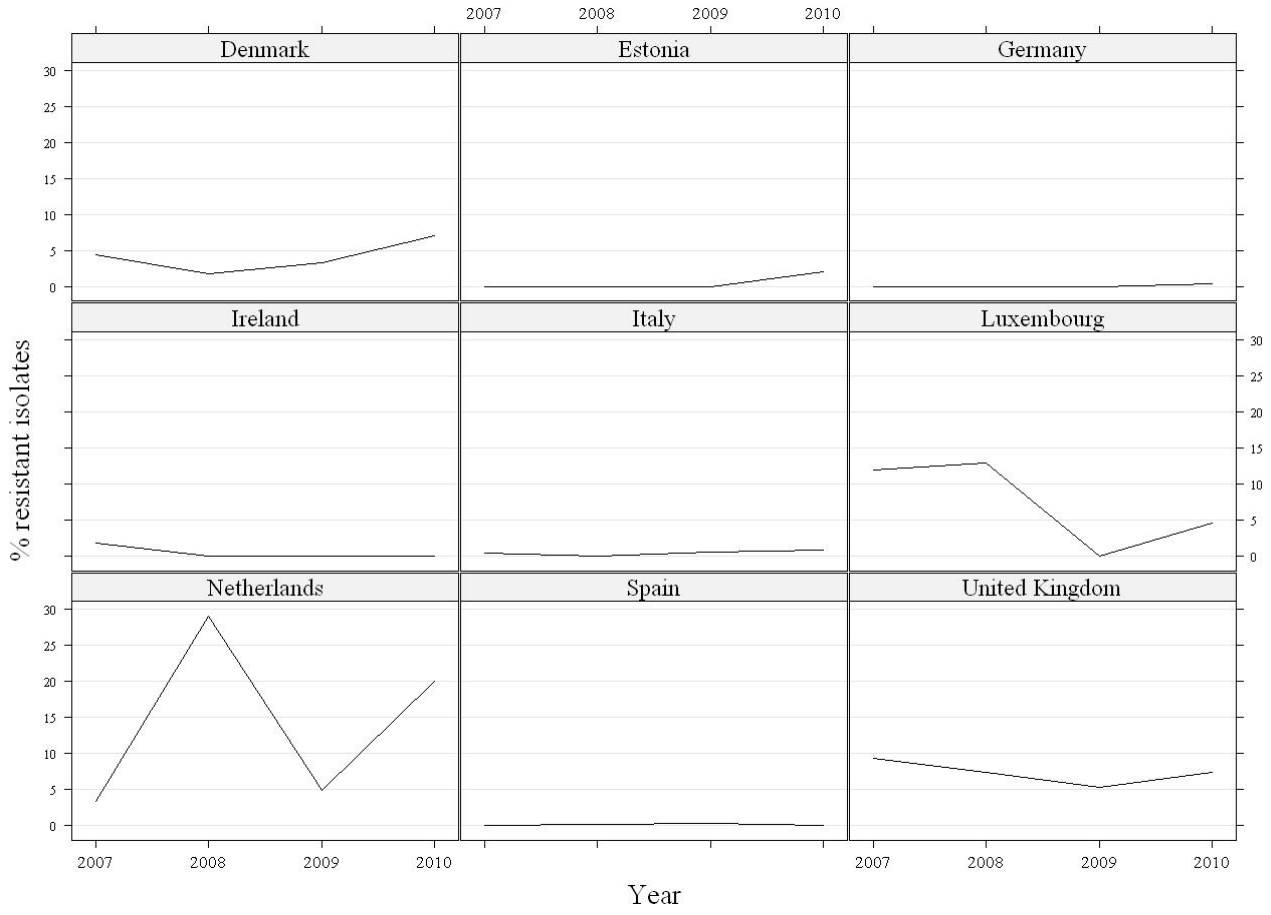
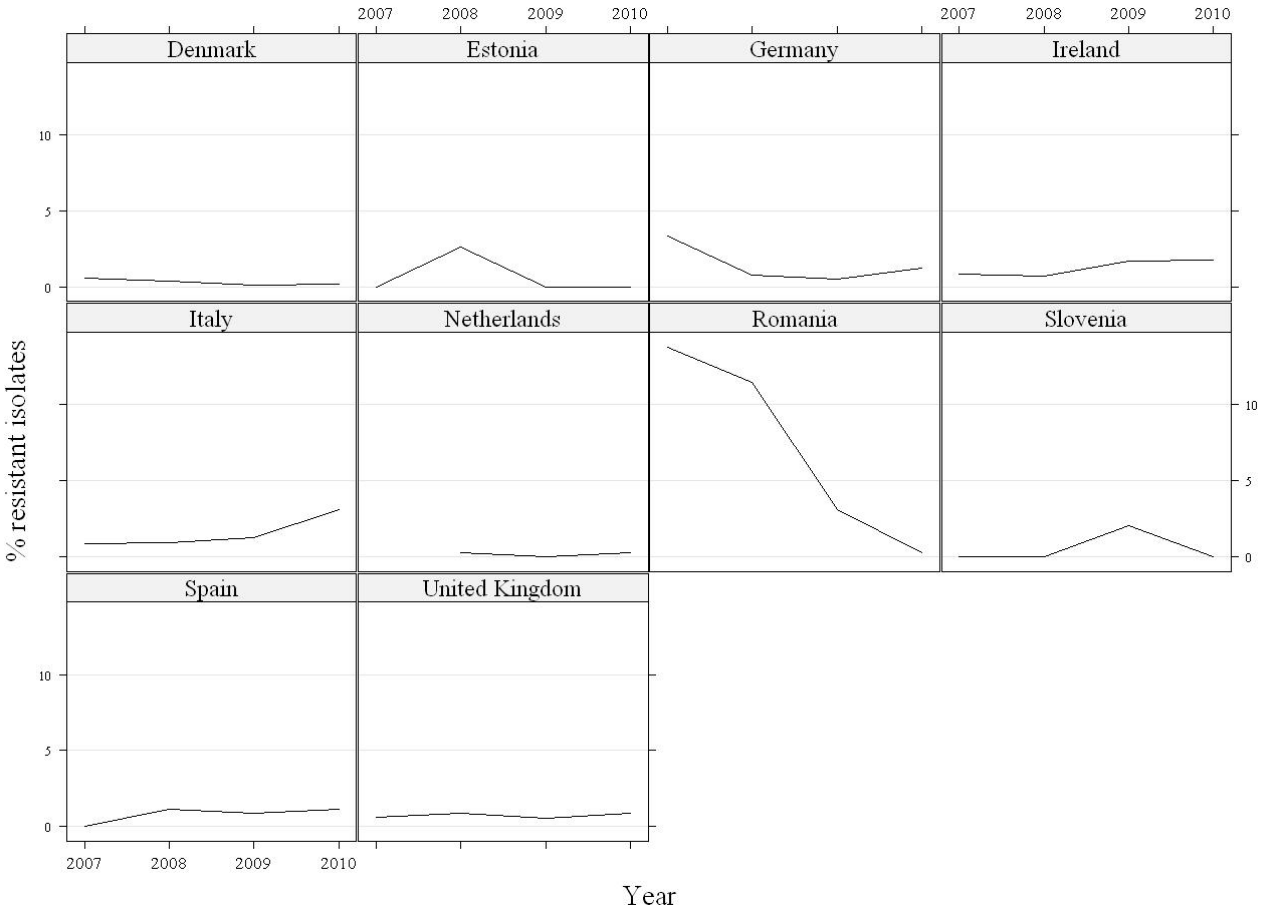


***Figure SA4. Resistance to cefotaxime in* Salmonella *Typhimurium in humans in reporting Member States, 2007–2010***



## 3.3 Antimicrobial resistance in *Salmonella* isolates from animals and food

Twenty-one MSs and two non-MSs (Norway and Switzerland) reported quantitative data on the antimicrobial resistance of *Salmonella* isolates recovered from animals and food in 2010. Tables SA4–6 detail the MSs reporting quantitative data, either MIC or IZD data, for each animal or food category. The results of 93 448 MIC susceptibility tests performed on the *Salmonella* isolates were included in the analyses, as well as the results of 15 274 disc diffusion tests. As quantitative IZD data constitute a relatively small percentage (16 %) of the total data available, these data have therefore been analysed as qualitative data only. The susceptibility test results for *Salmonella* isolates reported as qualitative data are presented in Chapter 7.

***Table SA4. Overview of countries reporting antimicrobial resistance data using MIC and disc inhibition zones on* Salmonella *spp. (all serovars) from various animal and food categories in 2010***

| Method | Origin | Total number of MSs reporting | Countries |
|---|---|---|---|
| Diffusion | *Gallus gallus* (fowl) | 4 | **MSs:** CY, ES, HU, RO |
| | Turkeys | 3 | **MSs:** ES, HU, RO |
| | Pigs | 2 | **MSs:** HU, RO |
| | Cattle (bovine animals) | 1 | **MS:** HU |
| | Meat from broilers *(Gallus gallus)* | 1 | **MS:** RO |
| | Meat from turkeys | 1 | **MS:** RO |
| | Meat from pig | 2 | **MSs:** ES, RO |
| | Meat from bovine animals | 1 | **MS:** RO |
| Dilution | *Gallus gallus (fowl)* | 18 | **MSs:** AT, CY, CZ, DE, DK, ES, FI, FR, IE, IT, LV, NL, PL, PT, SE, SI, SK, UK |
| | | | **Non-MS:** NO |
| | Turkeys | 11 | **MSs:** AT, CZ, DE, DK, ES, FR, IE, IT, PL, SK, UK |
| | Pigs | 13 | **MSs:** CZ, DE, DK, EE, ES, FI, IE, IT, LV, NL, PL, SE, SI |
| | | | **Non-MSs:** CH, NO |
| | Cattle (bovine animals) | 13 | **MSs:** CZ, DE, DK, EE, ES, FI, GR, IE, IT, LV, NL, PL, SE |
| | | | **Non-MSs:** CH, NO |
| | Meat from broilers *(Gallus gallus)* | 11 | **MSs:** BE, CZ, DE, EE, GR, IE, IT, LV, NL, SK, SI |
| | Meat from turkeys | 7 | **MSs:** CZ, DE, IE, IT, LV, NL, SI |
| | Meat from pig | 11 | **MSs:** BE, CZ, DE, DK, EE, GR, IE, IT, LV, NL, PT |
| | Meat from bovine animals | 8 | **MSs:** CZ, DE, GR, IE, IT, LV, NL, PT |

***Table SA5. Overview of countries reporting antimicrobial resistance data using MIC and disc inhibition zones on* Salmonella *Typhimurium from various animal and food categories in 2010***

| Method | Origin | Total number of MSs reporting | Countries |
|---|---|---|---|
| Diffusion | *Gallus gallus* (fowl) | 2 | **MSs**: HU, RO |
| | Turkeys | 2 | **MSs:** ES, HU |
| | Pigs | 2 | **MSs:** HU, RO |
| | Cattle (bovine animals) | 1 | **MS:** HU |
| | Meat from pig | 2 | **MSs:** ES, RO |
| | Meat from bovine animals | 1 | **MS:** RO |
| Dilution | *Gallus gallus* (fowl) | 15 | **MSs:** AT, CZ, DE, DK, ES, FR, IE, IT, NL, PL, PT, SE, SI, SK, UK |
| | Turkeys | 6 | **MSs:** CZ, DE, FR, IT, SK, UK |
| | Pigs | 12 | **MSs:** CZ, DE, DK, EE, ES, FI, IE, IT, LV, NL, SE, SI |
| | | | **Non-MSs:** CH,NO |
| | Cattle (bovine animals) | 10 | **MSs:** CZ, DE, DK, EE, ES, FI, IE, IT, NL, SE |
| | | | **Non-MS:** CH |
| | Meat from broilers (*Gallus gallus*) | 2 | **MSs:** BE, DE |
| | Meat from turkeys | 1 | **MS:** DE |
| | Meat from pig | 8 | **MSs:** BE, CZ, DE, DK, EE, GR, IE, PT |
| | Meat from bovine animals | 6 | **MSs:** CZ, DE, IE, IT, LV, PT |

***Table SA6. Overview of countries reporting antimicrobial resistance data using MIC and disc inhibition zones on* Salmonella *Enteritidis from various animal and food categories in 2010***

| Method | Origin | Total number of MSs reporting | Countries |
|---|---|---|---|
| Diffusion | *Gallus gallus* (fowl) | 4 | **MSs:** CY, ES, HU, RO |
| | Cattle (bovine animals) | 1 | **MS:** HU |
| | Meat from broilers (*Gallus gallus*) | 1 | **MS:** RO |
| | Meat from pig | 1 | **MS:** RO |
| Dilution | *Gallus gallus* (fowl) | 15 | **MSs:** AT, CY, CZ, DE, DK, ES, FR, IT, LV, NL, PL, PT, SI, SK, UK |
| | Turkeys | 4 | **MSs:** AT, CZ, DE, FR |
| | Pigs | 4 | **MSs:** DE, EE, LV, SI |
| | Cattle (bovine animals) | 1 | **MS:** DE |
| | | | **Non-MS:** CH |
| | Meat from broilers (*Gallus gallus*) | 6 | **MSs:** BE, CZ, DE, IT, LV, SK |
| | Meat from turkeys | 1 | **MS:** DE |
| | Meat from pig | 1 | **MS:** BE |
| | Meat from bovine animals | 4 | **MSs:** CZ, DE, GR, LV |

The antimicrobials selected by the different MSs and non-MSs for susceptibility testing of *Salmonella* are shown in Chapter 11, Materials and Methods, Table MM4. In this chapter, resistance to ampicillin, cefotaxime, ciprofloxacin, chloramphenicol, gentamicin, nalidixic acid, sulfonamides and tetracyclines is analysed in detail.

In this report, data on antimicrobial resistance in all reported *Salmonella* isolates were amalgamated to give a figure for *Salmonella* spp. (covering all reported serovars) for each country, year and animal/food category. In addition, data for the *Salmonella* serovars most prevalent and most significant for public health, *S.* Enteritidis and *S.* Typhimurium, are reported separately when sufficient quantitative data were available from the various animal/food categories. Whenever fewer than 10 isolates from one country were subjected to susceptibility testing for a given animal or food category, then these data were not included in any further analyses in this report. In addition, tables were generated, and analysis performed, only if four or more countries tested and reported quantitative data for a given *Salmonella* category and sampling origin.

Where the minimum criteria for detailed analysis were met, temporal trend graphs were generated showing resistance to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines for *Salmonella* isolates from animals and food over the 2005–2010 period, by plotting the level of resistance against the year of sampling. Only countries which had reported three or more years in the 2005–2010 period were included. Data from 2004 were excluded from the temporal trends graphs owing to the relative scarcity of data compared with the 2005–2010 period.

The spatial distributions of ampicillin, nalidixic acid and tetracycline resistance rates in *Salmonella* spp. from *Gallus gallus* are presented. In the case of countries for which resistance level figures for 2010 were not available, 2009 figures were used. For other animal species, the number of reporting countries was lower than with regards to *Gallus gallus,* and therefore no spatial distribution maps were generated.

For further information on reported MIC distributions and number of resistant isolates for apramycin, ceftazidime, ceftiofur, florfenicol, neomycin, spectinomycin and trimethoprim, refer to the level 3 tables published on the EFSA website.

### 3.3.1 Antimicrobial resistance in *Salmonella* isolates from food

This section reports MIC data for isolates of *Salmonella* spp. and *S.* Typhimurium from meat from broilers and meat from pigs. Additionally, seven MSs reported data on meat from turkeys and eight reported data on meat from cattle. However, as only one and two MSs tested more than 10 isolates from meat turkeys and meat from cattle, respectively, the corresponding data have not been included in the report.

#### 3.3.1.1 Meat from broilers (*Gallus gallus)*

Quantitative MIC susceptibility data for isolates of *Salmonella* spp. from broiler meat from seven MSs in 2010 are included in the following analysis. Data for *Salmonella* Typhimurium isolates are not presented separately for meat from broilers as only three MSs reported data.

##### Resistance levels in *Salmonella* spp.

Table SA7 shows the occurrence of resistance to selected antimicrobials for *Salmonella* spp. isolates recovered from broiler meat from MSs in 2010.

Taking data from all reporting MSs together, resistance levels to ampicillin, sulfonamides and tetracyclines were high at 21 %, 27 % and 20 %, respectively. Ampicillin, sulfonamide and tetracycline resistance was highly variable across reporting MSs, ranging from 0 % to 44 % for ampicillin, from 6 % to 64 % for sulfonamides and from 2 % to 64 % for tetracycline. Chloramphenicol and gentamicin resistance at reporting MS group level was, respectively, 3 % and 2 %, as chloramphenicol and gentamicin resistance was not observed in a number of MSs and variability in national resistance levels reported was low for both antimicrobials (ranging from 0 % to 9 % and from 0 % to 6 %, respectively).

In the reporting group of MSs, the level of resistance was 24 % for both ciprofloxacin and nalidixic acid. Within reporting MSs, the occurrence of resistance to each of these compounds was generally similar, and ranged from 4 % to 82 % between countries. The levels of resistance to ciprofloxacin and nalidixic acid recorded in Slovakia need to be treated with caution as they are based on a limited number of isolates. The overall level of resistance to cefotaxime was 4 % across the reporting MS group. The Czech Republic, Greece and Slovakia reported no resistance to cefotaxime. The proportion of cefotaxime resistance was low (2 % or 3 %) in Belgium, Germany and Ireland, and moderate in the Netherlands (11 %). The overall occurrence of resistance to cefotaxime is similar to that reported in 2009 (5 %). Belgium reported 9 % cefotaxime resistance in *Salmonella* spp. in 2009, although in 2010 the level of cefotaxime resistance reported decreased to 3 %. The Netherlands reported 4 % resistance to cefotaxime in 2009, which increased to 11 % in 2010.

##### Resistance levels in *Salmonella* Enteritidis

Resistance in *S.* Enteritidis from broiler meat in reporting MSs was generally lower than that reported in *Salmonella* spp. overall. Low numbers of isolates of *Salmonella* Enteritidis (fewer than 10) were recovered from meat from broilers in the Czech Republic, Italy, Latvia and Romania. These countries have been excluded from the detailed analysis, leaving only Belgium and Germany contributing to the analysis; thus there are insufficient data to present a specific table.

Neither Belgium nor Germany detected resistance to gentamicin, chloramphenicol, tetracyclines or sulfonamides, while the occurrence of resistance to ampicillin was 0.9 % in Belgium and 0 % in Germany. Belgium reported no resistance to ciprofloxacin or nalidixic acid among *S.* Enteritidis isolates in meat from broilers, while in Germany the level of resistance to both antimicrobials was 8.3 %. This was a decrease in resistance compared with the level reported by Germany in 2009 (23 %). Cefotaxime resistance was not detected in *S.* Enteritidis isolates from either country.

***Table SA7. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. from meat from broilers in Member States reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Belgium | 182 | 10 | 182 | 3 | 182 | 0.5 | 182 | 4 | 182 | 0 | 182 | 4 | 182 | 7 | 182 | 2 |
| Czech Republic | 82 | 6 | 82 | 0 | 82 | 1 | 82 | 33 | 82 | 1 | 82 | 33 | 82 | 24 | 82 | 29 |
| Germany | 103 | 33 | 103 | 3 | 103 | 9 | 103 | 43 | 103 | 6 | 103 | 43 | 103 | 40 | 103 | 25 |
| Greece | 16 | 25 | 17 | 0 | 16 | 0 | 16 | 31 | 16 | 0 | 16 | 31 | 16 | 6 | 16 | 25 |
| Ireland | 46 | 15 | 46 | 2 | 46 | 0 | 46 | 7 | 46 | 0 | 46 | 7 | 46 | 11 | 46 | 7 |
| Netherlands | 108 | 44 | 108 | 11 | 108 | 5 | 108 | 35 | 108 | 5 | 108 | 36 | 108 | 57 | 108 | 36 |
| Slovakia | 11 | 0 | 11 | 0 | 11 | 0 | 11 | 82 | 11 | 0 | 11 | 82 | 11 | 64 | 11 | 64 |
| **Total (7 MSs)** | **548** | **21** | **549** | **4** | **548** | **3** | **548** | **24** | **548** | **2** | **548** | **24** | **548** | **27** | **548** | **20** |

N = number of isolates tested.

% Res = percentage of resistant isolates.

### 3.3.1.2 Meat from pigs

Quantitative MIC data for *Salmonella* spp. from pig meat reported by 10 MSs in 2010 are included in the following antimicrobial resistance analyses. Data for *S.* Enteritidis isolates are not presented separately for meat from pigs as only three MSs reported data. Tables SA8 and SA9 set out the level of resistance to selected antimicrobials for, respectively, *Salmonella* spp. and *S*. Typhimurium isolates from pig meat.

#### Resistance levels in *Salmonella* spp.

Considering the reporting group of MSs, resistance to ampicillin, sulfonamides and tetracyclines was commonly observed in *Salmonella* spp. from pig meat, with levels of resistance of 47 %, 52 % and 50 %, respectively, reported. The occurrence of ampicillin and tetracycline resistance ranged from low to high or extremely high across the MSs, varying from 6 % to 62 % and from 5 % to 89 %, respectively. Chloramphenicol resistance was moderate, at 19 %, for all reporting MSs, and ranged from 6 % to 48 % across the MSs reporting positive results. Belgium, Estonia and Italy did not detect resistance to chloramphenicol. Overall, gentamicin resistance was 2 % in the reporting group of MSs; it was not detected in five MSs and ranged between 2 % and 6 % in the other five reporting MSs.

The level of resistance of *Salmonella* spp. isolates to ciprofloxacin and nalidixic acid was 5 % and 4 %, respectively, in the reporting group of MSs. Denmark, Estonia, Greece and Italy reported no resistance to ciprofloxacin or nalidixic acid. In the remaining countries the level of resistance was low to moderate, at 2 % to 17 %. Belgium reported no resistance to ciprofloxacin, but 5 % resistance to nalidixic acid. Considering all reporting MSs, the occurrence of resistance to cefotaxime was very low, at 0.2 %. Only Ireland reported resistance to cefotaxime in *Salmonella* spp. isolates from pig meat, and only at a very low level.

#### Resistance levels in *Salmonella* Typhimurium

Considering *S.* Typhimurium isolates from pig meat from all reporting MSs, the levels of resistance to sulfonamides, ampicillin, tetracyclines and chloramphenicol were high, at 64 %, 63 %, 56 % and 32 %, respectively, and were generally similar to the levels reported in *Salmonella* spp. isolates from pig meat. Similar wide ranges in the level of resistance for individual reporting MSs were observed for ampicillin, sulfonamides and tetracyclines (from 38 % to 100 %, from 39 % to 90 % and from 25 % to 90 %, respectively). Overall resistance to gentamicin was low in the reporting MS group (2 %), and reporting MSs did not detect resistance to cefotaxime.

Considering the individual reporting MSs, the prevalence of resistance to ciprofloxacin and nalidixic acid was similar for isolates from within a given MS. In all reporting MSs, the occurrence of resistance to ciprofloxacin was the same as nalidixic acid, 5 %. As in 2009, Denmark reported no resistance to ciprofloxacin or nalidixic acid; the levels of resistance to these compounds varied from 2 % to 20 % in the Czech Republic, Germany, Ireland and Portugal.

***Table SA8. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. isolates from meat from pigs in Member States reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Belgium | 19 | 26 | 19 | 0 | 19 | 0 | 19 | 0 | 19 | 5 | 19 | 5 | 19 | 21 | 19 | 21 |
| Czech Republic | 29 | 62 | 29 | 0 | 29 | 48 | 29 | 17 | 29 | 3 | 29 | 17 | 29 | 59 | 29 | 55 |
| Denmark | 85 | 38 | 85 | 0 | 85 | 6 | 85 | 0 | 85 | 0 | 85 | 0 | 85 | 39 | 85 | 25 |
| Estonia | 22 | 0 | 22 | 0 | 21 | 0 | 19 | 0 | 22 | 0 | 22 | 0 | 22 | 14 | 22 | 5 |
| Germany | 150 | 56 | 150 | 0 | 150 | 16 | 150 | 3 | 150 | 2 | 150 | 2 | 150 | 56 | 150 | 55 |
| Greece | 15 | 33 | 15 | 0 | 16 | 6 | 13 | 0 | 15 | 0 | 13 | 0 | 15 | 73 | 15 | 67 |
| Ireland | 138 | 53 | 138 | 0.7 | 138 | 25 | 138 | 7 | 138 | 3 | 138 | 7 | 138 | 62 | 138 | 57 |
| Italy | 18 | 6 | 18 | 0 | 18 | 0 | 18 | 0 | 18 | 0 | 18 | 0 | 18 | 22 | 18 | 39 |
| Netherlands | 15 | 47 | 15 | 0 | 15 | 33 | 15 | 13 | 15 | 0 | 15 | 13 | 15 | 60 | 15 | 67 |
| Portugal | 36 | 58 | 36 | 0 | 36 | 42 | 36 | 11 | 36 | 6 | 35 | 6 | 36 | 72 | 36 | 89 |
| **Total (10 MSs)** | **527** | **47** | **527** | **0.2** | **527** | **19** | **522** | **5** | **527** | **2** | **524** | **4** | **527** | **52** | **527** | **50** |

N = number of isolates tested.

% Res = percentage of resistant isolates.

***Table SA9. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Typhimurium isolates from meat from pigs in Member States reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Czech Republic | 10 | 100 | 10 | 0 | 10 | 90 | 10 | 20 | 10 | 0 | 10 | 20 | 10 | 90 | 10 | 90 |
| Denmark[1] | 85 | 38 | 85 | 0 | 85 | 6 | 85 | 0 | 85 | 0 | 85 | 0 | 85 | 39 | 85 | 25 |
| Germany | 51 | 69 | 51 | 0 | 51 | 33 | 51 | 2 | 51 | 2 | 51 | 2 | 51 | 67 | 51 | 69 |
| Ireland | 70 | 77 | 70 | 0 | 70 | 44 | 70 | 9 | 70 | 1 | 70 | 9 | 70 | 81 | 70 | 69 |
| Portugal | 27 | 78 | 27 | 0 | 27 | 56 | 27 | 15 | 27 | 7 | 27 | 7 | 27 | 82 | 27 | 89 |
| **Total (5 MSs)** | **243** | **63** | **243** | **0** | **243** | **32** | **243** | **5** | **243** | **2** | **243** | **5** | **243** | **64** | **243** | **56** |

N = number of isolates tested.

% Res = percentage of resistant isolates.

1. Denmark reported 10 monophasic *Salmonella* 1,4,[5],12:i:- isolates (four *Salmonella* 1,4,12:i:- and six *Salmonella* 1,4,5,12:i:-) as *S*. Typhimurium.

## 3.3.2 Antimicrobial resistance in *Salmonella* isolates from animals

### 3.3.2.1 Fowl (*Gallus gallus*)

This section includes data from breeding, laying hen and broiler flocks, as well as unspecified flocks of *Gallus gallus*. In 2010, 17 MSs submitted quantitative antimicrobial susceptibility data for *Salmonella* spp. from *Gallus gallus*.

#### Resistance levels in *Salmonella* spp.

Table SA10 shows the level of resistance to antimicrobials for *Salmonella* spp. in 2010.

The occurrence of resistance to tetracyclines in the reporting MS group was 20 % and varied between 0 % and 50 % across the reporting countries. Sulfonamide and ampicillin resistance was 22 % (range 0–61 %) and 13 % (range 0–34 %), respectively, across the reporting MSs. For chloramphenicol the level of resistance in the reporting MS group was 4 % and ranged from 0 % to 9 % between countries.

Considering the reporting MS group, the occurrence of resistance to ciprofloxacin was 24 % and to nalidixic acid was 23 %, and the level of resistance to both antimicrobials ranged from 0 % to 73 %. Considerable disparity was observed in resistance to ciprofloxacin among *Salmonella* isolates from different MSs, which may reflect the variability of serovars of *Salmonella* spp. included in the analyses of the different MSs. Gentamicin resistance was either not detected or detected at a low level of 0.3 % to 5 % across the reporting MSs; the occurrence of resistance considering all reporting MSs was 2 %.

The level of resistance to cefotaxime in the reporting group of 17 MSs was 1 %. The occurrence of cefotaxime resistance among countries reporting such resistance varied from at 0.6 % to 6 % for Austria, the Czech Republic, Germany, Ireland, Italy, the Netherlands and Poland. These figures can be compared with the figures obtained in 2009, when the Netherlands reported a level of cefotaxime resistance in *Salmonella* spp. of 12 %, whereas in the remaining countries which detected resistance the level varied between 0.2 % and 3 %.

#### Resistance levels in *Salmonella* Enteritidis

Twelve MSs reported susceptibility data on *S.* Enteritidis isolates from *Gallus gallus* in 2010 (Table SA11).

The level of resistance to tetracyclines was 6 % in the reporting MS group. Several MSs did not detect resistance to this antimicrobial, while, among those that did, the occurrence of resistance ranged from 0.4 % in the Czech Republic to 48 % in the United Kingdom. A similar observation was made for sulfonamides, resistance to which was also low, at 7 %, in the reporting MS group as a whole, but ranged from 0 % to 57 % across the reporting countries. In the case of ampicillin, resistance was low, at 4 %, in the reporting MS group, and several countries did not detect resistance to ampicillin. Among those that did, reported resistance ranged from 1 % to 17 %. Chloramphenicol resistance was relatively rare (0.2 %) in *S.* Enteritidis isolates in the reporting MS group and was detected only in isolates from Spain and the United Kingdom, and only at low levels. Poland was the only country to report gentamicin resistance, at a very low level (0.4 %).

The occurrence of ciprofloxacin and nalidixic acid resistance in the reporting MSs was 25 % and 23 %, respectively. This was an increase on the levels reported in 2009 (17 % and 16 %). The levels of ciprofloxacin and nalidixic acid resistance within each MS were generally very similar, as would be expected. The level of ciprofloxacin resistance varied from 0 % to 95 % among reporting MSs. The highest occurrence of ciprofloxacin resistance was reported by Portugal (95 %), followed by Spain (58 %) and then Poland (50 %). The level of ciprofloxacin resistance reported by Portugal and Poland is higher than the figures reported for 2009 (48 % and 29 %, respectively) whereas the level in Spain has decreased slightly from 65 %. Italy, which reported a 50 % level of ciprofloxacin resistance in *S.* Enteritidis in 2008, and 11 % resistance in 2009, reported another decrease, to 3 %, in 2010.

In 2010, resistance to cefotaxime in *S.* Enteritidis was reported only by the Czech Republic, and at a very low level of 0.9 %. Gentamicin resistance was reported only by Poland, and at a very low level (0.4 %).

### Resistance levels in *Salmonella* Typhimurium

Nine MSs reported quantitative MIC antimicrobial susceptibility data for *S.* Typhimurium isolates from *Gallus gallus* in 2010 (Table SA12).

The overall level of resistance to sulfonamides in the reporting MS group was 44 %. All MSs except Sweden reported resistance to sulfonamides, and the prevalence ranged from 8 % to 86 %. Overall resistance to tetracyclines, ampicillin and chloramphenicol was 40 %, 39 % and 27 %, respectively, with corresponding ranges among the reporting MSs of 0 % to 76 %, 0 % to 81 % and 0 % to 71 %. Resistance to gentamicin was 0.7 % in the reporting MS group, and was detected in only 8 % of *S.* Typhimurium isolates from the United Kingdom.

The occurrence of resistance to ciprofloxacin and nalidixic acid was 14 % and 15 %, respectively, in the reporting MS group. Considering different MSs, the level of ciprofloxacin and nalidixic acid resistance varied considerably from 0 % (Austria, Denmark, Germany, Spain, Sweden and the United Kingdom) to 76 % (Poland). Cefotaxime resistance was not detected in *S.* Typhimurium isolates from any reporting MSs.

***Table SA10. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. isolates from* Gallus gallus *in Member States reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 192 | 5 | 192 | 1 | 192 | 0 | 192 | 14 | 192 | 0 | 192 | 14 | 192 | 13 | 192 | 14 |
| Cyprus | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 17 | 12 | 0 | 12 | 0 | 12 | 8 | 12 | 0 |
| Czech Republic | 367 | 2 | 367 | 1 | 367 | 0.3 | 367 | 26 | 367 | 0 | 367 | 26 | 367 | 22 | 367 | 24 |
| Denmark | 50 | 12 | 50 | 0 | 50 | 0 | 50 | 0 | 50 | 0 | 50 | 0 | 50 | 12 | 50 | 6 |
| France | 323 | 10 | 323 | 0 | 323 | 6 | 323 | 3 | 323 | 0 | 323 | 2 | 323 | 12 | 323 | 12 |
| Germany | 169 | 8 | 169 | 4 | 169 | 1 | 169 | 6 | 169 | 0 | 169 | 5 | 169 | 4 | 169 | 5 |
| Ireland | 35 | 23 | 35 | 6 | 35 | 9 | 33 | 0 | 35 | 0 | 35 | 0 | 35 | 17 | 28 | 4 |
| Italy | 381 | 22 | 381 | 3 | 381 | 3 | 381 | 25 | 381 | 5 | 381 | 25 | 381 | 21 | 381 | 24 |
| Latvia | 35 | 3 | 36 | 0 | 36 | 0 | 36 | 3 | 36 | 0 | 36 | 3 | 36 | 0 | 36 | 0 |
| Netherlands | 203 | 34 | 193 | 5 | 193 | 3 | 188 | 28 | 193 | 4 | 193 | 27 | 193 | 33 | 193 | 20 |
| Poland | 336 | 16 | 336 | 0.6 | 336 | 9 | 336 | 53 | 336 | 0.3 | 336 | 52 | 336 | 16 | 336 | 11 |
| Portugal | 81 | 11 | 82 | 0 | 82 | 2 | 82 | 72 | 82 | 0 | 82 | 73 | 82 | 28 | 82 | 32 |
| Slovakia | 86 | 0 | 86 | 0 | 86 | 0 | 86 | 35 | 86 | 0 | 86 | 35 | 86 | 31 | 86 | 31 |
| Slovenia | 29 | 3 | 29 | 0 | 29 | 3 | 29 | 21 | 29 | 0 | 29 | 21 | 29 | 24 | 29 | 24 |
| Spain | 249 | 8 | 249 | 0 | 249 | 2 | 249 | 39 | 249 | 2 | 213 | 30 | 249 | 11 | 249 | 13 |
| Sweden | 15 | 7 | 15 | 0 | 15 | 0 | 15 | 0 | 15 | 0 | 15 | 0 | 15 | 7 | 15 | 7 |
| United Kingdom | 282 | 18 | 282 | 0 | 282 | 7 | 282 | 5 | 282 | 5 | 282 | 5 | 282 | 61 | 282 | 50 |
| **Total (17 MSs)** | **2,845** | **13** | **2,837** | **1** | **2,837** | **4** | **2,830** | **24** | **2,837** | **2** | **2,801** | **23** | **2,837** | **22** | **2,830** | **20** |

N = number of isolates tested.

% Res = percentage of resistant isolates.

***Table SA11. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Enteritidis isolates from* Gallus gallus *in Member States reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 52 | 0 | 52 | 0 | 52 | 0 | 52 | 0 | 52 | 0 | 52 | 0 | 52 | 0 | 52 | 2 |
| Czech Republic | 234 | 2 | 234 | 0.9 | 234 | 0 | 234 | 3 | 234 | 0 | 234 | 3 | 234 | 0.9 | 234 | 0.4 |
| France | 36 | 0 | 36 | 0 | 36 | 0 | 36 | 0 | 36 | 0 | 36 | 0 | 36 | 0 | 36 | 0 |
| Germany | 88 | 1 | 88 | 0 | 88 | 0 | 88 | 2 | 88 | 0 | 88 | 1 | 88 | 0 | 88 | 0 |
| Italy | 29 | 3 | 29 | 0 | 29 | 0 | 29 | 3 | 29 | 0 | 29 | 3 | 29 | 14 | 29 | 3 |
| Latvia | 34 | 3 | 35 | 0 | 35 | 0 | 35 | 3 | 35 | 0 | 35 | 3 | 35 | 0 | 35 | 0 |
| Netherlands | 24 | 4 | 24 | 0 | 24 | 0 | 24 | 8 | 24 | 0 | 24 | 8 | 24 | 4 | 24 | 0 |
| Poland | 230 | 8 | 230 | 0 | 230 | 0 | 230 | 50 | 230 | 0.4 | 230 | 48 | 230 | 6 | 230 | 2 |
| Portugal | 59 | 3 | 59 | 0 | 59 | 0 | 59 | 95 | 59 | 0 | 59 | 97 | 59 | 32 | 59 | 34 |
| Slovakia | 36 | 0 | 36 | 0 | 36 | 0 | 36 | 0 | 36 | 0 | 36 | 0 | 36 | 0 | 36 | 0 |
| Spain | 89 | 3 | 89 | 0 | 89 | 1 | 89 | 58 | 89 | 0 | 67 | 43 | 89 | 14 | 89 | 16 |
| United Kingdom | 23 | 17 | 23 | 0 | 23 | 4 | 23 | 0 | 23 | 0 | 23 | 4 | 23 | 57 | 23 | 48 |
| **Total (12 MSs)** | **934** | **4** | **935** | **0.2** | **935** | **0.2** | **935** | **25** | **935** | **0.1** | **913** | **23** | **935** | **7** | **935** | **6** |

N = number of isolates tested.

% Res = percentage of resistant isolates.

***Table SA12. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Typhimurium isolates from* Gallus gallus *in Member States reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 16 | 19 | 16 | 0 | 16 | 0 | 16 | 0 | 16 | 0 | 16 | 0 | 16 | 13 | 16 | 13 |
| Denmark[1] | 11 | 46 | 11 | 0 | 11 | 0 | 11 | 0 | 11 | 0 | 11 | 0 | 11 | 55 | 11 | 27 |
| France | 30 | 50 | 30 | 0 | 30 | 47 | 30 | 7 | 30 | 0 | 30 | 3 | 30 | 60 | 30 | 53 |
| Germany | 12 | 8 | 12 | 0 | 12 | 8 | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 8 | 12 | 17 |
| Poland | 21 | 81 | 21 | 0 | 21 | 71 | 21 | 76 | 21 | 0 | 21 | 76 | 21 | 86 | 21 | 76 |
| Portugal | - | - | 10 | 0 | 10 | 20 | 10 | 20 | 10 | 0 | 10 | 20 | 10 | 40 | 10 | 40 |
| Spain | 14 | 21 | 14 | 0 | 14 | 21 | 14 | 0 | 14 | 0 | - | - | 14 | 21 | 14 | 21 |
| Sweden | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 0 |
| United Kingdom | 13 | 46 | 13 | 0 | 13 | 15 | 13 | 0 | 13 | 8 | 13 | 0 | 13 | 69 | 13 | 69 |
| **Total (9 MSs)** | **129** | **39** | **139** | **0** | **139** | **27** | **139** | **14** | **139** | **0.7** | **125** | **15** | **139** | **44** | **139** | **40** |

N = number of isolates tested.

% Res = percentage of resistant isolates.

1. Denmark reported three monophasic *Salmonella* 1,4,[5],12:i:- isolates (one *Salmonella* 1,4,12:i:- and two *Salmonella* 1,4,5,12:i:-) as *S*. Typhimurium.

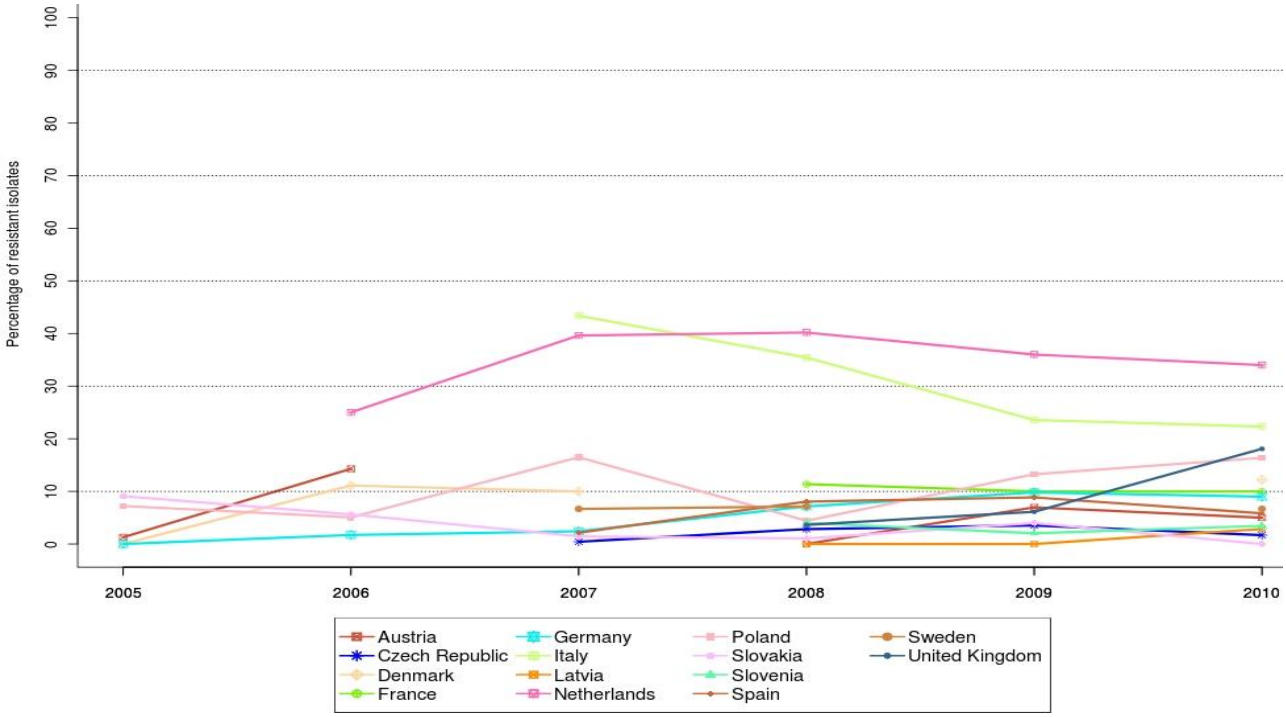
### Temporal trends in resistance among *Salmonella* spp. isolates from *Gallus gallus*

Figures SA5–10 show how the level of resistance in *Salmonella* spp. to selected antimicrobials has changed over the period 2005–2010 in the MSs and non-MSs. It should be noted that fluctuations in the occurrence of resistance in *Salmonella* spp. isolates within a country may result from changes in the proportions of different *Salmonella* serovars which contribute to the total numbers of *Salmonella* spp. isolates tested. This is because some antimicrobial resistance is associated with particular serovars or clones within serovars.

The level of resistance to cefotaxime in *Salmonella* spp. was either low, very low or absent in reporting MSs between 2005 and 2010, and no significant trends were detected over this period. As regards resistance to (fluoro)quinolones, ciprofloxacin and nalidixic acid, statistically significant increasing trends were registered in three MSs for 5 or more years over the 2005–2010 period, while Spain was the only MS recording a statistically significant decreasing trend. In addition, the Czech Republic experienced an increase in resistance to (fluoro)quinolones although this was limited to the last 4 years only.

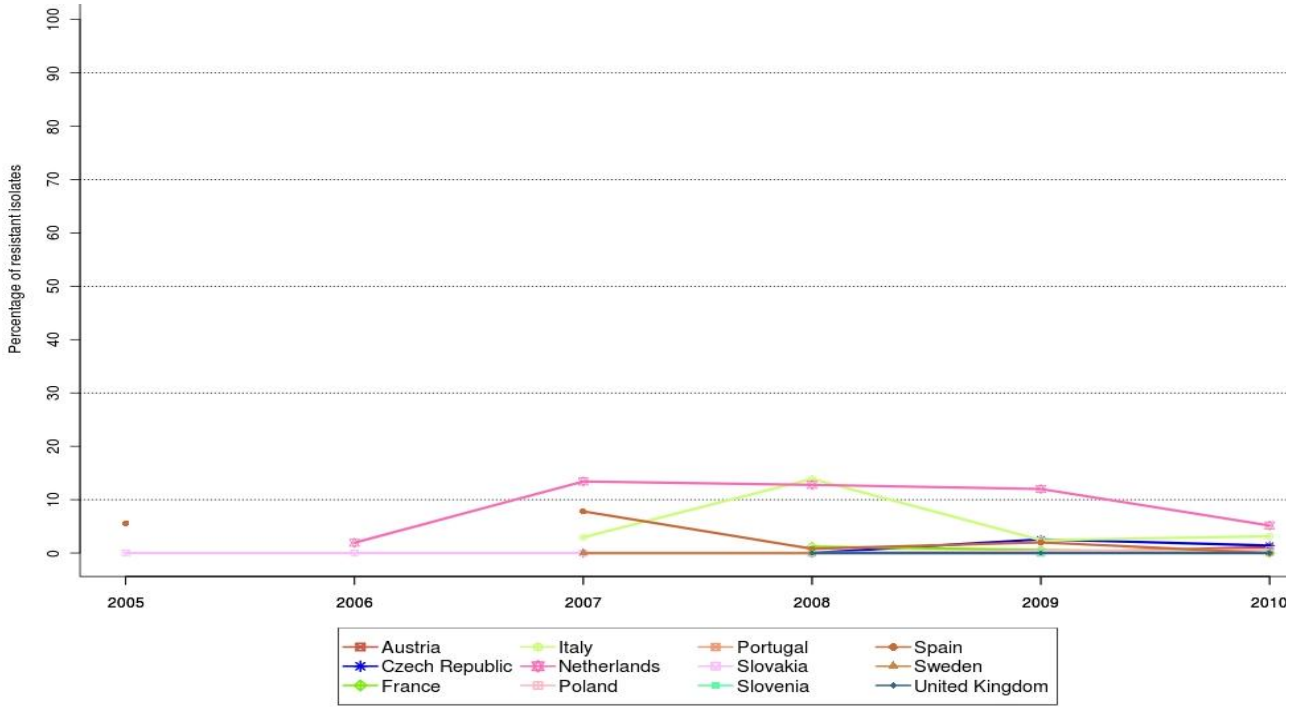
Regarding ampicillin, sulfonamides and tetracyclines, increasing trends were observed in several (between two and four per substance) MSs for 5 or more years. An exception was Slovakia, which experienced a statistically significant decreasing trend in ampicillin resistance over the same period. In addition, Italy registered a decrease tetracycline in resistance, although it was limited to the last 4 years. Resistance levels to gentamicin were low to very low and stable over the 2005–2010 period, with the exception of the Netherlands, where an increasing trend was observed.

***Figure SA5. Trends in ampicillin resistance in tested* Salmonella *spp. isolates from* Gallus gallus *in reporting Member States, 2005–2010, quantitative data***



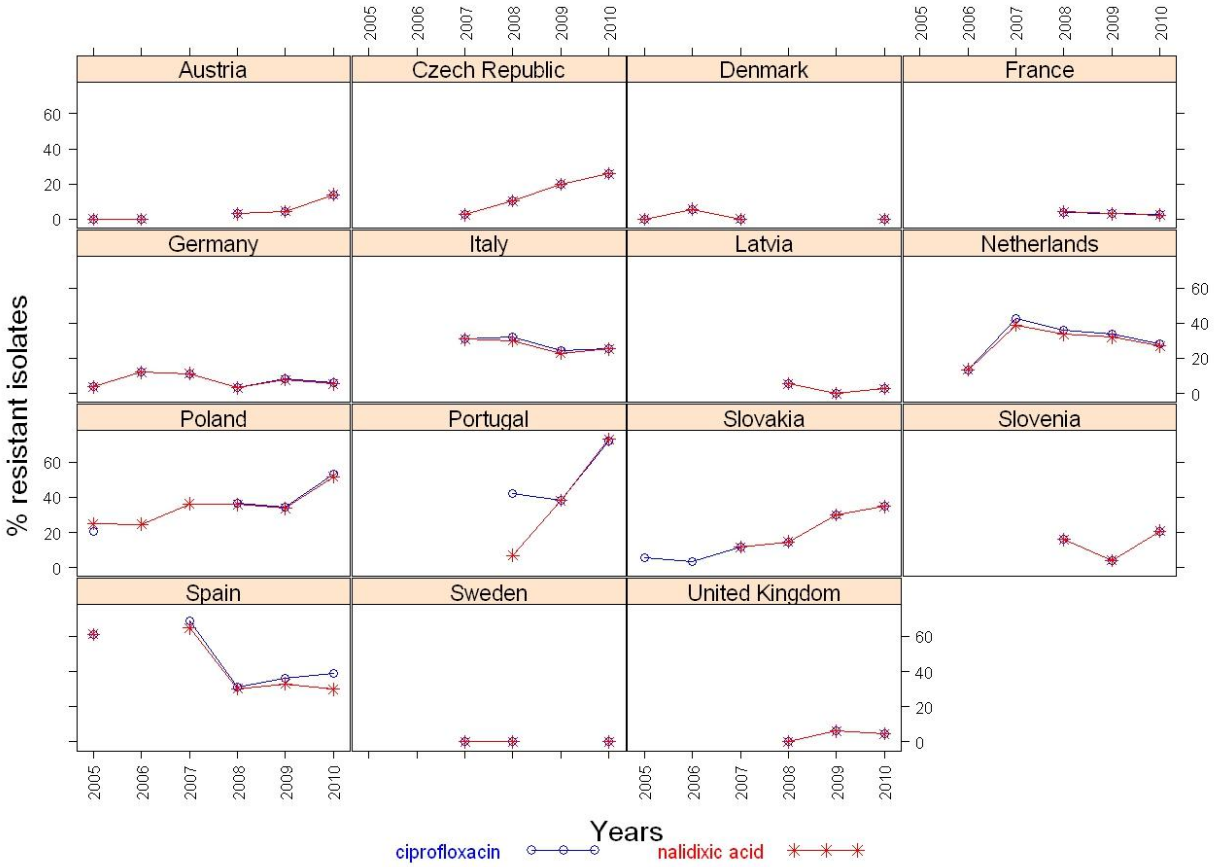

Note: Statistically significant increasing or decreasing trends for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Germany (↑), the Netherlands (↑), Poland (↑) and Slovakia (↓).

***Figure SA6. Trends in cefotaxime resistance in tested* Salmonella *spp. isolates from* Gallus gallus *in reporting Member States, 2005–2010, quantitative data***



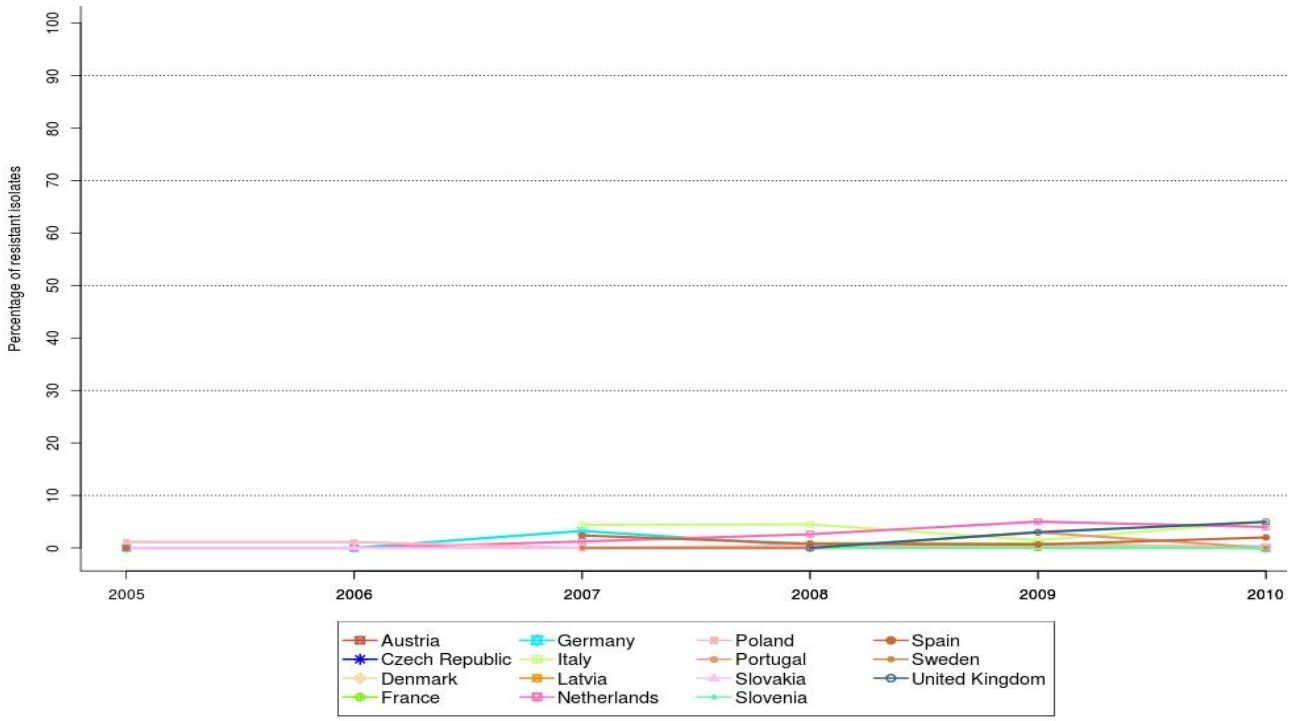

Note: No statistically significant trend for 5 or more years, as tested by logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure SA7. Trends in ciprofloxacin and nalidixic acid resistance in tested* Salmonella *spp. isolates from* Gallus gallus *in reporting Member States, 2005–2010, quantitative data***



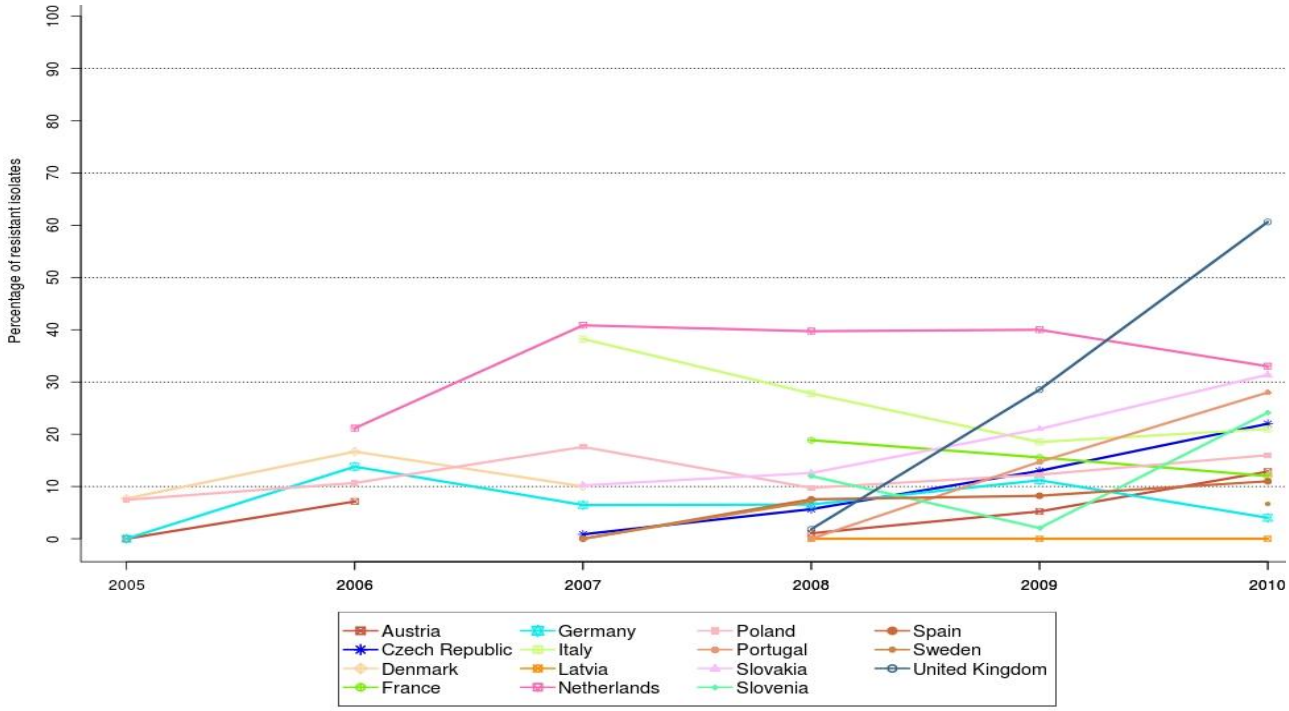

Note: A statistically significant increasing trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria for both ciprofloxacin and nalidixic acid, in Poland for nalidixic acid and in Slovakia for ciprofloxacin. A statistically significant decreasing trend was observed for both ciprofloxacin and nalidixic acid in Spain.

***Figure SA8. Trends in gentamicin resistance in tested* Salmonella *spp. isolates from* Gallus gallus *in reporting Member States, 2005–2010, quantitative data***



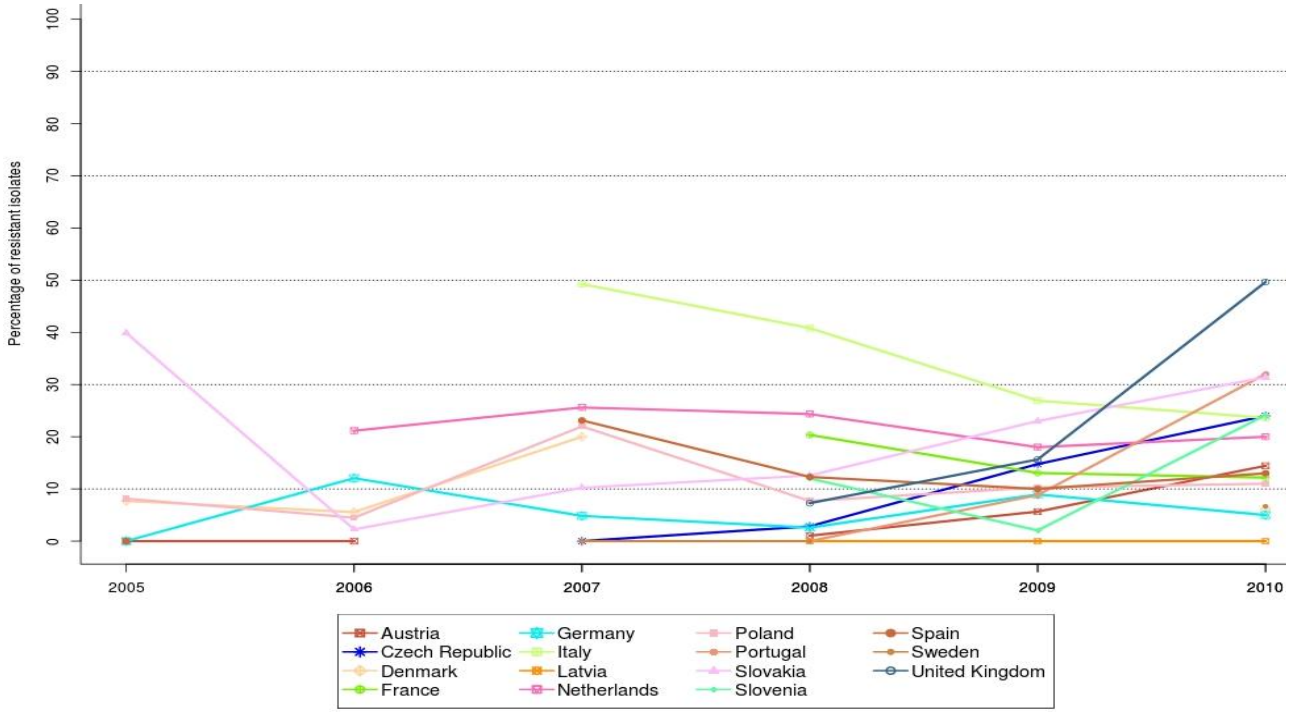

Note: A statistically significant increasing trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands.

***Figure SA9. Trends in sulfonamide resistance in tested* Salmonella *spp. isolates from* Gallus gallus *in reporting Member States, 2005–2010, quantitative data***




Note: A statistically significant increasing trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria, Germany, the Netherlands and Poland.

***Figure SA10. Trends in tetracycline resistance in tested* Salmonella *spp. isolates from* Gallus gallus *in reporting Member States, 2005–2010, quantitative data***



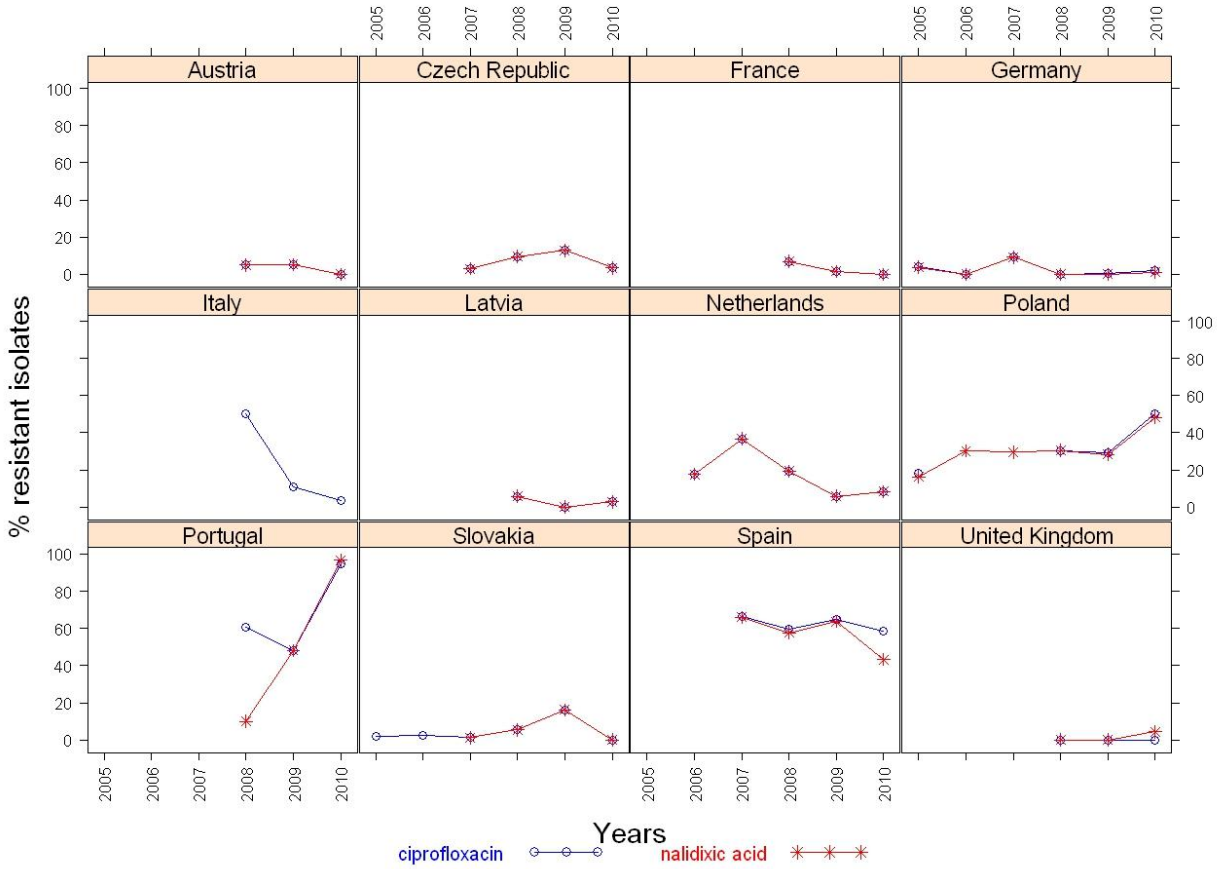

Note: A statistically significant increasing trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria and Germany.

### Temporal trends in resistance among *S.* Enteritidis isolates from *Gallus gallus*

The occurrence of resistance to the majority of antimicrobials, as reported by most MSs for *Salmonella* Enteritidis, was low and therefore only trends in resistance to ciprofloxacin and nalidixic acid are illustrated (Figure SA11).

For most MSs, the level of resistance to ciprofloxacin was close or identical to that detected for nalidixic acid; the trends were therefore very similar for both antimicrobials. For most other MSs reporting results for *S.* Enteritidis for *Gallus gallus*, the level of resistance to ciprofloxacin and nalidixic acid was relatively stable. A significantly increasing trend in ciprofloxacin resistance was observed in Slovakia from 2005 to 2010, despite the recent decrease from moderate levels in 2009 to no resistance in 2010. Nalidixic acid resistance significantly increased in Poland over the 2005–2010 period. In contrast, Germany and the Netherlands registered a decrease in resistance to both quinolones over the 2005–2010 period. A decrease in nalidixic acid resistance was also observed in Spain over the last 4 years.

***Figure SA11. Trends in ciprofloxacin and nalidixic acid resistance in tested* Salmonella *Enteritidis isolates from* Gallus gallus *in reporting Member States, 2005–2010, quantitative data***

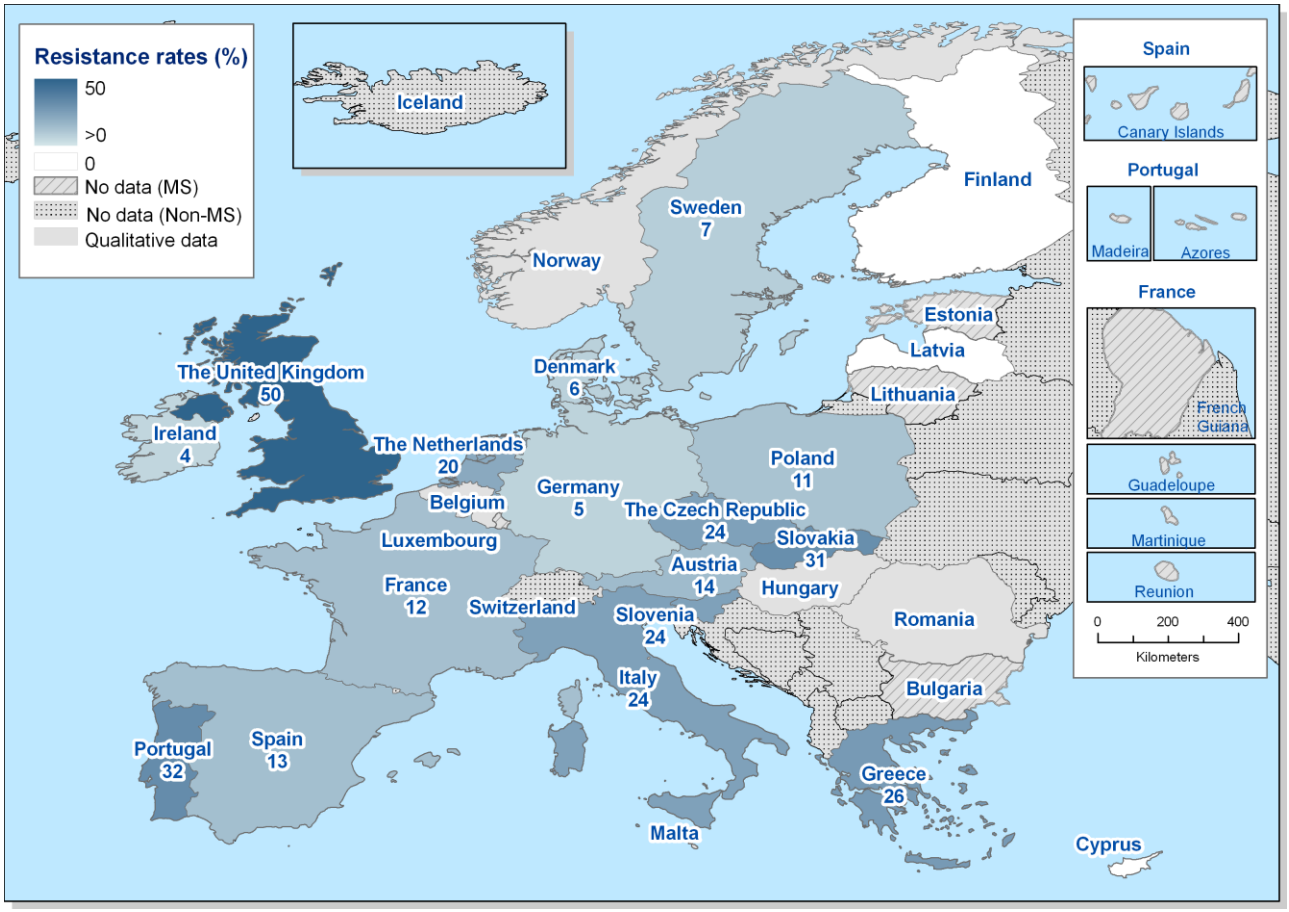



Note: A statistically significant decreasing trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Germany and the Netherlands for both ciprofloxacin and nalidixic acid. A statistically significant increasing trend was observed in Poland for nalidixic acid and in Slovakia for ciprofloxacin.

## Spatial distribution of resistance among *Salmonella*

The spatial distributions of tetracycline, ampicillin and nalidixic acid resistance in *Salmonella* spp. isolated from *Gallus gallus* in 2010 among the reporting MSs are shown in Figures SA12–14. Figures SA12 and SA13 illustrate the low to moderate level of tetracycline and ampicillin resistance in *Salmonella* spp. in many reporting countries and the absence of a clear spatial distribution across the EU. Figure SA14 illustrates the absence, or low prevalence, of resistance to nalidixic acid in *Salmonella* spp. in northern Europe, but high levels of resistance in southern and eastern Europe.

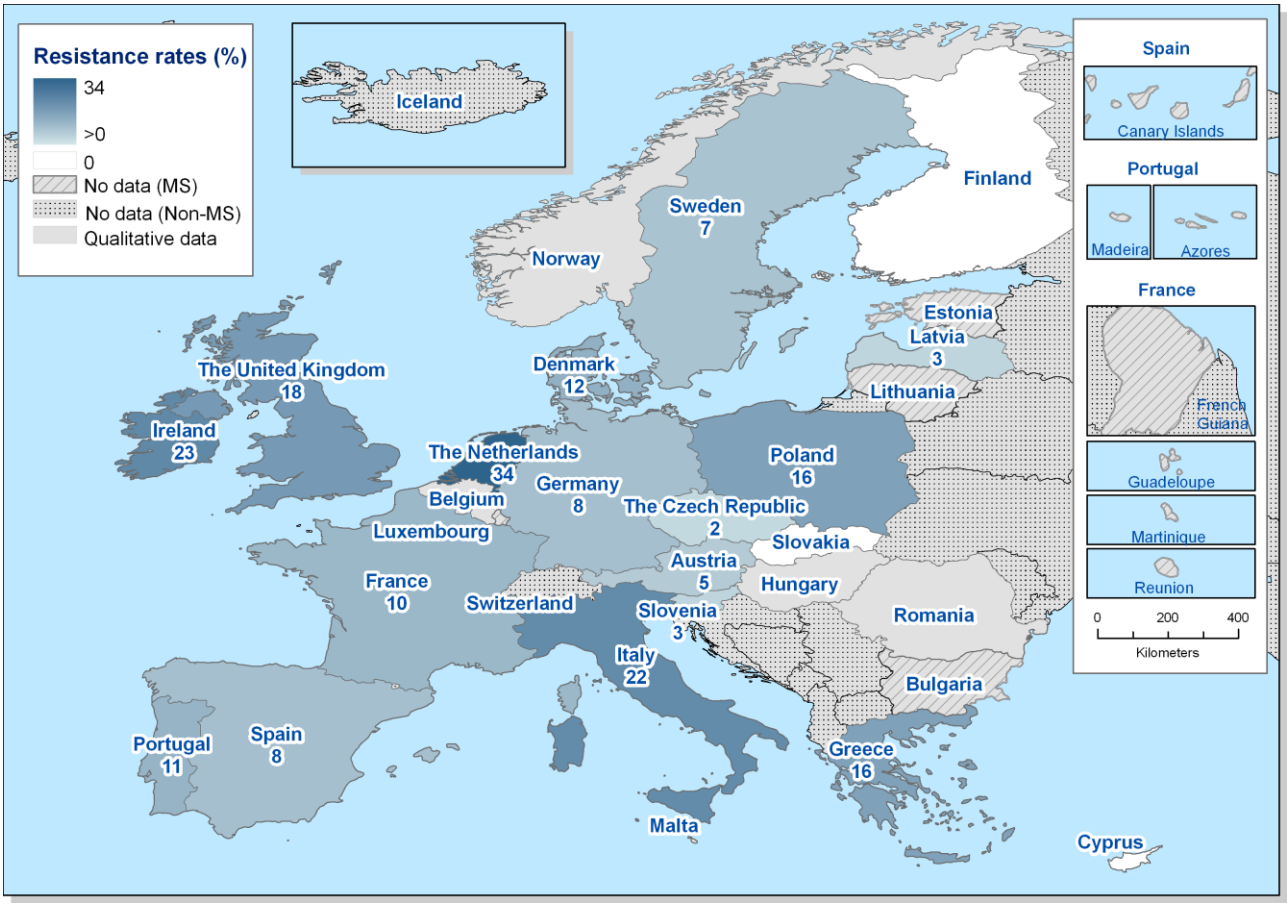
***Figure SA12. Spatial distribution of tetracycline resistance among* Salmonella *spp. from* Gallus gallus *in countries reporting MIC data in 2010***[1]




Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2010. When quantitative 2010 data were not available, 2009 data were used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates or purely qualitative data (as proportion of resistant isolates).

1. For Finland and Greece, 2009 data were used.

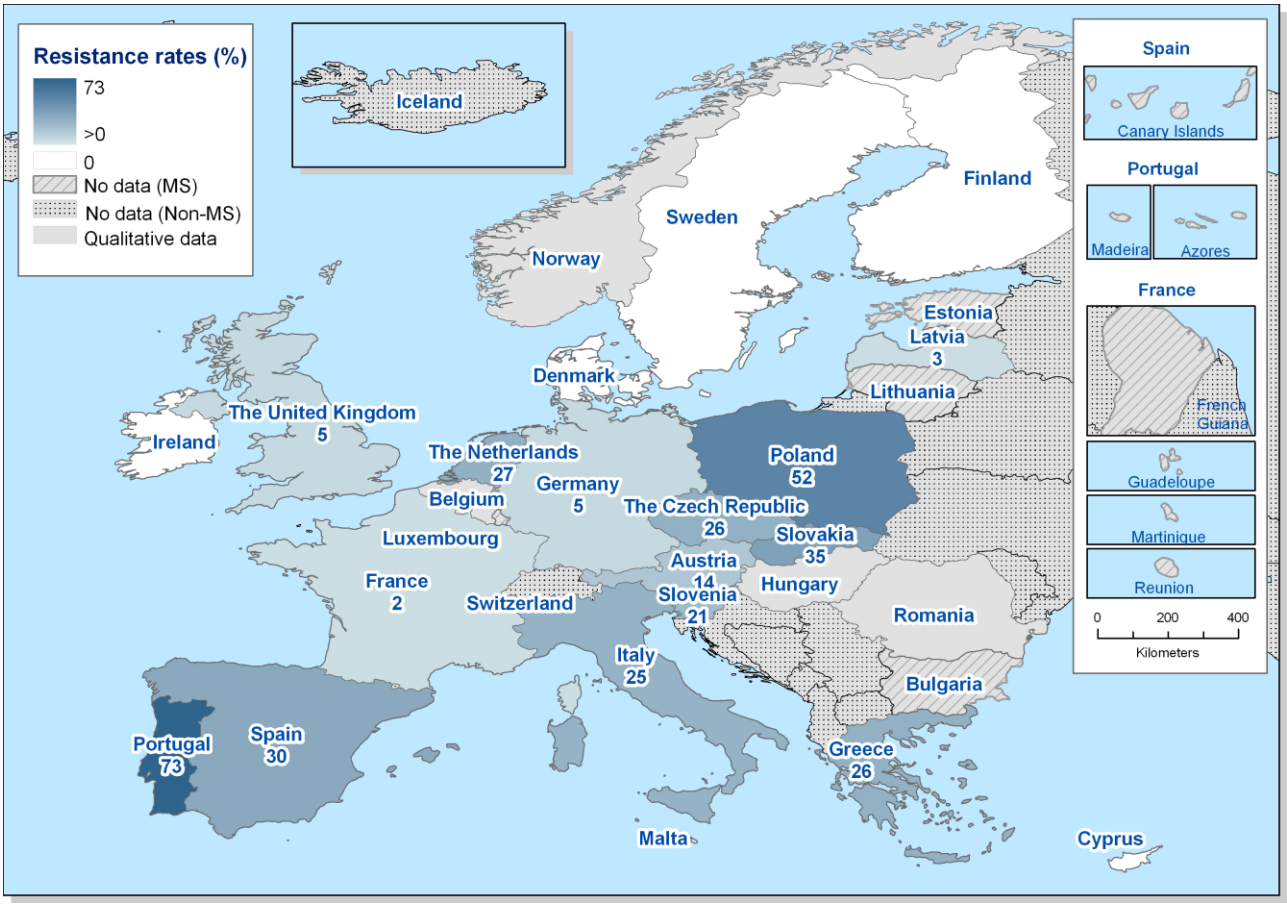
***Figure SA13. Spatial distribution of ampicillin resistance among* Salmonella *spp. from* Gallus gallus *in countries reporting MIC data in 2010[1]***




Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2010. When quantitative 2010 data were not available, 2009 data were used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates or purely qualitative data (as proportion of resistant isolates).

1. For Finland and Greece, 2009 data were used.

***Figure SA14. Spatial distribution of nalidixic acid resistance among* Salmonella *spp. from* Gallus gallus *in countries reporting MIC data in 2010*[1]**




Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2010. When quantitative 2010 data were not available, 2009 data were used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates or purely qualitative data (as proportion of resistant isolates).

1. For Finland and Greece, 2009 data were used.

### 3.3.2.2 Turkeys

This is the first year in which information on resistance levels among *Salmonella* isolates from turkeys has been included in this report. In 2010, nine MSs submitted quantitative antimicrobial susceptibility data for *Salmonella* spp. from turkeys, in accordance with the EU legislation. This section includes data from meat production flocks and mixed flocks of turkeys.

#### Resistance levels in *Salmonella* spp.

Nine MSs reported data on *Salmonella* spp. in turkeys in 2010, using harmonised epidemiological cut-off values (Table SA13). The occurrence of resistance to tetracyclines in the reporting MS group was 75 % and varied between 34 % and 96 % across the reporting countries. Sulfonamide and ampicillin resistance in the reporting MS group was 64 % and 51 %, respectively, and ranged from 34 % to 94 % and from 18 % to 93 %, respectively, across the reporting MSs. For chloramphenicol, the level of resistance in the reporting MS group was 7 % and ranged from 0 % to 39 % between countries. Gentamicin resistance was detected at varying levels ranging from 2 % to 48 % across the reporting MSs; the occurrence of resistance considering all reporting MSs was 12 %.

Overall resistance to ciprofloxacin in the reporting MS group was 28 % and to nalidixic acid was 25 %, and resistance levels ranged from 0 % to 84 % and from 0 % and 76 %, respectively. Considerable disparity was observed in the occurrence of resistance to ciprofloxacin among *Salmonella* isolates from different MSs, which may reflect the variability of prevalent serovars of *Salmonella* spp. included in the analyses by the different MSs. The overall level of resistance to cefotaxime in the reporting group of nine MSs was 0.3 %, with only France and Poland reporting any cefotaxime-resistant isolates, at low proportions of 0.6 % and 2 %, respectively.

Considering the nine MSs reporting resistance among *Salmonella* spp. isolates from both fowl (*Gallus gallus)* and turkeys, it is noticeable that the levels of resistance recorded are generally much higher in turkeys than in *Gallus gallus*, in particular for ampicillin, chloramphenicol, gentamicin, sulfonamides and tetracyclines. Resistance levels to ciprofloxacin and nalidixic acid were also higher in turkeys than in *Gallus gallus*, although of the same magnitude. Regarding cefotaxime, more reporting MSs detected no resistance in isolates from turkeys than in isolates from *Gallus gallus* and, among the nine MSs overall, resistance was lower (0.3 %) in turkeys than in *Gallus gallus* (1.1 %). However, except in France, estimated resistance levels among *Salmonella* spp. isolates from turkeys are based on low numbers of isolates compared with *Gallus gallus*.

### Resistance levels in *Salmonella* Typhimurium

Six MSs reported data on *Salmonella* Typhimurium in turkeys in 2010, using harmonised epidemiological cut-off values, but only two countries submitted sufficient data to warrant inclusion: France tested 10 isolates and Germany tested 22 isolates. Both countries reported extremely high levels of resistance to ampicillin, sulfonamides and tetracyclines. For all three antimicrobials, France reported higher resistance levels than Germany: 90 % compared with 77 % for ampicillin, 100 % compared with 77 % for sulfonamides and 90 % compared with 73 % for tetracyclines. In the case of chloramphenicol, Germany reported a slightly higher level of resistance than France (55 % compared with 50 %). For both ciprofloxacin and nalidixic acid, France reported 10 % resistance and Germany reported 9 % resistance. Germany reported 5 % resistance against gentamicin while France reported full sensitivity. Neither country reported resistance against cefotaxime.

***Table SA13. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. isolates from turkeys in Member States reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 32 | 25 | 32 | 0 | 32 | 0 | 32 | 34 | 32 | 0 | 32 | 34 | 32 | 34 | 32 | 34 |
| Czech Republic | 65 | 91 | 65 | 0 | 65 | 0 | 65 | 45 | 65 | 28 | 65 | 45 | 65 | 42 | 65 | 95 |
| France | 168 | 36 | 168 | 0.6 | 168 | 7 | 168 | 23 | 168 | 0 | 168 | 22 | 168 | 42 | 168 | 48 |
| Germany | 22 | 68 | 22 | 0 | 22 | 32 | 22 | 18 | 22 | 23 | 22 | 18 | 22 | 82 | 22 | 77 |
| Italy | 67 | 88 | 67 | 0 | 67 | 2 | 67 | 13 | 67 | 33 | 67 | 10 | 67 | 69 | 67 | 96 |
| Poland | 54 | 93 | 54 | 2 | 54 | 6 | 56 | 84 | 54 | 48 | 54 | 76 | 49 | 69 | 54 | 93 |
| Slovakia | 13 | 85 | 13 | 0 | 13 | 8 | 13 | 0 | 13 | 0 | 13 | 0 | 13 | 69 | 13 | 85 |
| Spain | 18 | 78 | 18 | 0 | 18 | 39 | 18 | 83 | 18 | 0 | 18 | 56 | 18 | 61 | 18 | 78 |
| United Kingdom | 168 | 18 | 168 | 0 | 168 | 8 | 168 | 10 | 168 | 2 | 168 | 9 | 168 | 94 | 168 | 86 |
| **Total (9 MSs)** | **607** | **51** | **607** | **0.3** | **607** | **7** | **609** | **28** | **607** | **12** | **607** | **25** | **602** | **64** | **607** | **75** |

N = number of isolates tested.

% Res = percentage of resistant isolates.

### 3.3.2.3 Pigs

Quantitative MIC data for *Salmonella* spp. isolated from pigs from 10 MSs in 2010 are included in the following analyses.

#### Resistance levels in *Salmonella* spp.

Table SA14 shows the occurrence of resistance to selected antimicrobials for isolates of *Salmonella* spp. from pigs.

Overall resistance to sulfonamides, tetracyclines, ampicillin and chloramphenicol was 59 %, 57 %, 55 % and 13 %, respectively, among the reporting MS group. The level of resistance to sulfonamides in *Salmonella* spp. from pigs ranged from 7 % to 78 % among reporting MSs. Similar wide variations were observed in the occurrence of resistance to tetracyclines (range 0–78 %), ampicillin (range 0–79 %) and chloramphenicol (range 0–42 %). Resistance to gentamicin was 4 % in the reporting MS group and was not detected in isolates from four MSs; a low (range 2–6 %) level of resistance was detected in Denmark, Germany, Italy, Slovenia and Spain, while Ireland reported a moderate level of resistance, at 16 %, although a relatively small number of isolates ($n$ = 19) was tested.

For ciprofloxacin and nalidixic acid, the level of resistance in the reporting MS group was 3 % and 2 % respectively. Four MSs detected no resistance to ciprofloxacin and five MSs reported no resistance to nalidixic acid in *Salmonella* spp. isolates from pigs. The occurrence of ciprofloxacin and nalidixic acid resistance in *Salmonella* spp. from pigs was very low to moderate (range 0.2–19 %) in isolates from Denmark, Germany, Slovenia and Spain, whereas Ireland reported high levels of resistance to ciprofloxacin (21 %) and Italy reported high levels of resistance to nalidixic acid (22 %).

The overall level of resistance to cefotaxime was 0.8 %. Most MSs did not detect cefotaxime resistance in *Salmonella* spp. isolates from pigs, whereas Germany reported cefotaxime resistance in 2 % of isolates.

#### Resistance levels in *Salmonella* Typhimurium

Five MSs reported quantitative MIC antimicrobial susceptibility results for *Salmonella* Typhimurium isolates from pigs. The occurrence of resistance to selected antimicrobials is presented in Table SA15.

The occurrence of resistance to commonly used antimicrobials among *S.* Typhimurium isolates from pigs was similar to that in *Salmonella* spp. in general, with the overall level of resistance in the reporting MS group being 63 % for sulfonamides, 59 % for ampicillin, 58 % for tetracyclines and 20 % for chloramphenicol. Among the individual reporting MSs, resistance to sulfonamides ranged from 53 % to 87 %, resistance to tetracyclines ranged from 48 % to 82 %, resistance to chloramphenicol from 9 % to 55 % and resistance to ampicillin ranged from 49 % to 87 %. The level of resistance to gentamicin was 4 % across the reporting MS group. Denmark, Germany, Slovenia and Spain reported low levels of resistance (range 2–9 %), while in Ireland the figure was higher, at 20 %, although this was a decrease from the level of resistance reported in 2009 (47 %).

The overall occurrence of resistance to ciprofloxacin and nalidixic acid in all reporting MSs was 2 %. Again, levels of resistance to the two antimicrobials reported by individual MSs were similar or identical. The overall level of resistance to both ciprofloxacin and nalidixic acid in 2010 (2 %) was the same as reported in 2009, and similar to the figure of 3 % reported in 2008.

In the reporting MS group, cefotaxime resistance was detected only in *S.* Typhimurium isolates from Germany, and at a very low level (0.6 %).

***Table SA14. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. isolates from pigs in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Czech Republic[1] | 13 | 46 | 13 | 0 | 13 | 23 | 13 | 0 | 13 | 0 | 13 | 0 | 13 | 39 | 13 | 31 |
| Denmark | 455 | 49 | 455 | 0 | 455 | 9 | 455 | 0.2 | 455 | 2 | 455 | 0 | 455 | 53 | 455 | 48 |
| Estonia | 19 | 21 | 19 | 0 | 19 | 16 | 19 | 0 | 19 | 0 | 19 | 0 | 19 | 21 | 19 | 21 |
| Germany[2] | 489 | 75 | 489 | 2 | 489 | 19 | 489 | 2 | 489 | 6 | 489 | 0.8 | 489 | 78 | 489 | 78 |
| Ireland | 19 | 79 | 19 | 0 | 19 | 42 | 19 | 21 | 19 | 16 | 19 | 16 | 19 | 74 | 19 | 74 |
| Italy | 37 | 46 | 37 | 0 | 37 | 14 | 37 | 19 | 37 | 5 | 37 | 22 | 37 | 68 | 37 | 78 |
| Netherlands | 96 | 13 | 96 | 0 | 96 | 3 | 96 | 0 | 96 | 0 | 96 | 0 | 96 | 14 | 96 | 14 |
| Slovenia | 34 | 27 | 34 | 0 | 34 | 18 | 34 | 18 | 34 | 3 | 34 | 18 | 34 | 24 | 34 | 32 |
| Spain | 38 | 40 | 38 | 0 | 38 | 11 | 38 | 18 | 38 | 3 | 38 | 18 | 38 | 55 | 38 | 66 |
| Sweden | 14 | 0 | 14 | 0 | 14 | 0 | 14 | 0 | 14 | 0 | 14 | 0 | 14 | 7 | 14 | 0 |
| **Total (10 MSs)** | **1,214** | **55** | **1,214** | **0.8** | **1,214** | **13** | **1,214** | **3** | **1,214** | **4** | **1,214** | **2** | **1,214** | **59** | **1,214** | **57** |

N = number of isolates tested. % Res = percentage of resistant isolates.

1. Czech Republic reported 13 *Salmonella* spp. isolates from clinical investigations.

2. Germany reported 489 *Salmonella* spp. isolates from clinical investigations.

***Table SA15. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Typhimurium isolates from pigs in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Denmark[1] | 455 | 49 | 455 | 0 | 455 | 9 | 455 | 0.2 | 455 | 2 | 455 | 0 | 455 | 53 | 455 | 48 |
| Germany[2] | 173 | 80 | 173 | 0.6 | 173 | 44 | 173 | 2 | 173 | 9 | 173 | 1 | 173 | 85 | 173 | 81 |
| Ireland | 15 | 87 | 15 | 0 | 15 | 53 | 15 | 20 | 15 | 20 | 15 | 20 | 15 | 87 | 15 | 80 |
| Slovenia | 11 | 73 | 11 | 0 | 11 | 55 | 11 | 55 | 11 | 9 | 11 | 55 | 11 | 73 | 11 | 73 |
| Spain | 17 | 82 | 17 | 0 | 17 | 24 | 17 | 12 | 17 | 6 | 17 | 12 | 17 | 82 | 17 | 82 |
| **Total (5 MSs)** | **671** | **59** | **671** | **0.2** | **671** | **20** | **671** | **2** | **671** | **4** | **671** | **2** | **671** | **63** | **671** | **58** |

N = number of isolates tested. % Res = percentage of resistant isolates.

1. Denmark reported 71 monophasic *Salmonella* 1,4,[5],12:i:- isolates (20 *Salmonella* 1,4,12:i:- and 51 *Salmonella* 1,4,5,12:i:-) as *S*. Typhimurium.

2. Germany reported 173 *S*. Typhimurium isolates from clinical investigations.

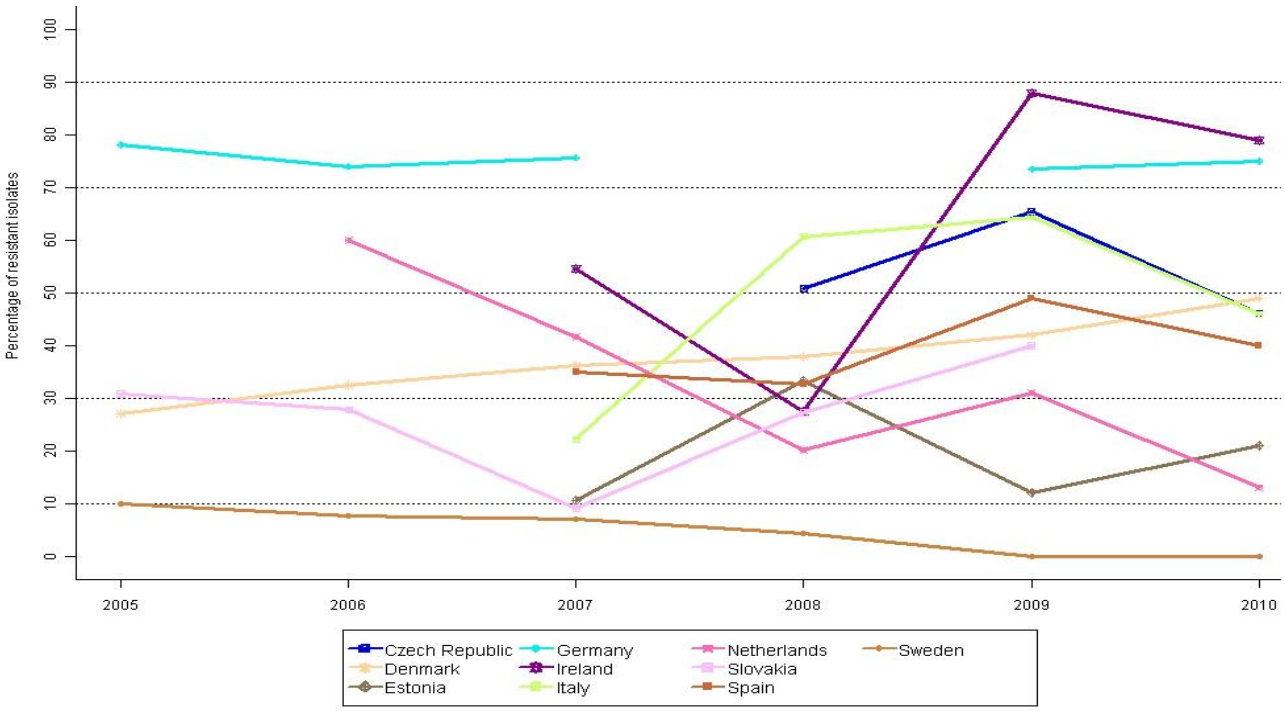
## Temporal trends in resistance among *Salmonella* isolates from pigs

Figures SA15–21 show the variation in the level of resistance to the selected antimicrobials in *Salmonella* spp. isolated from pigs in 2010. The figures demonstrate that, in some MSs, large differences in the occurrence of resistance were observed over the reporting period; however, in other countries the occurrence of resistance remained relatively unchanged from previous years. In 2009, the levels of resistance to several antimicrobials (including tetracyclines, chloramphenicol, ampicillin and sulfonamides) increased in a number of MSs. This trend was reversed in 2010, with a number of MSs reporting decreases in the levels of resistance to these antimicrobials.

Over the six reporting years, significantly decreasing trends in resistance to ampicillin, sulfonamides and tetracyclines were reported by the Netherlands, while Denmark experienced an increase in resistance to the same three antimicrobials, and, in the case of ampicillin and tetracyclines, the differences were statistically significant. Considering resistance to (fluoro)quinolones, ciprofloxacin and nalidixic acid, both Denmark and Germany reported statistically decreasing trends over the 2005–2010 period. In contrast, Ireland and Italy showed increasing trends in resistance to these two substances, although data were limited to the last 4 years.

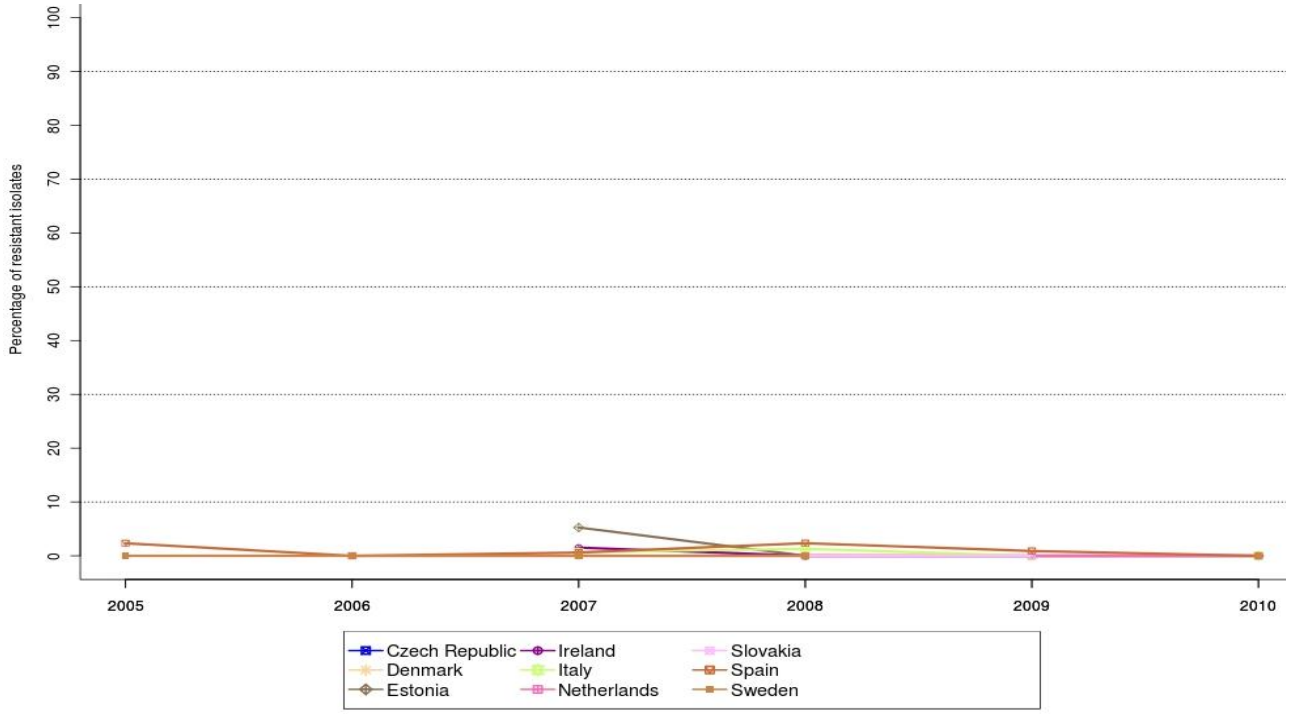
Resistance to cefotaxime in *Salmonella* spp. from pigs was either low, very low or absent in the reporting MSs between 2005 and 2010; and no significant trends were detected over the last 5 years. Similarly, levels of resistance to gentamicin were low, very low or absent over the reporting period, with the exception of Ireland, which reported greater resistance in 2009 and 2010. In the case of chloramphenicol, a greater variability in the levels of resistance was recorded among the reporting MSs, whereas stable trends were generally observed within most of the reporting MSs. Exceptions are Germany and the Netherlands, which reported statistically significant decreasing trends over the period.

***Figure SA15. Trends in ampicillin resistance in* Salmonella *spp. from pigs in reporting Member States, 2005–2010, quantitative data***



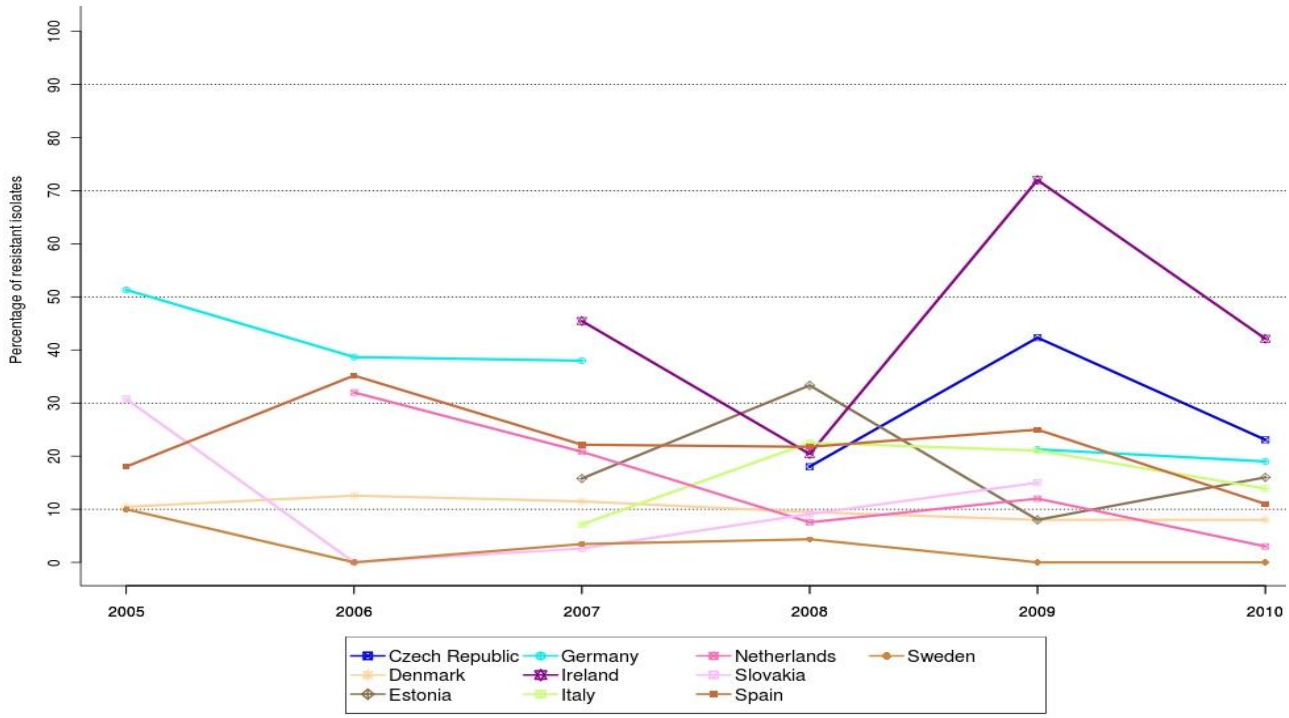

Note: Statistically significant increasing or decreasing trends for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Denmark (↑), and the Netherlands (↓).

***Figure SA16. Trends in cefotaxime resistance in* Salmonella *spp. from pigs in reporting Member States, 2005–2010, quantitative data***



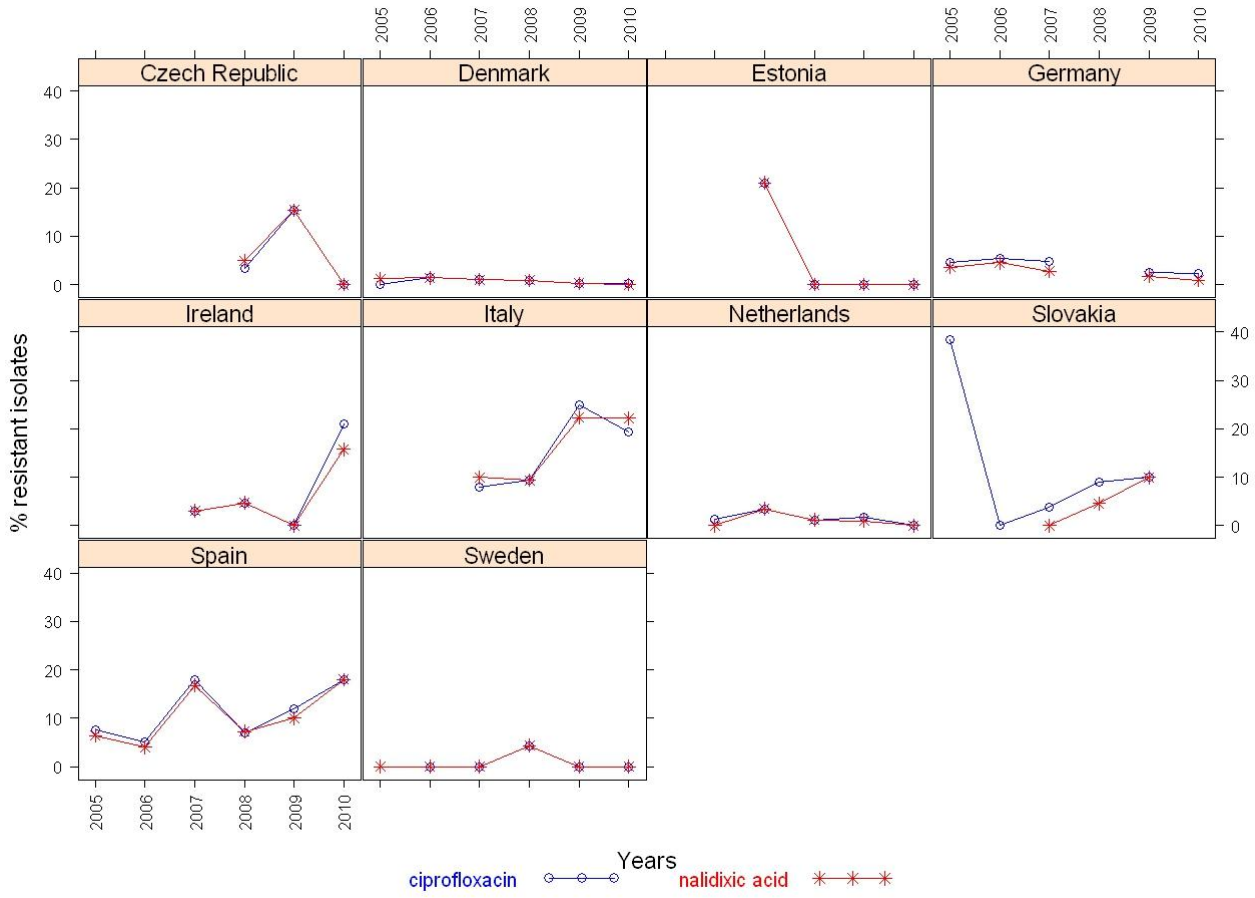

Note: No statistically significant trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure SA17. Trends in chloramphenicol resistance in* Salmonella *spp. from pigs in reporting Member States, 2005–2010, quantitative data***



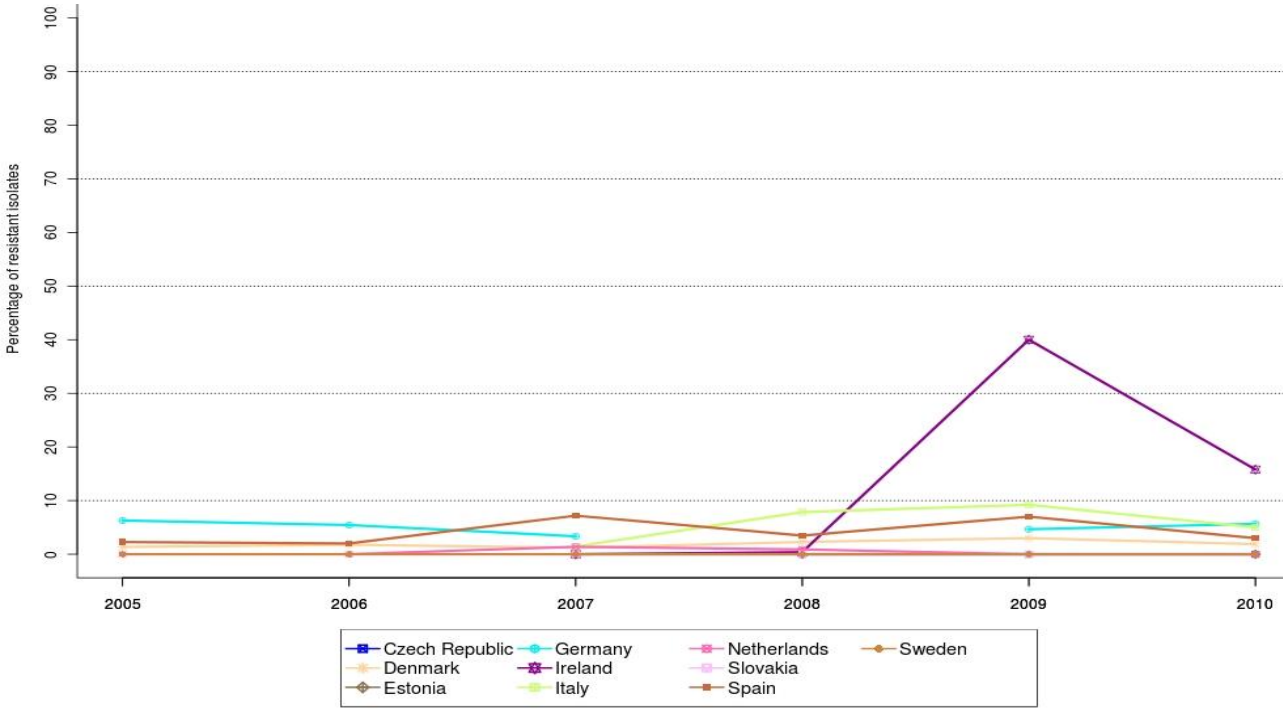

Note: A statistically significant decreasing trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Germany and the Netherlands.

***Figure SA18. Trends in ciprofloxacin and nalidixic acid resistance in* Salmonella *spp. from pigs in reporting Member States, 2005–2010, quantitative data***



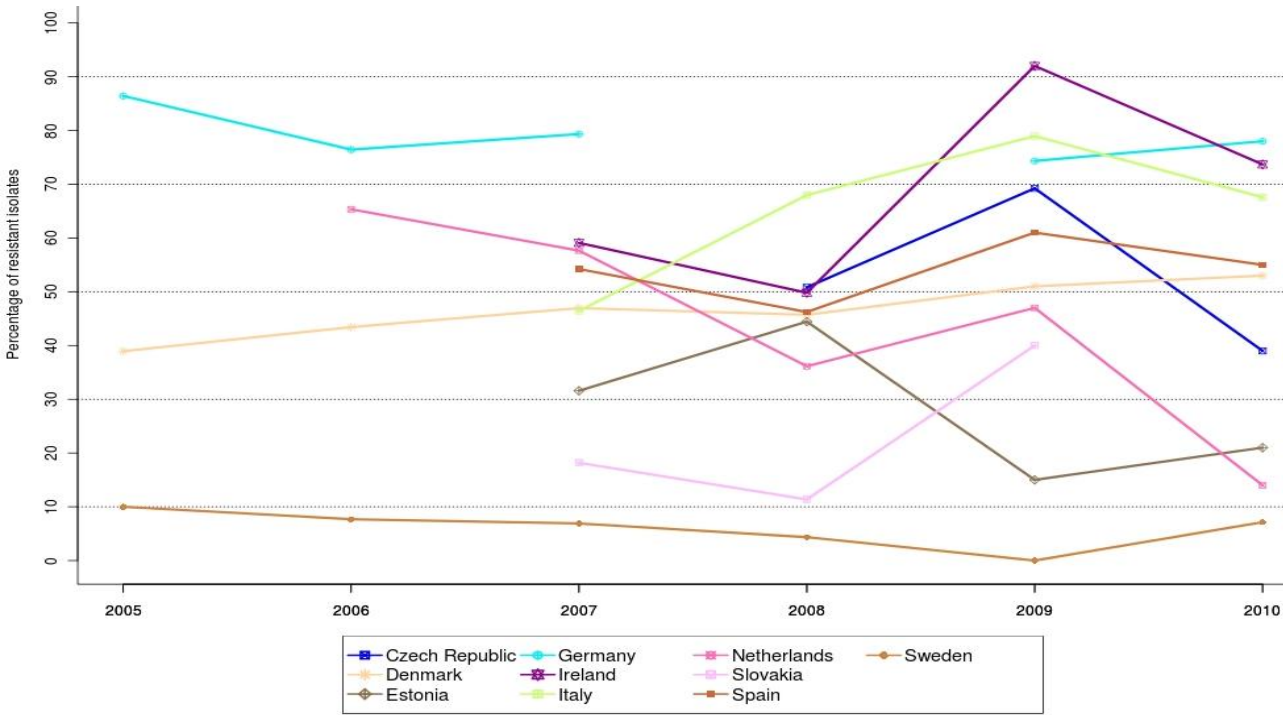

Note: Statistically significant decreasing trends for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed for ciprofloxacin resistance in Germany and for nalidixic acid resistance in Denmark and Germany.

***Figure SA19. Trends in gentamicin resistance in* Salmonella *spp. from pigs in reporting Member States, 2005–2010, quantitative data***



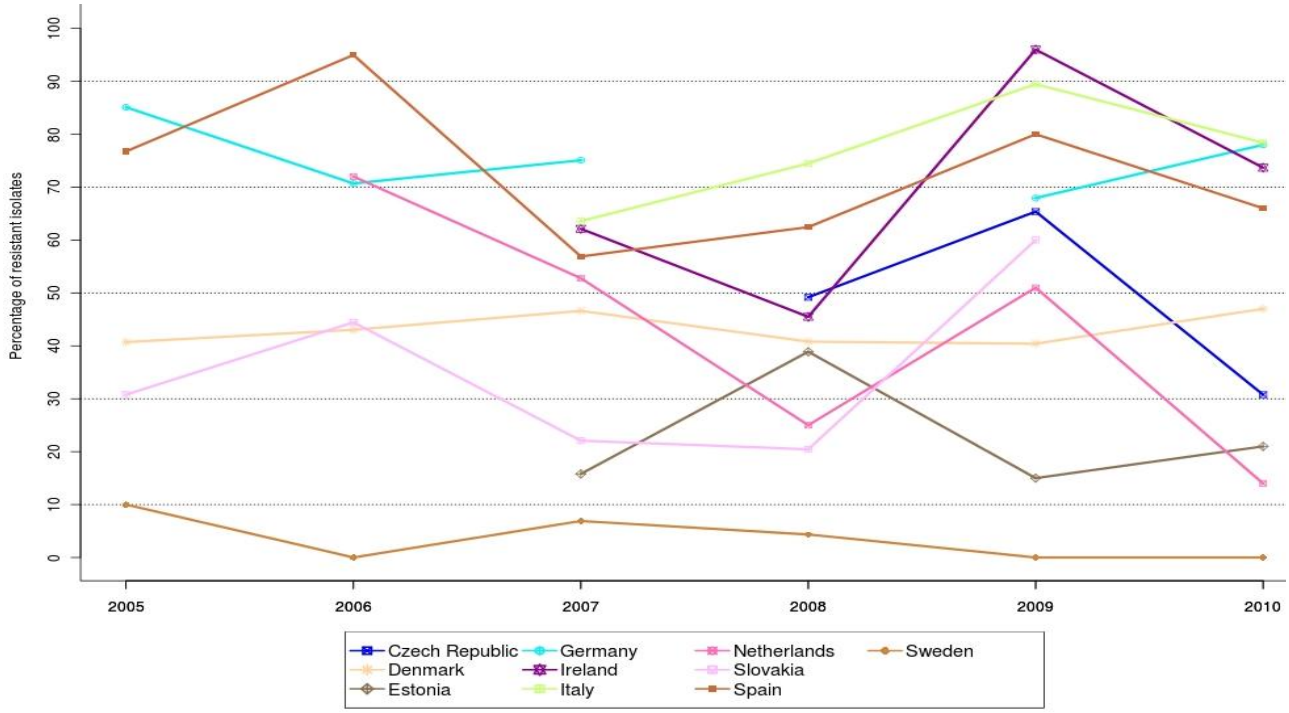

Note: No statistically significant trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure SA20. Trends in sulfonamide resistance in* Salmonella *spp. from pigs in reporting Member States, 2005–2010, quantitative data***




Note: Statistically significant increasing or decreasing trends for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Denmark (↑) and the Netherlands (↓).

***Figure SA21. Trends in tetracycline resistance in* Salmonella *spp. from pigs in reporting Member States, 2005–2010, quantitative data***

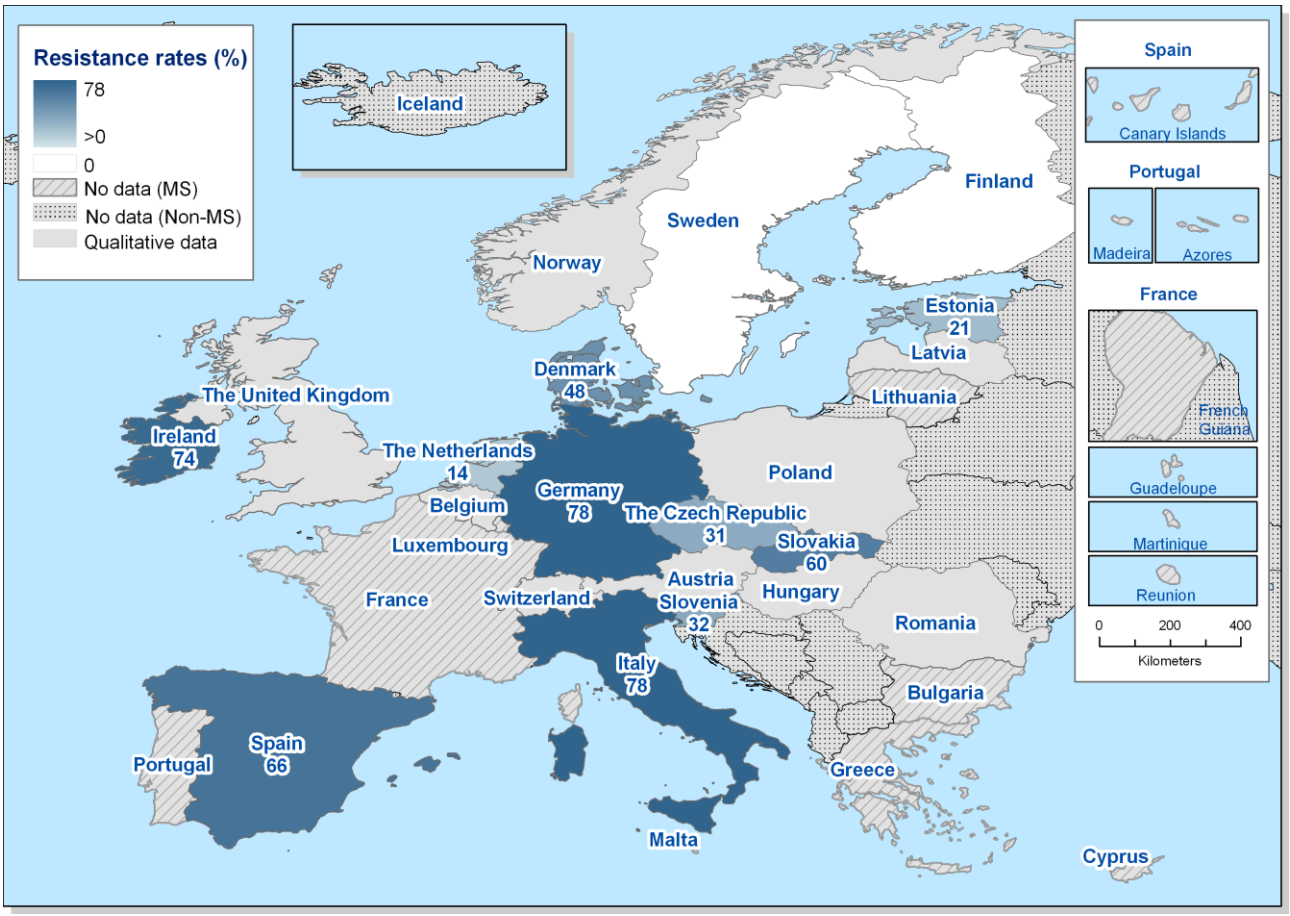



Note: A statistically significant decreasing trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands (↓) and Spain (↓).

## Spatial distribution of resistance among *Salmonella*

The spatial distribution of tetracycline, ampicillin and nalidixic acid resistance in *Salmonella* spp. from pigs in 2010 is shown in Figures SA22–24. Figures SA22 and SA23 emphasise the large differences in tetracycline and ampicillin resistance rates in different MSs, although no clear spatial distributions were observed. In most countries, nalidixic acid resistance in *Salmonella* spp. isolated from pigs was reported to be low, with no clear spatial distribution apparent (Figure SA24).

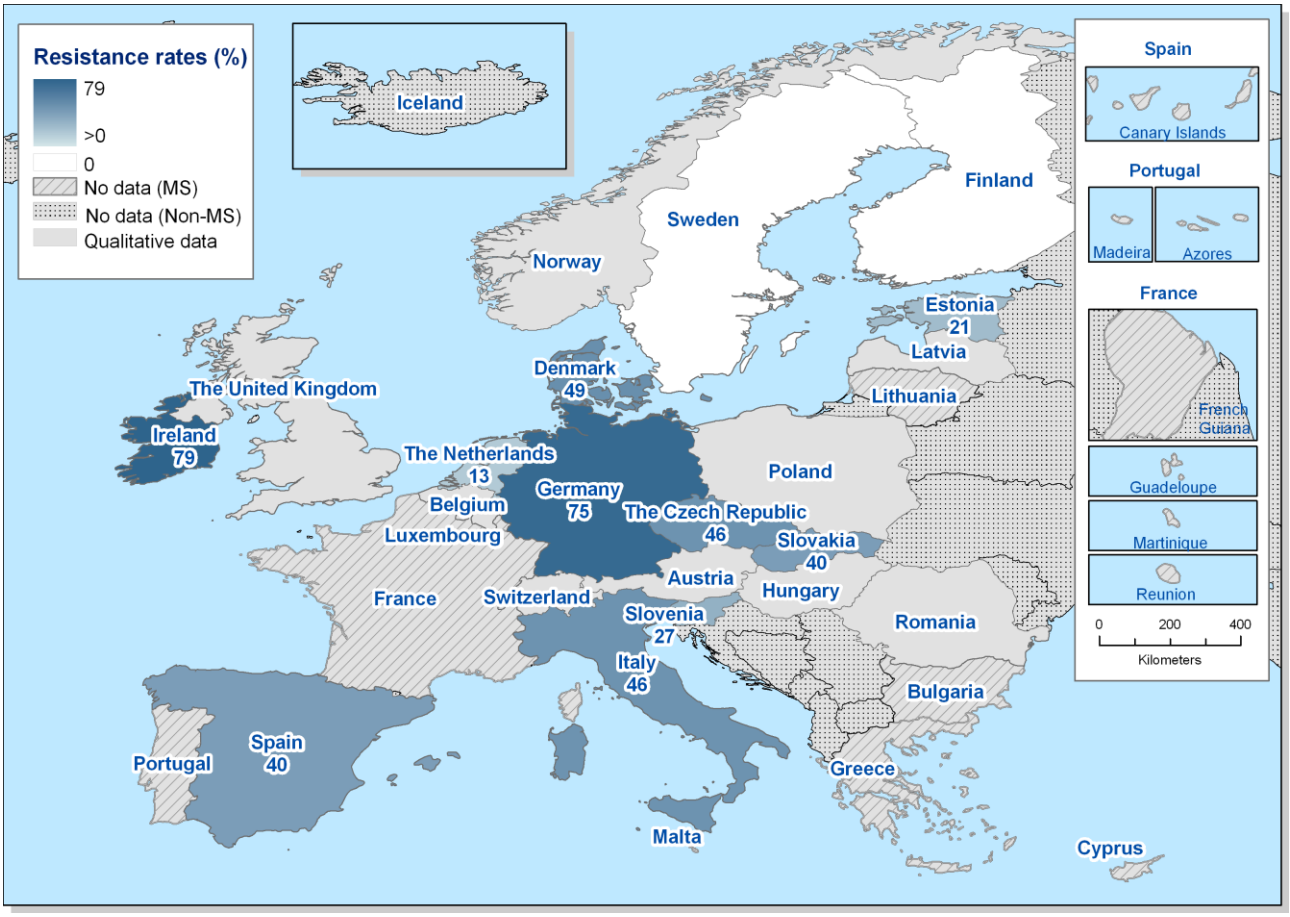
***Figure SA22. Spatial distribution of tetracycline resistance among* Salmonella *spp. from pigs in countries reporting MIC data in 2010[1]***




Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2010. When quantitative 2010 data were not available, 2009 data were used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates or purely qualitative data (as proportion of resistant isolates).

1. For Finland and Slovakia, 2009 data were used.

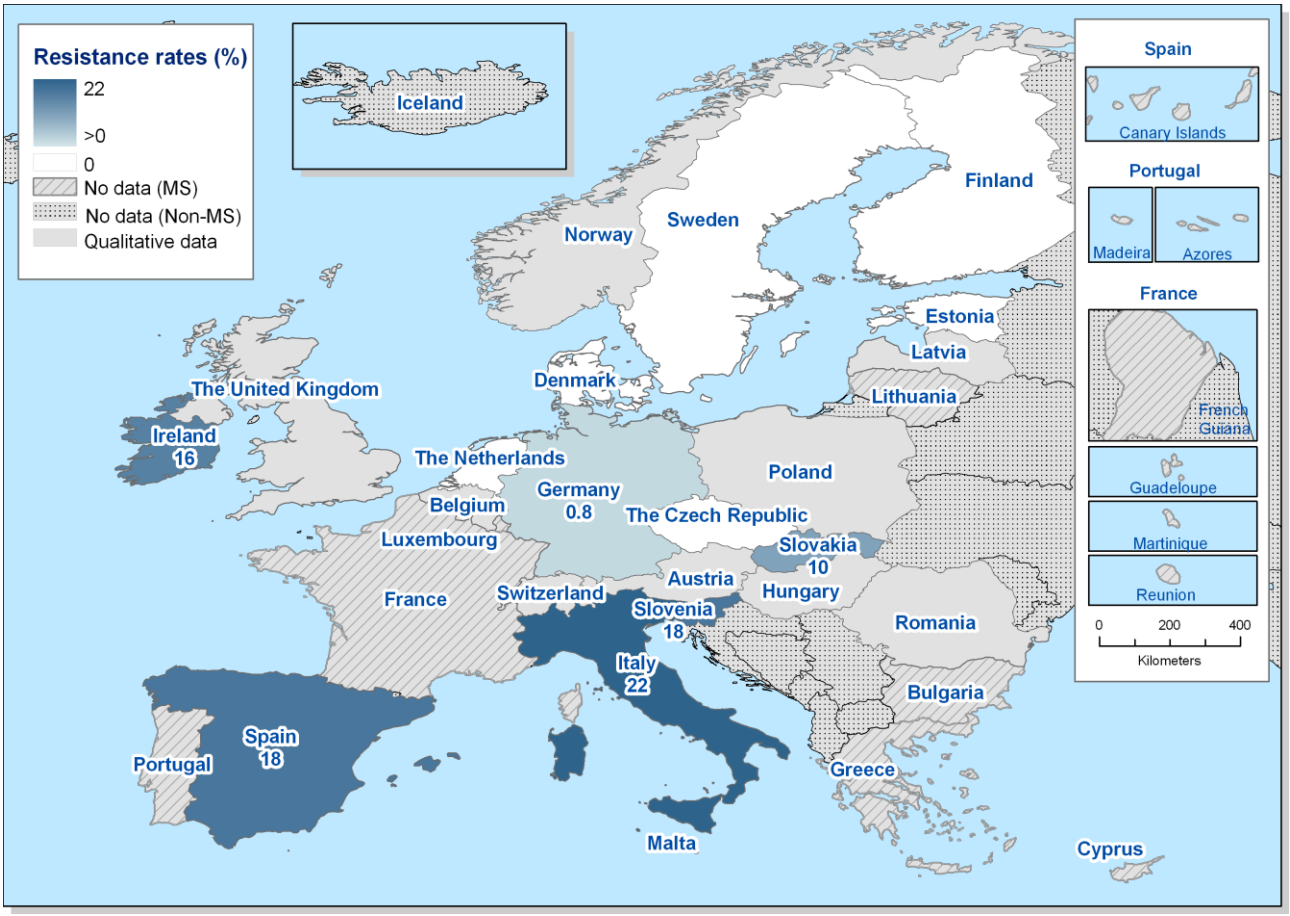
***Figure SA23. Spatial distribution of ampicillin resistance among* Salmonella *spp. from pigs in countries reporting MIC data in 2010[1]***




Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2010. When quantitative 2010 data were not available, 2009 data were used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates or purely qualitative data (as proportion of resistant isolates).

1. For Finland and Slovakia, 2009 data were used.

***Figure SA24. Spatial distribution of nalidixic acid resistance among* Salmonella *spp. from pigs in countries reporting MIC data in 2010[1]***




Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2010. When quantitative 2010 data were not available, 2009 data were used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates or purely qualitative data (as proportion of resistant isolates).

1. For Finland and Slovakia, 2009 data were used.

### 3.3.2.4 Cattle (bovine animals)

Calves, dairy cattle, beef cows and heifers are included under the term 'cattle' in this report. Quantitative MIC data for *Salmonella* spp. isolated from cattle in seven MSs in 2010 are included in the following analysis of antimicrobial resistance levels.

#### Resistance levels in *Salmonella* spp.

Table SA16 shows the occurrence of resistance to selected antimicrobials for isolates of *Salmonella* spp. from cattle. Resistance to sulfonamides, tetracyclines, ampicillin and chloramphenicol was commonly reported in *Salmonella* spp. from cattle; considering all reporting MSs, the level of resistance was 45 %, 39 %, 36 % and 13 %, respectively. Tetracycline resistance ranged from 0 % to 61 % across reporting MSs, while the equivalent figures for the other antimicrobials were 0 % to 33 % for chloramphenicol, 3 % to 56 % for ampicillin and 21 % to 60 % for sulfonamide. No MSs reported resistance to gentamicin.

For all reporting MSs the overall occurrence of resistance to both ciprofloxacin and nalidixic acid was 2 %. Germany and the Netherlands were the only MSs to report resistance to ciprofloxacin or nalidixic acid in *Salmonella* spp. isolates from cattle and for both these countries the levels reported were low (3 % or 4 %).

For all reporting MSs, the overall occurrence of cefotaxime resistance was 0.3 %. Cefotaxime resistance was only reported by Germany, where the proportion of resistant isolates was 0.5 %.

#### Resistance levels in *Salmonella* Typhimurium

The level of resistance among *S.* Typhimurium isolates from cattle is reported in Table SA17. Six MSs reported results for at least 10 isolates of *Salmonella* Typhimurium from cattle in 2010.

Across all reporting MSs, the level of resistance to sulfonamides, tetracyclines, ampicillin and chloramphenicol was 60 %, 52 %, 49 % and 33 %, respectively. The proportions of resistance among the different MSs ranged from 0 % to 64 % for tetracyclines and ampicillin, from 25 % to 93 % for sulfonamides and from 0 % to 57 % for chloramphenicol. Resistance to gentamicin in *S.* Typhimurium from cattle was not detected in any reporting MS.

In the reporting MS group as a whole, the occurrence of resistance to both ciprofloxacin and nalidixic acid was 3 %. The level of resistance to both ciprofloxacin and nalidixic acid was low, 7 % or less, in Germany and the Netherlands. None of the remaining MSs reported any resistance to these antimicrobials.

Cefotaxime resistance in *S.* Typhimurium isolates from cattle in 2010 was reported only by Germany at the low level of 2 %.

***Table SA16. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. isolates from cattle in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Denmark[1] | 18 | 56 | 18 | 0 | 18 | 6 | 18 | 0 | 18 | 0 | 18 | 0 | 18 | 56 | 18 | 61 |
| Finland | 13 | 23 | 13 | 0 | 13 | 0 | 13 | 0 | 13 | 0 | 13 | 0 | 13 | 23 | 13 | 0 |
| Germany[2] | 220 | 42 | 220 | 0.5 | 220 | 13 | 220 | 4 | 220 | 0 | 220 | 3 | 220 | 47 | 220 | 41 |
| Ireland | 30 | 53 | 30 | 0 | 30 | 33 | 30 | 0 | 30 | 0 | 30 | 0 | 30 | 60 | 30 | 57 |
| Netherlands | 36 | 31 | 36 | 0 | 36 | 22 | 36 | 3 | 36 | 0 | 36 | 3 | 36 | 47 | 36 | 33 |
| Spain | 30 | 3 | 30 | 0 | 30 | 3 | 30 | 0 | 30 | 0 | 30 | 0 | 30 | 37 | 30 | 40 |
| Sweden | 29 | 14 | 29 | 0 | 29 | 0 | 29 | 0 | 29 | 0 | 29 | 0 | 29 | 21 | 29 | 17 |
| **Total (7 MSs)** | **376** | **36** | **376** | **0.3** | **376** | **13** | **376** | **2** | **376** | **0** | **376** | **2** | **376** | **45** | **376** | **39** |
| Switzerland[3] | 34 | 44 | 34 | 0 | 34 | 27 | 34 | 0 | 34 | 0 | 34 | 0 | 34 | 44 | 34 | 44 |

N = number of isolates tested.

% Res = percentage of resistant isolates.

1. Denmark reported 18 *S.* Typhimurium isolates from clinical investigations.
2. Germany reported 220 *Salmonella* spp. isolates from clinical investigations.
3. Switzerland reported 34 *Salmonella* spp. isolates from clinical investigations.

***Table SA17. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Typhimurium from cattle in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Denmark[1,2] | 18 | 56 | 18 | 0 | 18 | 6 | 18 | 0 | 18 | 0 | 18 | 0 | 18 | 56 | 18 | 61 |
| Finland | 10 | 30 | 10 | 0 | 10 | 0 | 10 | 0 | 10 | 0 | 10 | 0 | 10 | 30 | 10 | 0 |
| Germany[3] | 60 | 55 | 60 | 2 | 60 | 42 | 60 | 5 | 60 | 0 | 60 | 5 | 60 | 62 | 60 | 60 |
| Ireland | 18 | 61 | 18 | 0 | 18 | 56 | 18 | 0 | 18 | 0 | 18 | 0 | 18 | 72 | 18 | 61 |
| Netherlands | 14 | 50 | 14 | 0 | 14 | 57 | 14 | 7 | 14 | 0 | 14 | 7 | 14 | 93 | 14 | 64 |
| Sweden | 12 | 8 | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 25 | 12 | 17 |
| **Total (6 MSs)** | **132** | **49** | **132** | **0.8** | **132** | **33** | **132** | **3** | **132** | **0** | **132** | **3** | **132** | **60** | **132** | **52** |
| Switzerland[4] | 27 | 41 | 27 | 0 | 27 | 33 | 27 | 0 | 27 | 0 | 27 | 0 | 27 | 41 | 27 | 41 |

N = number of isolates tested.

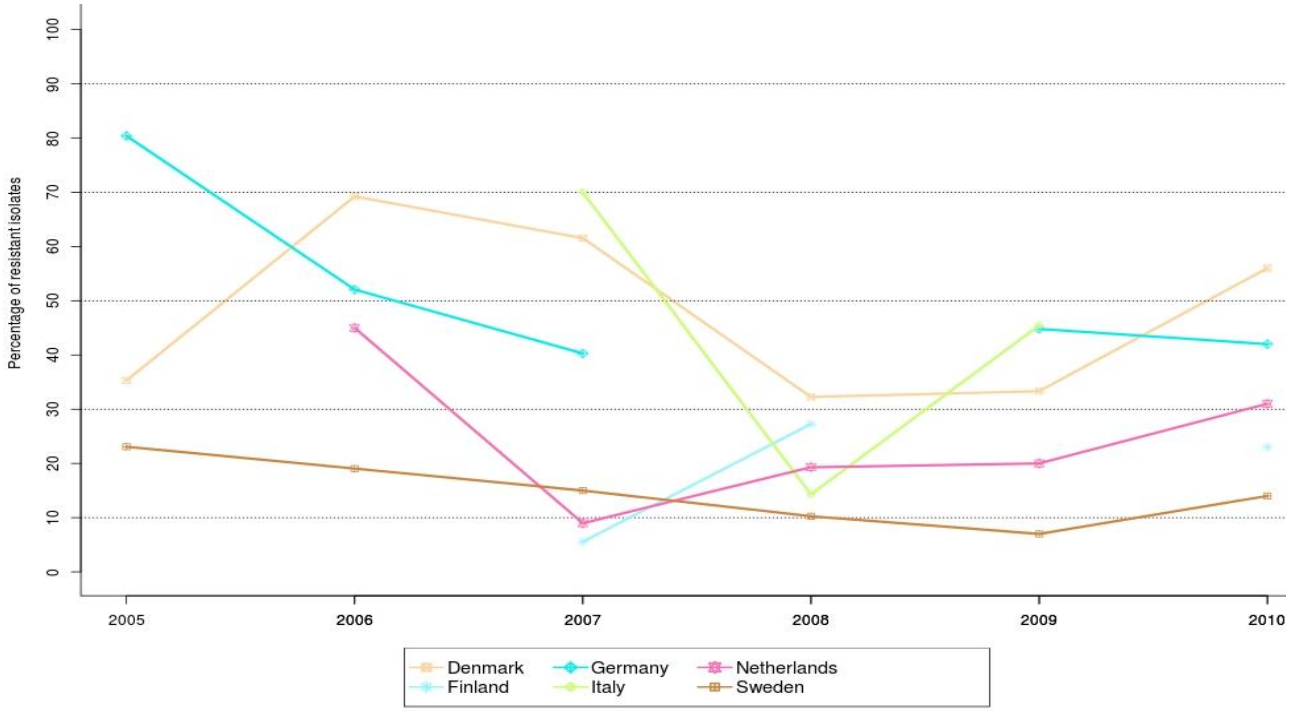
% Res = percentage of resistant isolates.

1. Denmark reported 18 *S*. Typhimurium isolates from clinical investigations.
2. Denmark reported seven monophasic *Salmonella* 1,4,[5],12:i:- isolates (one *Salmonella* 1,4,12:i:- and six *Salmonella* 1,4,5,12:i:-) as *S*. Typhimurium.
3. Germany reported 60 *S*. Typhimurium isolates from clinical investigations.
4. Switzerland reported 27 *S.* Typhimurium isolates from clinical investigations.

### Temporal trends in resistance among *Salmonella* isolates from cattle

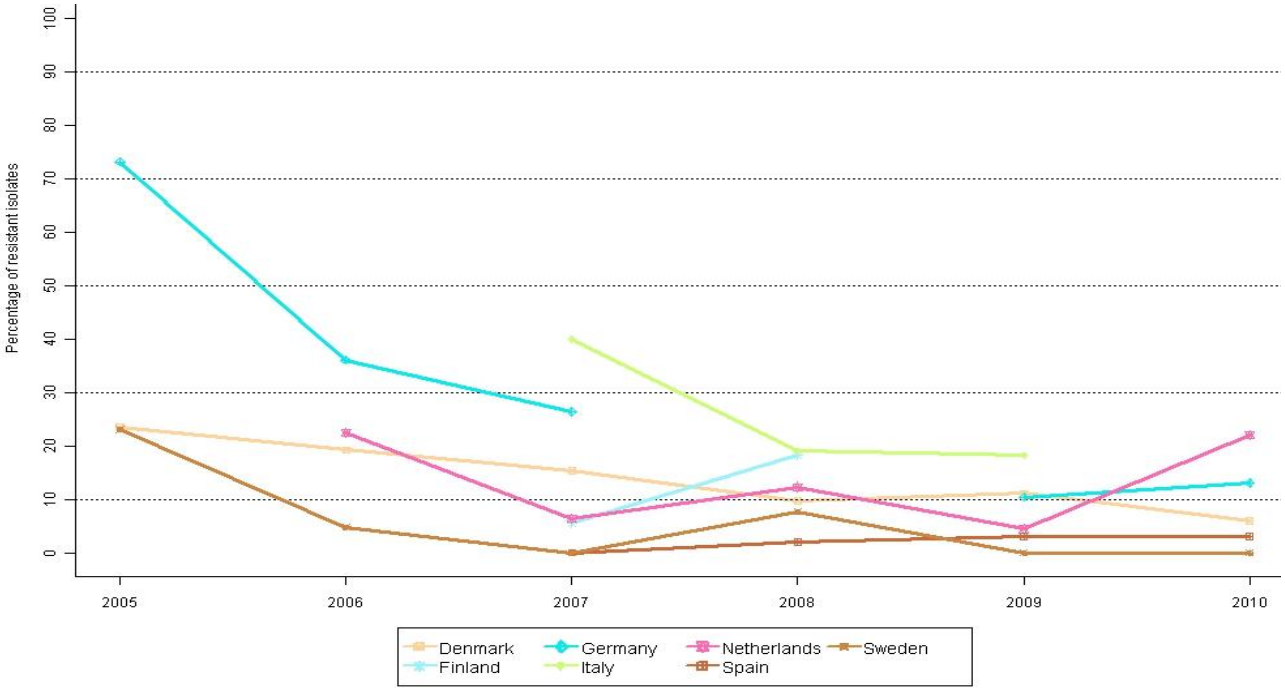
Figures SA25–30 show that in 2010 large variations in the level of resistance to some antimicrobials were observed between different MSs. The figures also illustrate the trends in resistance to ampicillin, chloramphenicol, ciprofloxacin, nalidixic acid, sulfonamides and tetracyclines among *Salmonella* isolates from cattle from 2005 to 2010. In general, decreasing trends in resistance were mainly observed over time among *Salmonella* spp. from cattle, although Denmark, the Netherlands and Sweden recorded increases in tetracycline, ampicillin and sulfonamide resistance in 2010 compared with 2009. Germany and Sweden experienced statistically significant decreasing trends in resistance to ampicillin, chloramphenicol. Germany also reported decreasing trends in resistance to gentamicin, sulfonamides and tetracyclines, all of these reaching statistical significance from 2005 to 2010. Regarding cefotaxime resistance, the five MSs that reported consistently from 2005 to 2010, namely Denmark, Finland, Italy, the Netherlands and Sweden, did not detect any resistance over the period.

***Figure SA25. Trends in ampicillin resistance in* Salmonella *spp. from cattle in reporting Member States, 2005–2010, quantitative data***



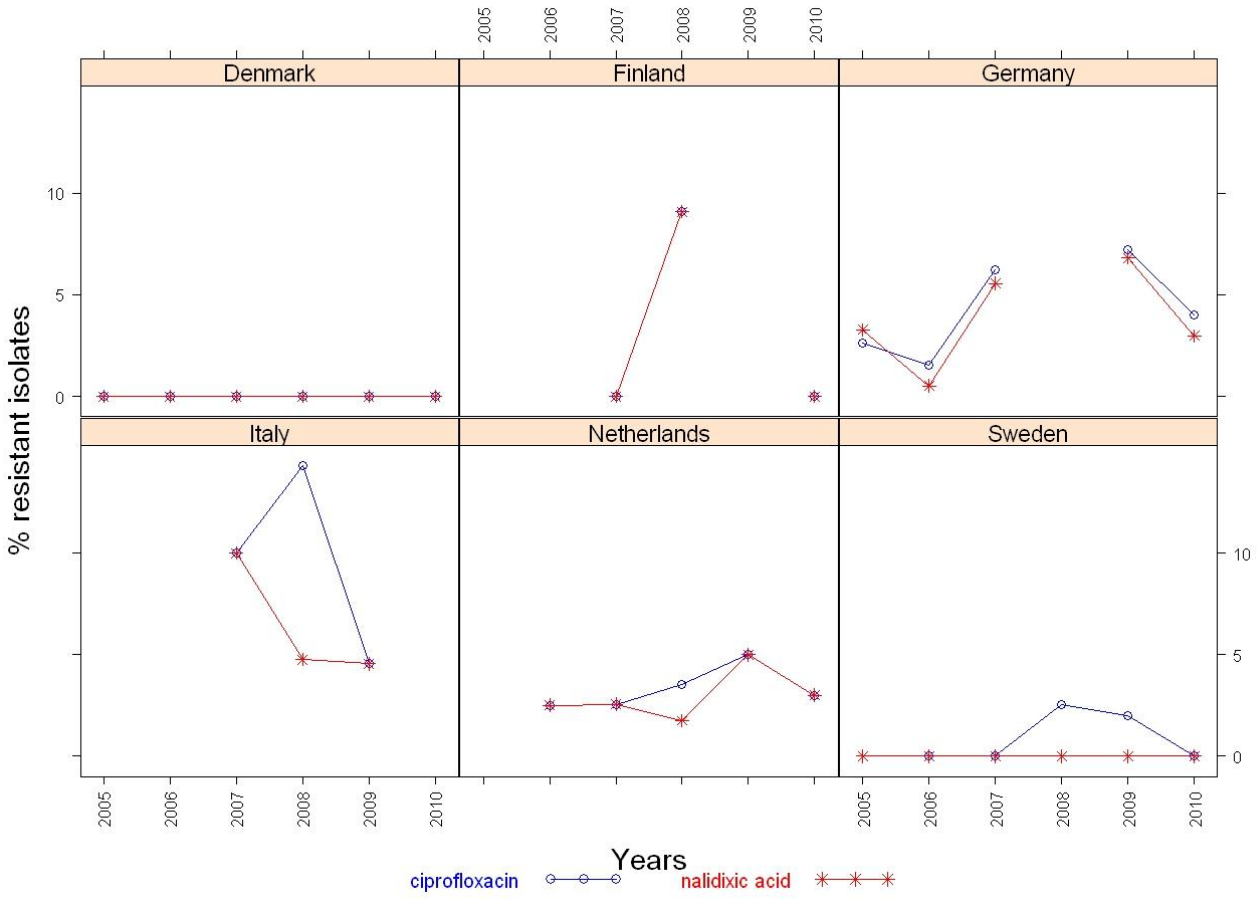

Note: A statistically significant decreasing trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Germany and Sweden.

***Figure SA26. Trends in chloramphenicol resistance in* Salmonella *spp. from cattle in reporting Member States, 2005–2010, quantitative data***



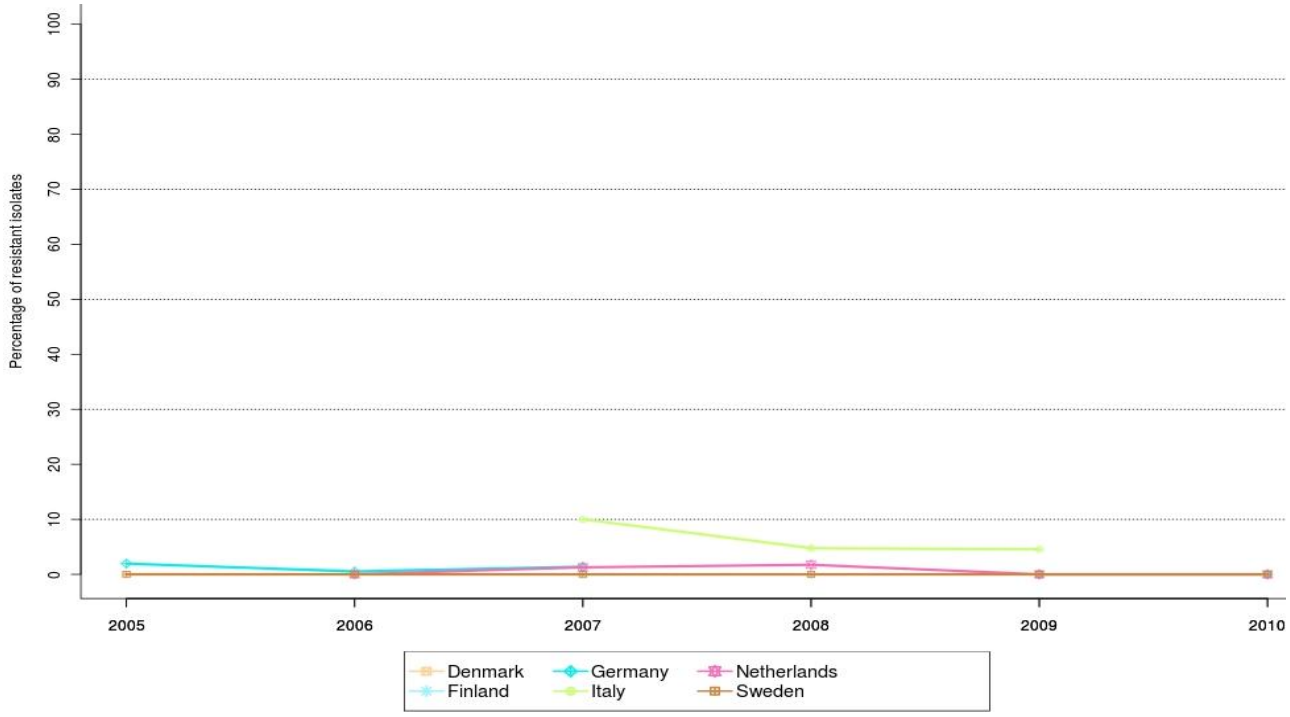

Note: A statistically significant decreasing trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Germany and Sweden.

***Figure SA27. Trends in ciprofloxacin and nalidixic acid resistance in* Salmonella *spp. from cattle in reporting Member States, 2005–2010, quantitative data***



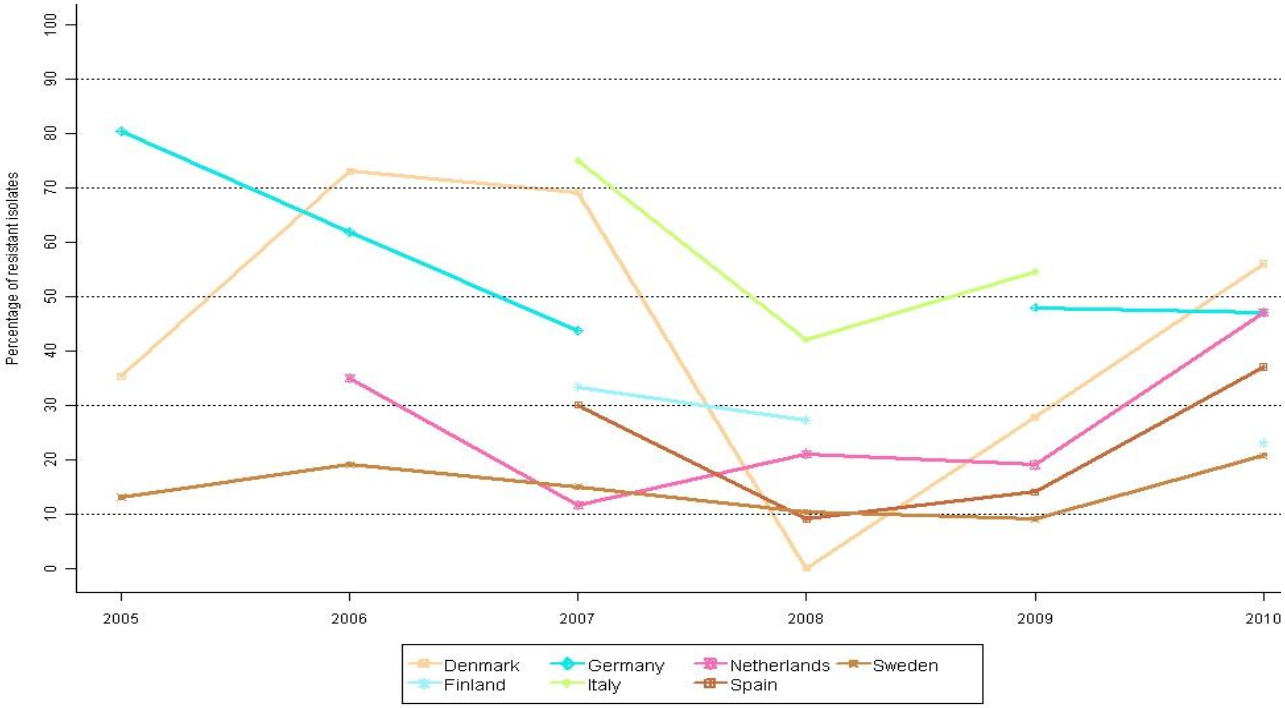

Note: For both ciprofloxacin and nalidixic acid, no statistically significant trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure SA28. Trends in gentamicin resistance in* Salmonella *spp. from cattle in reporting Member States, 2005–2010, quantitative data***



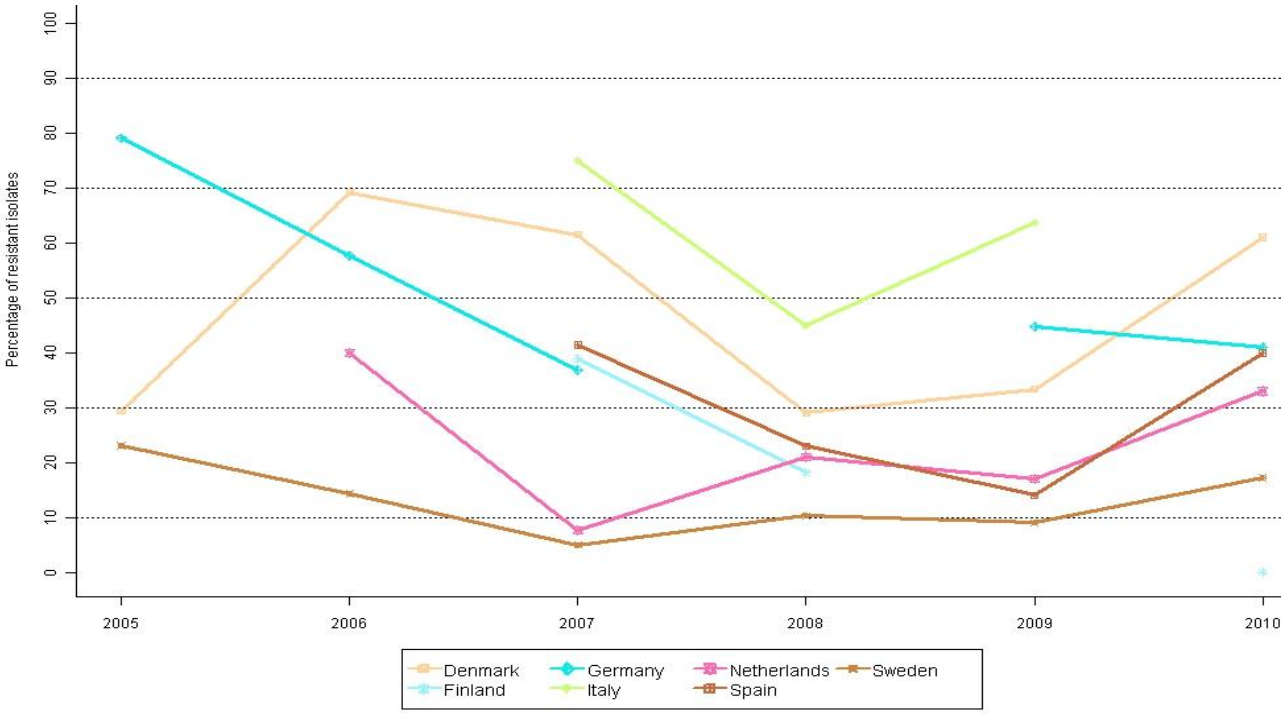

Note: A statistically significant decreasing trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Germany.

***Figure SA29. Trends in sulfonamide resistance in* Salmonella *spp. from cattle in reporting Member States, 2005–2010, quantitative data***




Note: A statistically significant decreasing trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Germany.

***Figure SA30. Trends in tetracycline resistance in* Salmonella *spp. from cattle in reporting Member States, 2005–2010, quantitative data***




Note: A statistically significant decreasing trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Germany.

### 3.3.2.5 Resistance among other *Salmonella* serovars of public health significance

#### Resistance levels in monophasic *S.* Typhimurium

Monophasic *S.* Typhimurium has been considered a new pandemic strain of *Salmonella* in Europe, typically showing resistance to four antimicrobials (ampicillin, streptomycin, sulfonamides and tetracyclines) (Mossong et al., 2007; Hopkins et al., 2010). Many isolates are genetically related and, of definitive phage types, DT120 or DT193 and have been detected in several European countries, with pigs considered the likely reservoir of infection. However, monophasic Typhimurium isolates belonging to phage type U302 have also been previously detected in Spain; these isolates have commonly been found to express additional resistance to gentamicin and trimethoprim/sulfonamides and/or chloramphenicol (Echeita et al., 1999). In monophasic *S.* Typhimurium of phage types DT120 and DT193, the resistance genes appear to be located on a new resistance island and it seems that deletions of parts of this island in related strains of the organism account for differences in the observed ampicillin, streptomycin, sulfonamide and tetracycline pattern of resistance (Hopkins et al., 2010).

In this report, the *Salmonella* serovars considered as monophasic are *S.* 1,4,[5],12:i:-, *S.* 4,12:i:-, *S.* 4,5,12:i:- and those reported as '*S.* Typhimurium, monophasic'. In order to present a complete overview of the animal populations and food categories in which monophasic *S.* Typhimurium has been recovered, all reported data are presented in Table SA18. In general, very small numbers of isolates were tested, so the levels of resistance reported as proportions should be interpreted with caution and as a consequence of the small sample size might be subject to considerable variation. The results are presented for all monophasic *S.* Typhimurium isolates specifically reported as such by MSs. However, some MSs may have incorporated monophasic *S*. Typhimurium isolates within the *S.* Typhimurium group and therefore these data could not be captured in this analysis.

Of the five MSs reporting antimicrobial resistance in monophasic *Salmonella* serovars isolated from pigs and pig meat, only two MSs (Germany and Ireland) submitted sufficient data to meet the inclusion criteria. Germany reported extremely high levels of resistance to ampicillin (93 %), sulfonamides (93 %) and tetracyclines (92 %) and low levels of resistance to cefotaxime (3 %), chloramphenicol (3 %), ciprofloxacin (3 %) and gentamicin (2 %) among 212 isolates from pigs tested in relation to clinical investigations. Germany also tested 49 isolates from pig meat and reported extremely high levels of resistance to ampicillin, sulfonamides and tetracyclines (82 %, 78 % and 71 %, respectively) and low levels of resistance to chloramphenicol, ciprofloxacin, gentamicin and nalidixic acid (10 %, 4 %, 4 % and 2 %, respectively). Ireland tested 13 isolates of monophasic *S.* Typhimurium, from pig meat that was sampled in relation to HACCP (hazard analysis and critical control points) and its own checks and reported extremely high levels of resistance to ampicillin, sulfonamides and tetracyclines (92 % for all three antimicrobials) and no resistance to cefotaxime, chloramphenicol, ciprofloxacin, gentamicin or nalidixic acid. In the case of MSs submitting data that did not meet the inclusion criteria (fewer than 10 isolates submitted), reported resistance to ampicillin, sulfonamides and tetracyclines was very or extremely high. In most cases resistance to cefotaxime, chloramphenicol, ciprofloxacin, gentamicin and nalidixic acid was not found or was reported at a moderate level.

Five countries reported data on monophasic *S.* Typhimurium in *Gallus gallus* but all tested fewer than 10 isolates. Resistance was recorded to ampicillin, chloramphenicol, sulfonamides and tetracyclines. Germany also tested four isolates from meat from broilers and found all isolates to be resistant to ampicillin and sulfonamides and two isolates to be resistant to tetracyclines.

Four countries reported data on monophasic *S.* Typhimurium in cattle. Germany tested 79 isolates in relation to clinical investigations and reported very or extremely high levels of resistance to ampicillin (73 %), tetracyclines (65 %) and sulfonamides (76 %) and a low level of resistance to chloramphenicol (4 %). The Czech Republic, Ireland and Sweden reported data from two, five and three isolates, respectively, and found all isolates to be resistant to ampicillin, sulfonamides and tetracyclines. Germany also tested 14 isolates from meat from bovine animals and found all isolates to be resistant to ampicillin and sulfonamides and nine isolates (64 %) to be resistant to tetracyclines.

Resistance to the antimicrobials typically associated with monophasic *S.* Typhimurium (ampicillin, streptomycin, sulfonamides and tetracyclines) was high and consistent with that described in previous studies (Hopkins et al., 2010). Germany also reported isolates with resistance to chloramphenicol and gentamicin. Isolate-level data were not analysed for this report and so it is not possible to comment on the patterns of multi-resistance shown by isolates, but resistance to chloramphenicol and gentamicin has been shown by monophasic *S.* Typhimurium phage type U302 isolates from Spain. The detection of cefotaxime resistance in monophasic *S.* Typhimurium isolates in 2010 is an important finding, as this antimicrobial might be used to treat invasive human *Salmonella* infections. The 2009 report also mentioned that monophasic *S.* 4,12:i:- and 4,5,12:i:- resistant to third-generation cephalosporins were detected in pigs, *Gallus gallus* and cattle in several MSs.

***Table SA18. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among monophasic* Salmonella *Typhimurium from pigs, cattle and meat products thereof in 2010, using harmonised epidemiological cut-off values***

| Species | Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| *Gallus gallus* (fowl) | France | 3 | 100 | 3 | 0 | 3 | 33 | 3 | 0 | 3 | 0 | 3 | 0 | 3 | 100 | 3 | 100 |
| | Germany | 3 | 67 | 3 | 0 | 3 | 0 | 3 | 0 | 3 | 0 | 3 | 0 | 3 | 67 | 3 | 33 |
| | Italy | 2 | 100 | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 100 | 2 | 50 |
| | Sweden | 1 | 100 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 100 | 1 | 100 |
| | United Kingdom | 9 | 78 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 100 | 9 | 100 |
| **Total (5 MSs)** | | **18** | **83** | **18** | **0** | **18** | **6** | **18** | **0** | **18** | **0** | **18** | **0** | **18** | **94** | **18** | **83** |
| Pigs | Germany | 212 | 93 | 212 | 3 | 212 | 3 | 212 | 3 | 212 | 2 | 212 | 0 | 212 | 93 | 212 | 92 |
| | Ireland | 1 | 100 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 100 | 1 | 100 |
| | Italy | 5 | 100 | 5 | 0 | 5 | 20 | 5 | 40 | 5 | 20 | 5 | 40 | 5 | 80 | 5 | 100 |
| **Total (3 MSs)** | | **218** | **94** | **218** | **3** | **218** | **3** | **218** | **4** | **218** | **3** | **218** | **0.9** | **218** | **93** | **218** | **92** |
| Cattle (bovine animals) | Czech Republic | 2 | 100 | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 100 | 2 | 100 |
| | Germany | 79 | 73 | 79 | 0 | 79 | 4 | 79 | 0 | 79 | 0 | 79 | 0 | 79 | 76 | 79 | 65 |
| | Ireland | 5 | 100 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 100 | 5 | 100 |
| | Sweden | 3 | 100 | 3 | 0 | 3 | 0 | 3 | 0 | 3 | 0 | 3 | 0 | 3 | 100 | 3 | 100 |
| **Total (4 MSs)** | | **89** | **76** | **89** | **0** | **89** | **3** | **89** | **0** | **89** | **0** | **89** | **0** | **89** | **79** | **89** | **69** |

***Table SA18 (continued). Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among monophasic* Salmonella *Typhimurium from pigs, cattle and meat products thereof in 2010, using harmonised epidemiological cut-off values***

| Species | Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Meat from broilers (*Gallus gallus*) | Germany | 4 | 100 | 4 | 0 | 4 | 0 | 4 | 0 | 4 | 0 | 4 | 0 | 4 | 100 | 4 | 50 |
| **Total (1 MS)** | | **4** | **100** | **4** | **0** | **4** | **0** | **4** | **0** | **4** | **0** | **4** | **0** | **4** | **100** | **4** | **50** |
| Meat from pig | Czech Republic | 3 | 100 | 3 | 0 | 3 | 67 | 3 | 0 | 3 | 0 | 3 | 0 | 3 | 100 | 3 | 100 |
| | Germany | 49 | 82 | 49 | 0 | 49 | 10 | 49 | 4 | 49 | 4 | 49 | 2 | 49 | 78 | 49 | 71 |
| | Greece | 3 | 67 | 3 | 0 | 4 | 0 | 1 | 0 | 3 | 0 | 1 | 0 | 3 | 100 | 3 | 67 |
| | Ireland | 13 | 92 | 13 | 0 | 13 | 0 | 13 | 0 | 13 | 0 | 13 | 0 | 13 | 92 | 13 | 92 |
| **Total (4 MSs)** | | **68** | **84** | **68** | **0** | **69** | **10** | **66** | **3** | **68** | **3** | **66** | **2** | **68** | **82** | **68** | **77** |
| Meat from bovine animals | Czech Republic | 1 | 100 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 100 | 1 | 100 |
| | Germany | 14 | 100 | 14 | 0 | 14 | 0 | 14 | 0 | 14 | 0 | 14 | 0 | 14 | 100 | 14 | 64 |
| | Greece | 1 | 100 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 100 | 1 | 100 |
| **Total (3 MSs)** | | **16** | **100** | **16** | **0** | **16** | **0** | **16** | **0** | **16** | **0** | **16** | **0** | **16** | **100** | **16** | **69** |

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data based on testing of fewer than 10 isolates and data reported by fewer than four countries.

### Resistance levels in *S.* Java from *Gallus gallus*

The D-tartrate-fermenting variant of *S. enterica* subspecies *enterica* serovar Paratyphi B dT+ is commonly referred to as *S.* Java and two distinct clonal lines have been described – one frequently associated with aquaria, in particular tropical fish aquaria, and another associated with poultry. Strains associated with tropical fish commonly demonstrate resistance to ampicillin, chloramphenicol, streptomycin, sulfonamides and tetracyclines (Denny et al., 2007). Reports in Eurosurveillance show that in the Netherlands the proportion of *Salmonella* isolates in poultry accounted for by *S.* Java increased from less than 2 % prior to 1996 to 60 % in 2002. Despite likely exposure through the food chain, cases of *S.* Java infection in humans remain rare in the Netherlands (0.3 % of all *Salmonella* infections), although molecular typing has shown that 50 % of human isolates are identical to the poultry clone (van Pelt et al., 2003). The antimicrobial resistance monitoring report for the Netherlands for 2009 (MARAN, 2009) records that, of all ESBL-producing isolates, 22 (67 %) belonged to *S.* Java derived either from poultry or from an unspecified source.

In 2010, five MSs submitted data relating to antimicrobial resistance in *S.* Java from *Gallus gallus* (Table SA19); the United Kingdom and France each reported single isolates, which were susceptible to the core panel of antimicrobials tested. Austria reported data for two isolates, both of which were resistant to ampicillin, cefotaxime, ciprofloxacin, nalidixic acid, sulfonamides and tetracyclines. In total, only two MSs, Germany and the Netherlands, submitted information concerning 10 or more isolates and, therefore, meet the inclusion criteria. Both MSs reported very high to extremely high levels of resistance to nalidixic acid and ciprofloxacin, of 58 % to 96 %. Cefotaxime resistance was not detect in Germany, but was found in 8 % of isolates from the Netherlands. Considering ampicillin, sulfonamides and tetracyclines, isolates from Germany were less resistant (4 %, 13 %, 8 %, respectively) than isolates from the Netherlands (53 %, 55 %, 18 %, respectively). The Netherlands detected gentamicin resistance in 8 % of isolates; gentamicin resistance was not detected by the other reporting MSs.

The occurrence of resistance to cefotaxime recorded in the Netherlands national monitoring report was 23 % in 2009 (MARAN, 2009), whereas it was 8 % among isolates reported under the EFSA monitoring scheme in 2010. Although this serovar causes relatively few human infections, the occurrence of resistance to both ciprofloxacin and cefotaxime is likely to have treatment implications, since these antimicrobials may be used as the first-line treatments for human salmonellosis, where this is necessary. In addition, the Netherlands reported that 10 of 47 *S.* Java isolates from meat were resistant to colistin. Colistin can be used as one of the drugs of last resort in multi-resistant Gram-negative human infections and so this is also a potentially important finding.

### Resistance levels in *S.* Kentucky from poultry

Ireland recently reported the presence of *S.* Kentucky in broilers demonstrating resistance to third-generation cephalosporins (Boyle et al., 2010). Isolates were recovered from chicken neck skin, birds and broiler house dust samples, and affected broiler farms were stocked from one broiler breeder farm. The isolates were related at the molecular level to pan-susceptible *S.* Kentucky isolates from human, poultry and environmental sources. The cephalosporin resistant *S.* Kentucky isolates detected in Irish poultry possessed either an ESBL (SHV-12) or an AmpC (CMY2) enzyme. These isolates differ from those causing travel-associated *S.* Kentucky infections in humans, which generally show ESBL resistance through possession of CTX-M-1, as well as resistance to ciprofloxacin and trimethoprim/ sulfonamides (Collard et al., 2007).

However, isolates of *S.* Kentucky have also recently been described in turkeys, turkey neck skin and turkey products in Poland (Wasyl and Hoszowski 2012). In these Polish isolates, the most commonly observed resistance profile was ampicillin, streptomycin, sulfonamides, tetracyclines, gentamicin, nalidixic acid and ciprofloxacin, occurring in 68 % (49/72) of isolates. It was found that 89 % of the 72 isolates examined were resistant to both nalidixic acid and ciprofloxacin, with the unusual feature that the ciprofloxacin MIC was high at ≥ 8 mg/l in almost all resistant isolates. The most frequently observed pulsed-field gel electrophoresis (PFGE) pattern exhibited by the Polish *S.* Kentucky isolates was indistinguishable from that observed in *S.* Kentucky ST198 by Le Hello et al. (2011), who described the international spread of *S.* Kentucky ST198 resistant to ciprofloxacin in humans.

Five MSs reported results for *S.* Kentucky in *Gallus gallus* (Table SA20) and, of these, Austria, Slovakia and the United Kingdom reported only five, two and a single isolate, respectively. Interestingly, these isolates were susceptible to the panel of antimicrobials reported. Italy tested 28 isolates and found that 96 % were resistant to nalidixic acid and ciprofloxacin, but there was little resistance (7 %) to ampicillin, tetracyclines and sulfonamides. Ireland reported results for 19 isolates, of which 11 % were resistant to cefotaxime; none showed ciprofloxacin resistance. Two MSs reported results for *S.* Kentucky in turkeys and both detected extremely high levels of resistance to ampicillin, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines.

The isolates detected in animals do not show the same patterns of resistance as those reported in the literature as causing travel-associated infections in man, apart from the turkey isolates from the Czech Republic and Poland, which have a resistance pattern similar to that described in *S*. Kentucky ST198, a clone which is spreading internationally. These isolates were resistant to ciprofloxacin at ≥ 8 mg/l, reinforcing the usefulness of collecting quantitative data in the EU Monitoring Programme. A single Polish isolate was also resistant to cefotaxime, an important finding as ciprofloxacin and third-generation cephalosporins are important antimicrobials for the treatment of invasive salmonellosis in man (Le Hello et al., 2011; Wasyl and Hoszowski, 2012).

The reporting of quantitative data enables the results reported by MSs to be examined for ciprofloxacin resistance at ≥ 8 mg/l. However, because *S*. Kentucky is not always reported as a separate serovar in current reporting procedures, it is not currently possible to identify all of these isolates. The proposed change to isolate based data reporting will enable that analysis to be performed.

The EFSA monitoring suggests that pan-susceptible Kentucky as well as clones of Kentucky with resistance to third-generation cephalosporins (Ireland) or ciprofloxacin (Italy) are present in Europe. The limited data available for this serotype from other MSs may reflect the absence or a low prevalence of this serotype in these countries, or may just reflect the fact that this serotype was not reported separately by most MSs. The isolates detected in animals do not show the same patterns of resistance as those causing travel-associated infections in man.

***Table SA19. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Java*[1] *from* Gallus gallus *in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 2 | 100 | 2 | 100 | 2 | 0 | 2 | 100 | 2 | 0 | 2 | 100 | 2 | 100 | 2 | 100 |
| France | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| Germany | 24 | 4 | 24 | 0 | 24 | 0 | 24 | 96 | 24 | 0 | 24 | 96 | 24 | 13 | 24 | 8 |
| Netherlands | 60 | 53 | 60 | 8 | 60 | 2 | 60 | 62 | 60 | 8 | 60 | 58 | 60 | 55 | 60 | 18 |
| United Kingdom | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| **Total (5 MSs)** | **88** | **40** | **88** | **8** | **88** | **1** | **88** | **71** | **88** | **6** | **88** | **68** | **88** | **43** | **88** | **17** |

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: MSs reporting fewer than 10 isolates have been included.

1. *S.* Paratyphi B var. Java.

***Table SA20. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Kentucky from poultry in 2010, using harmonised epidemiological cut-off values***

| Species | Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| *Gallus gallus* | Austria | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 |
| | Ireland | 19 | 26 | 19 | 11 | 19 | 0 | 19 | 0 | 19 | 0 | 19 | 0 | 19 | 16 | 19 | 5 |
| | Italy | 28 | 7 | 28 | 0 | 28 | 0 | 28 | 96 | 28 | 0 | 28 | 96 | 28 | 7 | 28 | 7 |
| | Slovakia | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 0 |
| | United Kingdom | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 100 | 1 | 0 |
| **Total (5 MSs)** | | **55** | **13** | **55** | **4** | **55** | **0** | **55** | **49** | **55** | **0** | **55** | **49** | **55** | **11** | **55** | **6** |
| Turkeys | Czech Republic | 24 | 100 | 24 | 0 | 24 | 0 | 24 | 100 | 24 | 100 | 24 | 100 | 24 | 100 | 24 | 100 |
| | Poland | 26 | 96 | 26 | 4 | 26 | 4 | 26 | 100 | 26 | 92 | 26 | 100 | 26 | 92 | 26 | 92 |
| **Total (2 MSs)** | | **50** | **98** | **50** | **2** | **50** | **2** | **50** | **100** | **50** | **96** | **50** | **100** | **50** | **96** | **50** | **96** |

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data based on testing of fewer than 10 isolates and data reported by fewer than four countries. The turkey isolates from the Czech Republic and Poland were resistant to ciprofloxacin at ≥ 8 mg/l.

### Resistance levels in *S.* Saintpaul from turkeys

*Salmonella* Saintpaul was the fourth most frequently reported serovar in the baseline survey on the prevalence of *Salmonella* in turkey flocks, which was performed over a 1-year period in 2006–2007 (EFSA, 2008c). This serovar was detected in turkeys from 12 different countries in this survey; it is also reported as causing human cases of salmonellosis, and in 2006 it ranked in the top five causes of human salmonellosis in Europe (http://ecdc.europa.eu/en/publications/Pages/Surveillance_Reports.aspx).

In 2010, eight MSs submitted data regarding antimicrobial resistance among *S.* Saintpaul from turkeys (Table SA21). Data based on testing of fewer than 10 isolates or from fewer than four countries are included in this table. Germany tested 36 isolates but all other countries tested ≤ 15 isolates. In total, only four MSs, Austria, Germany, Italy and Poland, submitted information concerning ≥ 10 isolates and therefore met the inclusion criteria. All four MSs reported extremely high resistance against ampicillin, with an overall average level of resistance of 81 %, and resistance in the individual MSs ranging between 73 % (Austria) and 90 % (Italy). The overall resistance against sulfonamide and tetracyclines at the reporting MS group level was also extremely high, at 88 % and 78 %, respectively. The resistance levels in the individual MSs were slightly more variable than for ampicillin, ranging from 67 % (Poland) to 100 % (Italy) for sulfonamide and from 69 % (Germany) to 100 % (Italy) for tetracyclines. Thus, Italy had the highest resistance level for ampicillin, sulfonamides and tetracyclines, while Austria reported the same, comparatively low, resistance level for all three. There was also a high overall level of resistance to ciprofloxacin (49 %) and nalidixic acid (44 %). Italy reported the lowest level of resistance to both antimicrobials (10 %), while Austria reported the highest level of resistance to both (82 %). Unlike these two countries, Germany and Poland reported different levels of resistance for ciprofloxacin and nalidixic acid, respectively at 39 % and 36 %, in Germany and at 71 % and 60 %, in Poland. Regarding gentamicin, the overall level of resistance in the reporting MS group was high (26 %), although both Austria and Italy reported full sensitivity; Germany reported 50 % resistance while Poland reported 7 % resistance. Overall, there was a low level of resistance to chloramphenicol (4 %). Both Italy and Germany reported low levels of resistance (10 % and 6 %, respectively) whereas Austria and Poland reported no resistance. None of the four countries detected resistance against cefotaxime.

A study of *S.* Saintpaul isolates from turkeys in Germany (Beutlich et al., 2010) demonstrated that most isolates were resistant to ampicillin, streptomycin, sulfonamides and nalidixic acid, with full or intermediate resistance to gentamicin and ciprofloxacin (considering the antimicrobials included in this report). Gentamicin resistance was detected in 25 % of isolates in the study by Beutlich, similar to the figure of 26 % obtained in this EU monitoring programme. The fact that very similar isolates can be detected in turkeys, food products and humans strongly suggests that transmission occurs along the food chain (Beutlich et al., 2010).

***Table SA21. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Saintpaul from turkeys in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 11 | 73 | 11 | 0 | 11 | 0 | 11 | 82 | 11 | 0 | 11 | 82 | 11 | 73 | 11 | 73 |
| Germany | 36 | 78 | 36 | 0 | 36 | 6 | 36 | 39 | 36 | 50 | 36 | 36 | 36 | 97 | 36 | 69 |
| Italy | 10 | 90 | 10 | 0 | 10 | 10 | 10 | 10 | 10 | 0 | 10 | 10 | 10 | 100 | 10 | 100 |
| Poland | 15 | 87 | 15 | 0 | 15 | 0 | 17 | 71 | 15 | 7 | 15 | 60 | 15 | 67 | 15 | 87 |
| **Total (4 MSs[1])** | **72** | **81** | **72** | **0** | **72** | **4** | **74** | **49** | **72** | **26** | **72** | **44** | **72** | **88** | **72** | **78** |
| Czech Republic | 7 | 43 | 7 | 0 | 7 | 0 | 7 | 29 | 7 | 0 | 7 | 29 | 7 | 71 | 7 | 71 |
| Denmark | 1 | 100 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 100 | 1 | 100 |
| France | 6 | 67 | 6 | 0 | 6 | 33 | 6 | 0 | 6 | 0 | 6 | 0 | 6 | 67 | 6 | 83 |
| Slovakia | 9 | 100 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 89 | 9 | 89 |
| **Total (8 MSs)** | **95** | **79** | **95** | **0** | **95** | **5** | **95** | **40** | **95** | **20** | **95** | **36** | **95** | **85** | **95** | **79** |

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data based on testing of fewer than 10 isolates and data from fewer than four countries.

1. Four MSs reported more than 10 isolates.

## 3.4 Overview of the findings of antimicrobial resistance in *Salmonella* at reporting Member State group level, 2010

Figures SA31 and SA32 illustrate the resistance levels for the groups of MSs reporting quantitative MIC data in 2010. These data were not all derived from the same group of MSs, which needs to be considered when interpreting these figures. Broadly speaking, resistance levels in *S.* Typhimurium from *Gallus gallus* were higher than in *S.* Enteritidis from *Gallus gallus,* as was also observed in 2009. In terms of all *Salmonella* spp., resistance levels in isolates from broiler meat were similar to those in isolates from *Gallus gallus*. This represents a slight increase in resistance in isolates from *Gallus gallus* and a decrease in isolates from broiler meat compared with the levels reported in 2009. In general, resistance levels to tetracyclines, sulfonamides and ampicillin were higher in *Salmonella* isolated from turkeys, pigs and cattle than from *Gallus gallus*, whereas, for ciprofloxacin and nalidixic acid, the highest resistance was observed in turkeys and in *Gallus gallus.*

***Figure SA31. Resistance to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines in* Salmonella *spp., S. Enteritidis and S. Typhimurium from* Gallus gallus *and* Salmonella *spp. from meat from broilers at reporting Member State group level in 2010***

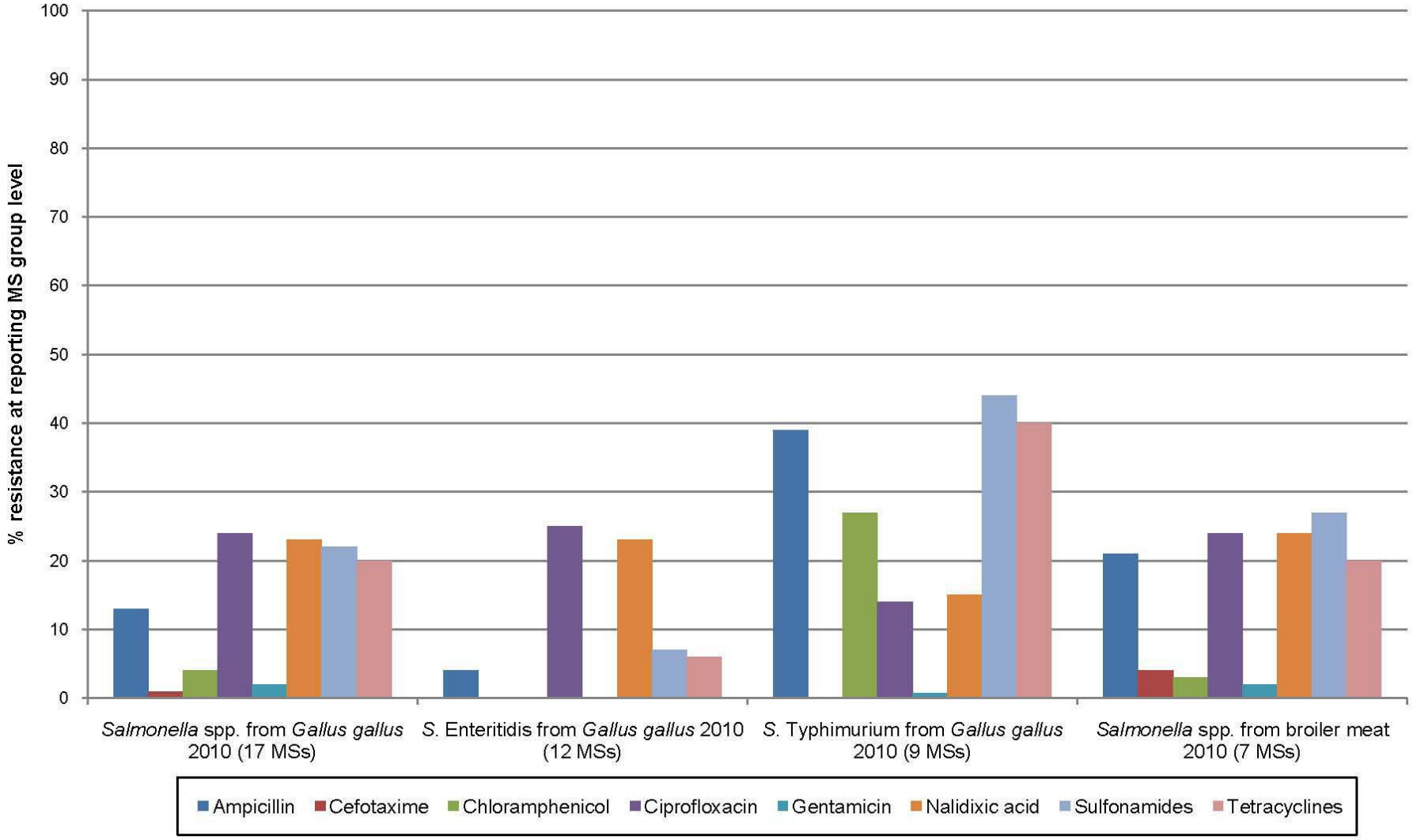
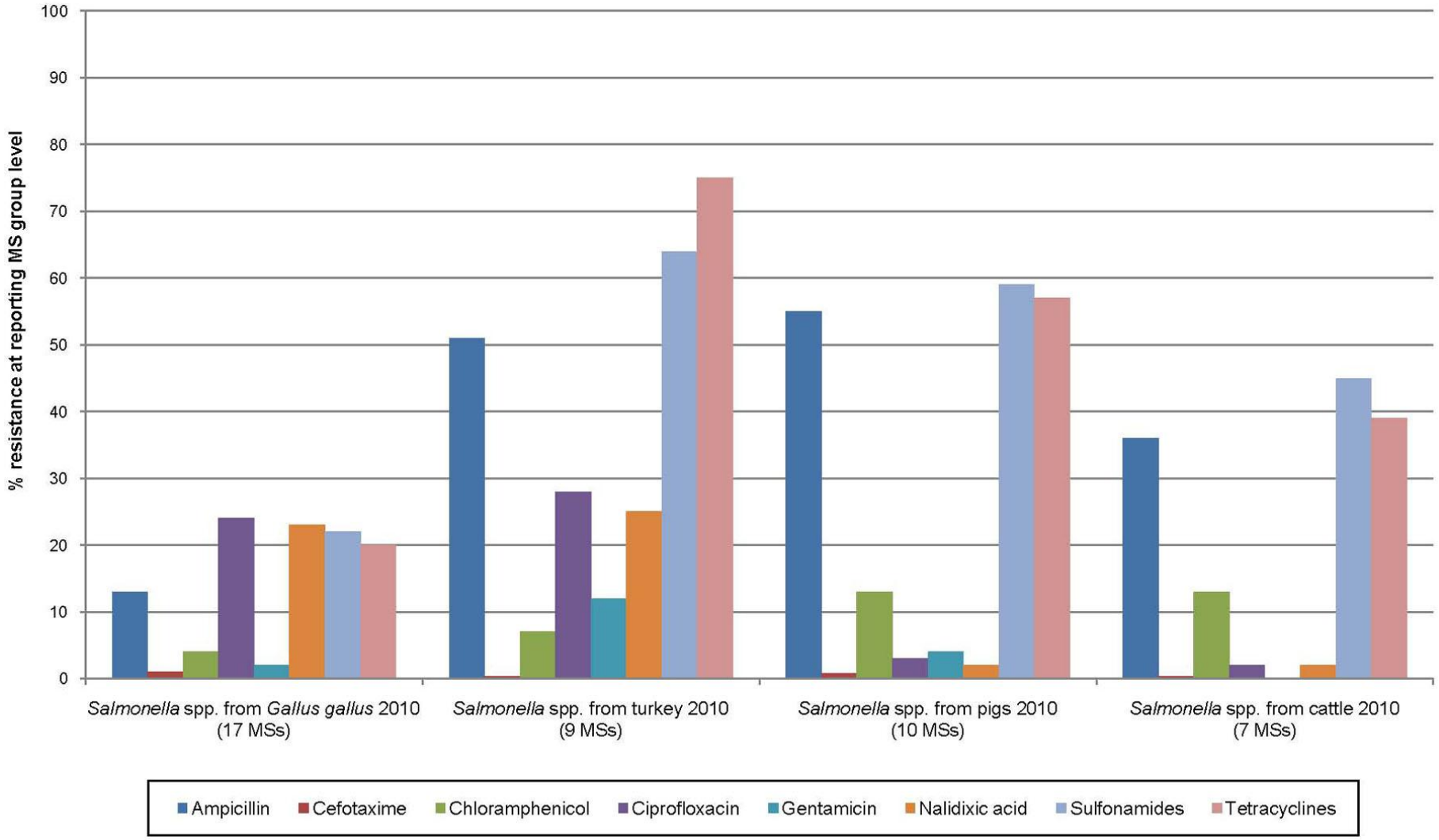


***Figure SA32. Resistance to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines in* Salmonella *spp. from* Gallus gallus*, turkey, pigs and cattle at reporting Member State group level in 2010***



## 3.5 Discussion

Salmonellosis continues to be the second most commonly reported zoonotic disease in humans in the EU, following campylobacteriosis for a number of years. However, the salmonellosis cases in humans is declining, with a trend that has been statistically significant over the period 2006–2010. This decrease is assumed to be mainly due to the reduction in *Salmonella* prevalence in poultry and in table eggs, most likely as a result of the national control programmes implemented by MSs (EFSA and ECDC, 2012). The occurrence of resistance in *Salmonella* isolates from humans within a MS tends to be influenced by factors including the proportion of isolates derived from imported foods or relating to foreign travel.

ECDC, EFSA and the European Medicines Agency (EMA), in a recent joint scientific opinion, identified resistance to quinolones (including fluoroquinolones) and resistance to cephalosporins (including third and fourth generations) in *Salmonella* as of major concern and most relevant for public health (EFSA, 2009b). The opinion is consistent with the World Health Organization (WHO) categorisation of Critically Important Antimicrobials (CIAs) for human medicine in which both of these antimicrobial groups are included.

In 2010, information on antimicrobial resistance in *Salmonella* isolates from human salmonellosis cases was reported by 19 MSs and one non-MS (Iceland). Data submitted by these countries represented isolates from around a quarter of the salmonellosis cases reported within the EU in 2010. Even though only a proportion of isolates are tested for antimicrobial susceptibility in most countries, MSs are actively encouraged to submit data in order to achieve better representativeness of the EU as a whole.

In the EU in 2010, resistance in *Salmonella* isolates from human salmonellosis cases was high for tetracyclines, ampicillin and sulfonamides. In contrast, resistance to the clinically important antimicrobials ciprofloxacin and cefotaxime was relatively low. Higher resistance rates for these antimicrobials were reported by the few countries using epidemiological cut-off values.

The highest resistance levels among *S.* Enteritidis from human isolates in 2010 were to nalidixic acid and ciprofloxacin; both of these antimicrobials belong to the quinolone class. Ciprofloxacin is the antimicrobial of choice for treatment of severe or invasive *Salmonella* infections in humans. Resistance to cefotaxime was generally low in the reporting MSs.

As in 2009, the highest level of resistance in *S.* Typhimurium from human isolates was reported for ampicillin, tetracyclines, sulfonamides and streptomycin. These are antimicrobials commonly used for treatment in human and animals. This year a separate section on monophasic *S.* Typhimurium is included in the report owing to the high prevalence of this serovar at EU level.

Information on antimicrobial resistance in *Salmonella* isolates from animals and meat was reported by 21 MSs and two non-MSs (Norway and Switzerland) in accordance with EFSA's recommendations (EFSA, 2007) in 2010. The quantitative (MIC) results obtained using the methods recommended by EFSA provide the most rigorously harmonised and comparable set of data for reporting MSs, and these data sets have therefore been analysed in detail.

Moderate to high levels of resistance to many antimicrobials were reported in *Salmonella* isolates from farm animals and meat by MSs by using the epidemiological cut-off values, particularly to antimicrobials such as ampicillin, tetracyclines and sulfonamides, which have been used therapeutically to treat the bacterial diseases of animals for many years. In 2009, resistance to ciprofloxacin was highest among *Salmonella* isolates from *Gallus gallus;* in the case of most of the other tested antimicrobials, resistance levels were higher in isolates from pigs, followed by isolates from cattle. The inclusion in 2010 of data on turkeys resulted in turkeys replacing *Gallus gallus* as the animal species in which *Salmonella* spp. with the highest levels of ciprofloxacin resistance were detected, followed by *Gallus gallus* and broiler meat. A number of reporting MSs showed increasing trends in ciprofloxacin and nalidixic acid resistance in *Salmonella* spp. isolates from *Gallus gallus* over the 2005–2010 period. Pigs, pig meat and cattle show low resistance levels when the figures for all reporting MSs are considered.

Resistance to third-generation cephalosporins was detected in *Salmonella* isolates from turkeys, *Gallus gallus*, pigs, cattle and the meat derived from broilers and pigs, but at low or very low levels when all reporting MSs were considered. However, some variability in resistance to third-generation cephalosporin was observed between different animals or meat of various origin in different MSs. Some MSs reported a decline in resistance to cefotaxime in *Salmonella* spp. from *Gallus gallus*. Data for *Salmonella* spp. reported here comprises the amalgamated results for all *Salmonella* serovars reported by a reporting MS for a different animal or food category. The relative contribution of different serovars possessing a particular resistance should ideally be considered when interpreting the results, in order to evaluate the influence of clonal dissemination of serovars. The proposed changes to isolate-based reporting will facilitate the evaluation of the results in this way. There are important differences in the occurrence and distribution of *Salmonella* serovars and phage types between different MSs and within different animal species, and because some *Salmonella* serovars, and phage types within such serovars, have particular patterns of antimicrobial resistance associated with them, clonal spread (i.e. spread of particular strains or clones) can influence the overall occurrence of resistance observed in an animal species.

Thus, antimicrobial resistance in certain *Salmonella* serovars and phage types may be related not only to the selective pressure exerted by the use of antimicrobials, but also to the clonal spread of these *Salmonella* serovars and phage types, and may also be influenced by factors such as animal movements.

The observed levels of resistance to ampicillin, chloramphenicol, streptomycin, sulfonamides and tetracyclines were much higher in *S*. Typhimurium than in *S.* Enteritidis isolates both from humans and from animals. This is likely because certain phage types of *S.* Typhimurium have an associated pattern of pentavalent resistance to these antimicrobials. Foremost among these in recent years has been *S.* Typhimurium DT104. In some MSs, *S.* Typhimurium DT104 is now declining in incidence and monophasic *S.* Typhimurium-like strains, in particular *S.* 1,4,[5],12:i:-, are emerging as the dominant serovar. These monophasic strains commonly, though not always, show resistance to ampicillin, streptomycin, sulfonamides and tetracyclines, and this is evident in the results for such isolates reported by MSs in 2010.

In 2010, for the first time, the MS-specific trends in resistant *Salmonella* isolates over the period 2005–2010 were analysed statistically. Some statistically significant increasing and decreasing trends were observed at MS-specific level. Generally, isolates from *Gallus gallus* showed more increasing trends than decreasing trends, whereas the opposite was observed for isolates from pigs. Among cattle isolates, the only significant trends observed were decreasing ones. Interestingly, in four MSs a significant increasing national trend in ciprofloxacin and/or nalidixic acid resistance could be identified in isolates from *Gallus gallus*, whereas in only one MS was there a significant decreasing trend in resistance to the same substances.

EFSA's proposal to collect antimicrobial resistance results from food and animals at isolate level will permit the data reported by MSs to be examined for particular resistance patterns and associations with particular *Salmonella* serovars. This will be an important and useful goal in the future as the surveillance programme is developed and enhanced.

# 4. ANTIMICROBIAL RESISTANCE IN *CAMPYLOBACTER*

## 4.1 Introduction

The *Campylobacter* species most commonly associated with human infection are *C. jejuni* followed by *C. coli* and *C. lari*, but other species are also known to cause human infection. The infective dose of these bacteria is generally low.

The incubation period in humans ranges from 2 to 5 days. Patients may experience mild to severe symptoms, commonly including watery, sometimes bloody diarrhoea, abdominal pain, fever, headache and nausea. Infections are usually self-limiting and last only a few days; treatment with antimicrobials is therefore usually not required. Extra-intestinal infections, invasive infections or post-infection complications such as reactive arthritis and neurological disorders can occur but these are infrequent. *C. jejuni* is a recognised antecedent cause of Guillain–Barré syndrome, a form of paralysis that can sometimes result in dysfunction of the respiratory and neurological systems and can even be fatal.

Thermophilic *Campylobacter* species are widespread in nature. The primary reservoirs are the alimentary tract of birds and mammals including food-producing animals (poultry, cattle, pigs and sheep). *Campylobacter* species have been isolated from pet animals, including cats and dogs, from wild birds, from water and from various environmental samples. Clinical disease resulting from infection with thermotolerant *Campylobacter* species is rare in animals.

*Campylobacter* can readily contaminate various food-stuffs including meat, raw milk and dairy products and less frequently fish and fish products, mussels and fresh vegetables. In the case of sporadic human cases, contact with live poultry, consumption of poultry meat, drinking water from untreated water sources and contact with pets and other animals have been identified as significant and major sources of infection. Raw milk and drinking water contaminated with *Campylobacter* have caused large outbreaks.

## 4.2 Antimicrobial resistance in *Campylobacter* isolates from humans

### 4.2.1 Antimicrobial resistance in *Campylobacter* spp. in humans

Thirteen MSs and one non-MS (Iceland) submitted data on the antimicrobial susceptibility of *Campylobacter* spp. isolates from human clinical cases to the ECDC for 2010. Twelve MSs and Iceland reported susceptibility results for more than 20 isolates and the data were included in the analyses. Large variation was observed among the reporting countries with regard to the number of antimicrobials tested, ranging from three countries testing for amoxicillin to all 13 countries testing for erythromycin (Table CA1). This most likely reflects the variation in the clinical importance of the antimicrobials, with the macrolide substance erythromycin bein the antimicrobial most commonly used in the treatment of severe campylobacteriosis, although fluoroquinolone antibiotics, such as ciprofloxacin, are also being increasingly used in many countries for this purpose. The maximum number of *Campylobacter* spp. isolates tested for susceptibility to different antibiotics was 34 838 or erythromycin, representing 16.4 % of the total number of confirmed cases of campylobacteriosis reported in 25 countries in EU (n = 212 402) (EFSA and ECDC, 2012).

The method of testing for antimicrobial susceptibility, and criteria for when to test, varied markedly between countries. In several countries, the reference laboratories type only a fraction of isolates. The remaining isolates are typed by hospital or local laboratories and the methods used by these are not reported. The guidelines used for the methodology and interpretation of antimicrobial susceptibility testing for *Campylobacter* differed substantially between countries and also within countries for different antimicrobials (for detailed information, see Chapter 11, Materials and methods, Table MM2). The guidelines used by several countries were from the Clinical and Laboratory Standards Institute (CLSI) and the French Society for Microbiology (CA-SFM). The results must therefore be interpreted with caution and no direct comparison between countries should be made.

The highest frequency of resistance in all *Campylobacter* spp. isolates tested was observed for nalidixic acid (44.2 %; N = 18 611), followed by ciprofloxacin (42.2 %; N = 34 673) and ampicillin (30.0 %; N = 5 887) (Table CA1). *Campylobacter jejuni* and *C. coli* were the most commonly reported *Campylobacter* spp. in reporting MSs in 2010, with 75 796 and 4 927 reported human cases, respectively. Results for antimicrobial resistance are presented separately for these two *Campylobacter* species.

### 4.2.2 Antimicrobial resistance in *C. jejuni* in humans

The highest frequencies of resistance in *C. jejuni* isolates were observed for ciprofloxacin (51.6 %; N = 9 728) and nalidixic acid (49.8 %; N = 5 278) (Table CA2). Ciprofloxacin is the second-choice drug for treatment of campylobacteriosis in humans although resistance evolves rapidly. The resistance to ciprofloxacin reported in each country was high to extremely high, ranging from 42.5 % to 72.4 % in the EU. Malta and Italy observed the highest level of resistance among reporting countries, at 72.4 % and 64.9 %, respectively (Table CA2).

Nalidixic acid is normally used as an indicator of ciprofloxacin resistance. The correlation between resistance for nalidixic acid and ciprofloxacin was good in the six countries reporting high levels of resistance (> 50 % of isolates) to nalidixic acid (Austria, Italy, Luxembourg and Slovenia) ranging from 55.3 % to 64.1 % (Table CA2), although the standards used differed between countries.

Erythromycin or another suitable macrolide is the first-choice drug for the treatment of campylobacteriosis in humans. In 2010, the level of resistance for erythromycin reported in humans was low, on average 1.7 % (N = 8 969). In the EU, the highest proportions of resistant isolates were reported by Malta, with 10.2 % (N = 127), and the United Kingdom, with 5.4 % (N = 222) (Table CA2), both applying sensitive breakpoints for resistance to this drug (see Table MM2).

Data for country-specific trends for ciprofloxacin and erythromycin over the years 2008 to 2010 were only available from only six and seven countries (Estonia, Lithuania, Italy, Malta, the Netherlands, Slovenia, and the United Kingdom), respectively. resistance to ciprofloxacin was fairly stable in all six countries over these three years (Figures CA1 and CA2). In contrast to *Salmonella*, the breakpoints used for MIC determination for ciprofloxacin for *Campylobacter* differed by a maximum of only two dilutions among the six countries. The disc diffusion zones used in five countries were also comparable, with the exception of one country (Italy) assigning a more sensitive breakpoint for resistance to ciprofloxacin.

For erythromycin, the trends were rather stable except for Malta where an increase was observed over the years from 0 % (N = 134) in 2008 and 2009 to 10.2 % (N = 127) in 2010 (Figure CA2). This might be a result of the increase in number of isolates tested, which was three times as high in 2010 as 2008.

### 4.2.3 Antimicrobial resistance in *C. coli* in humans

The number of reported isolates of *C. coli* tested for antimicrobial susceptibility in 2010, out of the 4 927 confirmed reported human cases due to *C. coli* in the EU, varied from 370 tested for tetracyclines to 1 163 tested for ciprofloxacin (EFSA and ECDC, 2012) (Table CA3). In 2010, nine MSs reported data on antimicrobial resistance on ≥ 20 isolates (used as limit for presenting the data) of *C. coli* and, since not all isolates were tested for all antimicrobials, the information available varied from two MSs for amoxicillin and ampicillin to nine MSs for ciprofloxacin (Table CA3).

The highest percentage of resistance among *C. coli* isolates was observed for nalidixic acid (69.0 %; N = 751) followed by ciprofloxacin (66.0 %; N = 1 163) and tetracycline (32.2 %; N = 370) (Table CA3). The percentage of resistance to ciprofloxacin was highly correlated with resistance to nalidixic acid in each of the four countries that tested both antimicrobials. Overall resistance of *C. coli* to ciprofloxacin in the EU was 66.0 %.

The percentage of human *C. coli* isolates resistant to erythromycin was 11 % (N = 1 099) and to gentamicin only 0.1 % (N = 698) (Table CA3). The highest resistance to erythromycin was reported from Italy (33.3 %; N = 27) and France (14.3 %; N = 581), but the numbers of tested isolates were low, particularly in Italy.

Data enabling country-specific trends over the years 2008 to 2010 to be identified were available from only three countries (Italy, the Netherlands and Slovenia) for ciprofloxacin and from only two countries (the Netherlands and Slovenia) for erythromycin. Resistance to ciprofloxacin in *C. coli* was similar to that in *C. jejuni* in the Netherlands and Slovenia but much higher in Italy. A steady increase in resistance was observed in Italy over these 3 years, whereas in Slovenia a noticeable decrease was observed in 2009 (Figure CA3). Resistance to erythromycin in *C. coli* was steady but compared with resistance in *C. jejuni* was slightly higher in both reporting countries, except in Slovenia in 2010, when 0 % resistance was reported. This could be due to the small sample size for *C. coli*. In 2008–2010, the number of isolates of *C. coli* tested for erythromycin resistance (N = 201–270) was small compared with the number of *C. jejuni* isolates tested (N = 2 527–3 465) (Figure CA4).

***Table CA1. Antimicrobial resistance in* Campylobacter *spp. from humans by Member State in 2010, TESSy data***

| Country | Amoxicillin | | Ampicillin | | Ciprofloxacin | | Erythromycin | | Gentamicin | | Nalidixic acid | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % R | N | % R | N | % R | N | % R | N | % R | N | % R | N | % R |
| Austria | 225 | 15.6 | 212 | 50.0 | 1,363 | 56.4 | 949 | 2.63 | 24 | 12.5 | 614 | 61.7 | 1,290 | 25.5 |
| Estonia | - | - | - | - | 186 | 45.7 | 187 | 0 | - | - | 32 | 31.3 | 127 | 20.5 |
| France | 4,038 | 0.1 | 4,037 | 25.2 | 4,038 | 48.0 | 4,038 | 2.8 | 4,038 | 0.1 | 4,037 | 51.3 | - | - |
| Italy | - | - | 53 | 58.5 | 257 | 67.7 | 271 | 7.0 | 233 | 3.0 | 77 | 63.6 | 252 | 51.6 |
| Lithuania | 8 | NA | - | - | 412 | 64.8 | 453 | 0 | - | - | - | - | - | - |
| Luxembourg | - | - | - | - | 583 | 55.1 | 595 | 4.5 | - | - | 595 | 56.5 | - | - |
| Malta | - | - | - | - | 174 | 71.3 | 175 | 8.6 | - | - | - | - | - | - |
| Netherlands | - | - | - | - | 3,475 | 52.4 | 3,017 | 2.5 | - | - | - | - | 2,014 | 18.3 |
| Romania | - | - | - | - | 80 | 56.3 | 80 | 1.3 | 80 | 0 | 80 | 58.8 | 80 | 30.0 |
| Slovakia | - | - | 183 | 6.0 | 684 | 27.3 | 867 | 0.4 | - | - | - | - | 846 | 6.4 |
| Slovenia | 771 | 6.9 | 1,022 | 34.7 | 1,022 | 61.6 | 1,022 | 2.5 | 1,022 | 0.8 | 771 | 58.5 | 1,022 | 18.3 |
| United Kingdom | - | - | 380 | 63.4 | 22,399 | 36.9 | 23,184 | 2.9 | 814 | 1.1 | 12,405 | 39.3 | 1,105 | 37.5 |
| **EU Total** | **5,042** | **1.8** | **5,887** | **30.0** | **34,673** | **42.2** | **34,838** | **2.8** | **6,211** | **0.5** | **18,611** | **44.2** | **6,736** | **22.8** |
| Iceland | - | - | - | - | 55 | 36.4 | 55 | 5.5 | - | - | - | - | - | - |

Note: NA = not applicable: Whenever there are fewer than 20 isolates tested, resistance levels are not calculated.

***Table CA2. Antimicrobial resistance in* Campylobacter jejuni *from humans by Member State in 2010, TESSy data***

| Country | Amoxicillin | | Ampicillin | | Ciprofloxacin | | Erythromycin | | Gentamicin | | Nalidixic acid | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % R | N | % R | N | % R | N | % R | N | % R | N | % R | N | % R |
| Austria | 156 | 19.9 | 190 | 50.5 | 1,120 | 53.9 | 668 | 1.1 | - | - | 560 | 59.8 | 1,038 | 24.5 |
| Estonia | - | - | - | - | 177 | 45.8 | 178 | 0 | - | - | 31 | 32.3 | 120 | 20.8 |
| France | 3,275 | 0 | 3,274 | 25.9 | 3,275 | 45.7 | 3,275 | 0.4 | 3,275 | 0.1 | 3,274 | 45.9 | - | - |
| Italy | - | - | 40 | 55.0 | 208 | 64.9 | 227 | 3.5 | 187 | 2.1 | 64 | 64.1 | 207 | 49.3 |
| Lithuania | - | - | - | - | 258 | 62.8 | 279 | 0 | - | - | - | - | - | - |
| Luxembourg | - | - | - | - | 513 | 53.8 | 528 | 3.6 | - | - | 528 | 55.3 | - | - |
| Malta | - | - | - | - | 127 | 72.4 | 127 | 10.2 | - | - | - | - | - | - |
| Netherlands | - | - | - | - | 2,977 | 51.8 | 2,552 | 2.0 | - | - | - | - | 1,678 | 15.4 |
| Romania | - | - | - | - | - | - | - | - | - | - | 15 | NA | - | - |
| Slovenia | 698 | 6.9 | 913 | 40.0 | 913 | 62.7 | 913 | 2.5 | 913 | 0.9 | 698 | 57.7 | 913 | 19.1 |
| United Kingdom | - | - | - | - | 160 | 42.5 | 222 | 5.4 | - | - | 108 | 33.3 | - | - |
| **EU Total** | **4,129** | **1.9** | **4,417** | **29.4** | **9,728** | **51.6** | **8,969** | **1.7** | **4,375** | **0.3** | **5,278** | **49.8** | **3,956** | **20.6** |
| Iceland | - | - | - | - | 54 | 37.0 | 54 | 5.6 | - | - | - | - | - | - |

Note: NA = not applicable: Whenever there are fewer than 20 isolates tested, resistance levels are not calculated.

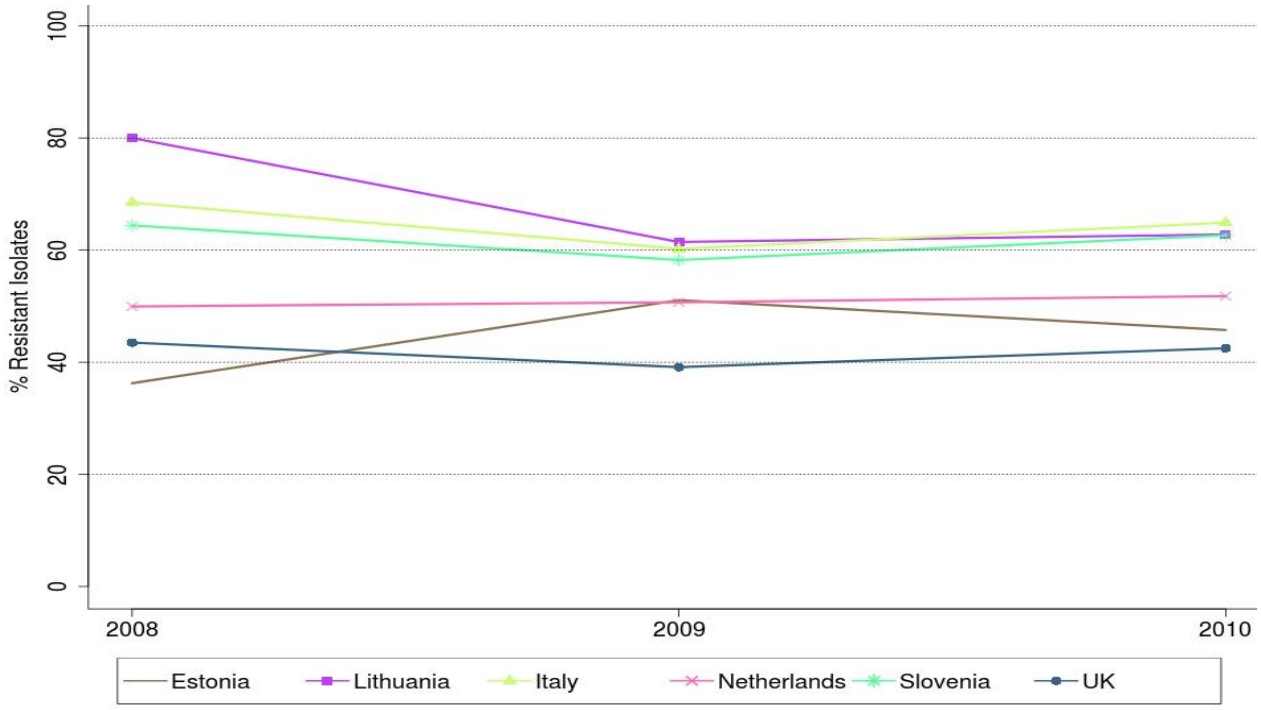
***Table CA3. Antimicrobial resistance in* Campylobacter coli *from humans by Member State in 2010, TESSy data***

| Country | Amoxicillin | | Ampicillin | | Ciprofloxacin | | Erythromycin | | Gentamicin | | Nalidixic acid | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % R | N | % R | N | % R | N | % R | N | % R | N | % R | N | % R |
| Austria | - | - | - | - | 99 | 73.7 | 76 | 4.0 | - | - | 34 | 70.6 | 94 | 33.0 |
| France | 581 | 0 | 581 | 34.0 | 581 | 71.1 | 581 | 14.3 | 581 | 0.2 | 581 | 71.3 | - | - |
| Italy | - | - | - | - | 30 | 86.7 | 27 | 33.3 | 28 | 0 | - | - | 26 | 61.5 |
| Lithuania | - | - | - | - | 29 | 82.8 | 35 | 0 | - | - | - | - | - | - |
| Luxembourg | - | - | - | - | 67 | 65.7 | 67 | 11.9 | - | - | 67 | 65.7 | - | - |
| Malta | - | - | - | - | 19 | NA | - | - | - | - | - | - | - | - |
| Netherlands | - | - | - | - | 249 | 53.0 | 224 | 7.6 | - | - | - | - | 161 | 32.9 |
| Romania | - | - | - | - | 43 | 37.2 | 43 | 2.3 | 43 | 0 | 43 | 41.9 | 43 | 25.6 |
| Slovenia | 26 | 4.2 | 46 | 44.4 | 46 | 56.5 | 46 | 0 | 46 | 0 | 26 | 69.2 | 46 | 17.4 |
| **EU Total** | **607** | **0.2** | **627** | **25.2** | **1,163** | **66.0** | **1,099** | **11.0** | **698** | **0.1** | **751** | **69.0** | **370** | **32.2** |

Note: NA = not applicable: Whenever there are fewer than 20 isolates tested, resistance levels are not calculated.

### *Figure CA1. Resistance to ciprofloxacin in* C. jejuni *in humans in reporting Member States in the EU, 2008–2010*

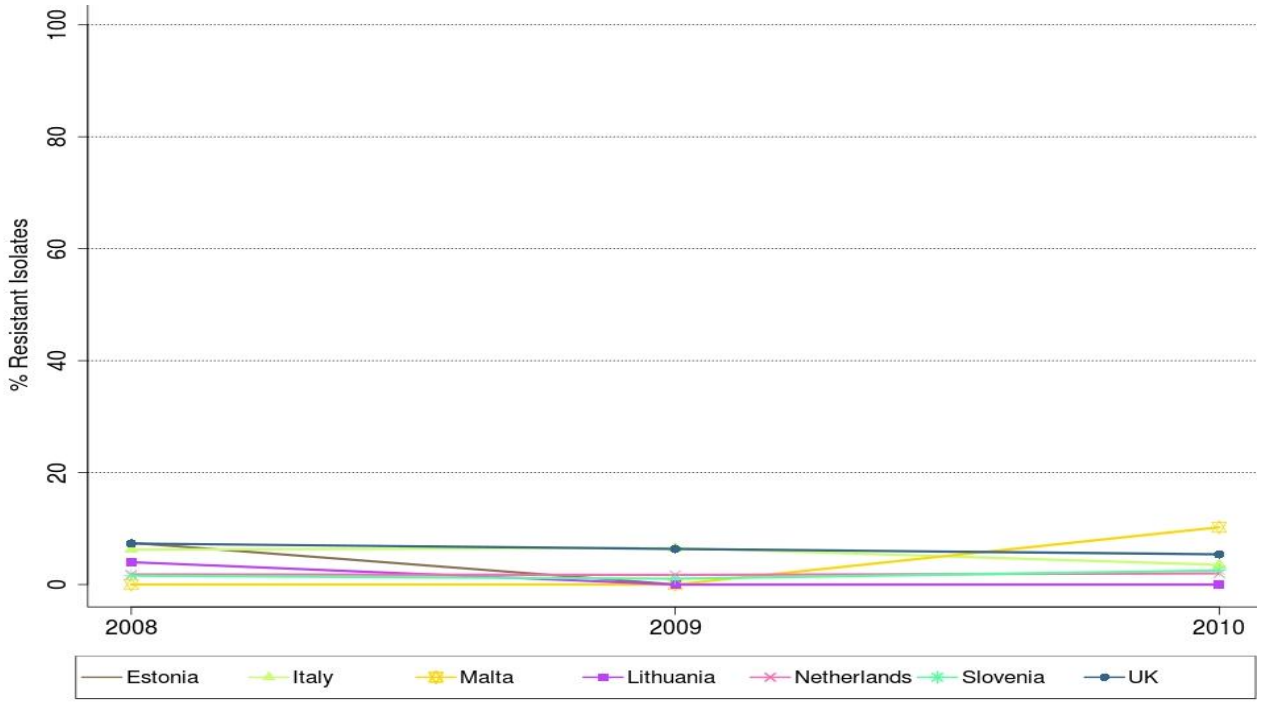
Direct comparisons between countries should be avoided owing to the use of different standards for testing[1]




[1] Guidelines used for AST: Estonia (CLSI dilution, SRGA-M disc diffusion), Lithuania (BSAC), Italy (CLSI), the Netherlands (unspecified), Slovenia (CLSI dilution, CA-SFM disc diffusion), the United Kingdom (modified BSAC). See also Table MM2.

### *Figure CA2. Resistance to erythromycin in* C. jejuni *in humans in reporting Member States in the EU, 2008–2010*

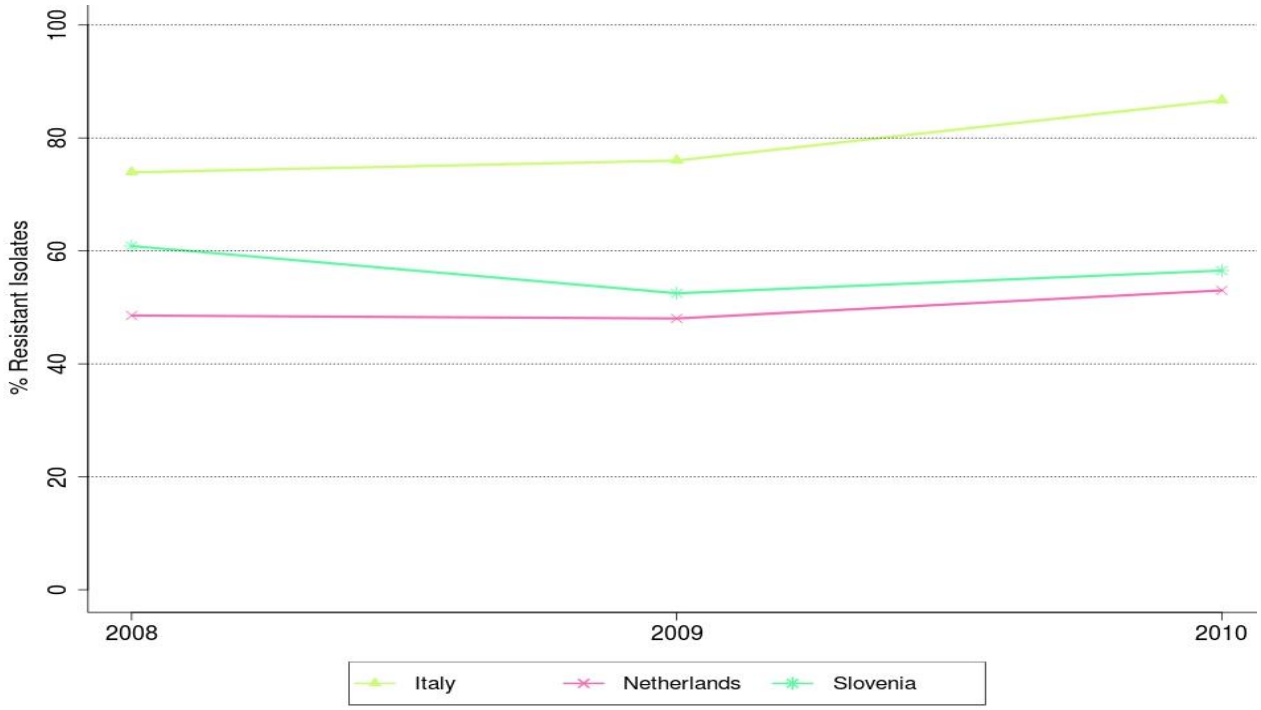
Direct comparisons between countries should be avoided owing to the use of different standards for testing[1]




[1] Guidelines used for AST: Estonia (SRGA-M), Lithuania (BSAC), Italy (CLSI), Malta (CA-SFM), the Netherlands (unspecified), Slovenia (CLSI dilution, CA-SFM disc diffusion), the United Kingdom (CLSI). See also Table MM2.

### *Figure CA3. Resistance to ciprofloxacin in* C. coli *in humans in reporting Member States in the EU, 2008–2010*

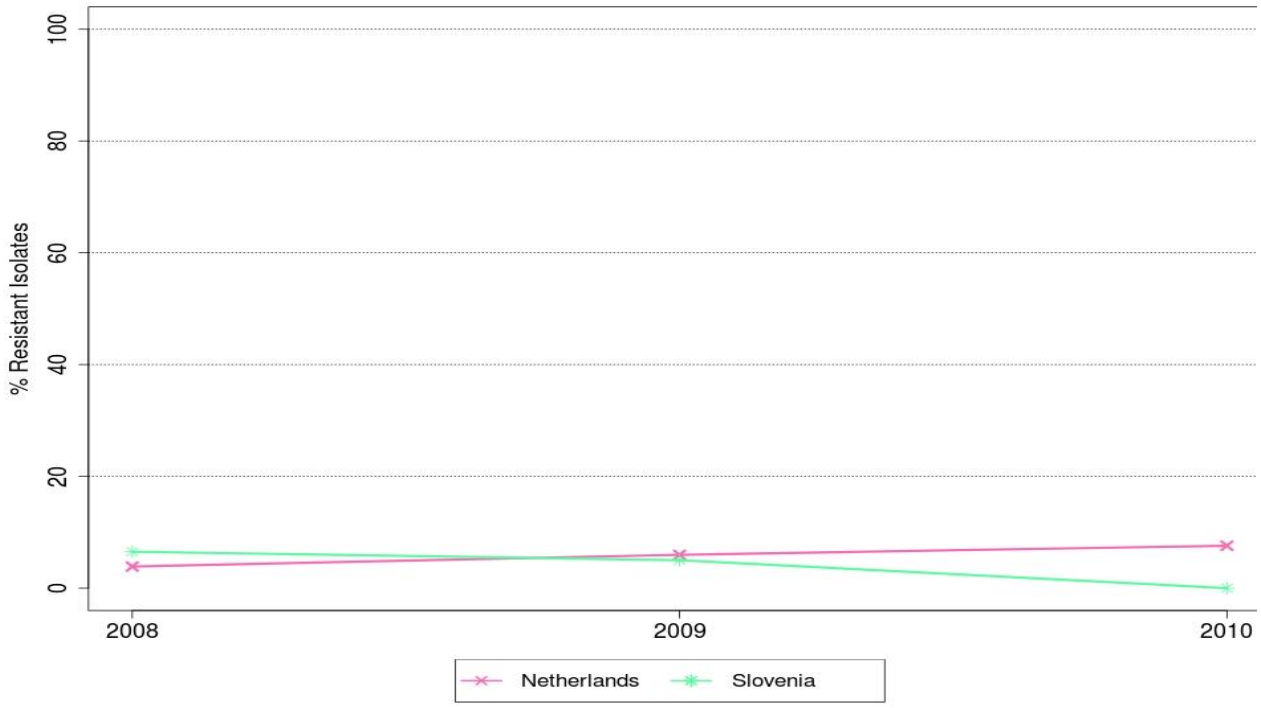
Direct comparisons between countries should be avoided owing to the use of different standards for testing[1]




[1] Guidelines used for AST: Italy (CLSI), the Netherlands (unspecified), Slovenia (CLSI dilution, CA-SFM disc diffusion). See also Table MM2.

### *Figure CA4. Resistance to erythromycin in* C. coli *in humans in reporting Member States in the EU, 2008–2010*

Direct comparisons between countries should be avoided owing to the use of different standards for testing[1]




[1] Guidelines used for AST: the Netherlands (unspecified), Slovenia (CLSI dilution, CA-SFM disc diffusion). See also Table MM2.

## 4.3 Antimicrobial resistance in *Campylobacter* isolates from animals and food

In total, 14 MSs and two non-MSs (Norway and Switzerland) reported data on antimicrobial resistance in *Campylobacter* isolates from animals and food. All quantitative *Campylobacter* data were reported as MIC values; in other words, no qualitative disc diffusion data were available for *Campylobacter* isolates in 2010. The total number of quantitative MIC tests performed on *Campylobacter* isolates from animals and food in 2010 by MSs and non-MSs was 35 669. Table CA4 presents the countries reporting *Campylobacter* MIC values, and the animal and food sampling origins, in 2010.

***Table CA4. Overview of countries reporting antimicrobial data using MIC on* Campylobacter jejuni *and* Campylobacter coli *from animals and food in 2010***

| Bacterial species | Origin | Total number of MSs reporting | Countries |
|---|---|---|---|
| *C. coli* | *Gallus gallus* (fowl) | 5 | **MSs:** AT, ES, FR, HU, NL |
| | | | **Non-MS:** CH |
| | Pigs | 6 | **MSs:** DK, ES, FI, HU, NL, PL |
| | | | **Non-MS:** CH |
| | Cattle (bovine animals) | 5 | **MSs:** AT, ES, HU, NL, PL |
| | | | **Non-MS:** CH |
| | Meat from broilers (*Gallus gallus*) | 7 | **MSs:** AT, BE, DK, IE, NL, PL, PT |
| | Meat from pig | 1 | **MS:** BE |
| *C. jejuni* | *Gallus gallus* (fowl) | 9 | **MSs:** AT, DK, ES, FI, FR, HU, NL, SE, SI |
| | | | **Non-MS:** CH |
| | Pigs | 2 | **MSs:** HU, PL |
| | Cattle (bovine animals) | 6 | **MSs:** AT, DK, ES, HU, NL, PL |
| | | | **Non-MSs:** CH, NO |
| | Meat from broilers (*Gallus gallus*) | 9 | **MSs:** AT, BE, DK, EE, IE, NL, PL, PT, SI |
| | Meat from pig | 1 | **MS:** BE |

Antimicrobials selected by the different MSs and non-MSs for susceptibility testing of *C. jejuni* and *C. coli* are shown in Chapter 11 Materials and Methods, Table MM6. In this chapter, resistance to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines is described in detail. Tables were generated if four or more countries reported quantitative data for a given *Campylobacter* species and sampling origin. In addition, data are included in the report only if based on findings from 10 or more isolates per country, per sampling origin, per year.

Where the minimum criteria were met, temporal trend graphs were generated, showing percentage resistance to different antimicrobials for *Campylobacter* isolates from animals and food over the period 2005–2010, by year of sampling. Only countries that reported three or more years in the period 2005–2010 were included. In the particular case of quinolones, such as ciprofloxacin and nalidixic acid, in the light of the known correlation between resistance to one and decreased susceptibility to the other agent, temporal trends are illustrated with trellis graphs combining data on these two antimicrobial substances.

The spatial distributions of ciprofloxacin, erythromycin and tetracycline resistance rates in *C. jejuni* and *C. coli* from *Gallus gallus* and of ciprofloxacin and erythromycin resistance rates in *C. coli* from pigs are presented. In the case of countries for which resistance level figures for 2010 were not available, 2009 figures were used instead. The number of countries reporting data for cattle was lower than the number reporting data for other animal species and, therefore, no spatial distribution maps for cattle were generated.

Further information on reported MIC distributions and numbers of resistant isolates to ciprofloxacin, chloramphenicol, erythromycin, gentamicin, nalidixic acid, streptomycin and tetracyclines for *C. jejuni* and *C. coli* can be found on the level 3 tables published on the EFSA website.

## 4.3.1 Antimicrobial resistance in *Campylobacter* isolates from food

### 4.3.1.1 Meat from broilers (*Gallus gallus*)

In reporting MSs, data on antimicrobial resistance in *Campylobacter* isolates from meat from broilers were derived from active monitoring programmes based on the random collection of samples of broiler meat performed at the slaughterhouse, at the processing plant or at retail outlets. For instance, in Poland and Slovenia, sampling of broiler meat was performed at processing plants, while in Denmark sampling was carried out at wholesale or retail outlets. In Belgium, *Campylobacter* isolates derived from carcasses (neck skin samples) were collected at the slaughterhouse and isolates from fresh meat and meat preparations were collected at the processing plant. In Ireland, neck skin samples were collected from carcasses at the slaughterhouse.

#### Resistance levels among *C. jejuni*

For 2010, quantitative antimicrobial resistance data for *C. jejuni* isolates from broiler meat were provided by seven MSs (Table CA5).

Resistance to tetracyclines was 22 % in the reporting MS group overall, with the lowest reported resistance being in the Netherlands (10 %) and the highest in Slovenia (55 %). Among the seven MSs reporting information on resistance to gentamicin, only Belgium reported any resistance, at a level of 2 %.

For all reporting MSs, the highest proportion of resistance observed was to ciprofloxacin and nalidixic acid, at 50 % and 48 %, respectively, and with some variability among the reporting MSs. In general, the levels of resistance to ciprofloxacin reported by MSs were moderate to high, and similar to those reported for nalidixic acid, with the exception of Austria and Slovenia, which reported resistance to nalidixic acid of 44 % and 50 %, respectively, compared with 69 % and 78 %, respectively, for ciprofloxacin. Where mutations in the *gyr*A or *par*C genes are responsible for quinolone resistance, this mechanism of resistance usually confers resistance to both quinolones and fluoroquinolones in *Campylobacter.* Because this is the commonest mechanism of resistance, the level of resistance to nalidixic acid and ciprofloxacin is generally similar for a given group of isolates. Resistance levels against erythromycin were overall low (2 %) in the reporting MSs, ranging from 0 % in Austria, Poland and Slovenia to 4 % in Belgium.

***Table CA5. Resistance (%) to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines among* Campylobacter jejuni *from meat from broilers in MSs reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ciprofloxacin | | Erythromycin | | Gentamicin | | Nalidixic acid | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 16 | 69 | 16 | 0 | 16 | 0 | 16 | 44 | 16 | 31 |
| Belgium | 274 | 43 | 274 | 4 | 274 | 2 | 274 | 47 | 274 | 45 |
| Denmark | 52 | 17 | 52 | 2 | 52 | 0 | 52 | 14 | 52 | 12 |
| Ireland | 51 | 27 | 51 | 2 | 51 | 0 | 51 | 28 | 51 | 39 |
| Netherlands | 171 | 56 | 171 | 0.6 | 171 | 0 | 171 | 56 | 801 | 10 |
| Poland | 46 | 83 | 46 | 0 | 46 | 0 | 46 | 80 | 46 | 46 |
| Slovenia | 60 | 78 | 60 | 0 | 60 | 0 | 60 | 50 | 60 | 55 |
| **Total (7 MSs)** | **670** | **50** | **670** | **2** | **670** | **0.7** | **670** | **48** | **1,300** | **22** |

N = number of isolates tested.

% Res = percentage of resistant isolates.

### Resistance levels among *C. coli*

For 2010, quantitative antimicrobial resistance data for *C. coli* isolates from broiler meat were provided by six MSs (Table CA6).

Overall, resistance to tetracyclines in the reporting MS group was 62 %, with the resistance level in individual countries ranging from 29 % in Ireland to 84 % in the Netherlands. No resistance to gentamicin was detected in the reporting MSs in 2010.

The overall resistance to ciprofloxacin in the reporting MS group was extremely high (72 %), although with substantial disparities among the reporting countries, ranging from 0 % reported by Denmark up to 100 % reported by the Netherlands. Again, the observed resistance to ciprofloxacin was similar to the level of resistance to nalidixic acid (67 %). As regards resistance to erythromycin, overall in the reporting MSs, this was observed at moderate level (12 %), ranging from 0 % in Austria, Denmark and Poland to 39 % in the Netherlands.

***Table CA6. Resistance (%) to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines among* Campylobacter coli *from meat from broilers in Member States reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ciprofloxacin | | Erythromycin | | Gentamicin | | Nalidixic acid | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 24 | 79 | 24 | 0 | 24 | 0 | 24 | 79 | 24 | 67 |
| Belgium | 118 | 69 | 118 | 18 | 118 | 0 | 118 | 63 | 118 | 74 |
| Denmark | 20 | 0 | 20 | 0 | 20 | 0 | 20 | 0 | 20 | 35 |
| Ireland | 70 | 56 | 70 | 1 | 70 | 0 | 70 | 56 | 70 | 29 |
| Netherlands | 50 | 100 | 61 | 39 | 61 | 0 | 49 | 78 | 61 | 84 |
| Poland | 81 | 90 | 81 | 0 | 81 | 0 | 81 | 90 | 81 | 62 |
| **Total (6 MSs)** | **363** | **72** | **374** | **12** | **374** | **0** | **362** | **67** | **374** | **62** |

N = number of isolates tested.

% Res = percentage of resistant isolates.

## 4.3.2 Antimicrobial resistance in *Campylobacter* isolates from animals

### 4.3.2.1 Fowl (*Gallus gallus*)

In this section, data on antimicrobial resistence in *Campylobacter* isolates from fowl (*Gallus gallus*) include data from broiler flocks. In all reporting MSs, active monitoring programmes were based on random sampling of healthy broiler chicken carcasses at the slaughterhouse. The sampling plan was generally stratified per slaughterhouse, the sample size per slaughterhouse being proportionate to the annual throughput of carcasses slaughtered. The sampling was evenly distributed throughout the year or a significant part of the year to account for a possible seasonal effect. Only one representative sample of caecal content per flock/batch, derived from either a unique carcass or a number of carcasses, was gathered to account for clustering. Only *C. jejuni* and *C. coli* were tested for susceptibility, all other *Campylobacter* species being excluded from the programme. Typically, given the relatively high prevalence of *Campylobacter* in broilers, representative subsets of *C. jejuni* and *C. coli* isolates recovered from caecal samples, each representing one flock, were randomly selected at the laboratory for susceptibility testing.

#### Resistance levels among *C. jejuni*

In 2010, quantitative data on *C. jejuni* from *Gallus gallus* were provided by nine MSs and one non-MS (Table CA7). The levels of resistance to ciprofloxacin, nalidixic acid and tetracyclines varied considerably between countries.

Considering the reporting MS group overall, the resistance level to tetracyclines was 32 % and, when Finland was excluded, tetracycline resistance was detected in all countries reporting results. Levels of tetracycline resistance were low to moderate in the remaining Nordic MSs and higher in the other reporting countries. As regards gentamicin, the level of resistance observed at the level of the reporting MS group overall was very low (0.8 %), and all reporting countries either did not detect resistance or recorded low to very low resistance.

Overall, high levels of resistance to ciprofloxacin and nalidixic acid were observed in the group of reporting MSs, at 47 % and 43 %, respectively. However, the occurrence of resistance to these two substances was highly variable among the reporting MSs, ranging from 92 % in Spain to 2 % in Finland for both ciprofloxacin and nalidixic acid. In most reporting MSs, the levels of resistance to ciprofloxacin and nalidixic acid were approximately the same, with the exception of Slovenia. Among the nine MSs reporting data on erythromycin, the overall level of resistance observed was very low, with only Spain detecting resistance, which was at a low level (6 %).

***Table CA7. Resistance (%) to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines among* Campylobacter jejuni *from* Gallus gallus *in countries reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ciprofloxacin | | Erythromycin | | Gentamicin | | Nalidixic acid | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 134 | 56 | 134 | 0 | 134 | 0 | 134 | 53 | 134 | 25 |
| Denmark | 41 | 20 | 41 | 0 | 41 | 0 | 41 | 17 | 41 | 17 |
| Finland | 84 | 2 | 84 | 0 | 84 | 1 | 84 | 2 | 84 | 0 |
| France | 49 | 51 | 49 | 0 | 49 | 0 | 49 | 49 | 49 | 63 |
| Hungary | 55 | 89 | 55 | 0 | 55 | 0 | 55 | 91 | 55 | 45 |
| Netherlands | 97 | 54 | 97 | 0 | 97 | 1 | 97 | 49 | 97 | 46 |
| Slovenia | 30 | 83 | 30 | 0 | 30 | 0 | 30 | 40 | 30 | 67 |
| Spain | 48 | 92 | 47 | 6 | 48 | 4 | 48 | 92 | 48 | 85 |
| Sweden | 100 | 21 | 100 | 0 | 100 | 1 | 100 | 18 | 100 | 2 |
| **Total (9 MSs)** | **638** | **47** | **637** | **0.5** | **638** | **0.8** | **638** | **43** | **638** | **32** |
| Switzerland | 107 | 29 | 107 | 0.9 | 107 | 0 | 107 | 30 | 107 | 17 |

N = number of isolates tested.

% Res = percentage of resistant isolates.

### Resistance levels among *C. coli*

In 2010, quantitative data on *C. coli* isolates from *Gallus gallus* from five MSs and one non-MS were included in the analysis (Table CA8).

Resistance to tetracyclines was high to extremely high, considering both the reporting MS group as a whole (73 %) and the reporting countries individually. Five MSs reported data for gentamicin, and the level of resistance in the reporting group was 8 %, varying between no resistance detected in Austria, France and the Netherlands and a high level recorded in Spain (25 %).

Considering the reporting MSs group, the overall levels of resistance to ciprofloxacin and nalidixic acid among *C. coli* were 84 % and 76 %, respectively and, therefore, extremely high. Among the individual reporting MSs, the levels of resistance to ciprofloxacin and nalidixic acid varied between 64 % and 100 % in 2010, a situation similar to what had been observed in 2009 and 2008. In most countries, the levels of resistance to ciprofloxacin and nalidixic acid were similar in isolates of *C. coli*, although in France resistance to nalidixic acid was slightly lower than that observed to ciprofloxacin. Spain did not report data on *C. coli* nalidixic acid resistance in *Gallus gallus* in 2010.

In the case of erythromycin, the overall level of resistance in *C. coli* was 15 %, higher than the value observed for erythromycin resistance in *C. jejuni* (0.5 %; see Table CA7). At the level of the individual MSs, resistance was not reported by Hungary, whereas the level of resistance observed was low in Austria and the Netherlands (9 % and 5 %, respectively), moderate in France (10 %) and high in Spain (34 %).

***Table CA8. Resistance (%) to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines among* Campylobacter coli *from* Gallus gallus *in countries reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ciprofloxacin | | Erythromycin | | Gentamicin | | Nalidixic acid | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 46 | 80 | 46 | 9 | 46 | 0 | 46 | 80 | 46 | 52 |
| France | 59 | 66 | 59 | 10 | 59 | 0 | 59 | 64 | 59 | 92 |
| Hungary | 41 | 83 | 41 | 0 | 41 | 2 | 41 | 83 | 41 | 41 |
| Netherlands | 21 | 86 | 21 | 5 | 21 | 0 | 21 | 86 | 21 | 52 |
| Spain | 76 | 100 | 76 | 34 | 76 | 25 | - | - | 76 | 95 |
| **Total (5 MSs)** | **243** | **84** | **243** | **15** | **243** | **8** | **167** | **76** | **243** | **73** |
| Switzerland | 19 | 47 | 19 | 11 | 19 | 0 | 19 | 47 | 19 | 37 |

N = number of isolates tested.

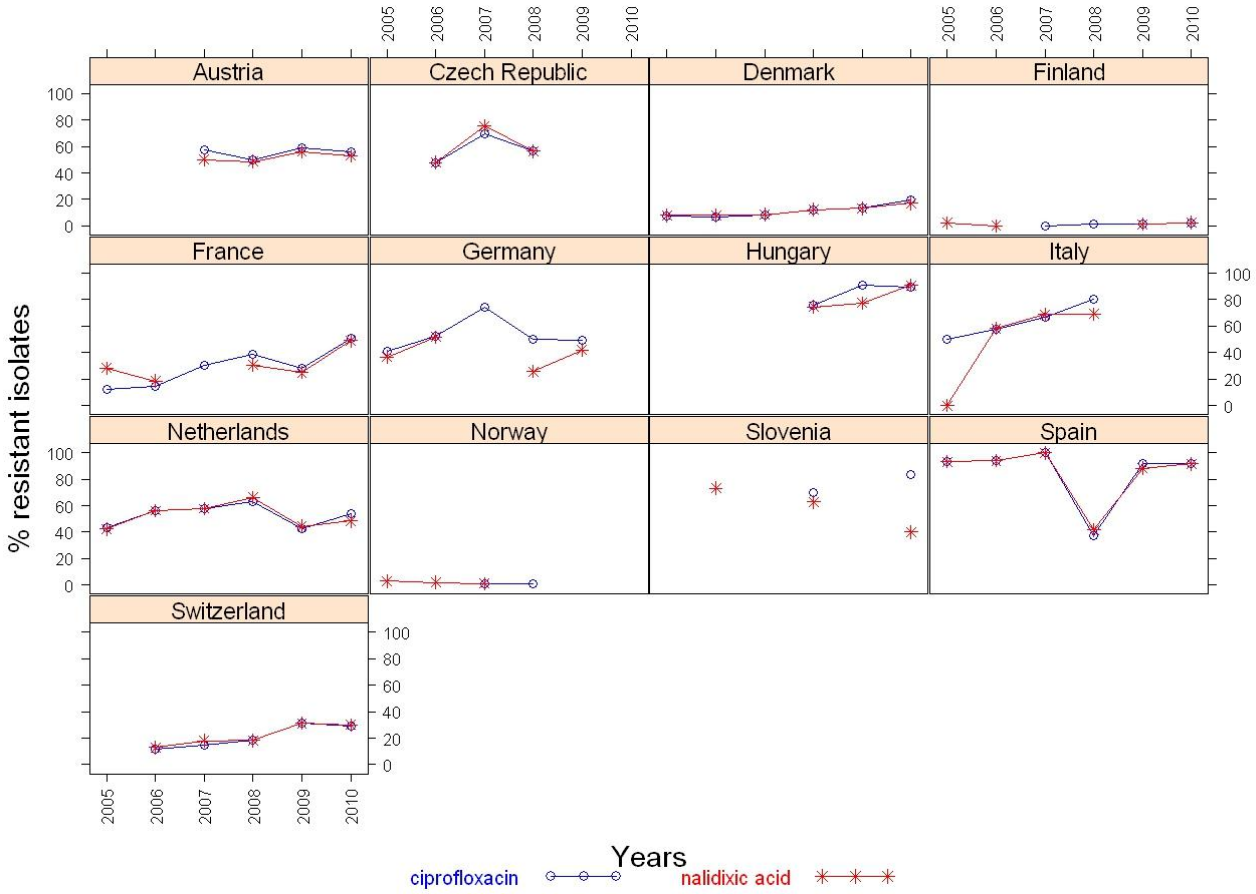
% Res = percentage of resistant isolates.

## Temporal trends in resistance among *C. jejuni*

Figures CA5–8 display the temporal trends in antimicrobial resistance in *C. jejuni* isolates from *Gallus gallus* over the period 2005–2010. As noted in 2009, the figures emphasise that the occurrence of ciprofloxacin, nalidixic acid and tetracycline resistance varied considerably between countries, with some countries detecting no or low resistance whereas other countries reported very high levels of resistance (Figures CA5 and CA8).

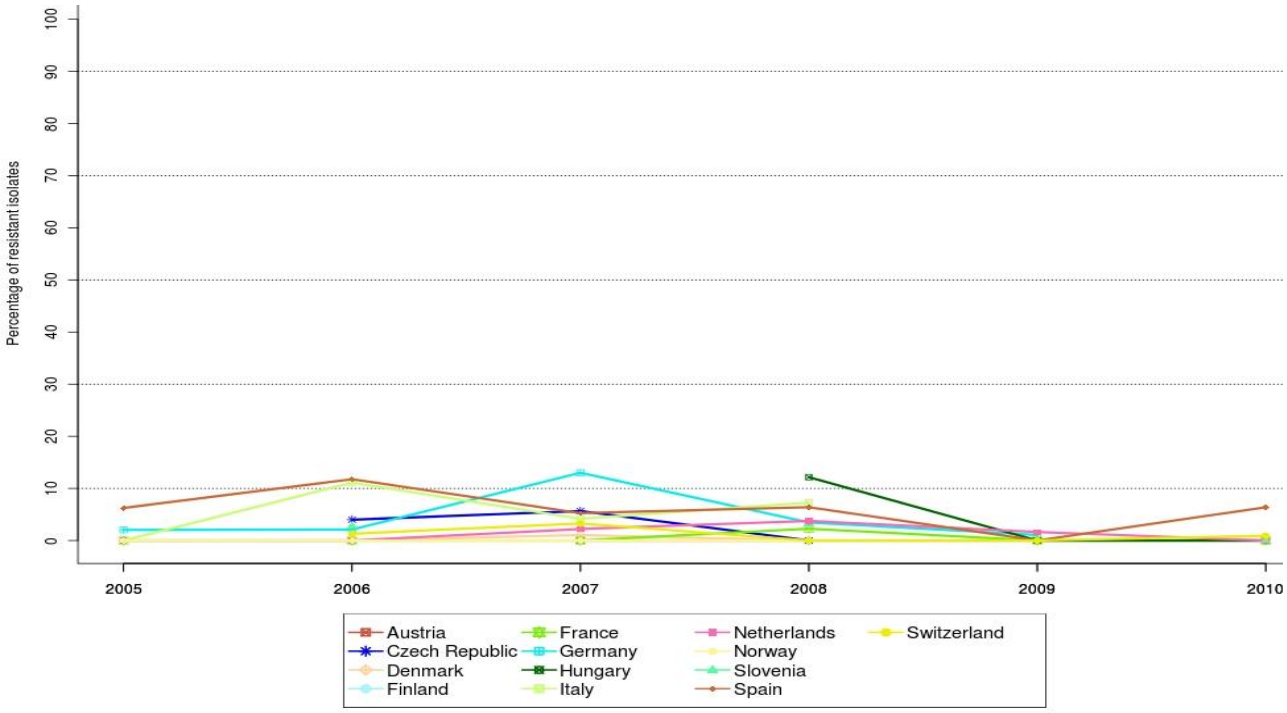
As regards trends in resistance to ciprofloxacin and nalidixic acid, statistically significant increasing trends for the last 5 or more years were observed in France and Switzerland. For Denmark, a statistically significant increasing trend was observed for ciprofloxacin alone (Figure CA5). Levels of resistance to erythromycin remained absent or very low over the period 2005–2010, and no statistically significant trend was detected. For gentamicin, statistically significant decreasing trends were observed in France, Germany and Switzerland. For tetracyclines, Denmark and Germany showed diverging trends with a statistically significant increase in the former and a decrease in the latter over the period 2005–2010.

***Figure CA5. Trends in ciprofloxacin and nalidixic acid resistance in* Campylobacter jejuni *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***



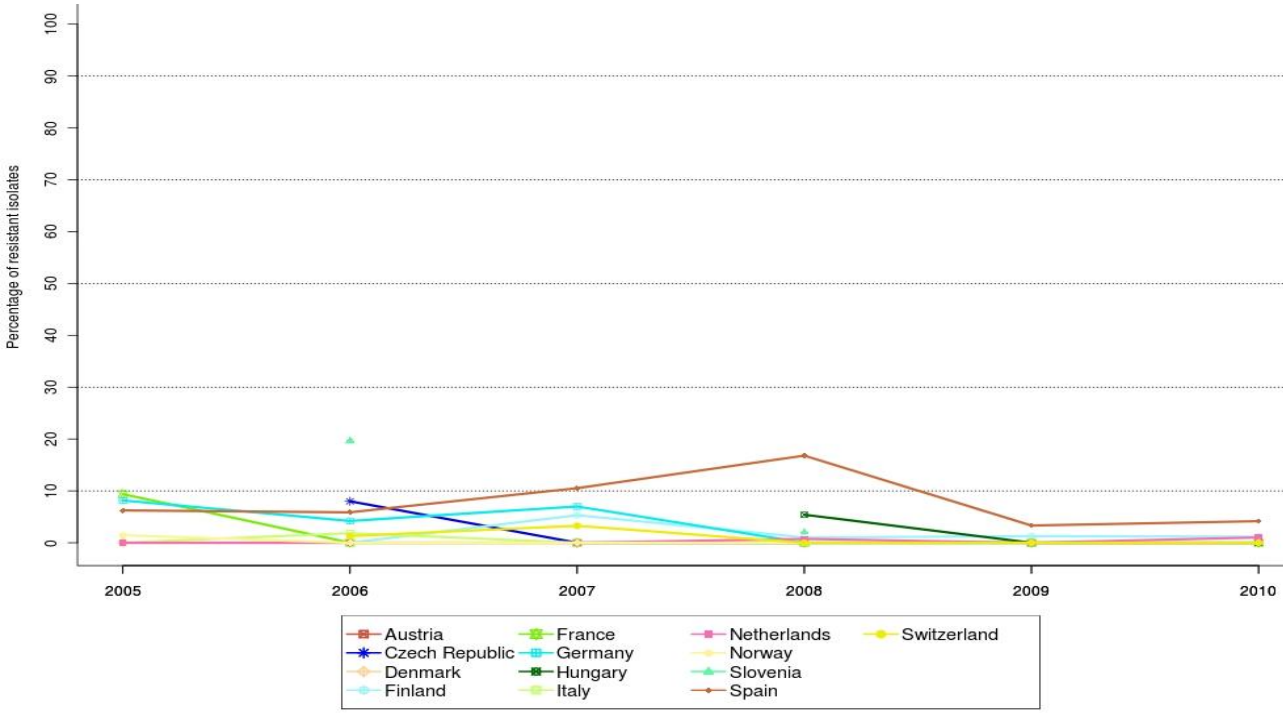

Note: A statistically significant increasing trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in France and Switzerland for both ciprofloxacin and nalidixic acid and in Denmark for ciprofloxacin.

***Figure CA6. Trends in erythromycin resistance in* Campylobacter jejuni *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***



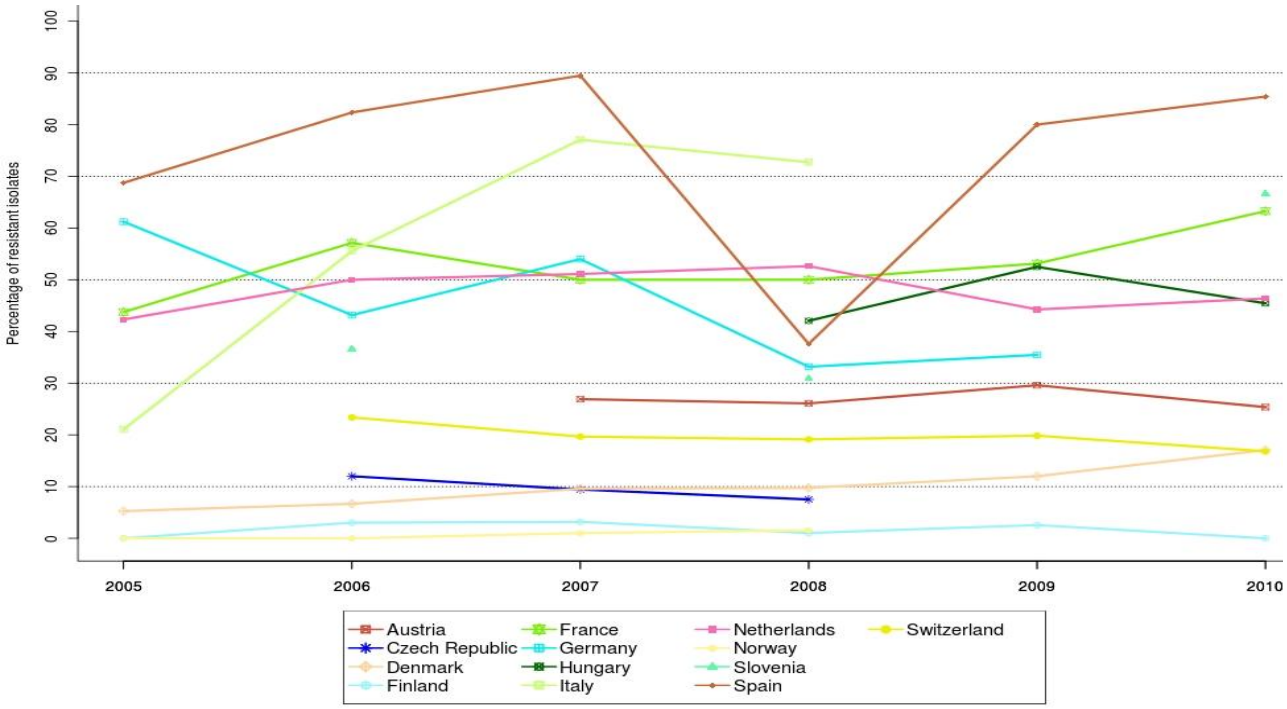

Note: No statistically significant trend over 5 or more years, as tested by logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure CA7. Trends in gentamicin resistance in* Campylobacter jejuni *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***




Note: A statistically significant decreasing trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in France, Germany and Switzerland.

***Figure CA8. Trends in tetracycline resistance in* Campylobacter jejuni *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***



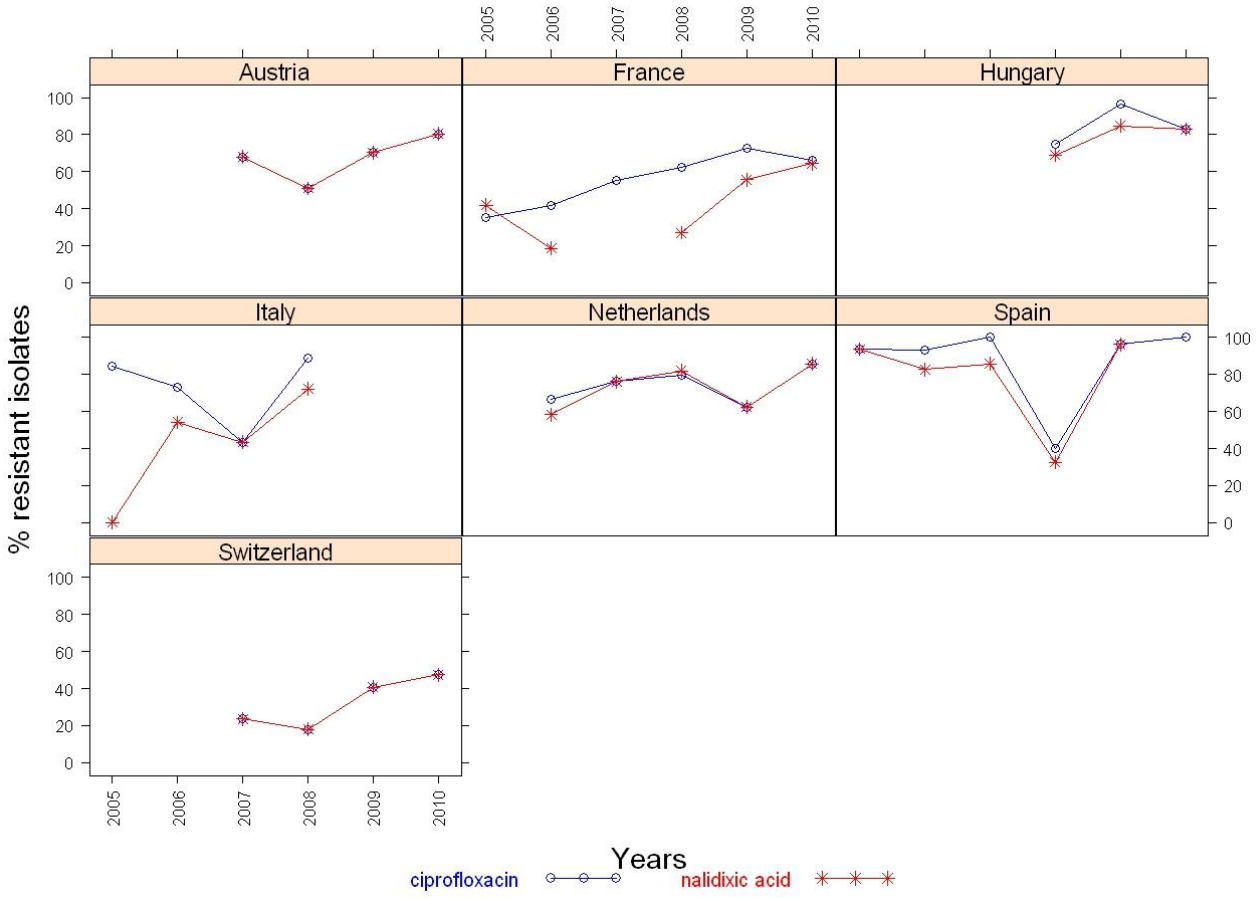

Note: Statistically significant increasing and decreasing trends over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were respectively observed in Denmark (↑) and Germany (↓).

### Temporal trends in resistance among *C. coli*

Figures CA9–12 present observed trends in antimicrobial resistance in *C. coli* from *Gallus gallus*. A large variation in resistance to tetracyclines, ciprofloxacin and nalidixic acid was observed among reporting MSs in 2010. In general, fluctuations in the levels of resistance within MSs were more pronounced for *C. coli* than for *C. jejuni*.

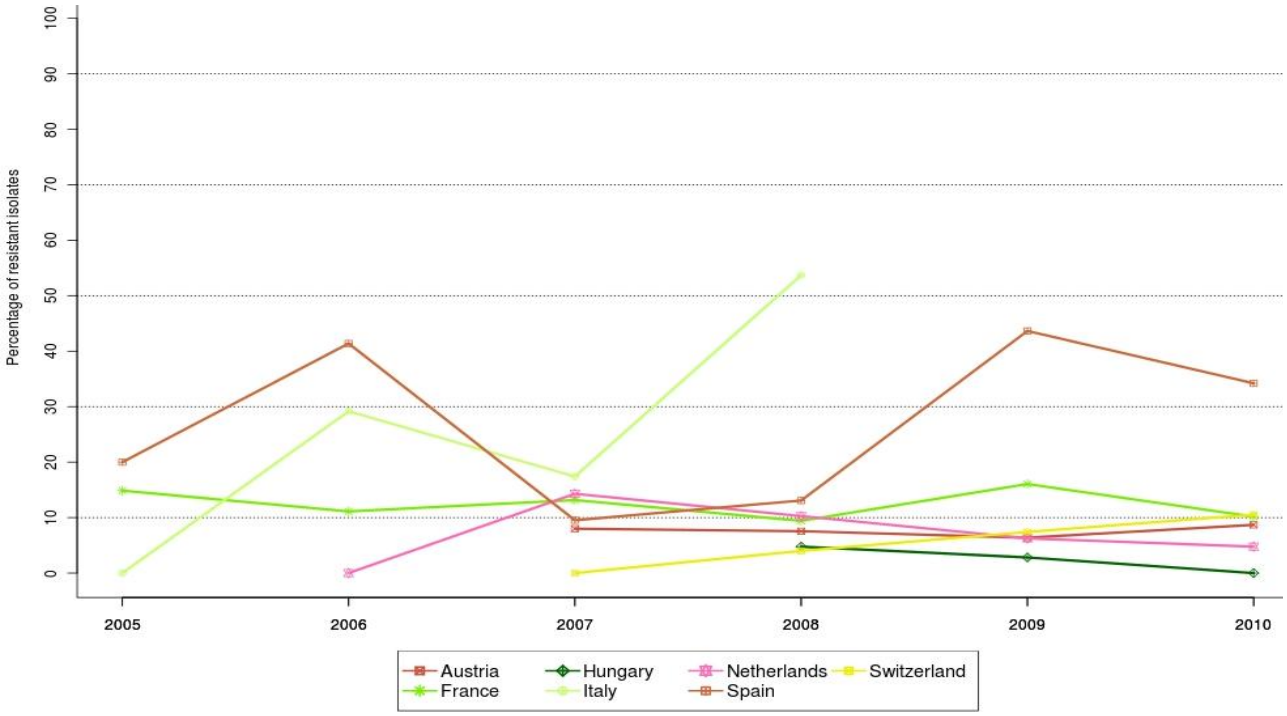
As regards trends in resistance to ciprofloxacin and nalidixic acid, statistically significant increasing trends for the last 5 or more years were observed in France and Spain (Figure CA9). Austria and Switzerland showed similar increasing trends, albeit these were limited to the last 4 years. Spain also exhibited statistically increasing trends in resistance to erythromycin, gentamicin and tetracyclines. Resistance to gentamicin was generally absent or very low, except in Spain. In France, resistance to tetracyclines also increased significantly over the same period.

***Figure CA9. Trends in ciprofloxacin and nalidixic acid resistance in* Campylobacter coli *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***



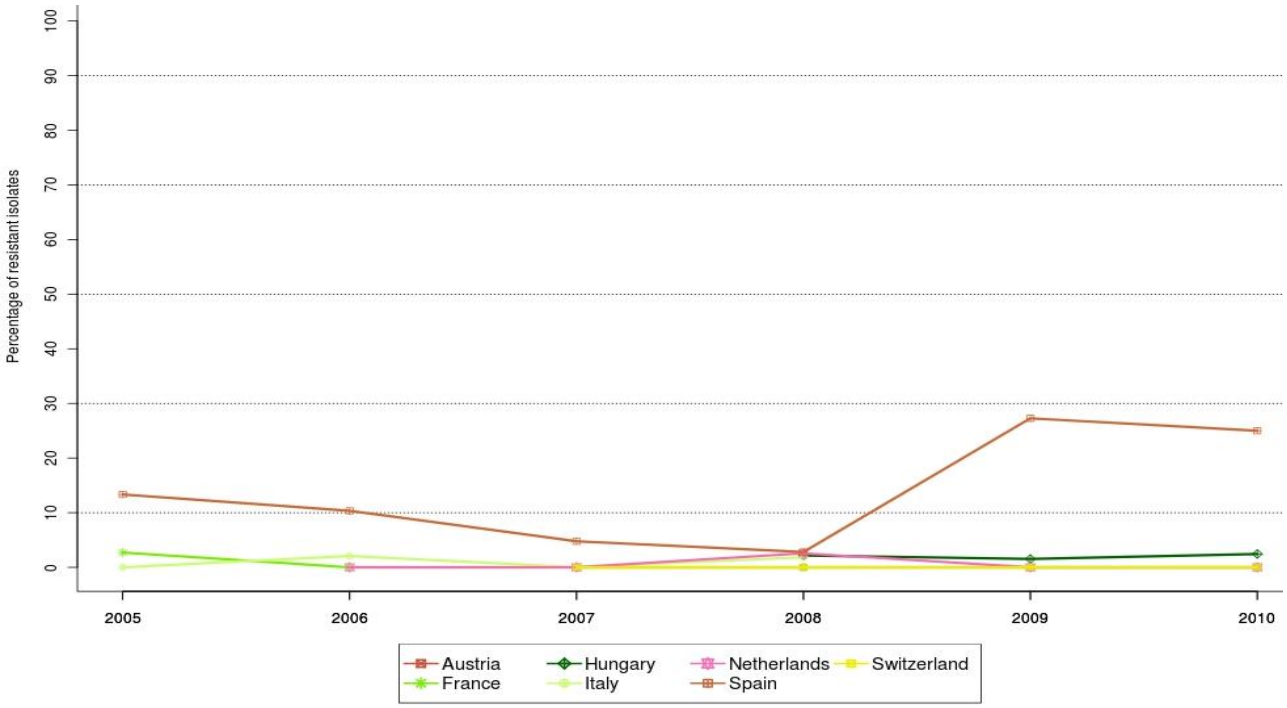

Note: A statistically significant increasing trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in France and Spain for both ciprofloxacin and nalidixic acid.

***Figure CA10. Trends in erythromycin resistance in* Campylobacter coli *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***



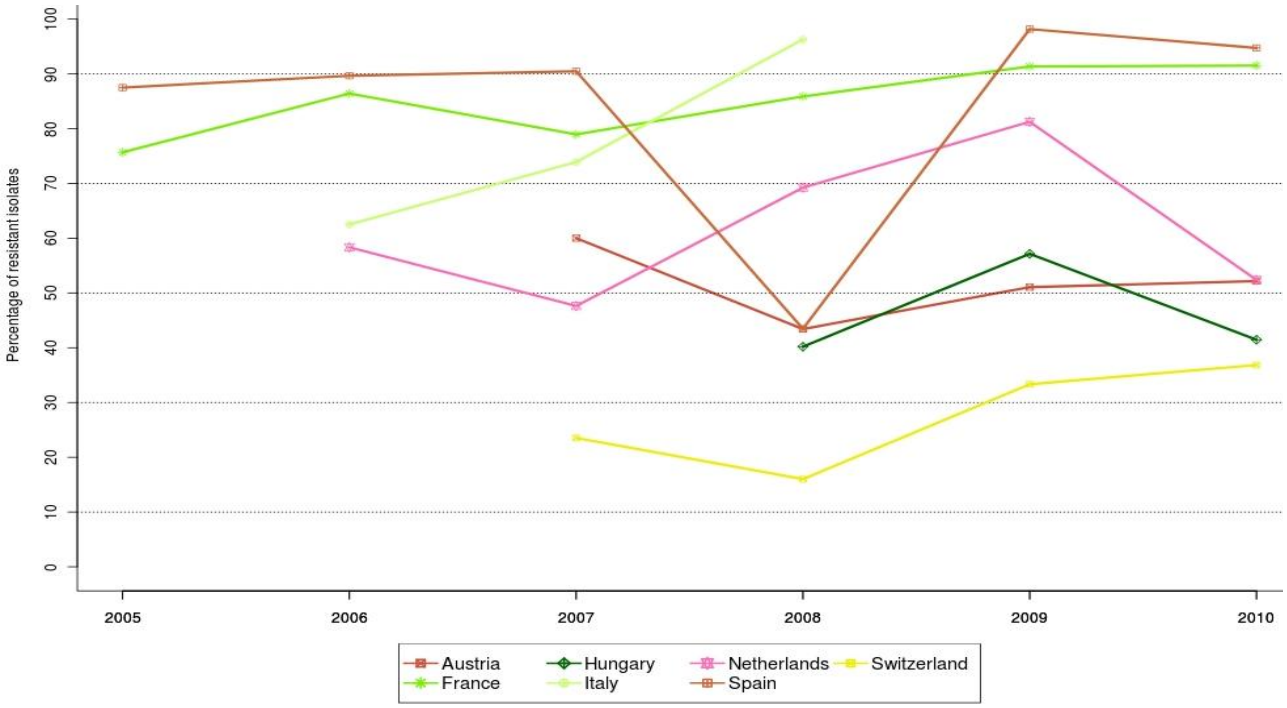

Note: A statistically significant increasing trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Spain.

***Figure CA11. Trends in gentamicin resistance in* Campylobacter coli *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***




Note: Statistically significant increasing and decreasing trends over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Spain (↑) and France (↓).

***Figure CA12. Trends in tetracycline resistance in* Campylobacter coli *from* Gallus gallus *in reporting MSs and non-MS, 2005-2010, quantitative data***

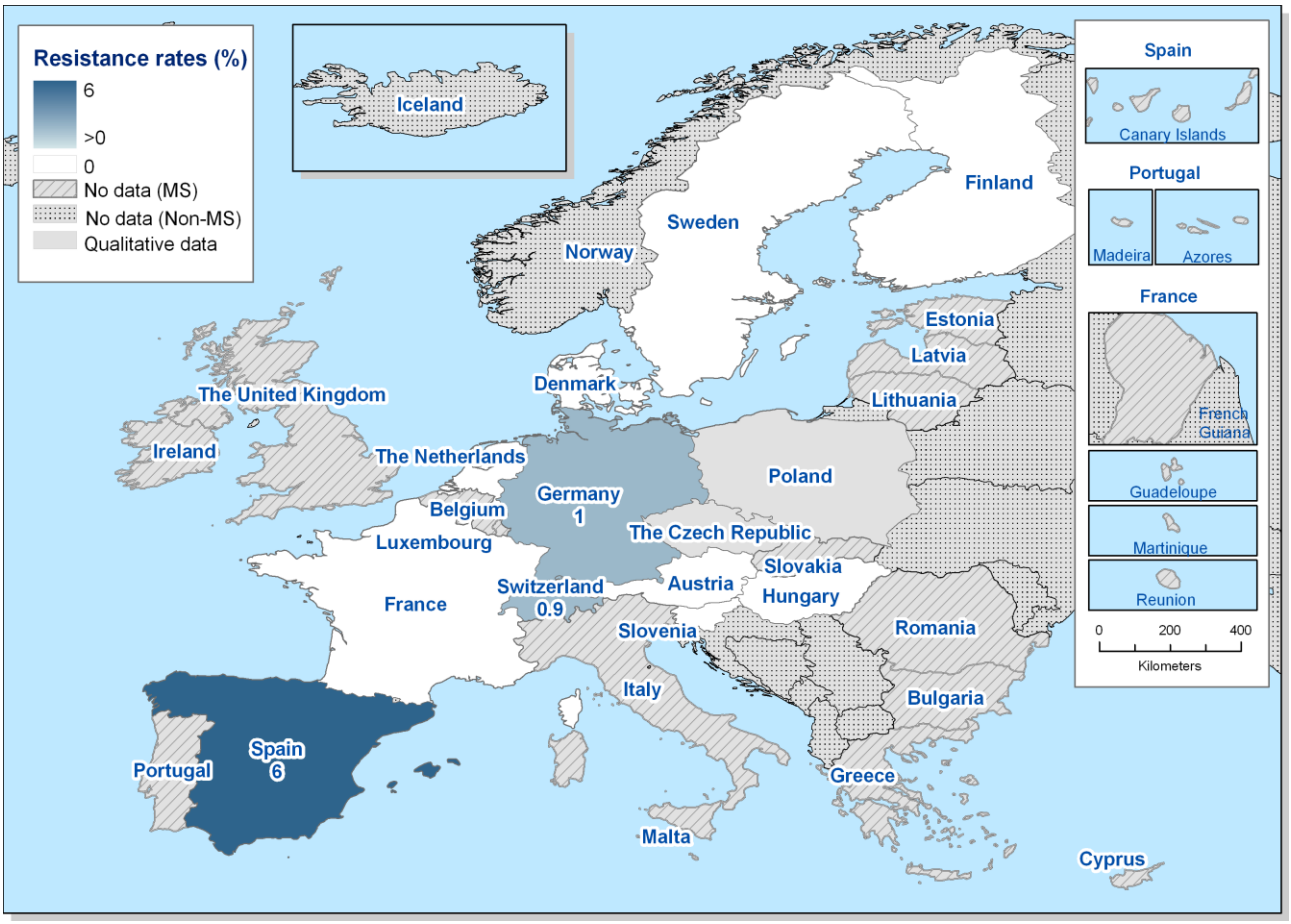



Note: A statistically significant increasing trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in France and Spain.

## Spatial distribution of resistance among *C. jejuni*

The spatial distributions of erythromycin and ciprofloxacin resistance in *C. jejuni* from *Gallus gallus* are shown in Figures CA13 and CA14. The occurrence of erythromycin resistance was generally low in *C. jejuni*, with the majority of countries not detecting resistance or detecting low to very low resistance (Figure CA13). Figure CA14 shows the levels of ciprofloxacin resistance in reporting MSs; the level of resistance was again lowest in the Nordic countries.

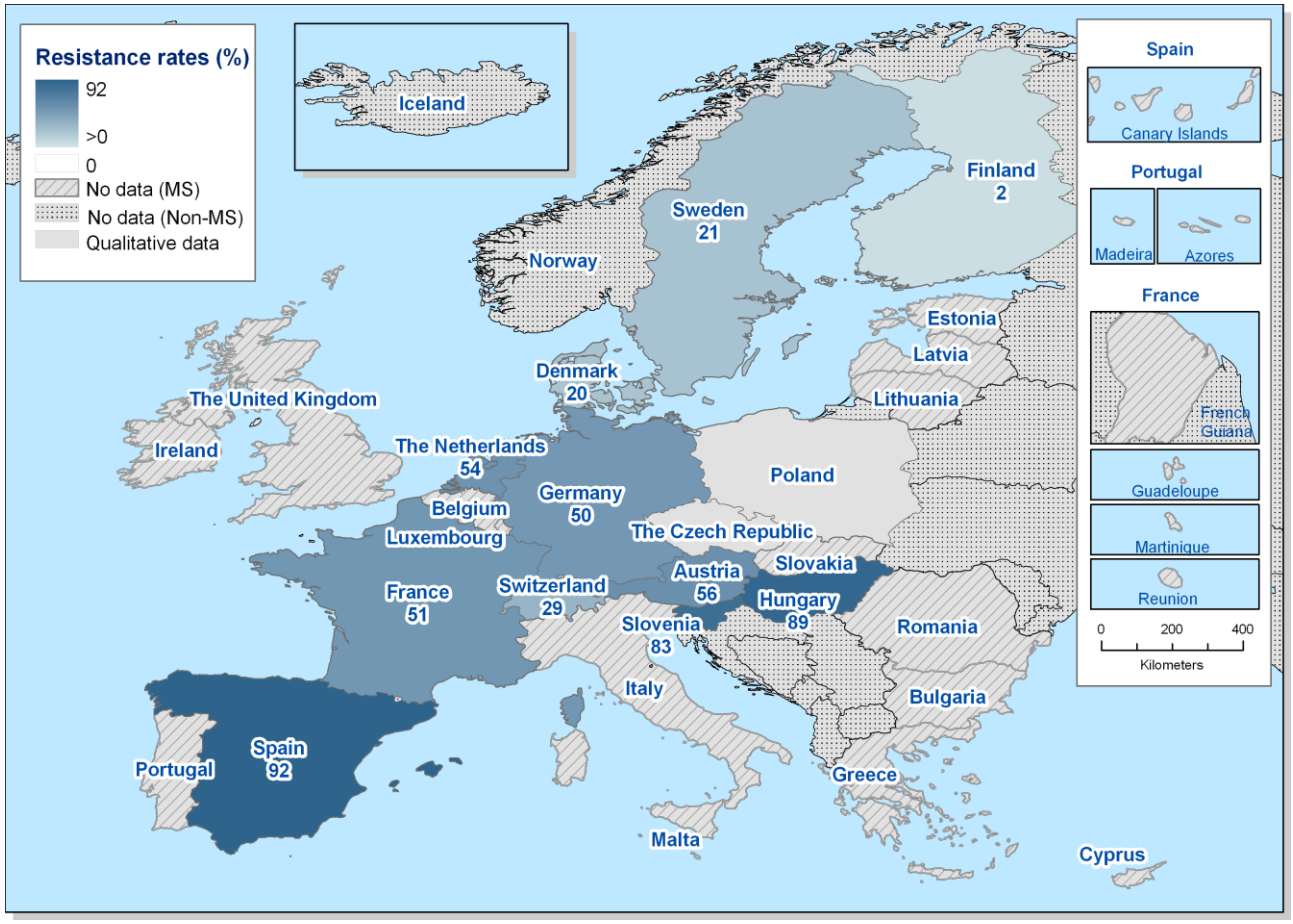
***Figure CA13. Spatial distribution of erythromycin resistance among* Campylobacter jejuni *from* Gallus gallus *in countries reporting MIC data in 2010[1]***




Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2010. When quantitative 2010 data were not available, 2009 data were used instead. The countries labelled as 'qualitative data' therefore include those reporting MIC data for fewer than 10 isolates or purely qualitative data (as proportion of resistant isolates).

1. For Germany, 2009 data were used.

***Figure CA14. Spatial distribution of ciprofloxacin resistance among* Campylobacter jejuni *from* Gallus gallus *in countries reporting MIC data in 2010[1]***




Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2010. When quantitative 2010 data were not available, 2009 data were used instead. The countries labelled as 'qualitative data' therefore include those reporting MIC data for fewer than 10 isolates or purely qualitative data (as proportion of resistant isolates).

1. For Germany, 2009 data were used.

### 4.3.2.2 Pigs

In the reporting MSs, the antimicrobial resistance monitoring in *Campylobacter* isolates from pigs was based on active monitoring plans based on random sampling of healthy pig carcasses at the slaughterhouse. The sampling plan was typically stratified per slaughterhouse by allocating the number of samples collected per slaughterhouse proportionally to the annual throughput of the slaughterhouse. An approximately equal distribution of the collected samples over the year enabled the different seasons to be covered. Only one representative faecal sample per epidemiological unit (batch/farm), either derived from a unique carcass or pooled from a number of carcasses, was gathered to account for clustering. In Switzerland, rectal swabs were sampled instead of faecal samples. Generally, the number of samples to be collected was determined in order to achieve 170 isolates by accounting for the prevalence of the bacteria species monitored. In the reporting MSs, antimicrobial resistance monitoring in *Campylobacter* spp. in pigs focused on *C. coli*, as it is the more prevalent *Campylobacter* species in pigs. Because of the very low *C. jejuni* prevalence in pigs, the number of samples required to be collected to achieve a sufficient amount of *C. jejuni* isolates would have been too large to be really cost-effective. In some reporting countries, representative subsets of *C. coli* isolates recovered from faecal samples were randomly selected at the laboratory for susceptibility testing, whereas, in some others, all *C. coli* isolates were tested for susceptibility.

#### Resistance levels among *C. coli*

For 2010, quantitative data on *C. coli* isolates from pigs were provided by six MSs and one non-MS (Table CA9).

The highest resistance level in the reporting MS group was observed for tetracyclines, with an overall level of resistance of 60 %. It should, however, be noted that this value varied greatly among the individual MSs, with Finland reporting the absence of resistance (0 %), Denmark reporting moderate resistance (12 %) and the other reporting MSs recording extremely high levels of resistance. Resistance to gentamicin was overall moderate (12 %) in the reporting MS group and ranged from 0 % in Denmark and the Netherlands to 56 % in Spain.

The level of resistance to both ciprofloxacin and nalidixic acid in the reporting MS group was high overall (40 % for both antimicrobials); among the individual MSs, resistance was low in Denmark and the Netherlands, high in Finland, very high in Hungary and Poland and extremely high in Spain. Resistance to erythromycin in pigs was high overall (25 %), with values ranging from 0 % to 67 % among the individual reporting MSs.

In *C. coli* from pigs in Switzerland, the level of resistance to ciprofloxacin, nalidixic acid and tetracyclines was high, to erythromycin was low and to gentamicin was very low.

***Table CA9. Resistance (%) to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines among* Campylobacter coli *from pigs in countries reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ciprofloxacin | | Erythromycin | | Gentamicin | | Nalidixic acid | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Denmark | 103 | 8 | 103 | 16 | 103 | 0 | 103 | 8 | 103 | 12 |
| Finland | 87 | 26 | 87 | 0 | 87 | 1 | 87 | 26 | 87 | 0 |
| Hungary | 113 | 52 | 114 | 15 | 113 | 2 | 113 | 51 | 112 | 88 |
| Netherlands | 106 | 8 | 106 | 26 | 106 | 0 | 106 | 9 | 106 | 89 |
| Poland | 22 | 68 | 22 | 9 | - | - | 22 | 68 | 22 | 73 |
| Spain | 106 | 95 | 105 | 67 | 106 | 56 | 106 | 95 | 106 | 98 |
| **Total (6 MSs)** | **537** | **40** | **537** | **25** | **515** | **12** | **537** | **40** | **536** | **60** |
| Switzerland | 192 | 38 | 192 | 7 | 192 | 0.5 | 192 | 38 | 192 | 31 |

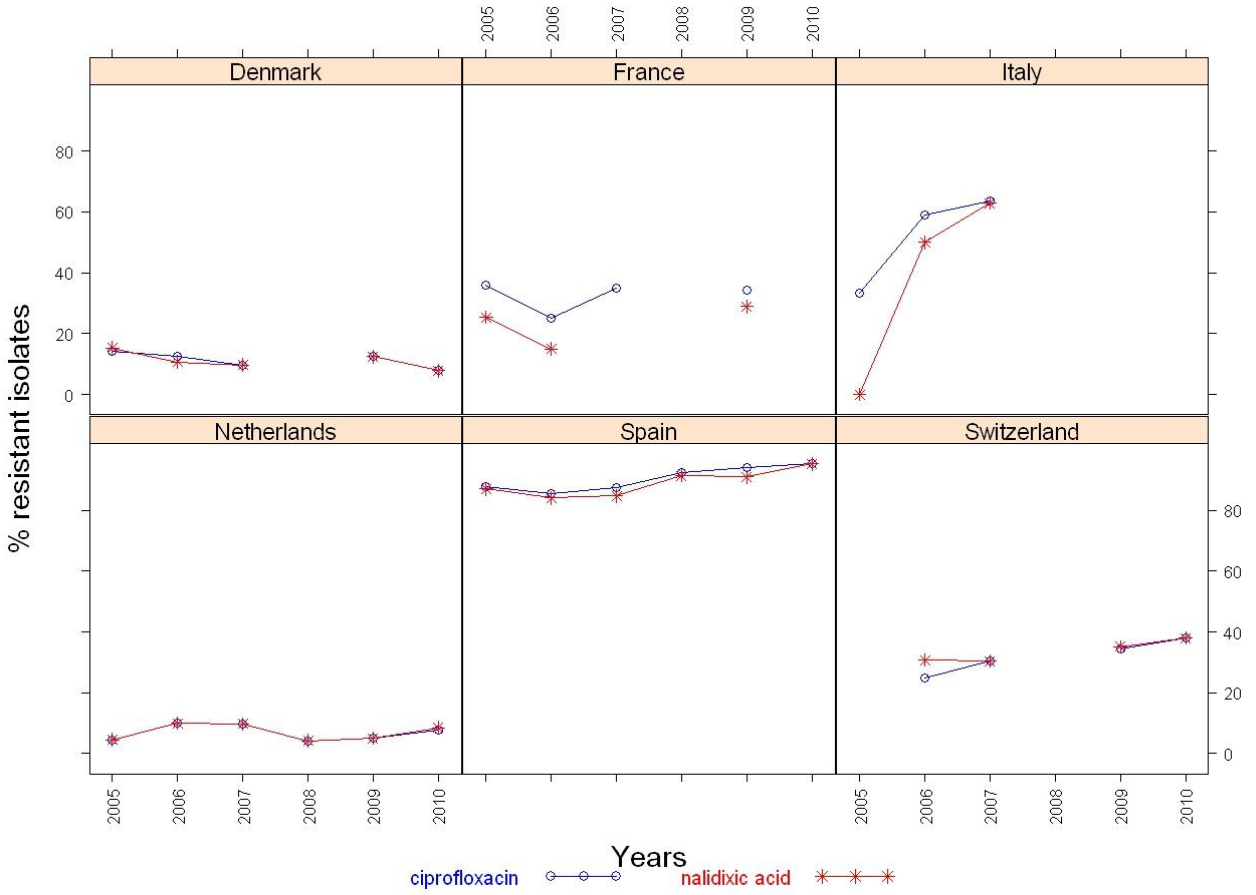
N = number of isolates tested.

% Res = percentage of resistant isolates.

### Temporal trends in resistance among *C. coli*

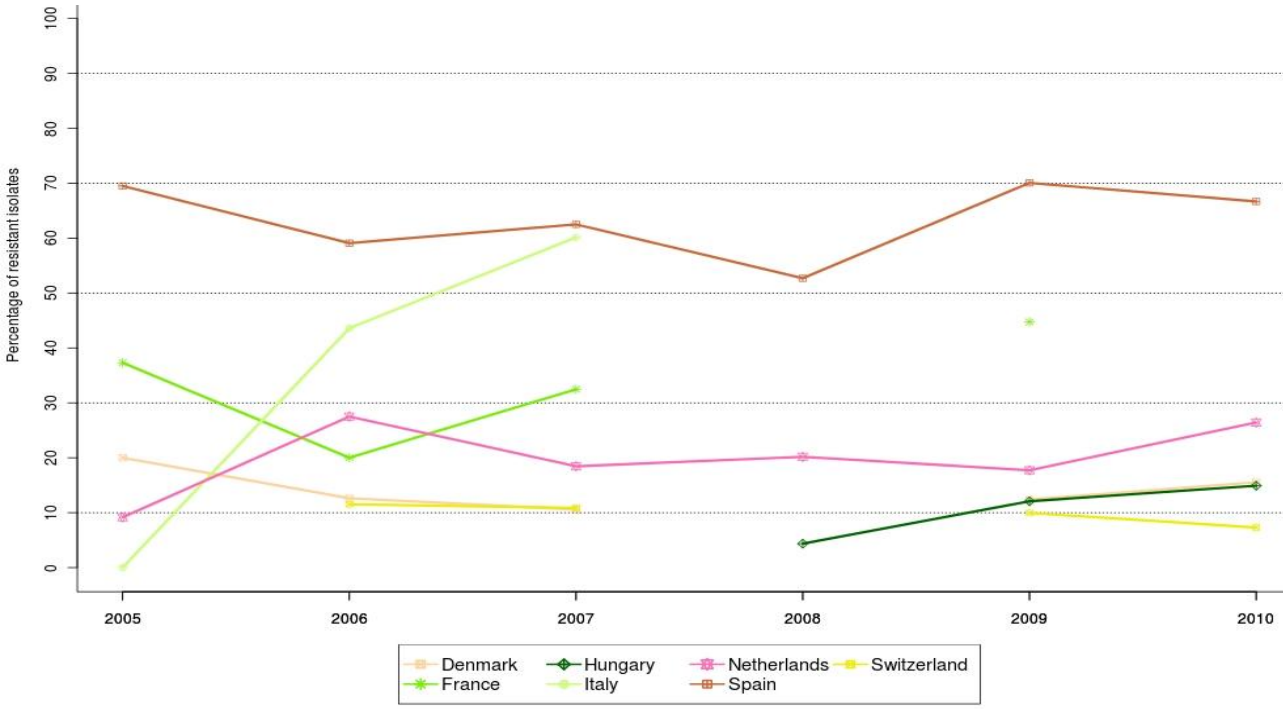
Figures CA15–18 show the trends in antimicrobial resistance observed in *C. coli* from pigs over the period 2005–2010. In many of the MSs reporting results in 2010, resistance to many antimicrobials appears to have remained relatively stable over the period, with the exception of resistance to ciprofloxacin, gentamicin and nalidixic acid in *C. coli* from pigs in Spain, which shows an increase since 2005; this increasing trend was significant for all three antimicrobials when tested by logistic regression. The Netherlands registered a statistically significant increase in erythromycin resistance over the period 2005–2010.

***Figure CA15. Trends in ciprofloxacin and nalidixic acid resistance in* Campylobacter coli *from pigs in reporting Member States and non-Member State, 2005–2010, quantitative data***



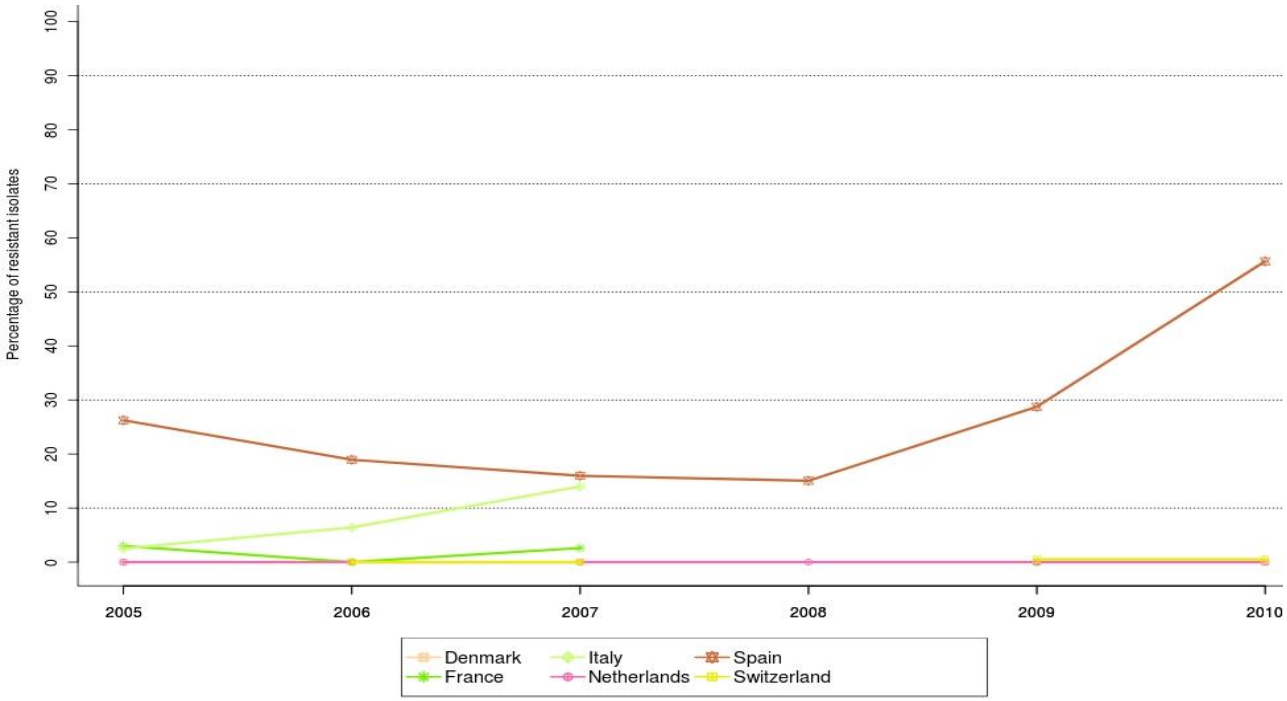

Note: A statistically significant increasing trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Spain for both ciprofloxacin and nalidixic acid.

***Figure CA16. Trends in erythromycin resistance in* Campylobacter coli *from pigs in reporting Member States and non-Member States, 2005–2010, quantitative data***



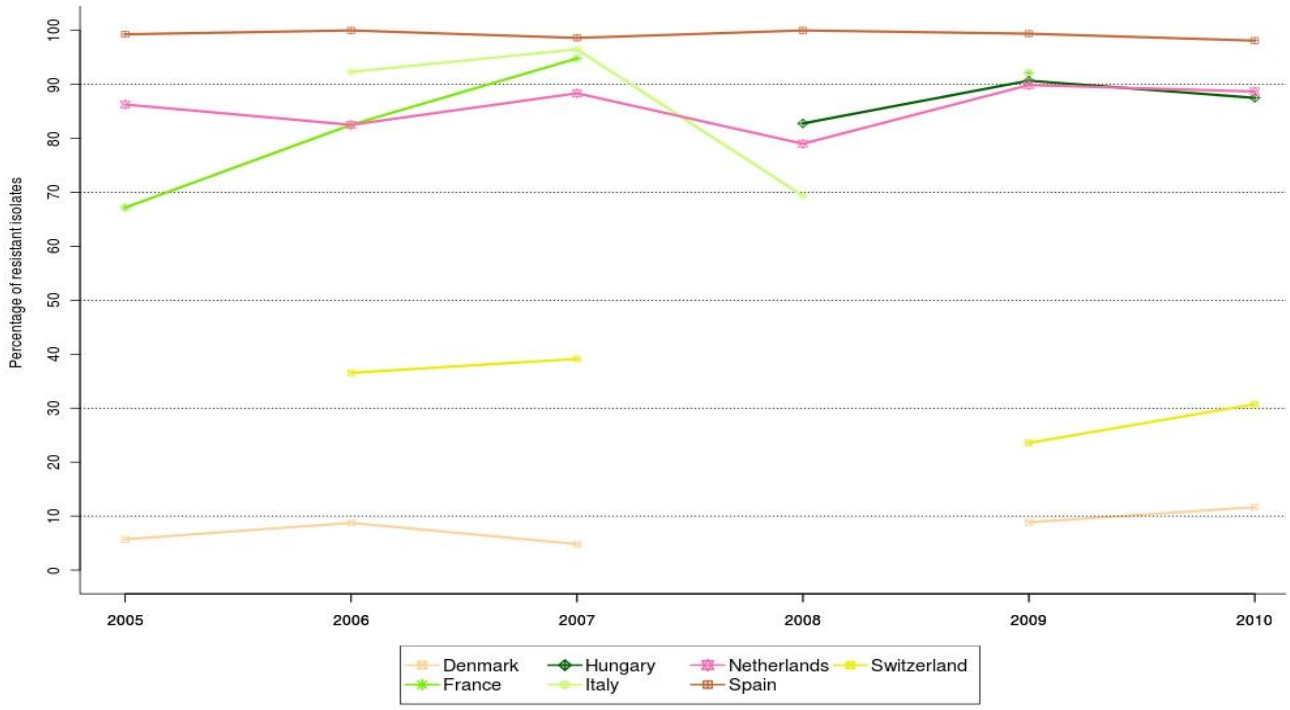

Note: A statistically significant increasing trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands.

***Figure CA17. Trends in gentamicin resistance in* Campylobacter coli *from pigs in reporting MSs and non-MS, 2005-2010, quantitative data***




Note: A statistically significant increasing trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Spain.

***Figure CA18. Trends in tetracycline resistance in* Campylobacter coli *from pigs in reporting Member States and non-Member State, 2005–2010, quantitative data***

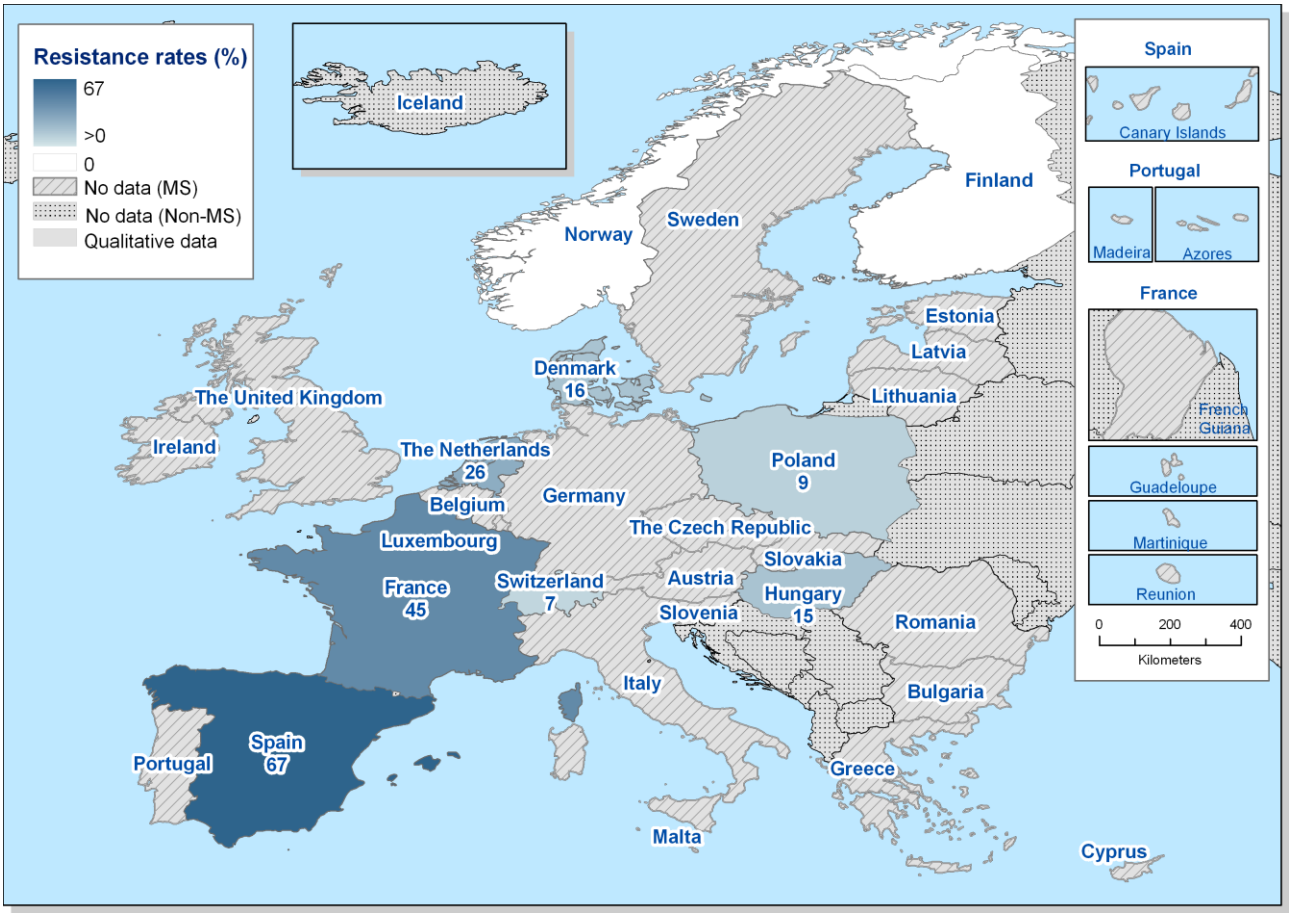



Note: No statistically significant trend over 5 or more years, as tested by logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

## Spatial distribution of resistance among *C. coli*

The spatial distributions of erythromycin and ciprofloxacin resistance in *C. coli* from pigs are shown in Figures CA19 and CA20. As previously mentioned, the maps highlight the extreme variability of the occurrence of resistance among the individual reporting MSs.

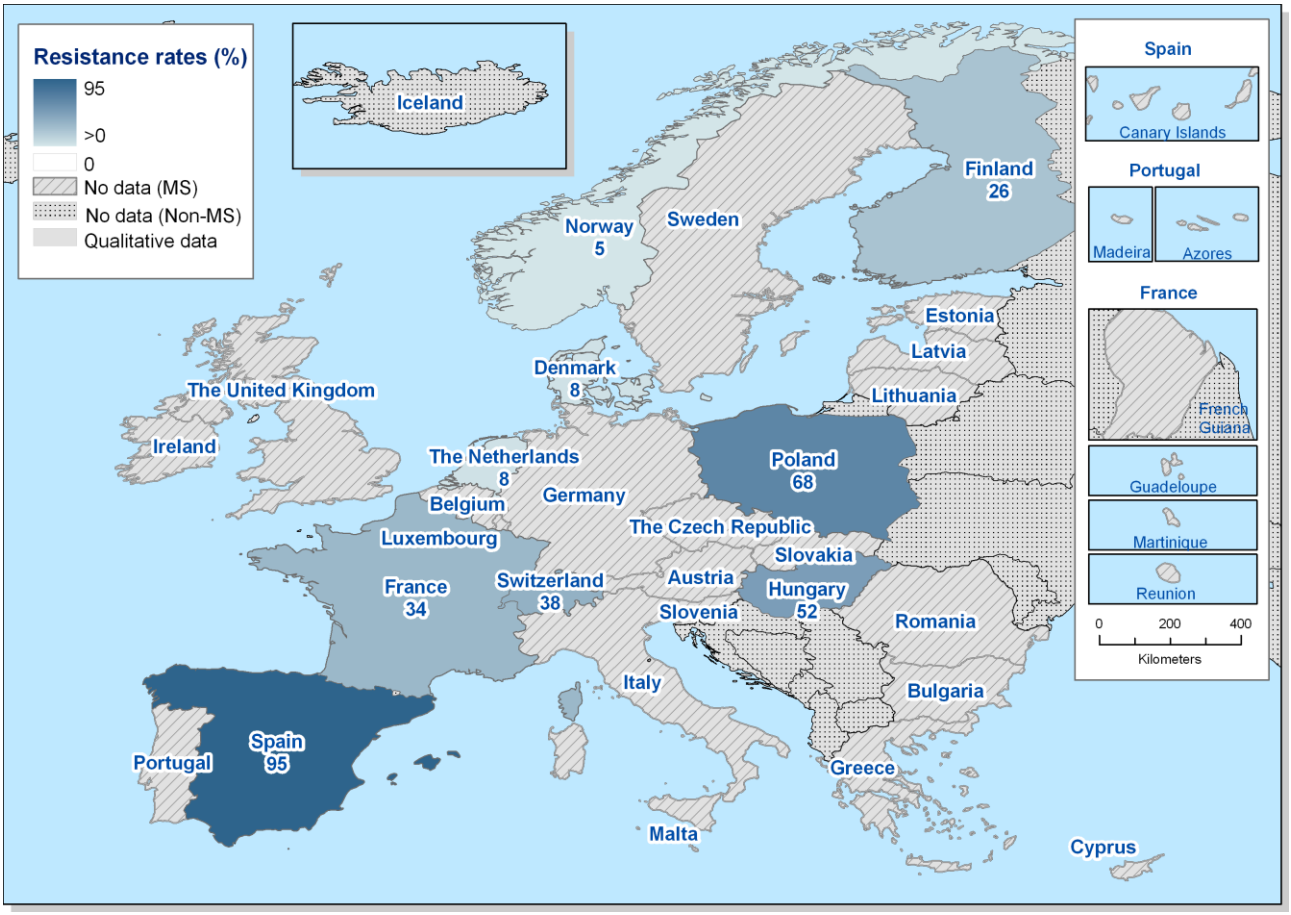
***Figure CA19. Spatial distribution of erythromycin resistance among* Campylobacter coli *from pigs in countries reporting MIC data in 2010[1]***




Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2010. When quantitative 2010 data were not available, 2009 data were used instead.

1. For France and Norway, 2009 data were used.

***Figure CA20. Spatial distribution of ciprofloxacin resistance among* Campylobacter coli *from pigs in countries reporting MIC data in 2010[1]***




Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2010. When quantitative 2010 data were not available, 2009 data were used instead.

1. For France and Norway, 2009 data were used.

### 4.3.2.3 Cattle (bovine animals)

In the reporting MSs, antimicrobial resistance monitoring in *Campylobacter* isolates from cattle was chiefly based on active monitoring plans of healthy bovine animals either sampled from randomly selected holdings (the Netherlands) or randomly selected within the slaughterhouses (Austria, Denmark, Spain, Switzerland). In Norway, faecal samples from healthy bovine animals included in various surveys were collected on farm. The sampling plans were generally stratified per slaughterhouse with proportional allocation of the number of samples to the annual slaughterhouse throughput. The sampling was evenly distributed throughout the year or a significant part of the year to account for a possible seasonal effect. Only one faecal sample per bovine animal carcass was collected. One isolate per positive farm was included for susceptibility testing in the Netherlands and Norway. In Switzerland, rectal swabs were sampled, while caecal contents were collected in Austria and colon contents in Spain. In Switzerland, the monitoring programme in 2010 focused specifically on calves under 1 year of age. The other reporting MSs provided no details of the type of bovine animal sampled. In some reporting countries, representative subsets of *Campylobacter* isolates recovered from animal samples were randomly selected at the laboratory for susceptibility testing, while, in some others, all isolates were tested for susceptibility.

#### Resistance levels among *C. jejuni*

For 2010, quantitative data on *C. jejuni* isolates from cattle were provided by four MSs and two non-MSs (Table CA10). All reporting MSs, Austria, Denmark, the Netherlands and Spain, sampled cattle at the slaughterhouse.

The highest levels of resistance in cattle were observed for both ciprofloxacin and nalidixic acid, with high overall occurrence of resistance 37 % and 38 %, respectively. Among the individual MSs, resistance to ciprofloxacin and nalidixic acid ranged from 20 % in Denmark to 59 % in Spain. A very low level of resistance for the reporting MS group was observed for erythromycin (0.2 %), with the Netherlands being the only country reporting resistance to this substance, albeit at very low level.

For all reporting MSs, the overall resistance level to tetracyclines was 34 % and the level of resistance varied between countries from 6 % to 72 %. Similarly, for gentamicin, most of the reporting countries did not detect any resistance, with the exception of Spain (13 %) and the Netherlands (1 %). Overall resistance to gentamicin was observed at 3 %.

***Table CA10. Resistance (%) to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines among* Campylobacter jejuni *from cattle in countries reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ciprofloxacin | | Erythromycin | | Gentamicin | | Nalidixic acid | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 159 | 39 | 159 | 0 | 159 | 0 | 159 | 40 | 159 | 13 |
| Denmark | 98 | 20 | 98 | 0 | 98 | 0 | 98 | 20 | 98 | 6 |
| Netherlands | 101 | 33 | 101 | 1 | 101 | 1 | 101 | 33 | 101 | 62 |
| Spain | 88 | 59 | 88 | 0 | 88 | 13 | 88 | 59 | 88 | 72 |
| **Total (4 MSs)** | **446** | **37** | **446** | **0.2** | **446** | **3** | **446** | **38** | **446** | **34** |
| Norway | 11 | 9 | 11 | 0 | 11 | 0 | 11 | 9 | 11 | 0 |
| Switzerland | 24 | 33 | 24 | 0 | 24 | 0 | 24 | 33 | 24 | 33 |

N = number of isolates tested.

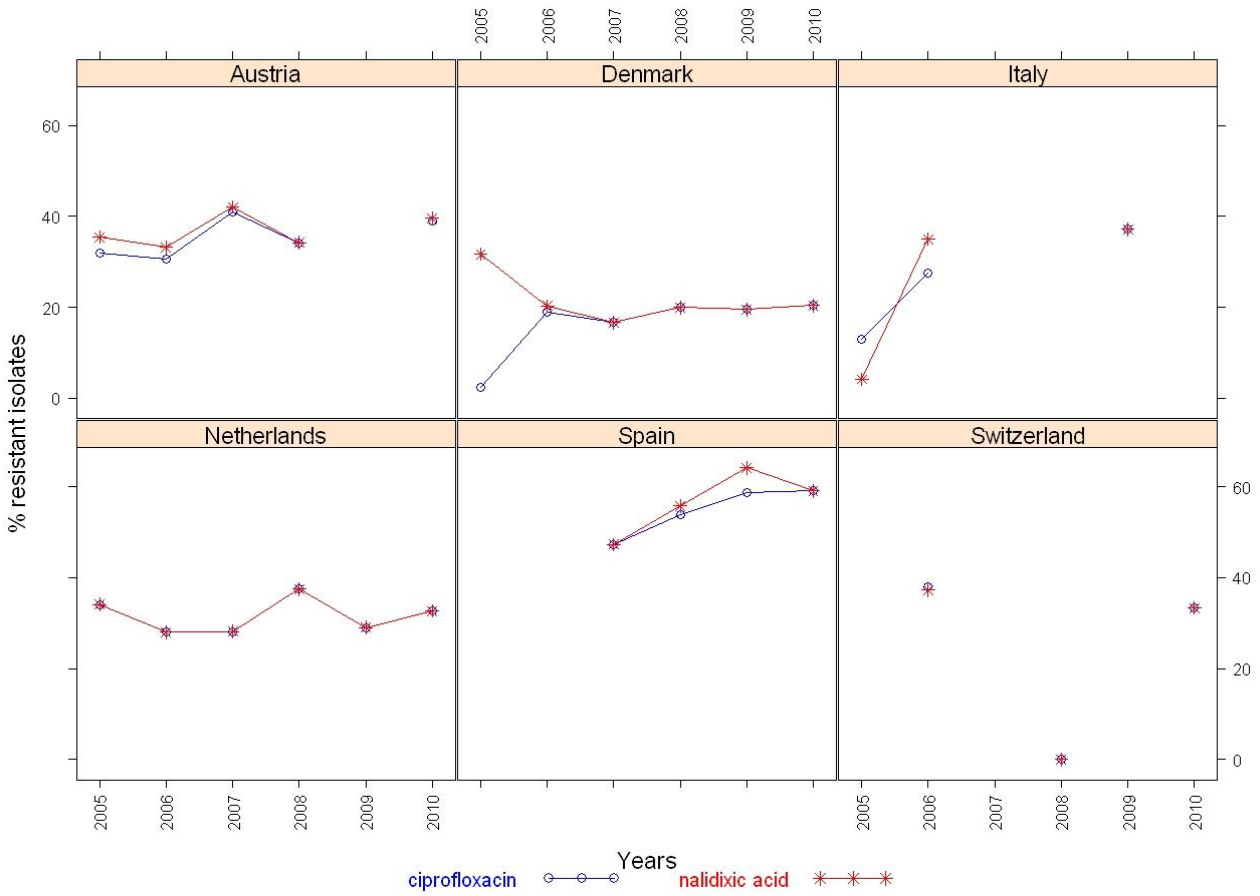
% Res = percentage of resistant isolates.

### Temporal trends in resistance among *C. jejuni*

Figures CA21–23 show the temporal trends in resistance for *C. jejuni* in cattle. Erythromycin and gentamicin resistance were relatively stable in reporting MSs over the period 2005–2010, with the exception only of Austria, where a decreasing trend in erythromycin resistance was observed in Spain, which, in contrast, reported increased resistance to gentamicin. In both cases the trends tested by a logistic regression model reached statistical significance ($p \leq 0.05$).

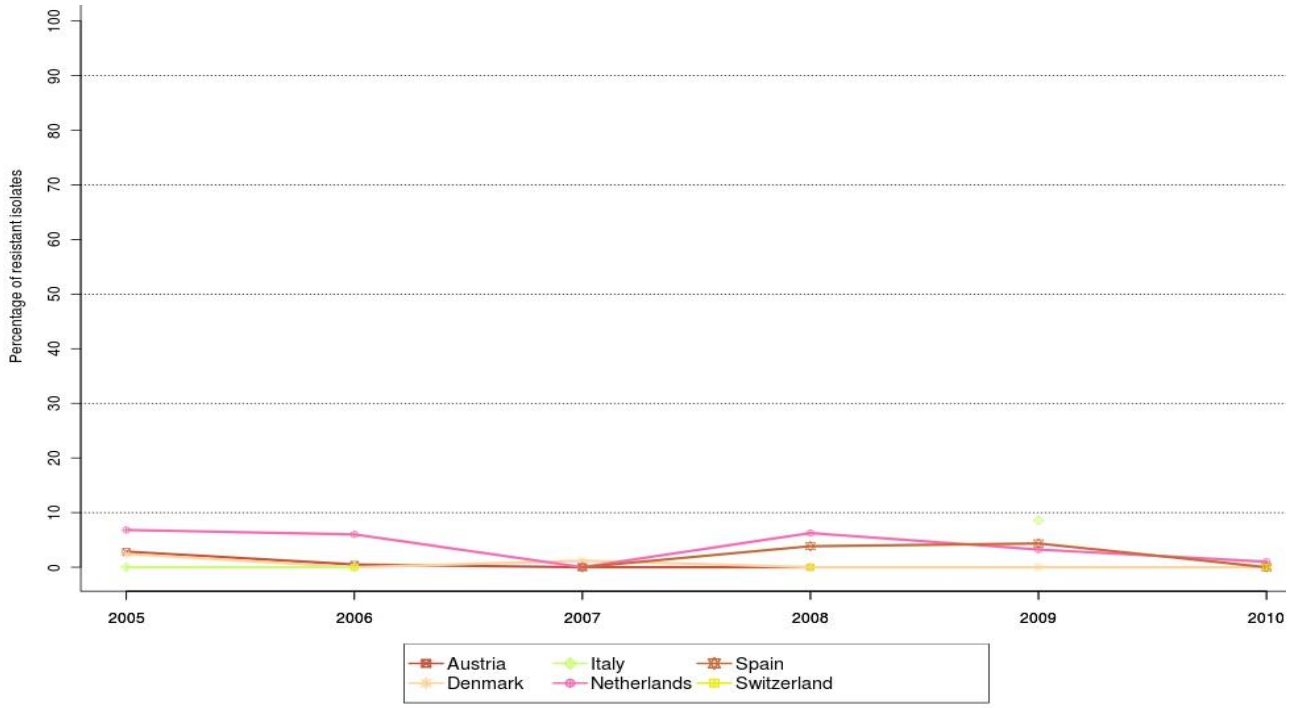
None of the trends in ciprofloxacin and nalidixic acid resistance observed for 5 or more years reached statistical significance when tested by a logistic regression model. As observed in *Gallus gallus* and pigs, Spain detected an increasing trend in resistance to gentamicin, although in the case of cattle this was limited to the last 4 years. In the case of erythromycin, the only significant trend observed was a decreasing one in Austria.

***Figure CA21. Trends in ciprofloxacin and nalidixic acid resistance in* Campylobacter jejuni *from cattle in reporting Member States and non-Member States, 2005–2010, quantitative data***



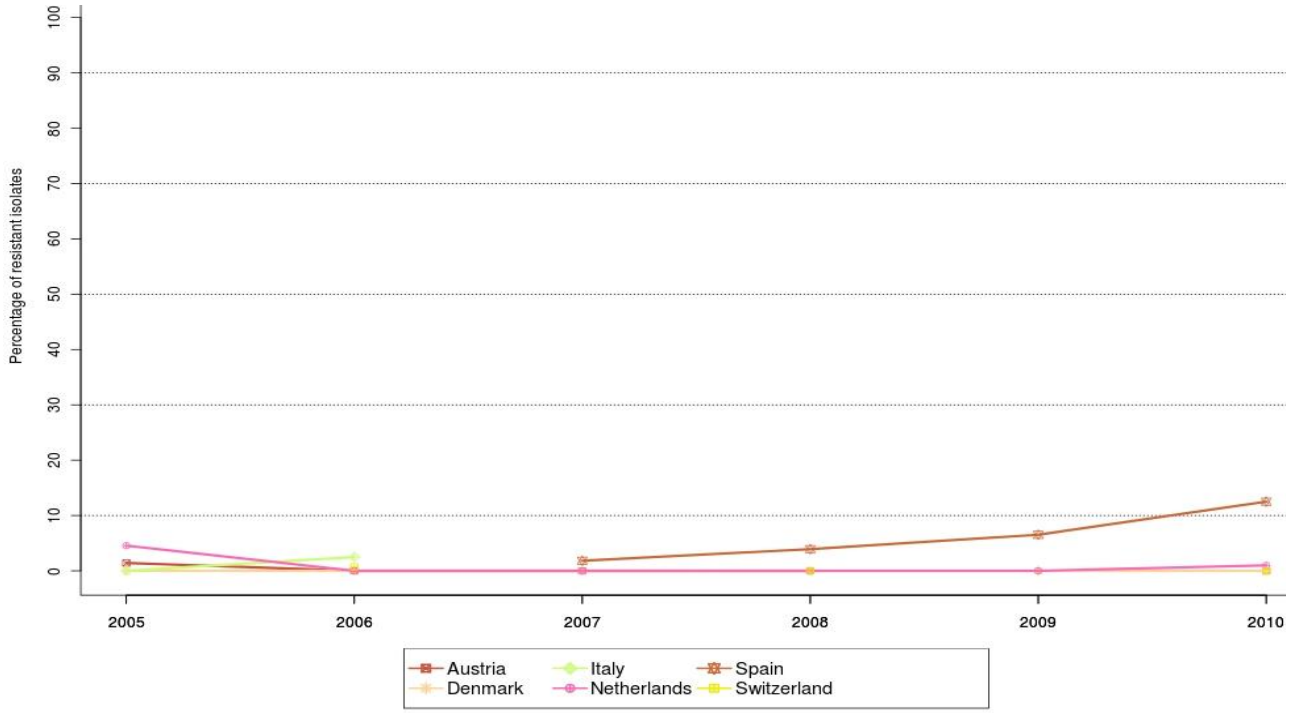

Note: No statistically significant trend for 5 or more years, as tested by logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure CA22. Trends in erythromycin resistance in* Campylobacter jejuni *from cattle in reporting Member States and non-Member States, 2005–2010, quantitative data***




Note: A statistically significant decreasing trend for 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria.

***Figure CA23. Trends in gentamicin resistance in* Campylobacter jejuni *from cattle in reporting Member States and non-Member States, 2005–2010, quantitative data***

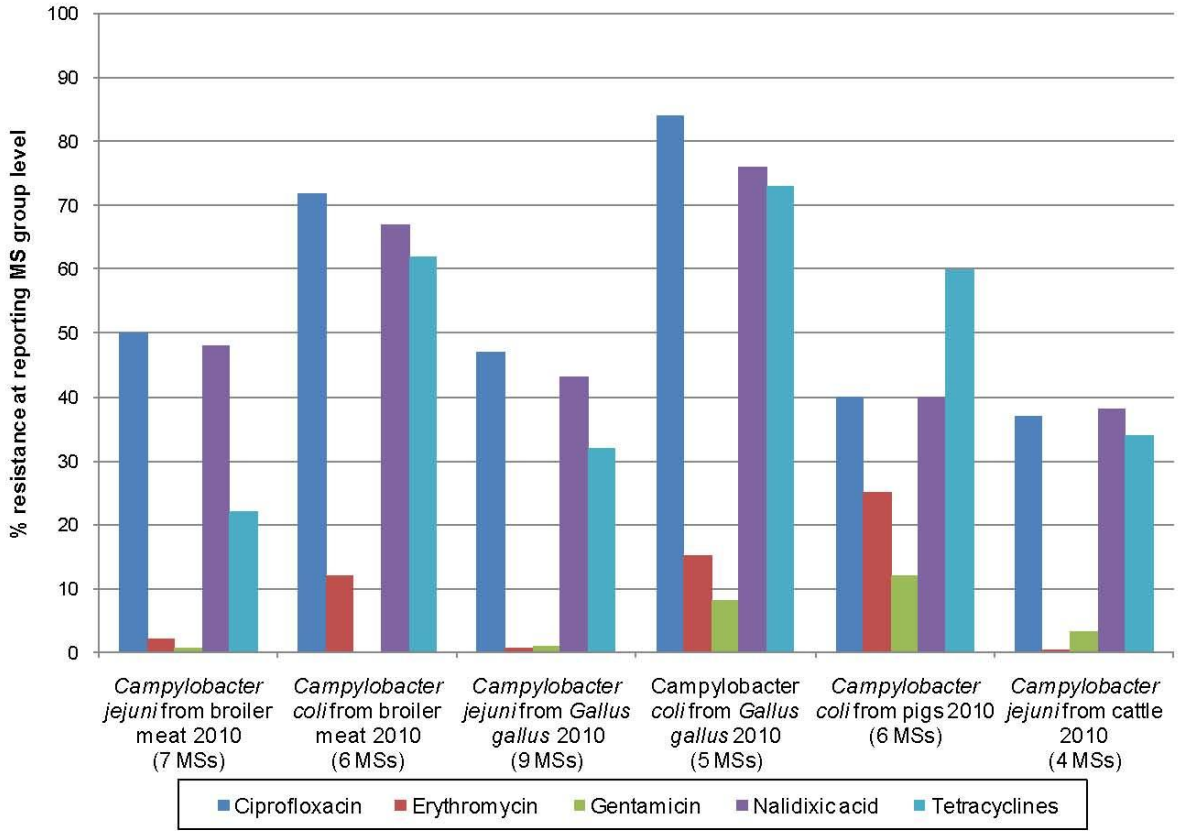



Note: No statistically significant trend for 5 or more years, as tested by logistic regression model ($p \leq 0.05$) was observed in any of the reporting countries.

## 4.4 Overview of the findings on antimicrobial resistance in *Campylobacter* at reporting Member State group level, 2010

Figure CA24 shows the resistance levels in the reporting MS group based on the quantitative data submitted in 2010 for the various animal species and meat derived from those animals. These data may derive from different MS groups, which needs to be considered when interpreting the figure. In general, *C. coli* isolates tend to be more resistant than *C. jejuni* isolates. Direct comparisons of the levels of resistance in *Campylobacter* from *Gallus gallus* and in broiler meat may not be entirely appropriate because different MSs have reported different types and proportions of isolates tested from meat and live fowl.

***Figure CA24. Resistance to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines in* Campylobacter jejuni *and* Campylobacter coli *from fowl, pigs and cattle at reporting MS group level in 2010***



## 4.5 Discussion

Campylobacteriosis has been the most frequently reported human food-borne zoonosis in the EU since 2004 (EFSA and ECDC, 2011). Although the numbers of cases of invasive human campylobacteriosis are usually extremely low, resistance to antimicrobials in *Campylobacter* isolates is of concern owing to the high number of human cases of gastroenteritis they cause and because some of these cases require treatment. In the joint scientific opinion from ECDC, EFSA and EMA, resistance to quinolones (including fluoroquinolones such as ciprofloxacin) and macrolides (e.g. erythromycin) in *Campylobacter* was regarded as being of major concern, and high relevance for public health on the basis of current evidence of possible human health consequences (EFSA, 2009a). This is also in accordance with the WHO categorisation of critically important antimicrobials (CIAs) for Human Medicine.

In 2010, information on antimicrobial resistance in *Campylobacter* isolates from human cases of campylobacteriosis was reported by 13 MSs and one non-MS (Iceland). The data submitted by these countries represented isolates from 16 % of the human campylobacteriosis cases reported within the EU in 2010. In most MSs, far from all isolates were tested for antimicrobial susceptibility, and countries are encouraged to submit data to achieve a better representativeness of the EU as a whole. A more systematic speciation of *Campylobacter* is also encouraged, because of the inherent differences in resistance patterns between *C. coli* and *C. jejuni*.

A very large discrepancy exists between the guidelines used for the testing and interpretation of antimicrobial susceptibility of *Campylobacter* isolated from human cases, both among and also within countries. Although breakpoints used for the dilution test for *Campylobacter* seem to be less variable than those for *Salmonella*, the breakpoints for disc diffusion differ significantly depending on the guidelines used. In addition, other aspects of the methodology may differ for both dilution and diffusion tests, such as incubation temperature and time. Many standardisation committees have advised against using disc diffusion for *Campylobacter* since the results are inconsistent over time. It is therefore difficult to compare reported *Campylobacter* results, and the need for harmonisation is evident. None of the reporting countries use EUCAST guidelines. EUCAST has currently established epidemiological cut-off values for dilution tests for *C. jejuni* and *C. coli* and a few clinical breakpoints; however, thresholds for disc diffusion were not available at the time of data collection for this report.

The highest resistance levels in *C. jejuni* isolated from humans were reported for ciprofloxacin and nalidixic acid. Although secondary to erythromycin owing to rapid resistance development, ciprofloxacin is nonetheless used in the treatment of severe *Campylobacter* infections. High levels of resistance to ciprofloxacin were reported in *C. jejuni* isolates of both human and poultry origin. This finding appears to be consistent with the widely held opinion that poultry products are the most important food source for human campylobacteriosis due to *C. jejuni*.

Among human isolates, levels of resistance to erythromycin, the most important drug for the treatment of humans with *Campylobacter* infection, were generally low but were higher in *C. coli* than in *C. jejuni*.

Among *Campylobacter* isolates from food-producing animals and meat, with the exception of some Nordic countries, very to extremely high levels of resistance to several antimicrobials were reported by MSs, particularly when using epidemiological cut-off values. In particular, extremely high resistance rates were detected for ciprofloxacin. Resistance to erythromycin, the first-choice drug for the treatment of campylobacteriosis, was observed mostly at a low to moderate level. This situation is similar to that observed in 2009.

In 2010, as in 2009, the highest levels of resistance to quinolones and fluoroquinolones were in general detected in *Campylobacter* isolates from *Gallus gallus*. This high level of resistance is of particular concern, since the EFSA BIOHAZ Panel, in its recent scientific opinion on the quantification of the risk of campylobacteriosis posed to humans by broiler meat, estimated that the handling, preparation and consumption of broiler meat may account for 20 % to 30 % of human campylobacteriosis cases, while 50 % to 80 % of cases may be attributed to the chicken (broiler) reservoir as a whole (EFSA, 2010a). However, *Campylobacter* strains from the broiler reservoir may also reach humans via routes other than food (e.g. by the environment or by direct contact).

In all reporting MSs, the level of resistance to erythromycin was highest in *C. coli* isolates from pigs and was lower in *C. jejuni* from cattle and in *C. coli* and *C. jejuni* from *Gallus gallus* and from broiler meat. These findings mirror those in 2009 and in many previous studies, in which macrolide-resistant isolates of *C. coli* from food animals have mainly been of porcine origin (Gibreel and Taylor, 2006).

The data relating to the susceptibility of *Campylobacter* of food and animal origin reported by MSs were, in general, well harmonised, with almost all MSs reporting the adoption of the EFSA guidelines and recommendations. No MSs reported disc diffusion data for *Campylobacter*.

# 5. ANTIMICROBIAL RESISTANCE IN INDICATOR *ESCHERICHIA COLI*

## 5.1 Introduction

*Escherichia coli* are commensal bacteria normally and naturally present in the intestine of most terrestrial farm animals. The monitoring of antimicrobial resistance in *E. coli* isolated from randomly selected healthy animals and chosen to be representative of the general population provides valuable data on resistance in that population. Commensal *E. coli* present in the intestine of farm animals constitute a reservoir of resistance genes that can spread horizontally to zoonotic and other bacteria occurring in the food chain. Determining the occurrence of resistance to antimicrobials in commensal intestinal *E. coli* provides data useful for investigating correlations with the selective pressure exerted by the use of antimicrobials on the intestinal population of bacteria in food animals. *E. coli* are also useful as representatives of the *Enterobacteriaceae* to monitor the emergence and changes in proportion of bacteria possessing extended-spectrum beta-lactamases (ESBLs).

*E. coli* is commonly chosen as an indicator Gram-negative bacterium as it is very commonly present in animal faeces, is relevant to human medicine and can often acquire conjugative plasmids, which can be transferred between enteric bacteria. Most terrestrial food animals generally carry indicator *E. coli*, and therefore randomised sampling strategies can be developed, allowing for statistical analysis of data and reducing the effect of sampling bias, as well as allowing extrapolations to be made from the random population sampled to the target population from which the sample was derived. Commensal indicator organisms, rather than pathogenic types of *E. coli* such as enterotoxigenic *E. coli* (ETEC) or verotoxigenic *E. coli* (VTEC), are therefore the target of the monitoring of indicator *E. coli*.

The EFSA monitoring guidelines (EFSA, 2008b) recommend that monitoring may be carried out at farm or slaughterhouse level and that at least 90 % of the animal population in a MS should be included in the sampling frame. Samples should be collected randomly from selected holdings or flocks or randomly selected within the slaughterhouse. Samples collected (and subsequently tested) in accordance with the EFSA recommendations should therefore be comparable between MSs.

It should be noted that antimicrobial resistance is not usually considered very significant in infections caused by 'classic' food-borne *E. coli* pathogens such as verotoxigenic *E. coli*; furthermore, human VTEC infections are commonly not treated with antimicrobials. Only one country submitted data concerning VTEC in 2010, and the results for these organisms are presented in section 10.4 of this report. There are a number of different types and strains of *E. coli* causing a range of infections in humans, ranging from urinary tract infections, through enteritis to bacteraemia and septic shock. The degree to which animals and humans share or exchange the same strains of *E. coli* is currently the subject of active research and debate. Resistance to key therapeutic antimicrobials can seriously compromise treatment of invasive *E. coli* infections as well as urinary tract infections in humans. Infections caused by such antimicrobial-resistant strains are becoming increasingly common worldwide and are posing serious health problems for human medicine (EARSS, 2008).

## 5.2 Antimicrobial resistance in indicator *Escherichia coli* isolates from animals and food

In total, eight MSs and two non-MSs (Norway and Switzerland) collectively reported quantitative MIC data on antimicrobial resistance in commensal (indicator) *E. coli* isolates from animals and food, and one MS reported inhibition zone data. Table EC1 shows the countries that reported *E. coli* MIC values in 2010. The total number of tests performed on isolates of *E. coli* from animals and food by MSs and non-MSs and for which quantitative MIC data are available was 80 033.

***Table EC1. Overview of countries reporting MIC and disc inhibition zones on indicator* Escherichia coli *from animals and food in 2010***

| Method | Origin | Total number of MSs reporting | Countries |
|---|---|---|---|
| Diffusion | *Gallus gallus* (fowl) | 1 | **MS:** HU |
| | Pigs | 1 | **MS:** HU |
| | Cattle (bovine animals) | 1 | **MS:** HU |
| Dilution | *Gallus gallus* (fowl) | 6 | **MSs:** AT, DE, DK, FR, NL, SE |
| | | | **Non-MS:** CH |
| | Pigs | 6 | **MSs:** AT, DK, EE, FI, FR, NL |
| | | | **Non-MS:** CH |
| | Cattle (bovine animals) | 5 | **MSs:** AT, DE, DK, EE, NL |
| | | | **Non-MSs:** CH, NO |
| | Meat from broilers (*Gallus gallus*) | 2 | **MSs:** DK, SE |
| | Meat from pig | 1 | **MS:** DK |
| | Meat from bovine animals | 1 | **MS:** DK |

Antimicrobials selected by the different MSs and non-MSs for quantitative susceptibility testing of *E. coli* are shown in Chapter 11, Materials and Methods, Table MM7. This chapter describes in detail resistance to the following antimicrobial agents: ampicillin, cefotaxime, ciprofloxacin, chloramphenicol, gentamicin, nalidixic acid, streptomycin, sulfonamides and tetracyclines. The tables were generated if more than four countries reported quantitative data per sampling origin. In addition, the report includes data only where 10 or more isolates were available per country, per sampling origin, per year.

In the graphs illustrating trends in the development of antimicrobial resistance over time, results for MIC data interpreted using epidemiological cut-off values are shown. Only a few MSs have reported data for the six consecutive years from 2005 to 2010.

For further information on reported MIC distributions and numbers of resistant isolates for ampicillin, apramycin, cefotaxime, ceftazidime, ceftiofur, ciprofloxacin, chloramphenicol, florfenicol, gentamicin, nalidixic acid, neomycin, spectinomycin, streptomycin, sulfonamides, tetracyclines and trimethoprim for *E. coli* in 2010, refer to the level 3 tables published on the EFSA website.

## 5.2.1 Antimicrobial resistance in indicator *Escherichia coli* isolates from food

### 5.2.1.1 Meat

In 2010, Denmark provided quantitative MIC data for *E. coli* isolates from meat from bovine animals, broilers (*Gallus gallus*) and pigs, and Sweden reported similar data concerning meat from broilers (*Gallus gallus*). Data on antimicrobial resistance in indicator *E. coli* isolates from the three kinds of meat reported by Denmark and Sweden were derived from active and representative monitoring programmes. In Denmark, *E. coli* isolates originated from meat sampled at wholesale and retail outlets, collected randomly in all regions of the country in the framework of three centrally coordinated sampling plans corresponding to each kind of meat. In Sweden, the programme is based on a stratified sampling plan. Samples from 100 frozen broiler fillets were randomly collected from 100 packages and from different batches; for each slaughterhouse, the sample size was proportional to the annual slaughter volume.

#### Resistance levels among *E. coli* isolates in broiler meat

Denmark and Sweden tested, respectively, 158 and 77 *E. coli* isolates from meat from broilers (*Gallus gallus*). Both countries reported moderate resistance to sulfonamides (15 % in Denmark and 17 % in Sweden). While moderate resistance to ampicillin (16 %), streptomycin (15 %) and tetracyclines (13 %) was reported in Denmark, Sweden recorded low levels of resistance to these antimicrobials, at 10 %, 4 % and 8 %, respectively.

Both countries reported a low level of resistance to nalidixic acid: 4 % in Denmark and 6 % in Sweden. Denmark reported a low resistance (4 %) to ciprofloxacin but Sweden reported no data for this antimicrobial. Sweden reported no resistance to cefotaxime, whereas Denmark reported one resistant isolate (0.6 %).

Both countries reported a single isolate resistant to chloramphenicol, giving resistance levels of 0.6 % for Denmark and 1 % for Sweden. Neither country detected any resistance to gentamicin.

In both Denmark and Sweden, the low prevalence of resistance in *E. coli* contaminating broiler meat reflected an equally low resistance level in indicator *E. coli* from broilers with the exception of sulfonamide resistance in *E. coli* recovered from broiler meat, which was more than twice as high as resistance in *E. coli* from broilers.

Of the other aminoglycosides tested, Denmark reported 4 % resistance to spectinomycin and 0.6 % resistance to neomycin, whereas Sweden reported 1 % resistance to kanamycin.

#### Resistance levels among *E. coli* isolates in meat from pigs

In 2010, Denmark also tested 68 samples of meat from pigs and reported a high level of resistance to streptomycin (38 %), ampicillin (24 %) and tetracyclines (24 %), and a moderate level of resistance to sulfonamides (19 %) and trimethoprim (16 %). In addition, it reported a low level of resistance to chloramphenicol (3 %), cefotaxime (1 %), ceftiofur (1 %), ciprofloxacin (1 %), gentamicin (1 %) and nalidixic acid (1 %).

#### Resistance levels among *E. coli* isolates in meat from bovine animals

Among the 32 isolates from meat from bovine animals tested for susceptibility in 2010, Denmark recorded low resistance to ampicillin (3 %), streptomycin (3 %), sulfonamides (6 %) and tetracyclines (3 %), while no resistance to cefotaxime, ceftiofur, chloramphenicol, ciprofloxacin, gentamicin or nalidixic acid was detected.

## 5.2.2 Antimicrobial resistance in indicator *Escherichia coli* isolates from animals

### 5.2.2.1 Fowl (*Gallus gallus*)

In this section, data on antimicrobial resistance in indicator *E. coli* isolates from fowl (*Gallus gallus*) include data from broilers reported by all countries and also from laying hen flocks reported by Germany.

In all reporting MSs, except Germany, active monitoring programmes were based on random sampling of healthy broiler chickens at the slaughterhouse. The slaughterhouses included in the monitoring programme accounted for a major proportion, typically 80 % or more, of the total production in the country. The sampling plan was stratified per slaughterhouse, the sample size per slaughterhouse being proportionate to the annual throughput of animals slaughtered. The sampling was evenly distributed throughout the year or a significant part of the year to account for any possible seasonal effect. Indicator *E. coli* isolates were isolated from caecal contents in France, the Netherlands and Sweden, from cloacal swabs in Switzerland, and from faecal samples in the other reporting MSs, by sampling healthy broilers at slaughter. Only one representative sample of caecal content per flock/batch, derived either from a unique or from a number of slaughtered animals, was gathered to account for clustering. In Germany, indicator *E. coli* isolates were obtained from faeces sampled from broiler and laying hen flocks on farm. Samples were collected in the framework of a national sampling plan, stratified per federal region and proportionally allocated with regard to the total number of broilers and laying hens per Land.

#### Resistance levels among *Escherichia coli*

In 2010, quantitative data from six MSs and one non-MS (Switzerland) were included in the analysis of antimicrobial resistance in *E. coli* from fowl (Table EC2).

Overall, at the reporting MS group level, high levels of resistance to ampicillin (35 %), sulfonamides (34 %), tetracyclines (31 %), ciprofloxacin (29 %), nalidixic acid (26 %) and streptomycin (26 %) were recorded and low levels of resistance to gentamicin (4 %), cefotaxime (5 %) and chloramphenicol (8 %) were reported. As in previous years, reported resistance to tetracyclines, ampicillin, ciprofloxacin, streptomycin, sulfonamides and nalidixic acid showed considerable variation between MSs. The variation in levels of resistance to cefotaxime, chloramphenicol and gentamicin was lower. For all three antimicrobials, most countries reported low or very low levels of resistance, with the only exception being the Netherlands.

The overall resistance levels in 2010 were lower than those in 2009 for all of the selected antimicrobials presented in Table EC2. In 2010, overall resistance data are mainly driven by German results, based on an *E. coli* isolate sample of a large size. However, there were no major changes in the levels reported by individual countries; some of the overall declines observed in 2010 could be attributable to the lack of data for 2010 from Spain, which reported relatively high levels of resistance for most antimicrobials in 2009. The Netherlands recorded relatively high levels of resistance compared with the other reporting countries, while Sweden reported relatively low levels of resistance.

***Table EC2. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, streptomycin, sulfonamides and tetracyclines among indicator* Escherichia coli *from* Gallus gallus *in countries reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 171 | 33 | 171 | 0.6 | 171 | 7 | 171 | 80 | 171 | 4 |
| Denmark | 118 | 21 | 118 | 0 | 118 | 3 | 118 | 9 | 118 | 0 |
| France | 201 | 49 | 201 | 4 | 201 | 5 | 201 | 27 | 201 | 2 |
| Germany[1] | 200 | 78 | 200 | 14 | 200 | 21 | 200 | 54 | 200 | 6 |
| Germany[2] | 1,001 | 19 | 1,001 | 3 | 1,001 | 3 | 1,001 | 7 | 1,001 | 3 |
| Netherlands | 284 | 76 | 284 | 18 | 284 | 26 | 284 | 64 | 284 | 10 |
| Sweden | 181 | 6 | 181 | 1 | 181 | 0 | - | - | 181 | 0 |
| **Total (6 MSs)** | **2,156** | **35** | **2,156** | **5** | **2,156** | **8** | **1,975** | **29** | **2,156** | **4** |
| Switzerland | 183 | 19 | 183 | 1 | 183 | 3 | 183 | 35 | 183 | 2 |

| Country | Nalidixic acid | | Streptomycin | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 171 | 79 | 171 | 37 | 171 | 40 | 171 | 28 |
| Denmark | 118 | 8 | 118 | 14 | 118 | 20 | 118 | 15 |
| France | 201 | 25 | 201 | 32 | 201 | 51 | 201 | 75 |
| Germany[1] | 200 | 54 | 200 | 61 | 200 | 4 | 200 | 57 |
| Germany[2] | 1,001 | 6 | 1,001 | 9 | 1,001 | 16 | 1,001 | 16 |
| Netherlands | 284 | 63 | 284 | 67 | 284 | 71 | 284 | 60 |
| Sweden | 181 | 13 | 181 | 7 | 181 | 7 | 181 | 8 |
| **Total (6 MSs)** | **2,156** | **26** | **2,156** | **26** | **2,156** | **34** | **2,156** | **31** |
| Switzerland | 183 | 34 | 183 | 16 | 183 | 31 | 183 | 30 |

N = number of isolates tested.

% Res = percentage of resistant isolates.

1. Isolates from broilers.

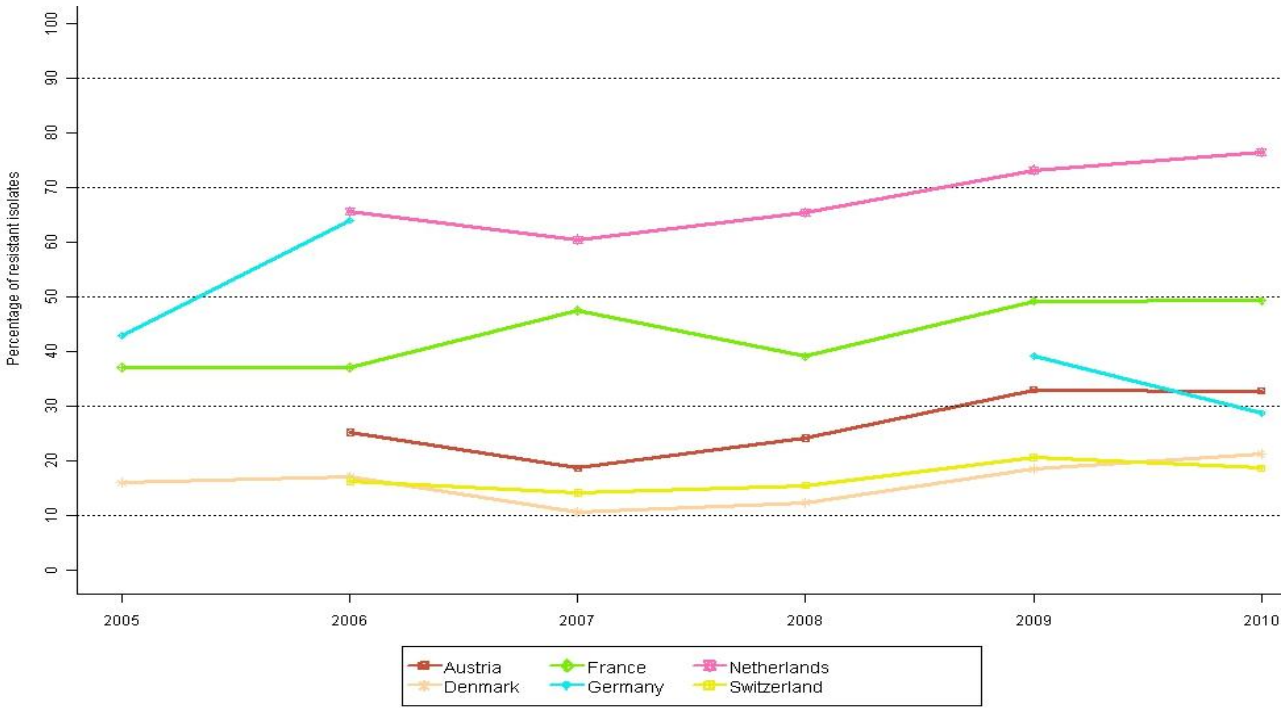
2. Isolates from laying hens.

### Temporal trends in resistance among indicator *Escherichia coli*

Figures EC1–8 illustrate the trends in resistance to selected antimicrobials in *E. coli* from *Gallus gallus*. It should be noted that the 2010 resistance data from Germany presented in the figures combine data from broilers and laying hens. The figures clearly show the large variation in resistance levels reported by different countries, in particular for ciprofloxacin (Figure EC4). In most MSs, resistance to several antimicrobials was relatively stable over time (e.g. ampicillin, cefotaxime, chloramphenicol, gentamicin and tetracyclines; Figures EC1, EC2, EC3, EC5 and EC8). Resistance to cefotaxime, chloramphenicol and gentamicin was low or moderate in most countries, while some countries reported very or extremely high levels of resistance to all the other antimicrobials. Figures EC1–8 also indicate that countries reporting a high level of resistance to one antimicrobial often reported high rates of resistance to several other antimicrobials; the Netherlands and Spain tended to have comparatively high levels of resistance for most antimicrobials, whereas Denmark often had the lowest levels of resistance.

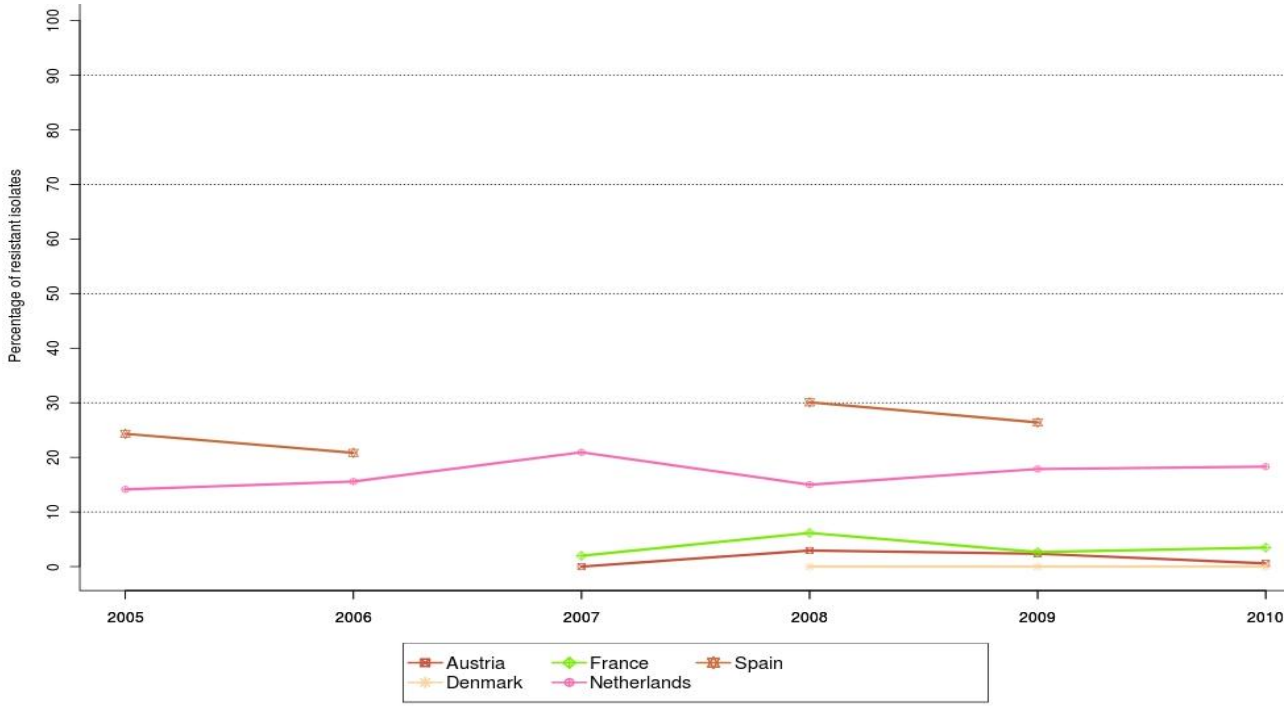
Gradual but continuous increases in resistance to some antimicrobials typically used therapeutically in animals, such as ampicillin, streptomycin, sulfonamides and tetracyclines, have been observed in some reporting MSs over the period 2005–2010. Statistically significant increasing trends were observed in the Netherlands for ampicillin and gentamicin. In addition, France and Denmark registered statistically increasing trends for ampicillin and tetracyclines, respectively. Austria recorded steady significant increases in resistance to both nalidixic acid and ciprofloxacin over the same period (Figure EC5). In the case of cefotaxime resistance, only stable trends have been observed in the reporting MSs over 5 years or more.

***Figure EC1. Trends in ampicillin resistance in indicator* Escherichia coli *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***



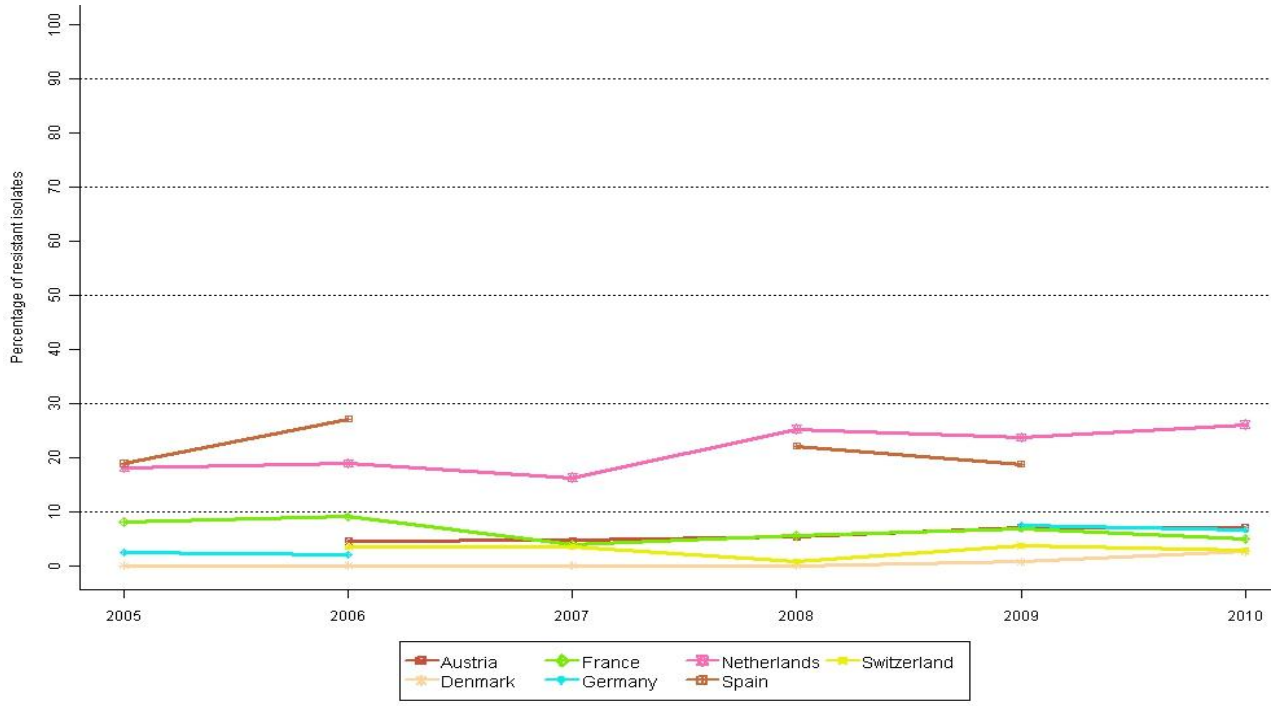

Note: Statistically significant increasing trends over 5 years or more, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria, France and the Netherlands.

***Figure EC2. Trends in cefotaxime resistance in indicator* Escherichia coli *from* Gallus gallus *in reporting Member States, 2005–2010, quantitative data***



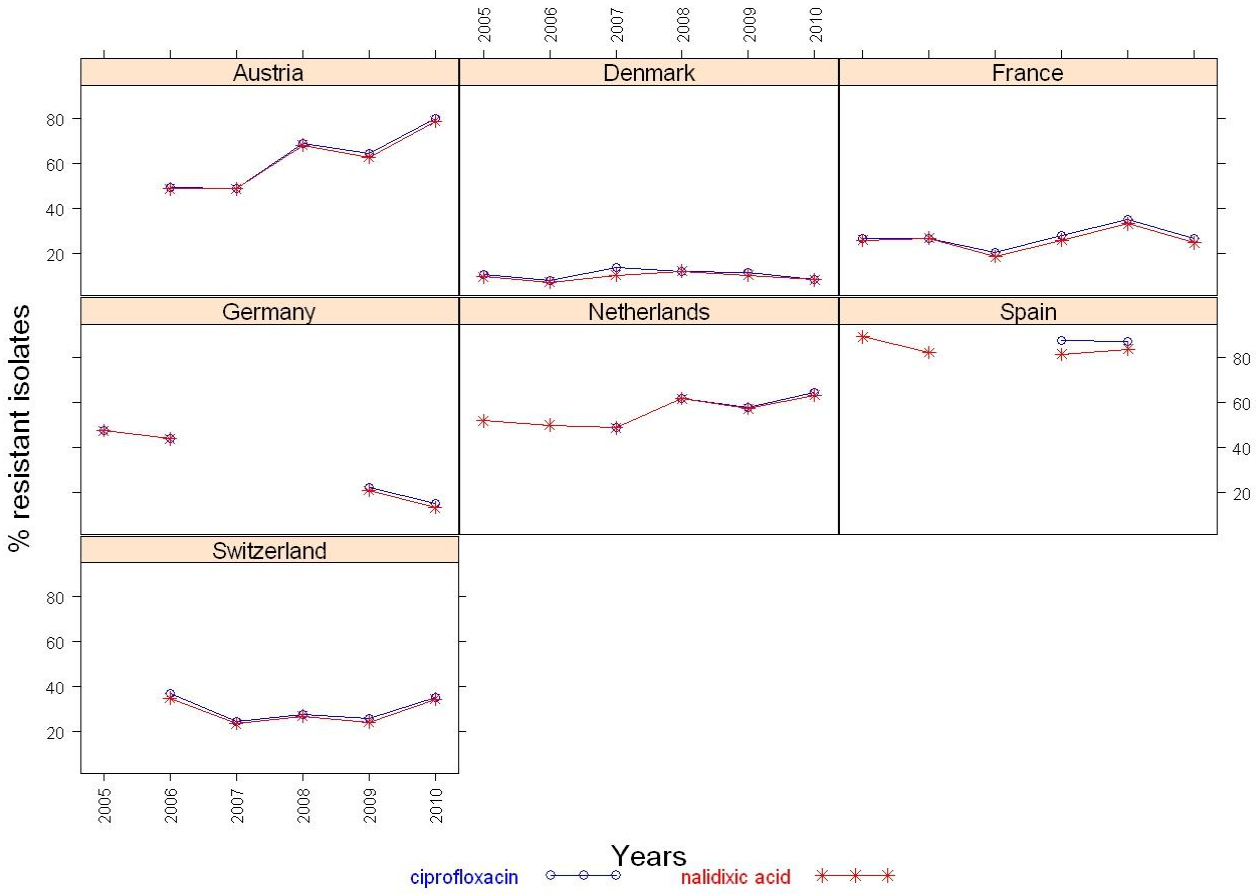

Note: No statistically significant trend over 5 or more years, as tested by logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EC3. Trends in chloramphenicol resistance in indicator* Escherichia coli *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***



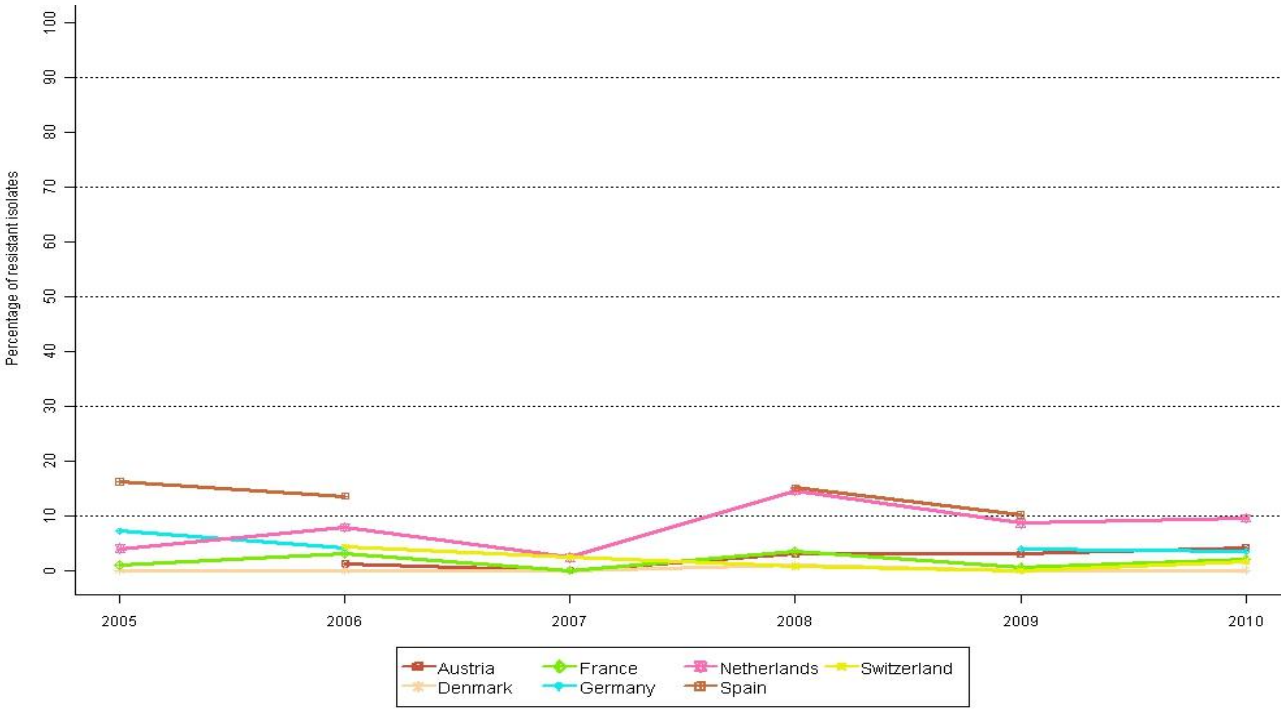

Note: A statistically significant increasing trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Denmark and the Netherlands.

***Figure EC4. Trends in ciprofloxacin and nalidixic acid resistance in indicator* Escherichia coli *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***



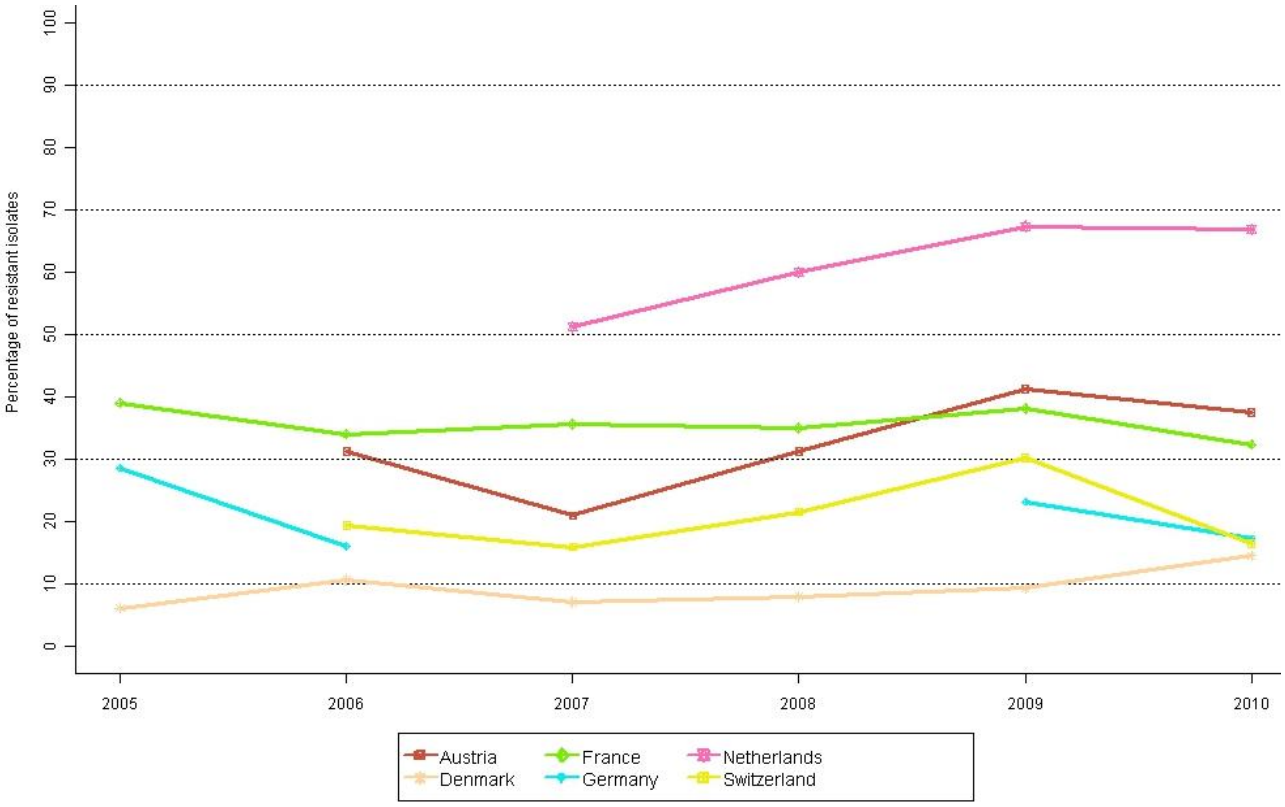

Note: A statistically significant increasing trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria for both ciprofloxacin and nalidixic acid, and in the Netherlands for nalidixic acid.

***Figure EC5. Trends in gentamicin resistance in indicator* Escherichia coli *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***



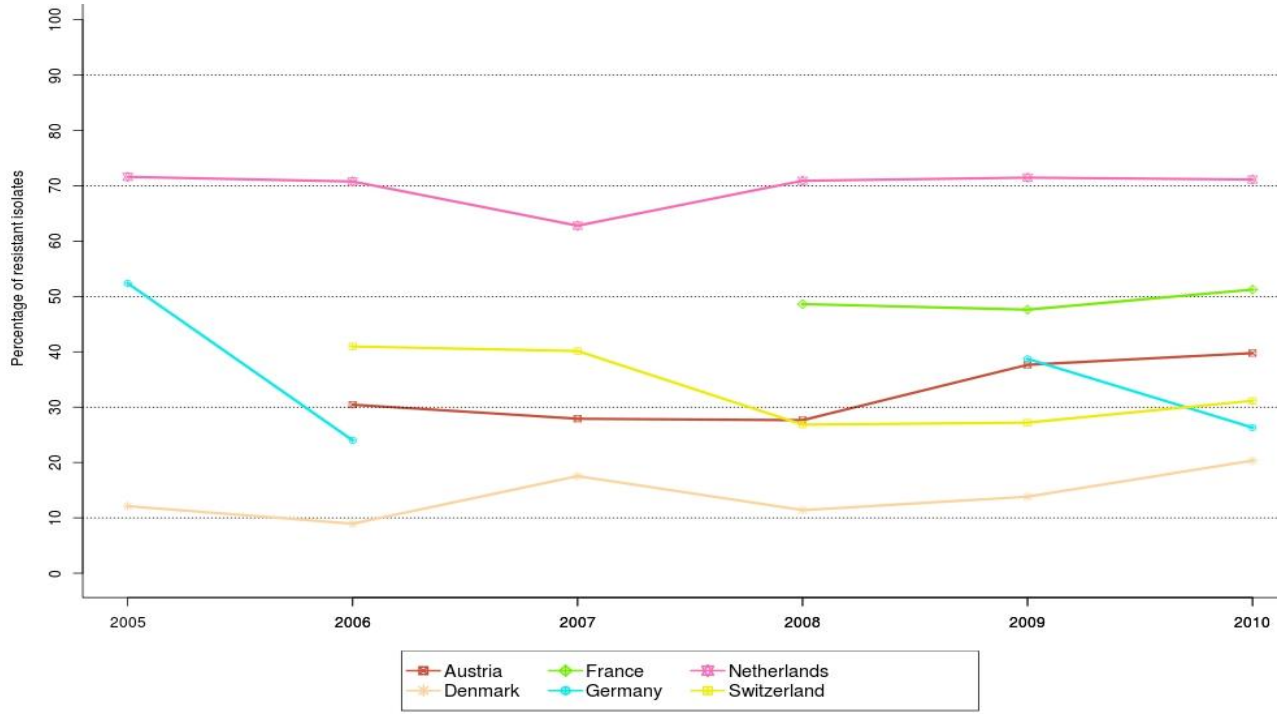

Note: Statistically significant increasing and decreasing trends over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria (↑), the Netherlands (↑) and Switzerland (↓).

***Figure EC6. Trends in streptomycin resistance in indicator* Escherichia coli *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***



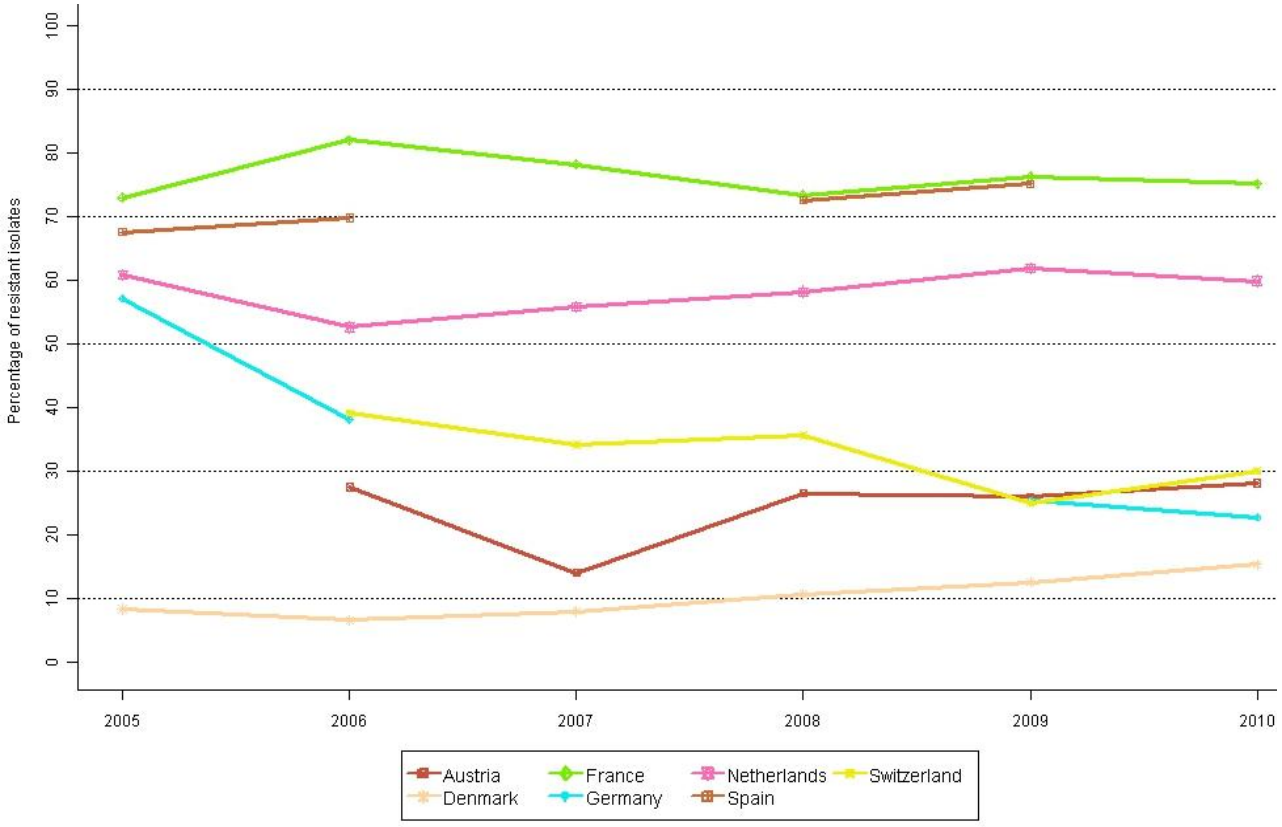

Note: A statistically significant increasing trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria.

***Figure EC7. Trends in sulfonamide resistance in indicator* Escherichia coli *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***




Note: Statistically significant increasing and decreasing trends over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria (↑) and Switzerland (↓).

***Figure EC8. Trends in tetracyclines resistance in indicator* Escherichia coli *from* Gallus gallus *in reporting Member States and non-Member States, 2005–2010, quantitative data***




Note: Statistically significant increasing and decreasing trends over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Denmark (↑) and Switzerland (↓).

### 5.2.2.2 Pigs

In 2010, six MSs and one non-MS (Switzerland) provided quantitative antimicrobial resistance data on indicator *E. coli* in pigs and were included in the following analysis (Table EC3). In the reporting MSs, the antimicrobial resistance monitoring in indicator *E. coli* isolates from pigs was based on active monitoring plans based on random sampling of healthy slaughter pig carcasses at the slaughterhouse. The slaughterhouses included in the monitoring programme accounted for a major proportion, typically 80 % or more, of the total production in the country. The sampling plan was typically stratified per slaughterhouse by allocating the number of samples collected per slaughterhouse proportionally to the annual throughput of the slaughterhouse. An approximately equal distribution of the collected samples over the year enabled the different seasons to be covered. Only one representative faecal sample per epidemiological unit (batch), either derived from a unique carcass or pooled from a number of carcasses, was gathered to account for clustering.

#### Resistance levels among *Escherichia coli*

In 2010, resistance to tetracyclines, ampicillin, streptomycin and sulfonamides was high overall in the reporting MS group (Table EC3). The resistance levels reported for these four antimicrobials varied considerably between MSs; for example, resistance to tetracyclines ranged between 19 % and 75 %. France and the Netherlands tended to have relatively high levels of resistance to all four antimicrobials while Finland reported the lowest level of resistance to all four antimicrobials. The overall resistance to chloramphenicol within the reporting MS group was 7 %, and most countries reported a low or very low level of resistance. For both gentamicin and nalidixic acid, the overall resistance level within the reporting MS group was 2 %. For gentamicin, Estonia reported a high level of resistance of 30 % while all other countries reported low levels ranging from 0.6 % to 3 %, while for nalidixic acid, the resistance levels within the individual MSs ranged between 0 % and 5 %. Estonia reported the highest resistance to both antimicrobials while Denmark reported the lowest resistance to both.

At the reporting MS group level, the overall occurrence of resistance to ciprofloxacin was low (2 %). All MSs reported low or very low levels of resistance; Denmark reported no resistance and Austria and Estonia reported the highest resistance (5 %). In 2010, the overall level of resistance to cefotaxime within the reporting MS group was 1 %. While Finland and Switzerland did not detect any resistance, resistance to cefotaxime in the remaining MSs was reported at low or very low levels, ranging from 0.7 % to 5 %.

For further information on reported MIC distribution data, refer to the level 3 tables published on the EFSA website.

Similar to the isolates from *Gallus gallus*, levels of resistance to all antimicrobials in isolates from pigs in 2010 were lower than the levels that were observed in 2009. This was particularly noticeable for ampicillin (21 % vs. 39 %), streptomycin (44 % vs. 57 %), sulfonamides (37 % vs. 51 %) and tetracyclines (48 % vs. 64 %). This could again be partly due to the lack of data from Spain, which reported relatively high levels of resistance in 2009 but did not report data in 2010. It could also be partly due to the inclusion of data from Finland in 2010, which reported relatively low levels of resistance for most antimicrobials yet did not report any data in 2009.

***Table EC3. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, streptomycin, sulfonamides and tetracyclines among isolates of indicator* Escherichia coli *from pigs in countries reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 169 | 17 | 169 | 1 | 169 | 6 | 169 | 5 | 169 | 1 |
| Denmark | 160 | 23 | 160 | 1 | 160 | 4 | 160 | 0 | 160 | 0.6 |
| Estonia | 40 | 13 | 40 | 5 | 40 | 5 | 40 | 5 | 40 | 30 |
| Finland[1] | 250 | 7 | 250 | 0 | 250 | 0.8 | - | - | 250 | 0.8 |
| France | 158 | 22 | 158 | 3 | 158 | 14 | 158 | 3 | 158 | 3 |
| Netherlands | 282 | 33 | 282 | 0.7 | 282 | 12 | 282 | 0.4 | 282 | 1 |
| **Total (6 MSs)** | **1,059** | **21** | **1,059** | **1** | **1,059** | **7** | **809** | **2** | **1,059** | **2** |
| Switzerland | 179 | 20 | 179 | 0 | 179 | 5 | 179 | 3 | 179 | 2 |

| Country | Nalidixic acid | | Streptomycin | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 169 | 5 | 169 | 57 | 169 | 32 | 169 | 57 |
| Denmark | 160 | 0 | 160 | 47 | 160 | 32 | 160 | 37 |
| Estonia | 40 | 5 | 40 | 38 | 40 | 23 | 40 | 30 |
| Finland | 250 | 2 | 250 | 15 | 250 | 12 | 250 | 19 |
| France | 158 | 2 | 158 | 56 | 158 | 58 | 158 | 75 |
| Netherlands | 282 | 0.4 | 282 | 55 | 282 | 55 | 282 | 63 |
| **Total (6 MSs)** | **1,059** | **2** | **1,059** | **44** | **1,059** | **37** | **1,059** | **48** |
| Switzerland | 179 | 3 | 179 | 45 | 179 | 43 | 179 | 30 |

N = number of isolates tested.

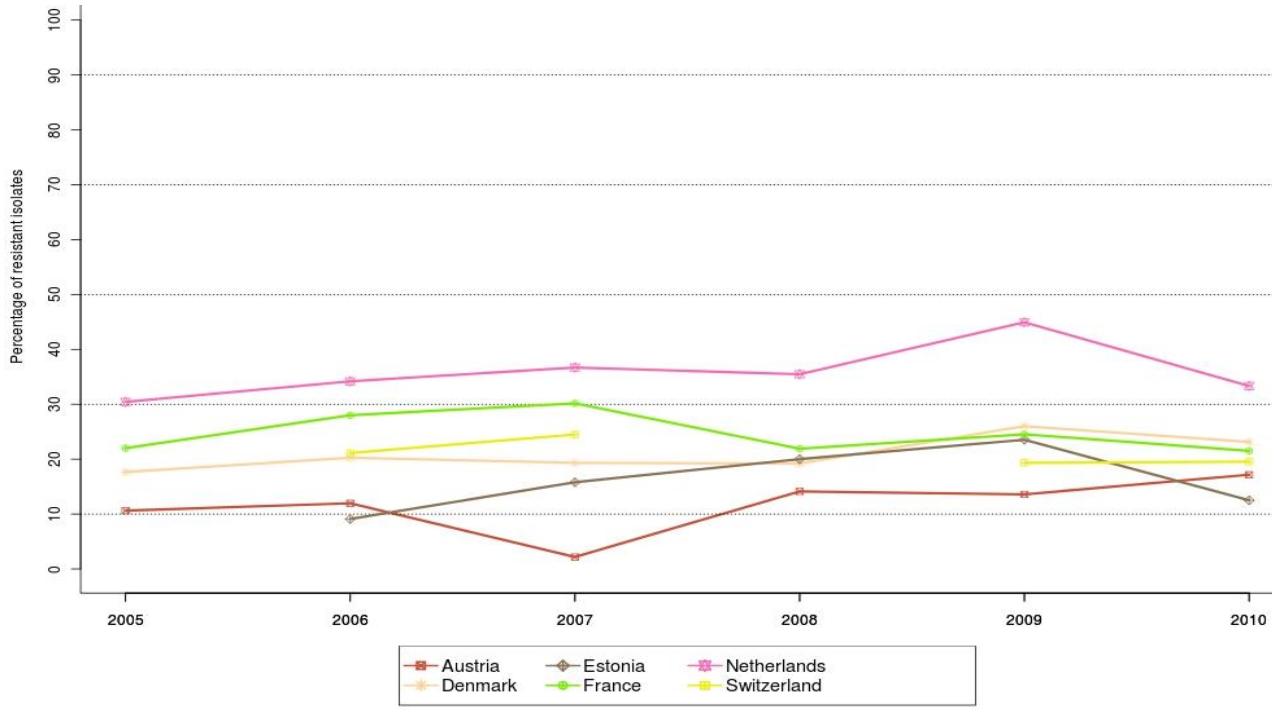
% Res = percentage of resistant isolates.

1. Finnish results for ciprofloxacin not included as the EUCAST cut-off value is not applicable to results obtained with the VetMIC method.

## Temporal trends in resistance among indicator *Escherichia coli*

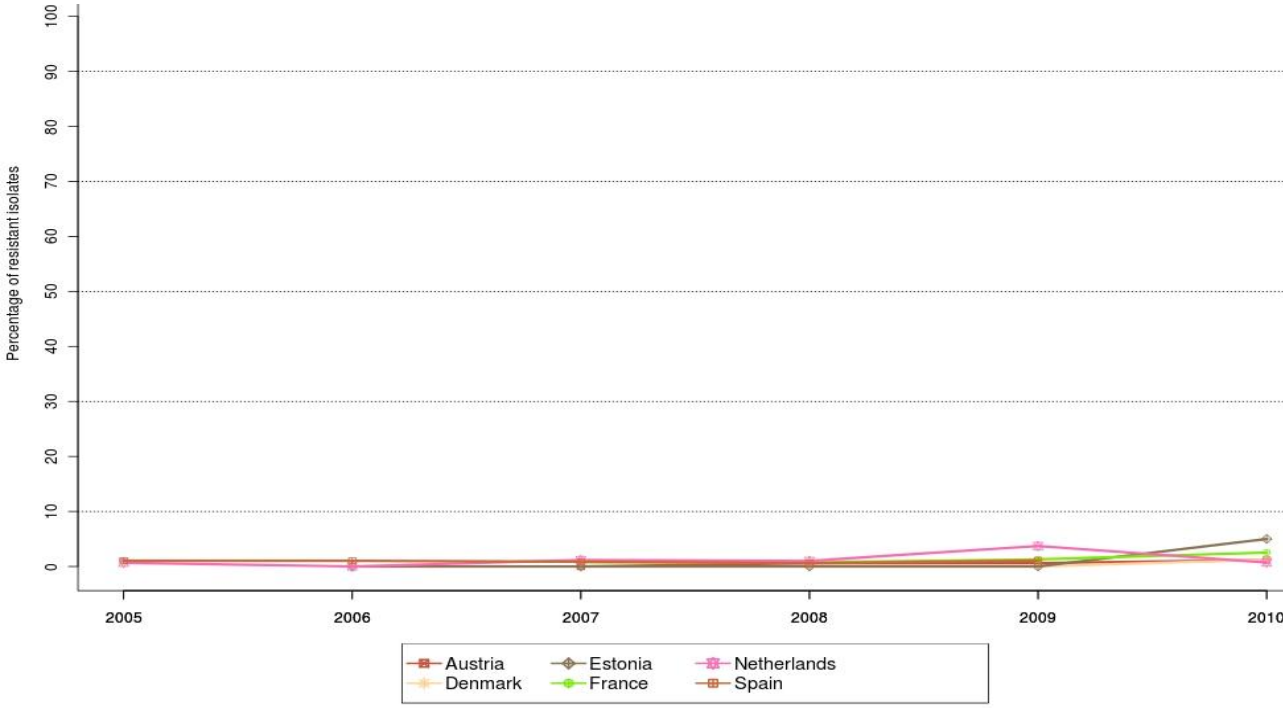
Figures EC9–16 illustrate the trends in resistance to selected antimicrobials in indicator *E. coli* from pigs. Again, the variation in resistance levels between reporting MSs is clearly visible in several of the figures, e.g. for ampicillin, ciprofloxacin, streptomycin, sulfonamides and tetracyclines. Similarly to the trends in *Gallus gallus*, the levels of resistance to numerous antimicrobials were relatively stable over time in most MSs, with only minor fluctuations and no apparent general trends (e.g. ampicillin, chloramphenicol, streptomycin and tetracyclines; Figures EC9, EC11, EC14, EC16). For ciprofloxacin and nalidixic acid, most countries reported low or moderate levels of resistance in 2009 and 2010 (Figure EC12). Cefotaxime resistance has been low since 2006 (Figure EC10). There are some indications of a marginal increase since then. As in *Gallus gallus*, resistance to gentamicin tended to be low in most MSs, although Estonia showed a significant increasing trend in resistance between 2006 and 2010, and this was particularly marked between 2009 and 2010 (Figure EC13). France, the Netherlands and Spain reported the highest levels of resistance for most antimicrobials, while Denmark tended to report comparatively low levels of resistance for many antimicrobials. However, a steady statistically significant increase in tetracycline resistance was also recorded in this country over the period 2005–2010.

***Figure EC9. Trends in ampicillin resistance in indicator* Escherichia coli *from pigs in reporting Member States and non-Member States, 2005–2010, quantitative data***



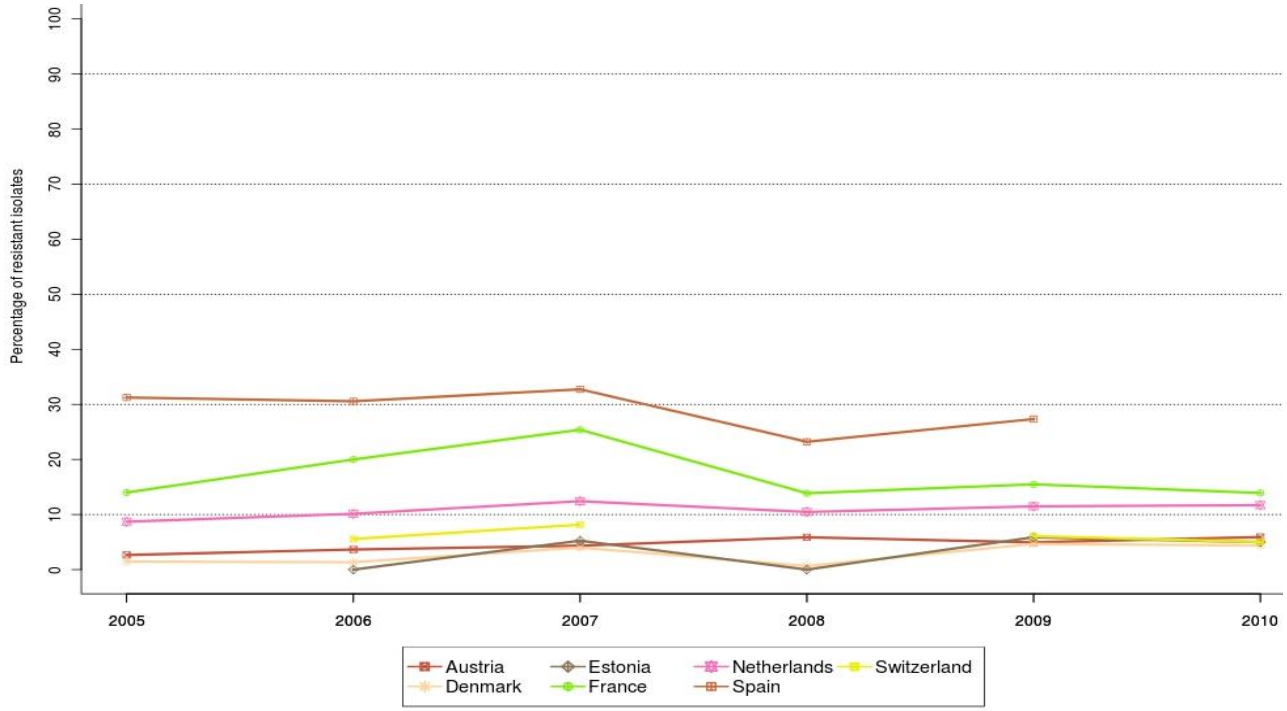

Note: Statistically significant increasing trends over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria and the Netherlands.

***Figure EC10. Trends in cefotaxime resistance in indicator* Escherichia coli *from pigs in reporting Member States, 2005–2010, quantitative data***



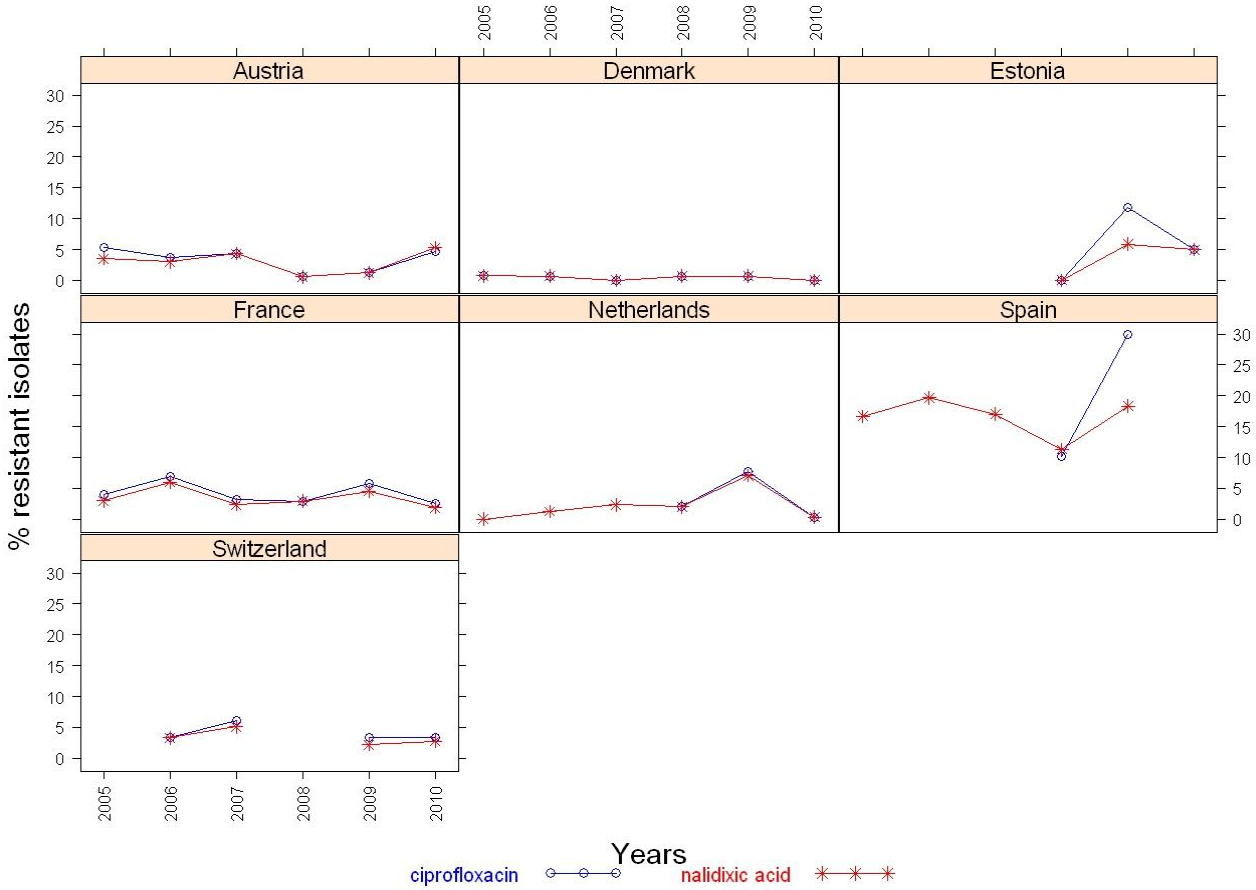

Note: No statistically significant trend over 5 or more years, as tested by logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EC11. Trends in chloramphenicol resistance in indicator* Escherichia coli *from pigs in reporting Member States and non-Member States, 2005-2010, quantitative data***



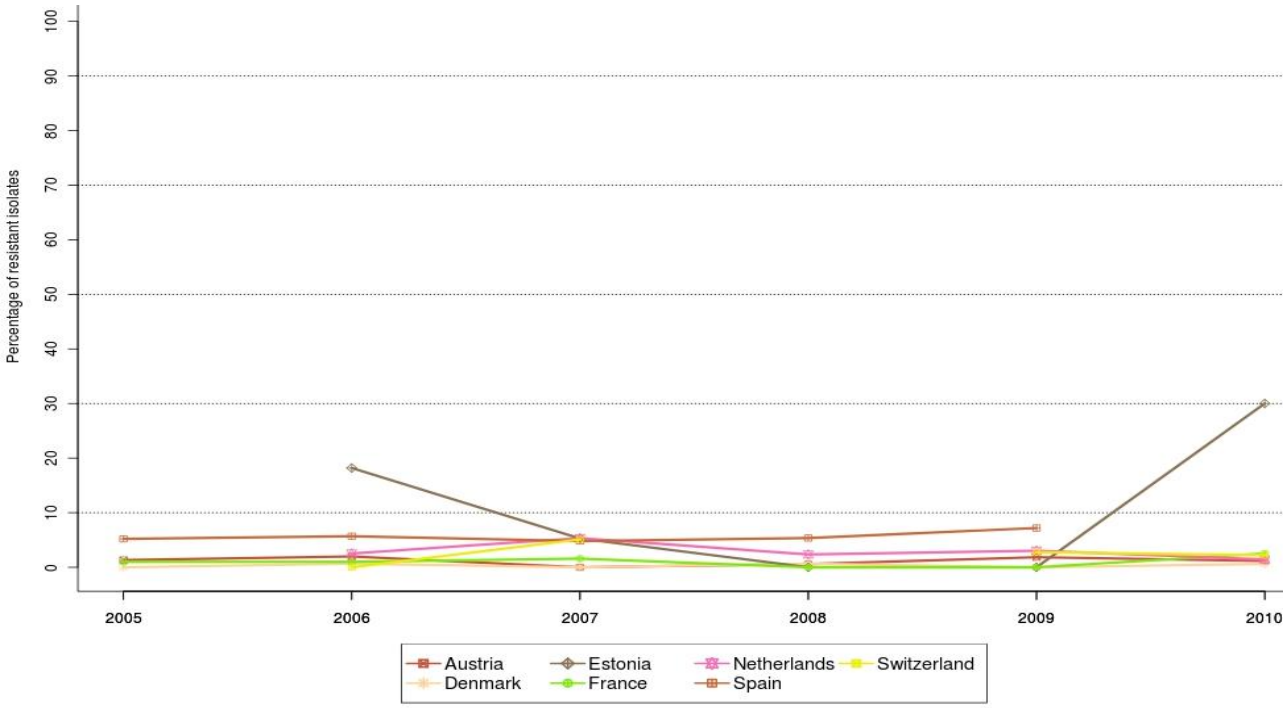

Note: No statistically significant trend over 5 or more years, as tested by logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EC12. Trends in ciprofloxacin and nalidixic acid resistance in indicator* Escherichia coli *from pigs in reporting Member States and non-Member States, 2005–2010, quantitative data***



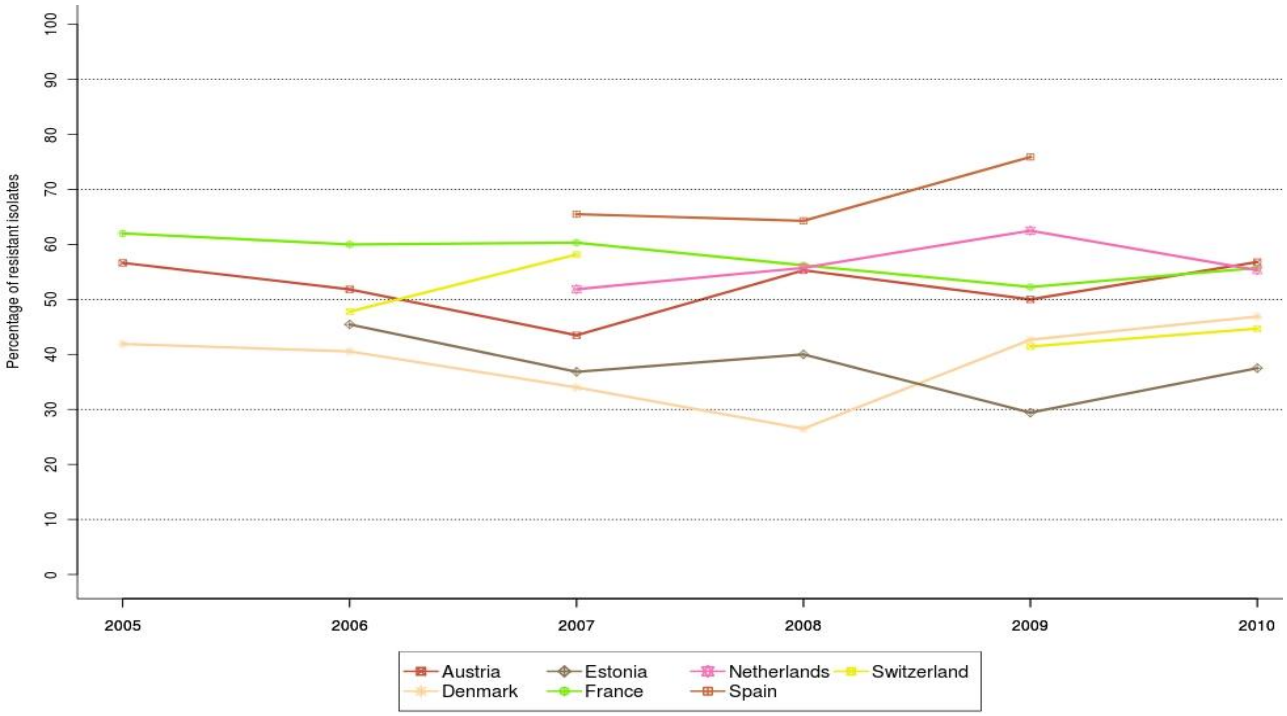

Note: No statistically significant trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed for either ciprofloxacin or nalidixic acid in any of the reporting MSs.

***Figure EC13. Trends in gentamicin resistance in indicator* Escherichia coli *from pigs in reporting Member States and non-Member States, 2005–2010, quantitative data***



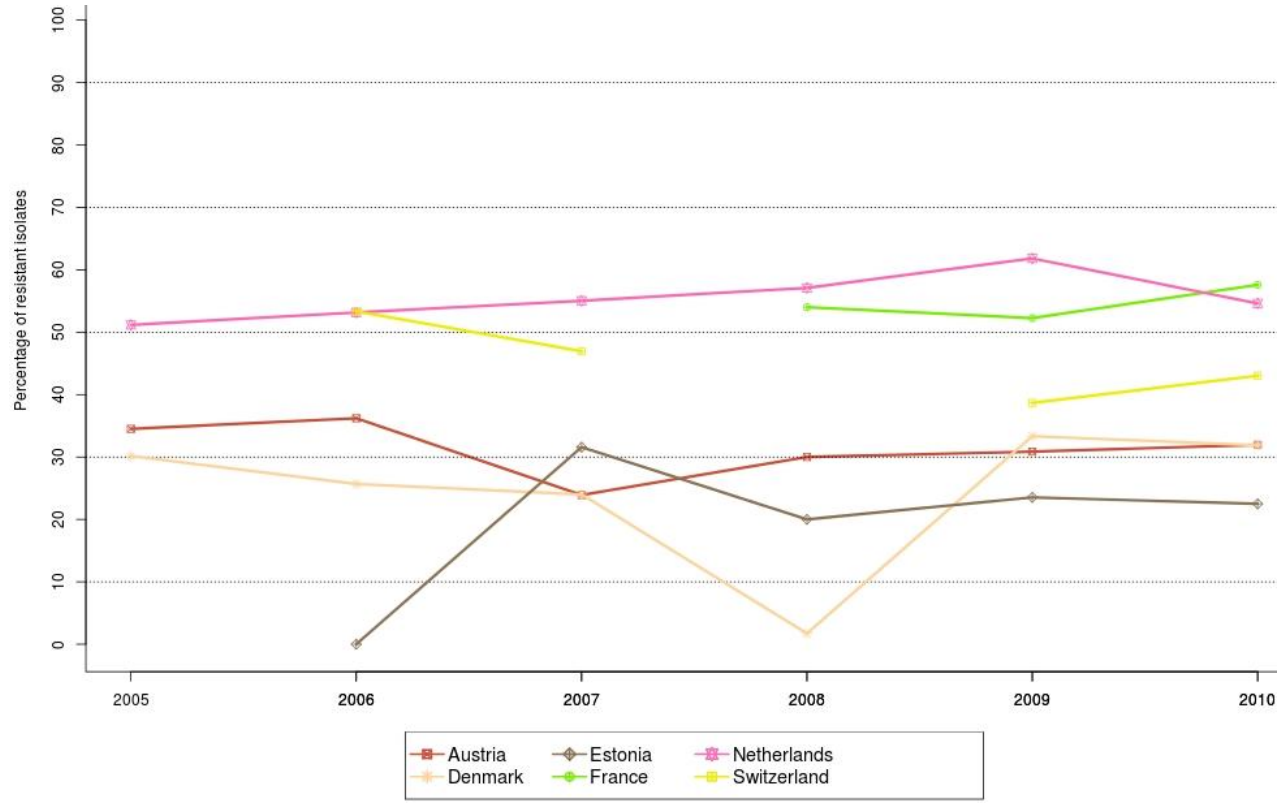

Note: A statistically significant increasing trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Estonia.

***Figure EC14. Trends in streptomycin resistance in indicator* Escherichia coli *from pigs in reporting Member States and non-Member States, 2005–2010, quantitative data***



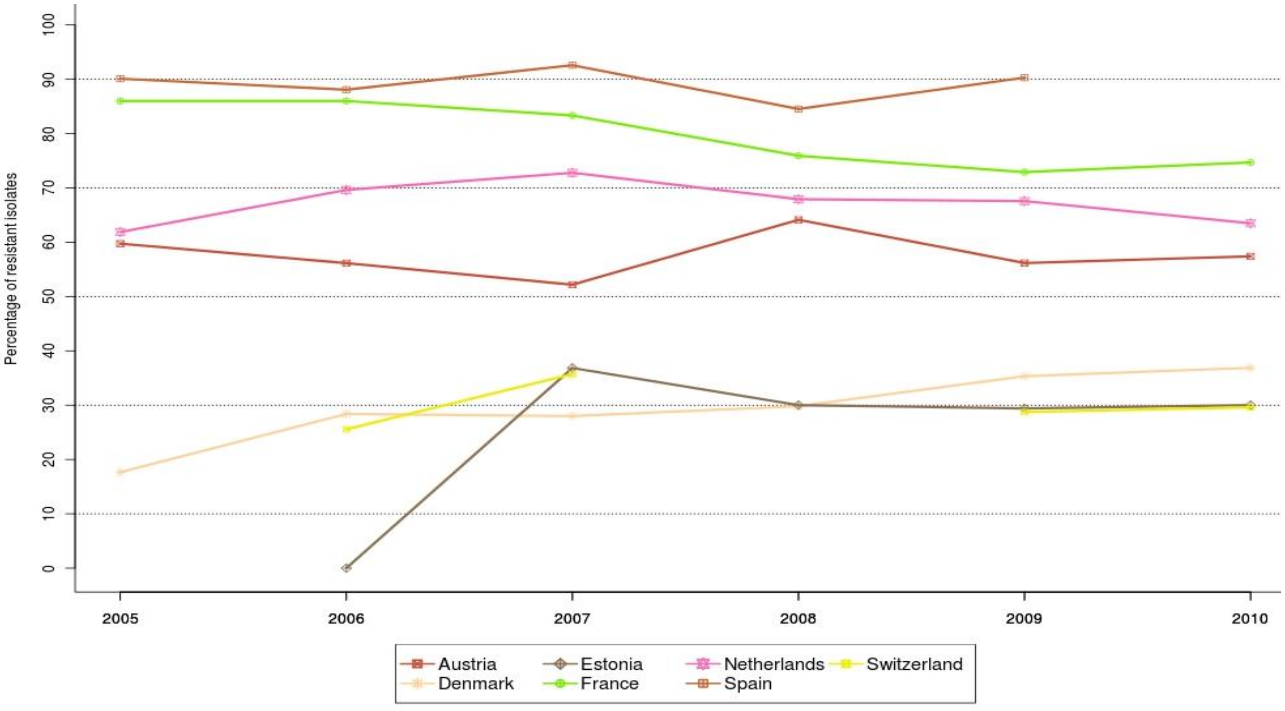

Note: No statistically significant trend over 5 or more years, as tested by logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EC15. Trends in sulfonamide resistance in indicator* Escherichia coli *from pigs in reporting Member States and non-Member States, 2005–2010, quantitative data***




Note: No statistically significant trend over 5 or more years, as tested by logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EC16. Trends in tetracycline resistance in indicator* Escherichia coli *from pigs in reporting Member States and non-Member States, 2005–2010, quantitative data***




Note: Statistically significant increasing and decreasing trends over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Denmark (↑) and France (↓).

### 5.2.2.3 Cattle (bovine animals)

For 2010, quantitative data for *E. coli* in cattle from five MSs and two non-MSs (Norway and Switzerland) were included in the following analyses (Table EC4). The data presented are the pooled data of dairy cows, beef animals and veal calves. In the reporting MSs, antimicrobial resistance monitoring in indicator *E. coli* isolates from cattle was chiefly based on active monitoring plans of healthy bovine animals either sampled from randomly selected herds (Germany, the Netherlands, Norway) or randomly selected within the slaughterhouses (Austria, Denmark, Switzerland). In both cases samples were of faecal origin. In the remaining reporting MS, Estonia, monitoring was passive, based on faecal samples from healthy cattle routinely received at the Veterinary and Food Laboratory. The sampling plans performed at slaughterhouses were stratified per slaughterhouse with proportional allocation of the number of samples to the annual slaughterhouse throughput. In any case, the sampling was evenly distributed throughout the year or a significant part of the year to account for any possible seasonal effect. Only one representative faecal sample was gathered per epidemiological unit, either individual bovine animal or herd, to account for clustering. In Germany and Switzerland, the monitoring programme in 2010 focused specifically on calves under 1 year of age and veal calves.

#### Resistance levels among *Escherichia coli*

In 2010, in cattle, as in pigs, resistance to tetracyclines (38 %), sulfonamides (34 %), streptomycin (33 %) and ampicillin (28 %) was high within the reporting MSs group overall (Table EC4). Again, the levels of resistance reported by individual MSs varied considerably; Germany reported extremely high levels of resistance to all four antimicrobials, while Austria, Denmark, Estonia and Norway reported low levels of resistance to all four antimicrobials. The resistance levels observed for these four antimicrobials were higher than those observed in 2009. At the reporting MS group level there was a moderate level of resistance to chloramphenicol (17 %), ciprofloxacin (15 %) and nalidixic acid (13 %). Again, Germany reported the highest levels of resistance to all of these antimicrobials (ranging between 38 % and 44 %), while other countries tended to report low levels of resistance. Denmark reported a resistance level of 0.9 % for chloramphenicol and no resistance to the other two antimicrobials, and Norway reported no resistance to chloramphenicol or nalidixic acid. The resistance levels observed for these three antimicrobials in 2010 also represent slight increases relative to those observed for cattle in 2009. Gentamicin resistance was low at the reporting MS group level (9 %), with three countries reporting no resistance and Germany reporting a high level of resistance (24 %). This compares with 3 % resistance overall in 2009. The overall level of cefotaxime resistance in 2010 was 3 %, which is marginally higher than in 2009 (0.7 % resistance). As in 2009, Austria and Denmark reported no resistance and Germany reported 10 % resistance while all other countries reported levels between 0.5 % and 2 %. Denmark was the only country to report data for ceftiofur in 2010 and found no resistance in the 106 tested isolates.

In previous years, levels of resistance to all of the antimicrobials tended to be lower in cattle than in indicator *E. coli* from *Gallus gallus* and pigs (Tables EC2 and EC3). However, as a result of the decreases in resistance in *Gallus gallus* and pigs observed in 2010, and concurrent increases in resistance levels in cattle in 2010, cattle now have more comparable resistance levels, and at the reporting MS group level they had the highest levels of resistance to both chloramphenicol and gentamicin.

Five MSs submitted data on *E. coli* in cattle in 2010 compared with the nine reporting in 2009; thus, it is difficult to interpret the trends in resistance levels. Regarding individuals MSs, in Germany, levels of resistance to most antimicrobials were considerably higher than those observed in 2009; otherwise most MSs reported levels roughly similar to those reported in 2009.

***Table EC4. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, streptomycin, sulfonamides and tetracyclines among isolates of* Escherichia coli *from cattle in countries reporting MIC data in 2010, using harmonised epidemiological cut-off values***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 181 | 2 | 181 | 0 | 181 | 1 | 181 | 2 | 181 | 0 |
| Denmark | 106 | 4 | 106 | 0 | 106 | 0.9 | 106 | 0 | 106 | 0 |
| Estonia | 44 | 2 | 44 | 2 | 44 | 2 | 44 | 2 | 44 | 18 |
| Germany[1] | 272 | 77 | 272 | 10 | 272 | 44 | 272 | 42 | 272 | 24 |
| Netherlands | 436 | 18 | 436 | 1 | 436 | 12 | 436 | 8 | 436 | 5 |
| **Total (5 MSs)** | **1,039** | **28** | **1,039** | **3** | **1,039** | **17** | **1,039** | **15** | **1,039** | **9** |
| Norway | 209 | 2 | 209 | 0.5 | 209 | 0 | - | - | 209 | 0 |
| Switzerland[1] | 184 | 39 | 184 | 1 | 184 | 17 | 184 | 4 | 184 | 5 |

| Country | Nalidixic acid | | Streptomycin | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 181 | 0.6 | 181 | 8 | 181 | 7 | 181 | 9 |
| Denmark | 106 | 0 | 106 | 6 | 106 | 5 | 106 | 9 |
| Estonia | 44 | 2 | 44 | 5 | 44 | 2 | 44 | 5 |
| Germany[1] | 272 | 38 | 272 | 79 | 272 | 86 | 272 | 85 |
| Netherlands | 436 | 7 | 436 | 23 | 436 | 23 | 436 | 31 |
| **Total (5 MSs)** | **1,039** | **13** | **1,039** | **33** | **1,039** | **34** | **1,039** | **38** |
| Norway | 209 | 0 | 209 | 9 | 209 | 3 | 209 | 2 |
| Switzerland[1] | 184 | 3 | 184 | 47 | 184 | 55 | 184 | 51 |

N = number of isolates tested.

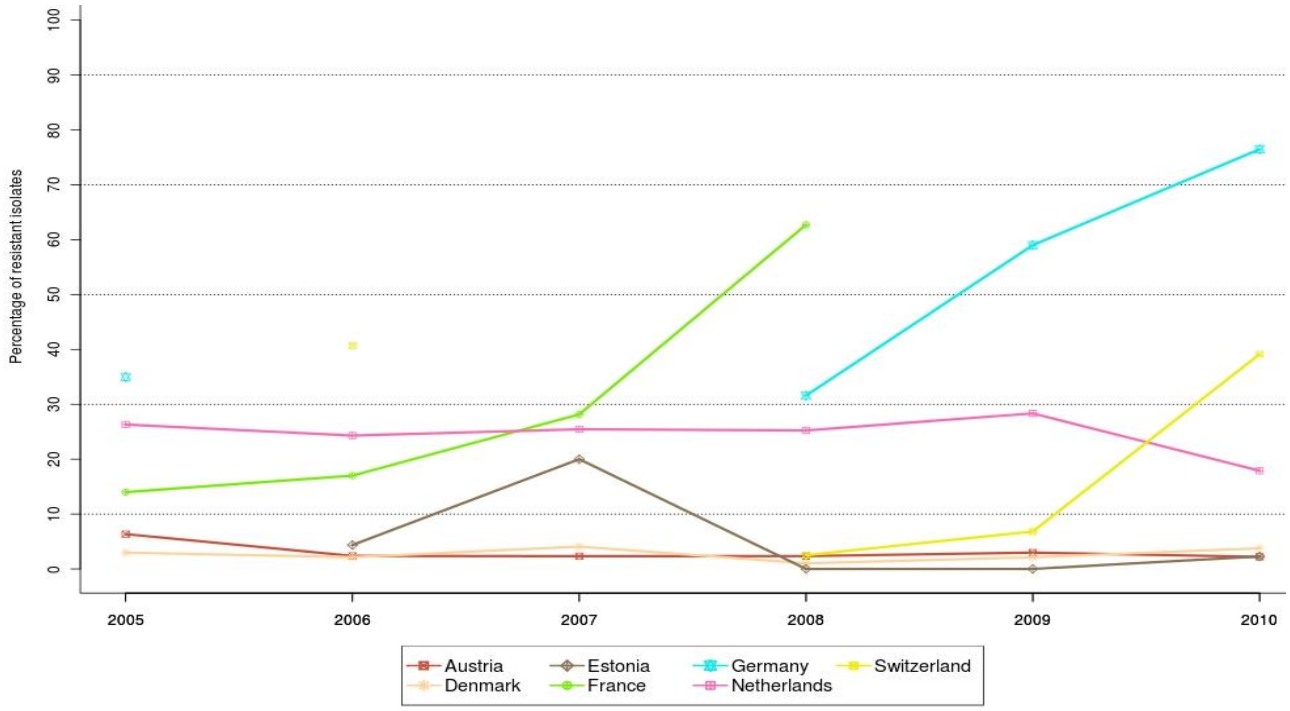
% Res = percentage of resistant isolates.

1. In Germany and Switzerland, the monitoring programmes focused specifically on calves under 1 year of age or veal calves only.

## Temporal trends in resistance among indicator *Escherichia coli*

Figures EC17–24 present the trends in resistance to selected antimicrobials in *E. coli* from cattle. As in pigs, there was considerable variation between MSs in the observed levels of resistance to ampicillin, ciprofloxacin and nalidixic acid, streptomycin, sulfonamides and tetracyclines. France, Germany, the Netherlands and Spain tended to report the highest levels of resistance to most antimicrobials, while Austria and Denmark tended to report relatively low levels of resistance to most antimicrobials. The greatest number of statistically significant trends was for streptomycin and sulfonamides, with three MSs showing significant decreasing trends in each case. Absence or very low levels of resistance and stable trends were observed for cefotaxime over the period 2005–2010.

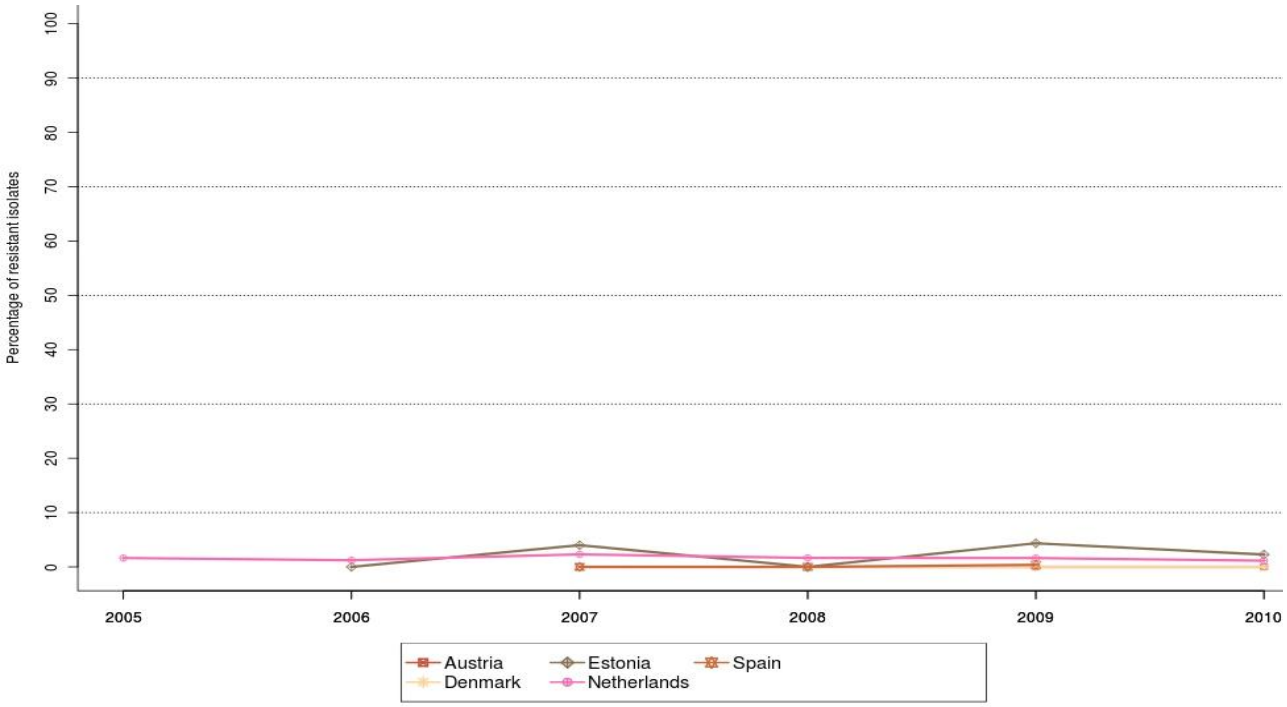
***Figure EC17. Trends in ampicillin resistance in indicator* Escherichia coli *from cattle[1] in reporting Member States and non-Member States, 2005–2010, quantitative data***




Note: Statistically significant decreasing trends over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria (↓) and the Netherlands (↓).

1. The data from Germany in 2009 and 2010, and from Switzerland in 2010, were from calves under 1 year of age or veal calves only. The data from France in 2005 and 2007 originated from various types of bovine animals, including calves under 1 year of age, whereas 2008 data were derived exclusively from calves under 1 year of age.

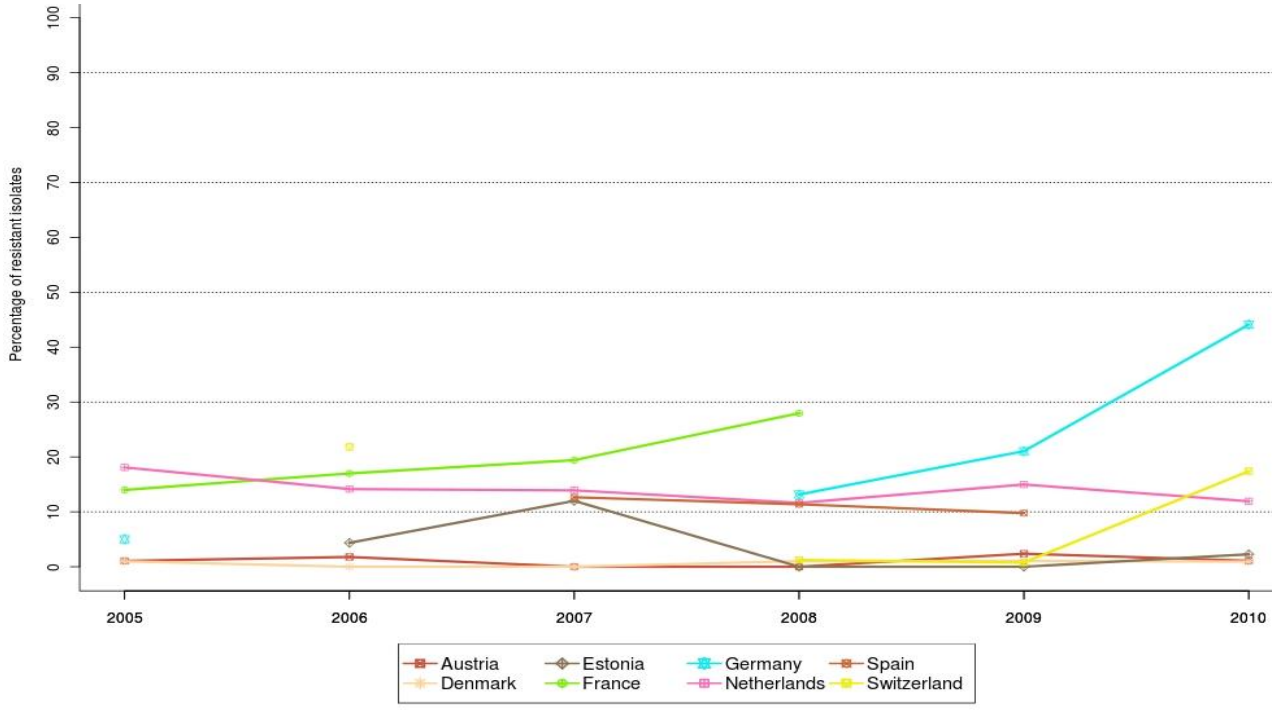
### *Figure EC18. Trends in cefotaxime resistance in indicator* Escherichia coli *from cattle[1] in reporting Member States, 2005–2010, quantitative data*




Note: No statistically significant trend over 5 or more years, as tested by logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

1. The data from Germany in 2009 and 2010, and from Switzerland in 2010, were from calves under 1 year of age or veal calves only.

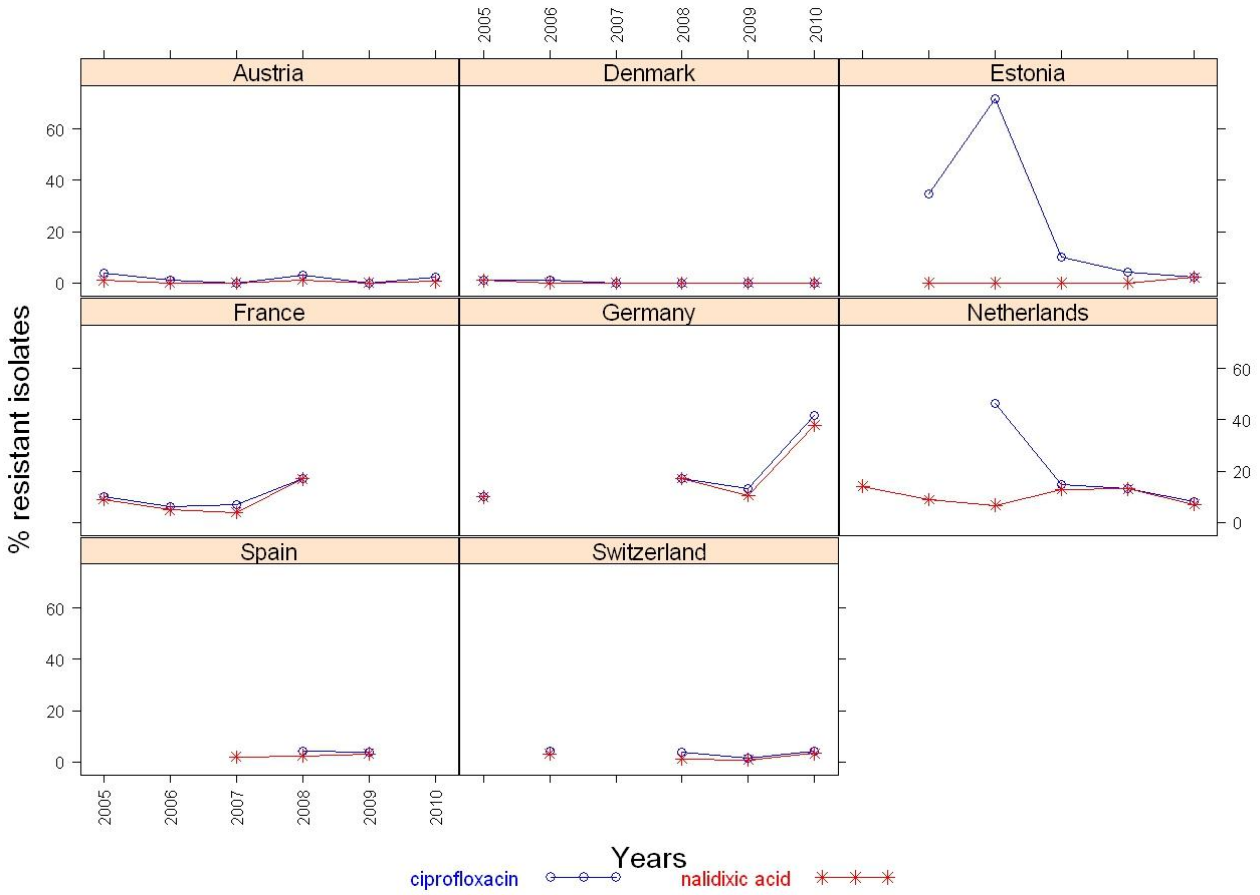
### *Figure EC19. Trends in chloramphenicol resistance in indicator* Escherichia coli *from cattle[1] in reporting Member States and non-Member States, 2005–2010, quantitative data*




Note: No statistically significant trend over 5 or more years, as tested by logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

1. The data from Germany in 2009 and 2010, and from Switzerland in 2010, were from calves under 1 year of age or veal calves only. The data from France in 2005 and 2007 originated from various types of bovine animals, including calves under 1 year of age, whereas 2008 data were derived exclusively from calves under 1 year of age.

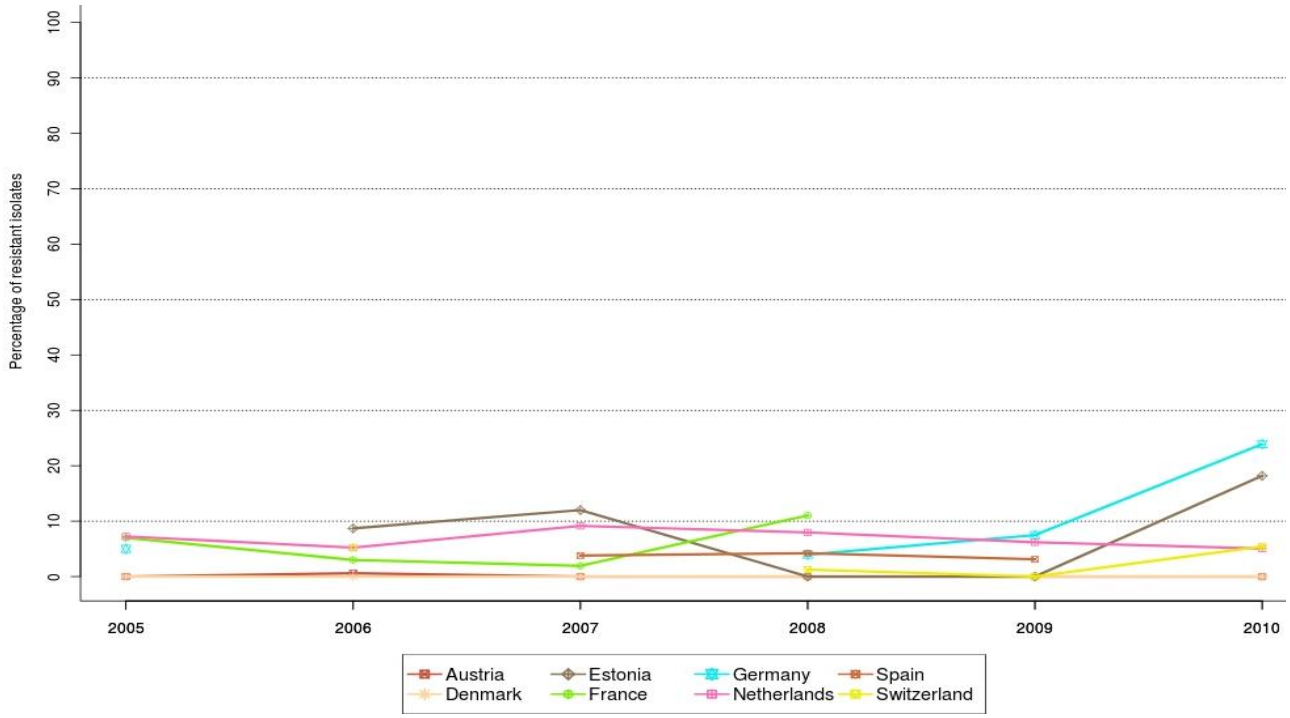
***Figure EC20. Trends in ciprofloxacin and nalidixic acid resistance in indicator* Escherichia coli *from cattle[1] in reporting Member States and non-Member States, 2005–2010, quantitative data***




Note: No statistically significant trend over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed for either ciprofloxacin or nalidixic acid in any of the reporting MSs.

1. The data from Germany in 2009 and 2010, and from Switzerland in 2010, were from calves under 1 year of age or veal calves only. The data from France in 2005 and 2007 originated from various types of bovine animals, including calves under 1 year of age, whereas 2008 data were derived exclusively from calves under 1 year of age.

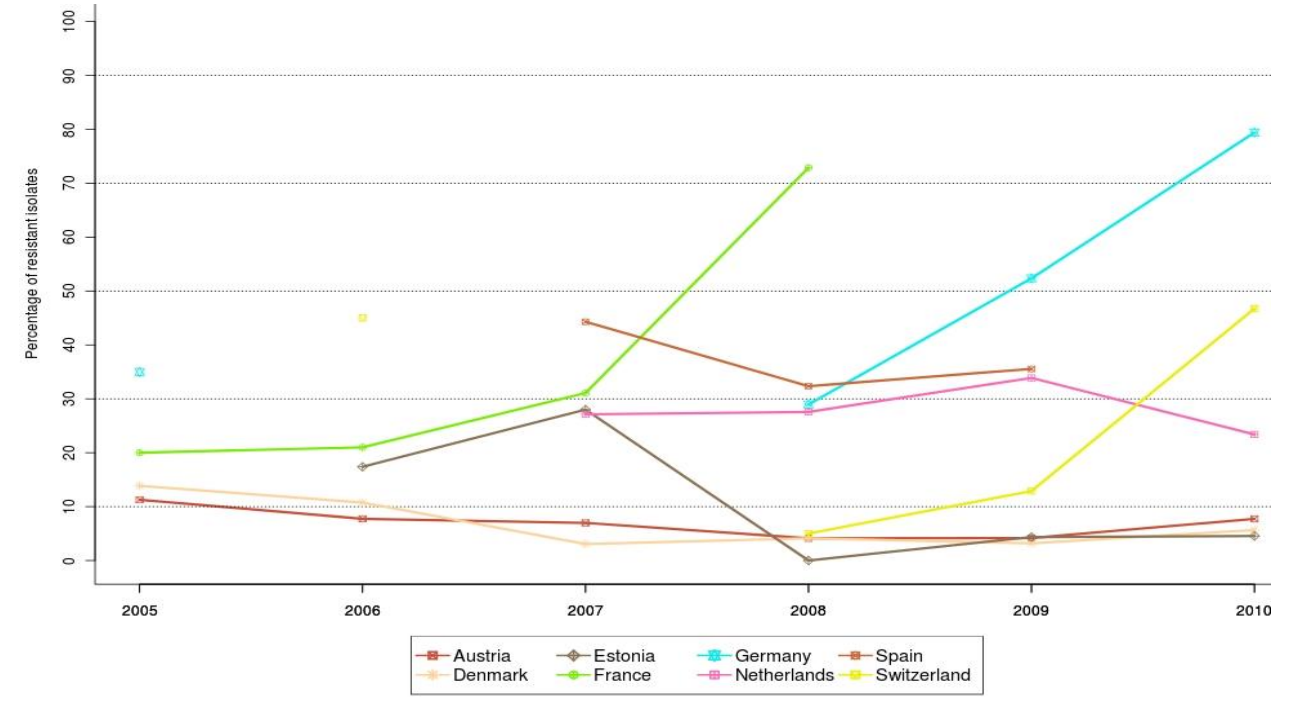
### *Figure EC21. Trends in gentamicin resistance in indicator* Escherichia coli *from cattle[1] in reporting Member States and non-Member States, 2005–2010, quantitative data*




Note: No statistically significant trend over 5 or more years, as tested by logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

1. The data from Germany in 2009 and 2010, and from Switzerland in 2010, were from calves under 1 year of age or veal calves only. The data from France in 2005 and 2007 originated from various types of bovine animals, including calves under 1 year of age, whereas 2008 data were derived exclusively from calves under 1 year of age.

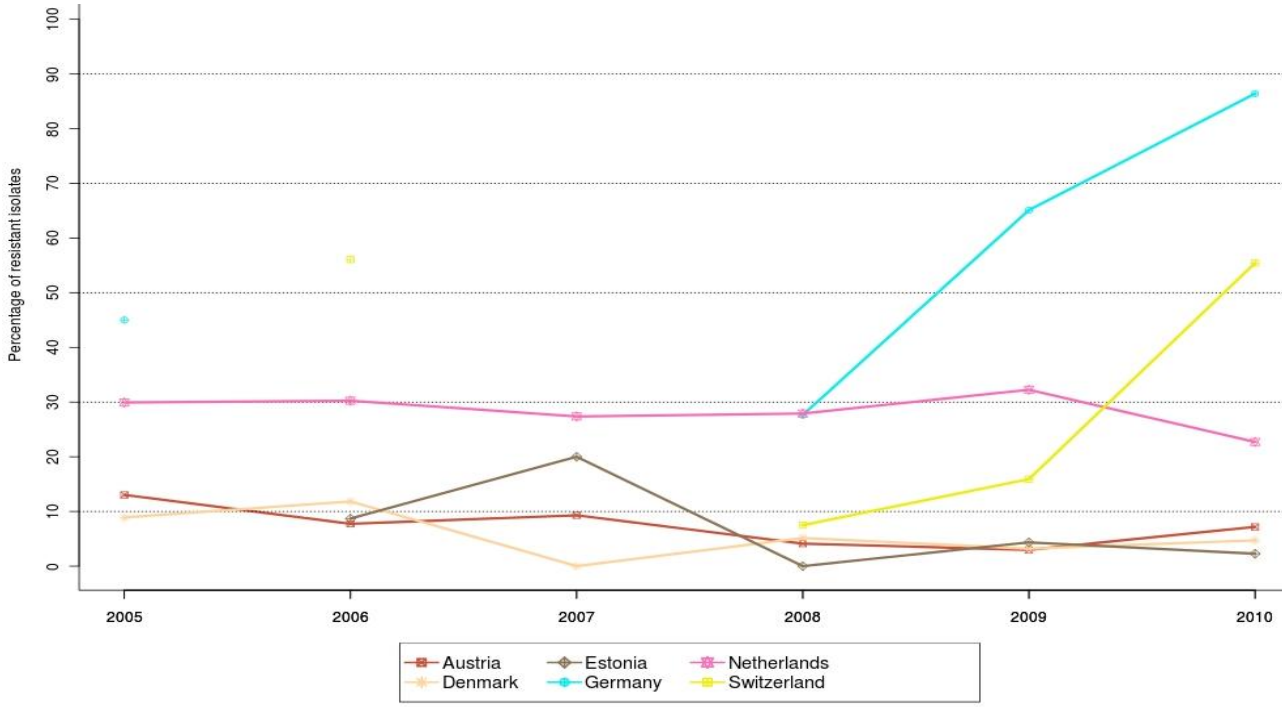
### *Figure EC22. Trends in streptomycin resistance in indicator* Escherichia coli *from cattle[1] in reporting Member States and non-Member States, 2005–2010, quantitative data*




Note: Statistically significant decreasing trends over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria, Denmark and Estonia.

1. The data from Germany in 2009 and 2010, and from Switzerland in 2010, were from calves under 1 year of age or veal calves only. The data from France in 2005 and 2007 originated from various types of bovine animals, including calves under 1 year of age, whereas 2008 data were derived exclusively from calves under 1 year of age.

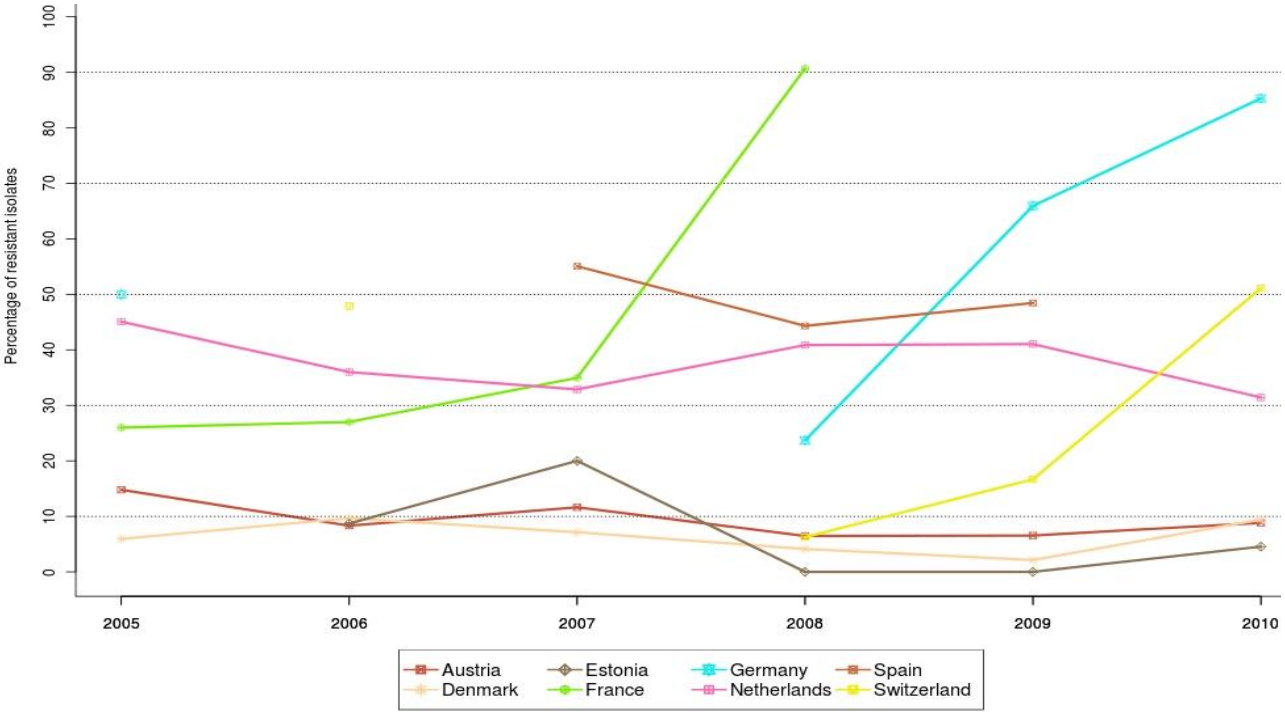
### *Figure EC23. Trends in sulfonamide resistance in indicator* Escherichia coli *from cattle[1] in reporting Member States and non-Member States, 2005–2010, quantitative data*




Note: Statistically significant decreasing trends over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria, Denmark and Estonia.

1. The data from Germany in 2009 and 2010, and from Switzerland in 2010, were from calves under 1 year of age or veal calves only.

### *Figure EC24. Trends in tetracycline resistance in indicator* Escherichia coli *from cattle[1] in reporting Member States and non-Member States, 2005–2010, quantitative data*




Note: Statistically significant decreasing trends over 5 or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria and the Netherlands.

1. The data from Germany in 2009 and 2010, and from Switzerland in 2010, were from calves under 1 year of age or veal calves only. The data from France in 2005 and 2007 originated from various types of bovine animals, including calves under 1 year of age, whereas 2008 data were derived exclusively from calves under 1 year of age.

## 5.3 Overview of findings on indicator *Escherichia coli* resistance at reporting Member State group level, 2010

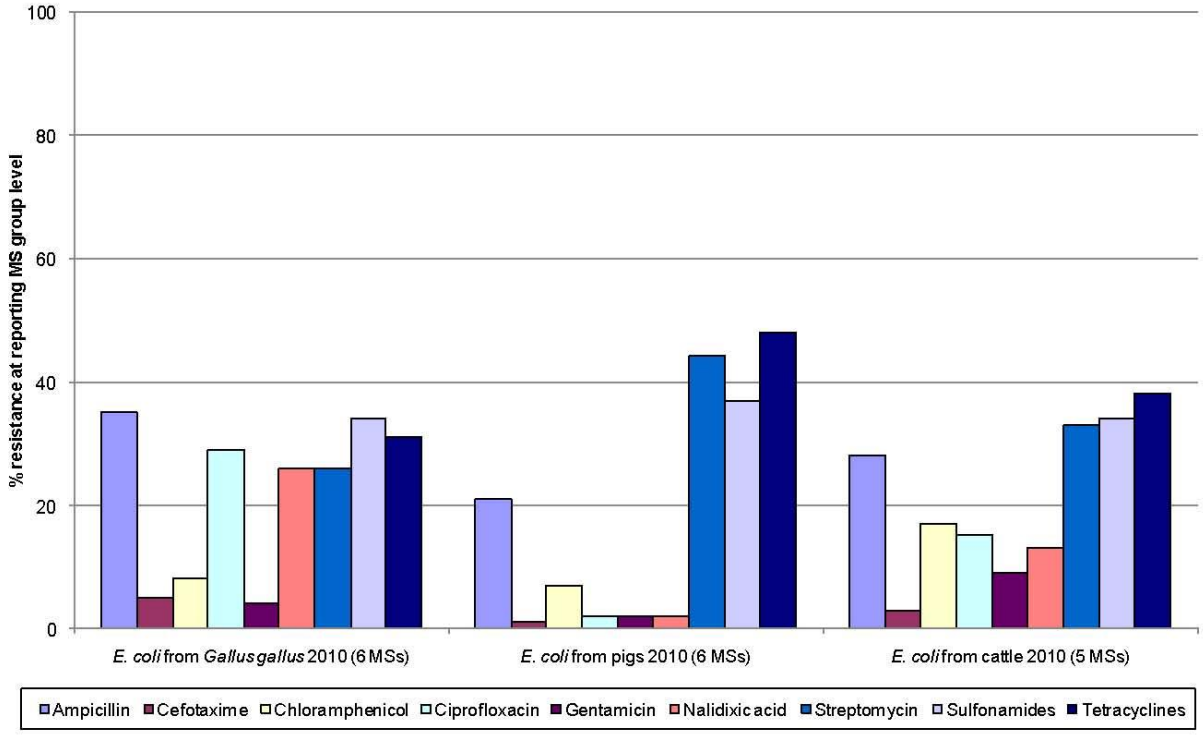
Figure EC25 shows resistance levels among *E. coli* isolates in the reporting MS group, based on quantitative data submitted in 2010 for the various animal species. The fact that data are derived from different groups of MSs needs to be considered when examining the figure.

In previous years, resistance tended to be lower in indicator *E. coli* from cattle than in isolates from pigs and *Gallus gallus*. However, as stated earlier, owing to the decreases in resistance in isolates from *Gallus gallus* and pigs in 2010, and increases in resistance levels in isolates from cattle, resistance levels are now broadly similar in all three animal groups. However, this could, at least partly, simply be an artefact of different MSs included in this analysis for different animal species and between years; within individual MSs that reported data for all three animal species (e.g. Austria and Denmark), the levels of resistance reported for cattle were often lower than for *Gallus gallus* or pigs. Additionally, the recent increases in resistance seen for cattle may only reflect variation in sample populations; Germany sampled veal calves only in 2009 and 2010, Switzerland sampled calves less than 1 year of age only in 2010 and France sampled calves less than 1 year of age only in 2008. These factors may have contributed to the apparent increase in resistance levels observed in cattle.

In 2010, there was a low level of resistance to chloramphenicol in *Gallus gallus* and pigs and a moderate level of resistance in cattle. Chloramphenicol has not been used for many years in food-producing animals in the EU; thus, resistance probably reflects either use of related compounds conferring cross-resistance (for example florfenicol) or persistence of chloramphenicol resistance genes in the bacterial population.

As in 2009, resistance to ampicillin, third-generation cephalosporins (cefotaxime), ciprofloxacin and nalidixic acid was higher in *E. coli* isolates from *Gallus gallus* than from pigs and cattle, whereas resistance to streptomycin, sulfonamides and tetracyclines was more often observed in pigs. The highest levels of resistance to chloramphenicol and gentamicin were reported in cattle.

***Figure EC25. Resistance in indicator* Escherichia coli *from fowl, pigs and cattle to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, streptomycin, sulfonamides and tetracyclines at reporting Member State group level in 2010***



## 5.4 Discussion

From an epidemiological perspective, antimicrobial resistance in indicator, commensal *E. coli* from animals and food can be used to investigate the reservoir of resistance genes occurring in those bacteria and which could be transferred to bacteria that are pathogenic for humans or animals. Indicator *E. coli* isolates are also of interest when investigating possible associations between the use of antimicrobials in a given country and the occurrence of resistance in an animal species, because of their ubiquity in food-producing animals.

Microbiological resistance to all of the antimicrobials tested was reported by MSs in *E. coli* isolates from food-producing animals and meats when using the epidemiological cut-off values. There was a high level of resistance to several antimicrobials, with very or extremely high levels reported by some individual MSs. This is of significance for both human and animal health since *E. coli* bacteria from farm animals and food thereof can form a reservoir of antimicrobial resistance genes that may be transferred to bacteria pathogenic to humans or animals. Some *E. coli* isolates occurring in the intestinal flora of animals may also be directly pathogenic to humans.

The major factor influencing the levels of resistance to antimicrobials in indicator *E. coli* is probably the selective pressures exerted by use of antimicrobials in the different food animal populations, which may contribute to the observed differences between these animal species.

Only one MS reported disc diffusion data for *E. coli* in 2010, whereas 10 countries submitted quantitative broth dilution data from *E. coli* from one or more category of animal or food. In general, for most categories there has been a slight decline in the number of countries reporting results. For example, in 2009, nine MSs reported data for cattle, whereas in 2010 the figure was five. The EFSA recommendations state that different animal species may be sampled once every 3 years, and this may account for the diminution in testing which is evident in 2010 for some categories. Reported data on antimicrobial resistance in *E. coli* isolates from food-producing animals and food were derived mainly from active and representative monitoring programmes, chiefly based on sampling performed at the slaughterhouse.

Resistance to antimicrobials recognised as critically important in human medicine, such as fluoroquinolones and third-generation cephalosporins, was also observed in the indicator *E. coli* isolates. In some reporting MSs, ciprofloxacin resistance in *Gallus gallus* (broilers) showed an increasing trend over the period 2005–2010, while only stable trends were recorded for cefotaxime resistance in animals studied over the same period. Only two Scandinavian countries reported results from meat, and where resistance to these compounds was assessed, it was low, very low or not detected. There was considerable variation between MSs in the reported levels of resistance to some antimicrobials in *E. coli* from some animals. This was evident, for example, in cattle and might reflect the different types of animal population sampled, such as veal calves, beef cattle and dairy cattle, or randomly selected abattoir samples and inclusion of veterinary clinical samples. Refinements to the monitoring recommendations are under discussion to take account of the different production systems and types of animal monitored.

Considering all reporting MSs, ciprofloxacin resistance was 29 % in *Gallus gallus*, 2 % in pigs and 15 % in cattle; resistance to third-generation cephalosporins similarly was highest in *Gallus gallus,* at 5 %, compared with 3 % in cattle and 1 % in pigs. The occurrence of resistance to gentamicin was highest in cattle, at 9 %, whereas it was 4 % in *Gallus gallus* and 2 % in pigs. In most cases, the level of resistance to nalidixic acid was similar to that to ciprofloxacin, suggesting that mutation in the topoisomerase enzymes (*gyrA* or *parC*) may, in these cases, have been responsible for resistance. However, in some MSs, the level of resistance to ciprofloxacin was higher than that found for nalidixic acid, suggesting that mechanisms such as transferable fluoroquinolone resistance conferred by *qnr* genes may have been the responsible resistance mechanism, as such plasmid-mediated mechanisms can result in that phenotypic pattern of resistance.

The occurrence of third-generation cephalosporin resistance was still generally low. The findings in relation to third-generation cephalosporin resistance are discussed further in Chapter 9.

In 2010, for the first time, MS-specific trends over the years 2005–2010 in the resistant indicator *E. coli* isolates were analysed statistically. Resistance levels mostly remained relatively stable over this period, although some statistically significant increasing and decreasing trends were observed in some MSs. Generally, more increasing trends than decreasing ones were detected in isolates from *Gallus gallus*, whereas in cattle all the significant trends observed were decreasing ones.

# 6. ANTIMICROBIAL RESISTANCE IN ENTEROCOCCI

## 6.1 Introduction

A number of commensal bacteria are naturally present in the intestine of farm animals and some of these, such as *E. coli* and certain species of *Enterococcus*, tend to be consistently present, occurring in the intestine of all or the majority of animals. These bacterial organisms (*E. coli* representing the gram-negative organisms and *Enterococcus* spp. representing gram-positive organisms) are therefore selected as indicator organisms which reflect the degree of resistance borne by the commensal flora of animals. They are considered a potential reservoir of resistance genes that can spread horizontally to zoonotic and other bacteria through the food chain (Neidhardt, 1996; Winokur et al., 2001; Wang et al., 2006). Of course, some antimicrobials have a largely gram-negative or gram-positive spectrum and the inclusion of both *E. coli* and *Enterococcus* spp. in the monitoring programme ensures that a broad range of important antimicrobials with a different spectrum of action can be covered.

The *Enterococcus* species, *E. faecium* and *E. faecalis,* are suitable as indicator bacteria since both species are commonly isolated from animal faeces; furthermore, these species of *Enterococcus* are also important in human medicine. *Enterococcus* species can occur in the intestinal tract of animals at a different prevalence, dependent upon the species of animal concerned, as well as varying, in some cases, with the age of the animal. The occurrence of *E. faecium* and *E. faecalis* in the intestinal tract of animals or food, even if not directly significant for humans, may constitute a reservoir of resistance genes that could be transferred either to pathogenic bacteria or to other commensal bacteria. In addition, they are considered good indicators of the selective pressure exerted by the use of antimicrobials on intestinal populations of gram-positive bacteria in food animals.

According to the EU legislation, the monitoring of antimicrobial resistance in enterococci in animals and food is not mandatory. However, harmonised technical specifications for this monitoring, including sampling protocols, have been proposed to volunteering MSs in the EFSA guidelines (EFSA, 2008b). These encourage development of randomised sampling strategies allowing for robust statistical analysis of data and reducing the effect of sampling bias. Monitoring in accordance with the recommendations may be carried out at the farm or slaughterhouse level.

## 6.2 Antimicrobial resistance in indicator enterococci isolates from animals and food

In 2010, a total of seven MSs and one non-MS (Switzerland) reported data on antimicrobial resistance in enterococci isolated from animals and food. Only Denmark and Sweden reported MIC data on isolates collected from food. Tables EN1 and EN2 present the countries that reported *E. faecium* and *E. faecalis* MIC values in 2010. Owing to the paucity of qualitative results for enterococci, no specific subsection on qualitative enterococci data has been prepared. The total number of tests performed on enterococci isolates from animals and food in 2010 by MSs and non-MS and for which quantitative MIC data are available was 42 248.

***Table EN1. Overview of countries reporting antimicrobial resistance data using MIC on* Enterococcus faecium *from animals and food in 2010***

| Method | Origin | Total number of MSs reporting | Countries |
|---|---|---|---|
| Dilution | *Gallus gallus* (fowl) | 5 | **MSs:** AT, DK, FR, NL, SE |
| | | | **Non-MS**: CH |
| | Pigs | 6 | **MSs:** AT, DK, EE, FI, FR, NL |
| | | | **Non-MS**: CH |
| | Cattle (bovine animals) | 3 | **MSs:** AT, EE, NL |
| | | | **Non-MS**: CH |
| | Meat from broilers (*Gallus gallus*) | 2 | **MSs:** DK, SE |
| | Meat from pig | 1 | **MS:** DK |
| | Meat from bovine animals | 1 | **MS:** DK |

***Table EN2. Overview of countries reporting antimicrobial resistance data using MIC on* Enterococcus faecalis *from animals and food in 2010***

| Method | Origin | Total number of MSs reporting | Countries |
|---|---|---|---|
| Dilution | *Gallus gallus* (fowl) | 5 | **MSs:** AT, DK, FR, NL, SE |
| | | | **Non-MS:** CH |
| | Pigs | 6 | **MSs:** AT, DK, EE, FI, FR, NL |
| | | | **Non-MS:** CH |
| | Cattle (bovine animals) | 3 | **MSs:** AT, EE, NL |
| | | | **Non-MS:** CH |
| | Meat from broilers (*Gallus gallus*) | 2 | **MSs:** DK, SE |
| | Meat from pig | 1 | **MS:** DK |
| | Meat from bovine animals | 1 | **MS:** DK |

The antimicrobials selected by the different MSs and non-MSs for susceptibility testing of *E. faecium* and *E. faecalis* are shown in Chapter 11, Materials and Methods, Table MM9.

The occurrence of resistance to ampicillin, erythromycin, streptomycin, tetracyclines and vancomycin is presented in Tables EN3–8 and described in detail in the text below. The tables presenting occurrence of resistance were generated if four or more MSs reported quantitative data per *Enterococcus* species and sampling origin, except for the table displaying resistance in *E. faecalis* isolates from cattle, which is based on data from only three reporting countries. In addition, the report includes only data based on 10 or more isolates per country, per sampling origin, per year.

Where the minimum criteria were met, temporal trend graphs have been generated, showing the percentage of *Enterococcus* isolates from animals and food resistant to different antimicrobials over the period 2006–2010. Only countries that reported data for three or more years over the period 2006–2010 were included. These trends are presented in Figures EN1–10, EN11–20 and EN21–30.

In addition, further information on reported MIC distributions and numbers of *E. faecium* and *E. faecalis* isolates resistant to tetracyclines, chloramphenicol, ampicillin, avilamycin, erythromycin, streptomycin, ciprofloxacin, florfenicol, gentamicin, kanamycin, lincomycin, linezolid, penicillin, quinupristin/dalfopristin, vancomycin, apramycin, ceftiofur, colistin, narasin, virginiamycin, neomycin, trimethoprim, cefotaxime, ceftazime and nalidixic acid can be found in the level 3 tables published on the EFSA website.

### 6.2.1 Antimicrobial resistance in indicator enterococci isolates from food

#### 6.2.1.1 Meat

In 2010, Denmark provided quantitative MIC data for enterococci isolates from meat from bovine animals, broilers (*Gallus gallus*) and pigs. Sweden also reported data concerning meat from broilers (*Gallus gallus*). Data on antimicrobial resistance in indicator enterococci isolates from the three types of meat reported by Denmark and from broiler meat reported by Sweden were derived from active and representative monitoring programmes. In Denmark, enterococci isolates originated from meat sampled at wholesale and retail outlets, and were collected randomly throughout all regions of the country in the framework of three centrally coordinated sampling plans corresponding to each type of meat. In Sweden, the programme is based on a sampling plan of broiler filets, stratified by slaughterhouses that participate and proportional to slaughterhouse broiler meat production capacity.

##### Resistance levels among tested enterococci isolated in broiler meat

Denmark tested 145 isolates of *E. faecium* and 59 isolates of *E. faecalis* in meat from broilers (*Gallus gallus*), while Sweden tested 17 isolates and 81 isolates, respectively. Denmark reported 10 % resistance to tetracyclines among *E. faecium* isolates while Sweden reported no resistance. In comparison, both countries reported a high level of resistance among *E. faecalis* (Denmark 46 %; Sweden 41 %). Denmark reported a high level of resistance (21 %) to erythromycin among *E. faecium* while Sweden reported a low level (6 %). In contrast, Denmark reported moderate resistance (17 %) among *E. faecalis* while Sweden reported a high level of resistance (23 %). Denmark reported a low level of resistance (3 %) to streptomycin in *E. faecium*, while Sweden reported full sensitivity in all isolates. Both countries reported a low level of resistance to streptomycin among *E. faecalis* (Denmark 8 %; Sweden 4 %). Denmark reported a low level of resistance to ampicillin in both *E. faecium* (1 %) and *E. faecalis* (2 %) while Sweden detected no resistance to ampicillin among enterococci. This rendered an overall average of 1 % resistance for *E. faecium* and 0.7 % resistance for *E. faecalis*. In the case of vancomycin, Denmark reported a single resistant *E. faecium* isolate (0.7 % resistance) but no resistance among *E. faecalis* and Sweden reported no resistance among either enterococci species.

##### Resistance levels among tested enterococci isolated in pig meat

Denmark tested 29 isolates of *E. faecium* and 84 isolates of *E. faecalis* in meat from pigs. A moderate level of resistance to tetracycline was observed: 17 % in *E. faecium* and 13 % in *E. faecalis*. There was a high level of resistance to erythromycin (31 %) among *E. faecium* but a low level of resistance (1 %) among *E. faecalis*. Two isolates (7 %) of *E. faecium* were resistant to streptomycin but none of the *E. faecalis* isolates were resistant to this antimicrobial. No resistance to ampicillin or vancomycin was detected in either enterococci species.

##### Resistance levels among tested enterococci isolated in bovine meat

In meat from bovine animals, Denmark tested 20 isolates of *E. faecium* and 27 isolates of *E. faecalis*. A high level of resistance against tetracyclines (22 %) among *E. faecalis* and a moderate level of resistance (10 %) among *E. faecium* could be observed in these isolates. One isolate of *E. faecium* was resistant to erythromycin (5 % resistance) but no resistance was detected among *E. faecalis*. One isolate of *E. faecalis* was resistant to streptomycin (4 % resistance) but none of the *E. faecium* isolates were resistant to this antimicrobial. No resistance was detected against ampicillin or vancomycin in either enterococci species.

## 6.2.2 Antimicrobial resistance in indicator enterococci isolates from animals

### 6.2.2.1 Fowl (*Gallus gallus*)

In this report, data for fowl (*Gallus gallus*) include data from broiler flocks of chickens. In all reporting MSs and Switzerland, active monitoring programmes were based on random sampling of broiler chickens at the slaughterhouse. The slaughterhouses included in the monitoring programme accounted for a major proportion, typically 80 % or more, of the total production in the country. The sampling plan was stratified by slaughterhouse, the sample size per slaughterhouse being proportionate to the annual throughput of animals slaughtered. The sampling was evenly distributed throughout the year or a significant part of the year to account for any possible seasonal effects. Indicator enterococci isolates were isolated from caecal contents in France, the Netherlands and Sweden, from cloacal swabs in Switzerland and from faecal samples in the other reporting MSs, by sampling healthy broilers at slaughter. Only one representative sample of caecal content per flock/batch, derived either from a unique animal or from a number of slaughtered animals, was gathered to account for clustering.

#### Resistance levels in tested isolates

In 2010, five MSs and one non-MS (Switzerland) reported quantitative antimicrobial resistance data on enterococci in *Gallus gallus.* Tables EN3 and EN4 present the occurrence of resistance to the selected five antimicrobials among *E. faecium* and *E. faecalis*, respectively. As in previous years, the levels of resistance to ampicillin, erythromycin, streptomycin and tetracyclines varied considerably between the reporting countries.

Overall, there was a very high level of tetracycline resistance in both *E. faecium* (56 %) and *E. faecalis* (60 %) in the reporting MS group. However, these levels are lower than those observed in 2009 (70 % and 89 %, respectively) and closer to the resistance levels recorded in 2008 (47 % and 62 %, respectively). There was substantial variation in the resistance levels observed in the individual MSs, ranging between 6 % and 93 % resistance for *E. faecium* and between 26 % and 86 % resistance for *E. faecalis*. The level of resistance was extremely high in *E. faecium* isolates from three MSs (Austria, France and the Netherlands) and in *E. faecalis* isolates from two MSs plus one non-MS (France, the Netherlands and Switzerland). In 2010, as in 2009, there was an overall moderate level of resistance to ampicillin in *E. faecium* in the reporting MS group. Denmark reported no resistance while the resistance levels in the other countries ranged from 2 % to 44 %. In contrast, there was a very low level of resistance to ampicillin in *E. faecalis* overall, with France being the only country to detect resistance.

Resistance to erythromycin was high among *E. faecium* and very high among *E. faecalis* in the reporting MS group (47 % and 56 % resistance, respectively). Again, this is lower than the resistance levels in 2009 (62 % and 70 %, respectively) but almost identical to the levels in 2008 (45 % and 55 %, respectively). There was considerable variation in the resistance levels reported by different MSs for both *E. faecium* and *E. faecalis*; for example, Sweden reported 13 % resistance among *E. faecium* while the Netherlands reported 78 % resistance. Streptomycin resistance at the reporting MS group level was high in both *E. faecium* (28 %) and *E. faecalis* (25 %), but slightly lower than the levels reported in 2009 (37 % and 40 %, respectively). In 2010, the Netherlands reported very high resistance for both enterococci species, and Austria reported a high level of resistance for both species, while Sweden reported no resistance among either species.

The overall level of resistance to vancomycin among *E. faecium* and *E. faecalis* in the reporting MS group was very low (0.3 % and 0.7 %, respectively), which is similar to the levels observed in 2009. France and the Netherlands reported very low levels of resistance (0.5 %) for *E. faecium,* and Austria and France reported low levels of resistance (1 % and 2 %, respectively) among *E. faecalis*; all other reporting countries detected no resistance.

The resistance levels in individual MSs were usually roughly comparable to those in 2009, or in some cases marginally higher, more commonly in *E. faecium*. An exception would be resistance in *E. faecalis* from Denmark, where resistance rates tended to have fallen. Some of the overall decreases in resistance that were observed in 2010 could be attributable to the lack of data from Spain, which reported relatively high levels of resistance to many of the antimicrobials in 2009 but did not report any data in 2010.

***Table EN3. Resistance (%) to ampicillin, erythromycin, streptomycin, tetracyclines and vancomycin among* Enterococcus faecium *from* Gallus gallus *in countries reporting MIC data in 2010***

| Country | Ampicillin | | Erythromycin | | Streptomycin | | Tetracyclines | | Vancomycin | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 15 | 7 | 15 | 53 | 15 | 40 | 15 | 73 | 15 | 0 |
| Denmark | 119 | 0 | 119 | 26 | 119 | 0.8 | 119 | 6 | 119 | 0 |
| France | 190 | 15 | 190 | 51 | 190 | 33 | 190 | 93 | 190 | 0.5 |
| Netherlands | 215 | 44 | 215 | 78 | 215 | 57 | 215 | 77 | 215 | 0.5 |
| Sweden | 136 | 2 | 136 | 13 | 136 | 0 | 136 | 13 | 136 | 0 |
| **Total (5 MSs)** | **675** | **19** | **675** | **47** | **675** | **28** | **675** | **56** | **675** | **0.3** |
| Switzerland | 20 | 15 | 20 | 30 | 20 | 0 | 20 | 30 | 20 | 0 |

***Table EN4. Resistance (%) to ampicillin, erythromycin, streptomycin, tetracyclines and vancomycin among* Enterococcus faecalis *from* Gallus gallus *in countries reporting MIC data in 2010***

| Country | Ampicillin | | Erythromycin | | Streptomycin | | Tetracyclines | | Vancomycin | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 172 | 0 | 172 | 57 | 172 | 25 | 172 | 59 | 172 | 1 |
| Denmark | 112 | 0 | 112 | 25 | 112 | 4 | 112 | 26 | 112 | 0 |
| France | 85 | 2 | 85 | 58 | 85 | 9 | 85 | 86 | 85 | 2 |
| Netherlands | 144 | 0 | 144 | 82 | 144 | 56 | 144 | 80 | 144 | 0 |
| Sweden | 35 | 0 | 35 | 31 | 35 | 0 | 35 | 31 | 35 | 0 |
| **Total (5 MSs)** | **548** | **0.4** | **548** | **56** | **548** | **25** | **548** | **60** | **548** | **0.7** |
| Switzerland | 165 | 0 | 165 | 30 | 165 | 4 | 165 | 76 | 165 | 0 |

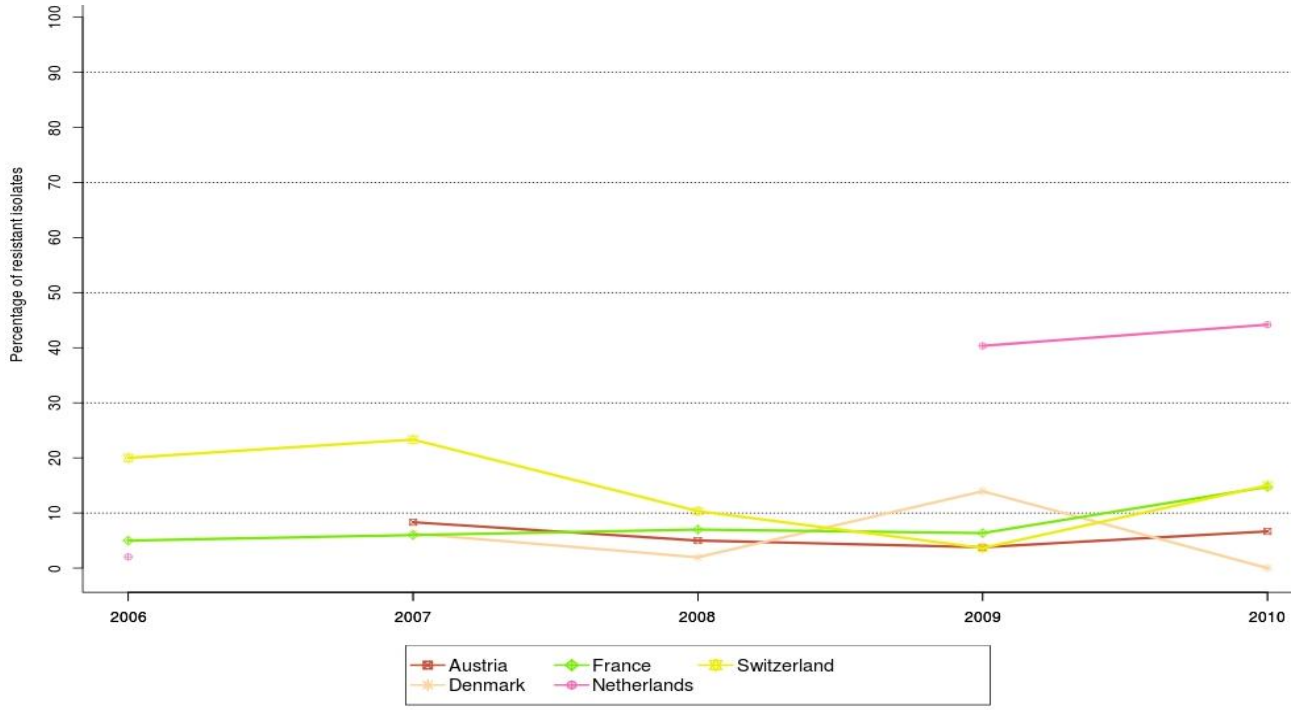
### Temporal trends in resistance among indicator enterococci

Figures EN1–10 show the trends in resistance to ampicillin, erythromycin, streptomycin, tetracyclines and vancomycin in *E. faecium* and *E. faecalis* isolated from *Gallus gallus* between 2006 and 2010. As noted in previous years' reports, there is substantial variation in the resistance levels between reporting countries (e.g. Figure EN4). The exceptions would be ampicillin resistance in *E. faecalis* and vancomycin resistance in both enterococci species, in which resistance levels have tended to be low or very low since 2006 (Figures EN5, EN6 and EN10).

There were often no clear overall trends in resistance levels, with countries simply showing fluctuations in resistance over the reporting period, sometimes in divergent directions. Levels of resistance to some antimicrobials reported by individual countries were very similar to those reported in 2009, such as erythromycin resistance in *E. faecium* (Figure EN2).

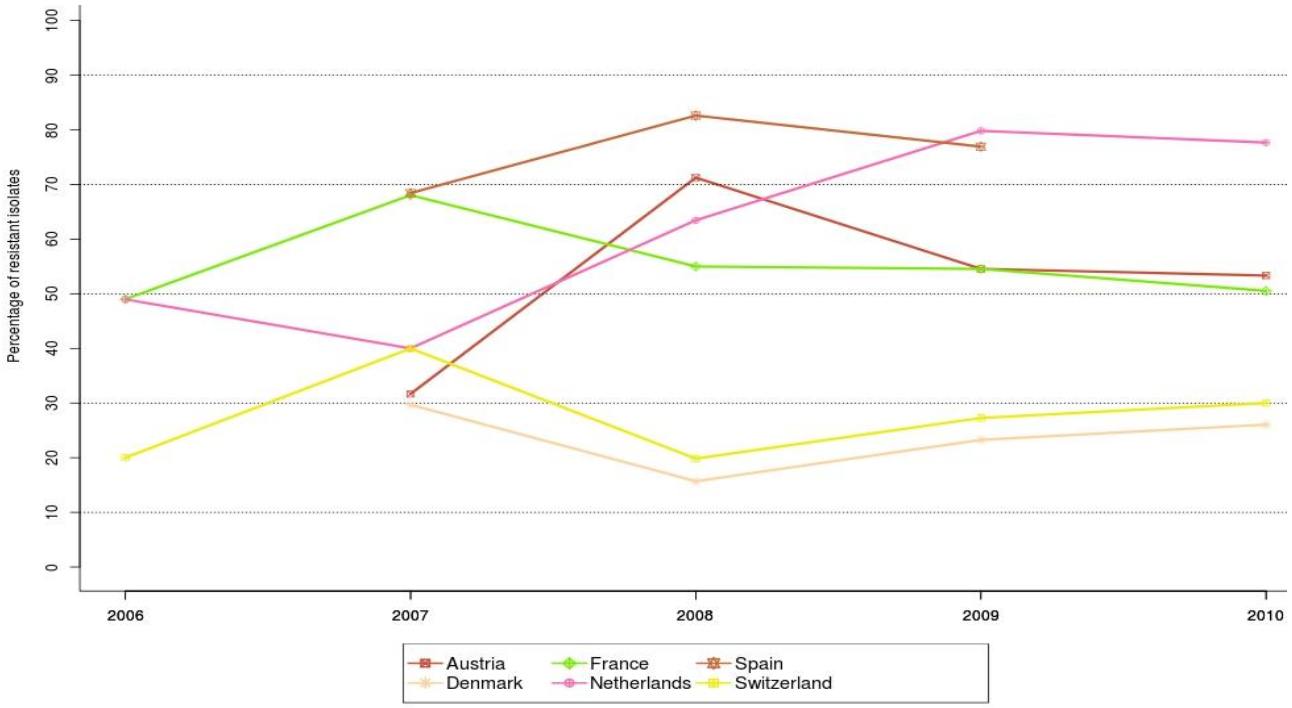
Denmark has shown a significant decreasing trend in streptomycin resistance in *E. faecium* since 2007. The decreases in Switzerland in resistance to tetracyclines in *E. faecalis* and to vancomycin in *E faecium* were also significant over the period 2006–2010. Austria exhibited similar trends in the last 4 years. The Netherlands and Switzerland were responsible for many of the other significant trends recorded; in the former there was a significant increasing trend in tetracycline in *E. faecium* while in the latter they were largely significant decreasing trends (e.g. streptomycin in *E. faecalis* and ampicillin in *E. faecium*). France showed a significant increasing trend in ampicillin resistance in *E. faecium* over the last 5 years.

***Figure EN1. Trends in ampicillin resistance in* Enterococcus faecium *from* Gallus gallus *in reporting Member States and non-Member States, 2006–2010, quantitative data***



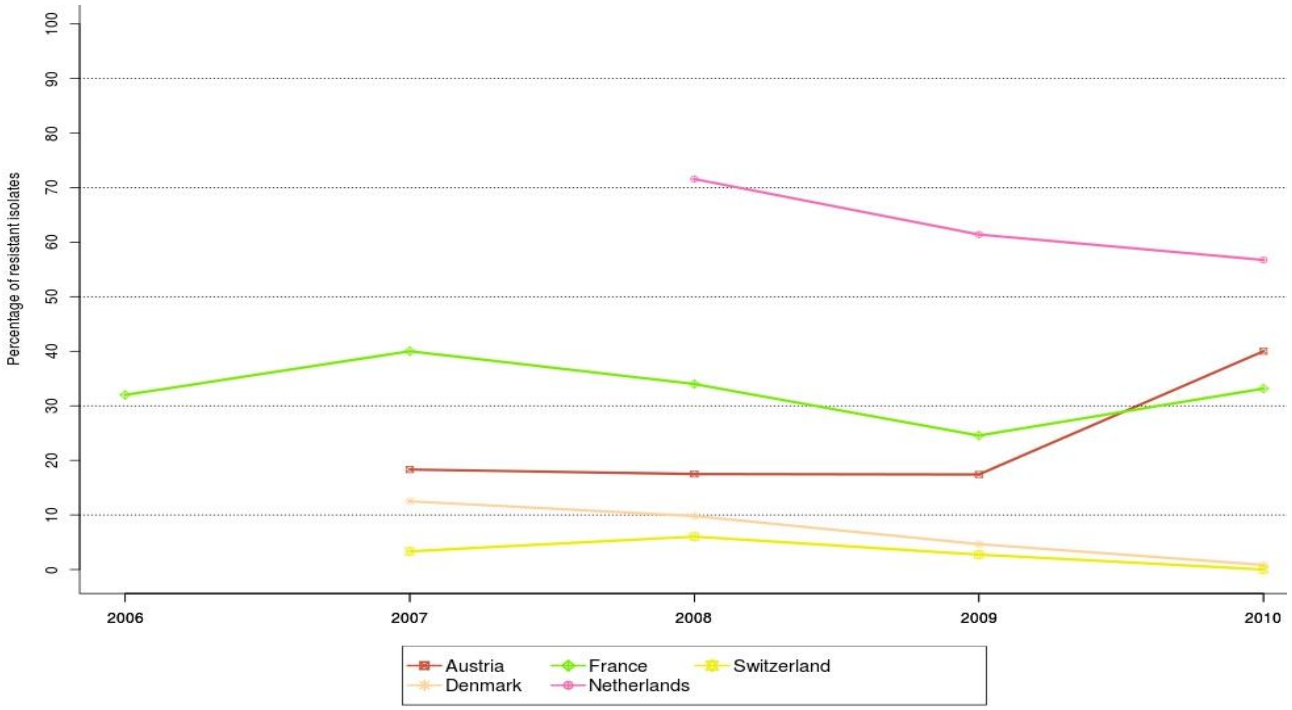

Note: A statistically significant increasing or decreasing trend, over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in France (↑) and Switzerland (↓).

***Figure EN2. Trends in erythromycin resistance in* Enterococcus faecium *from* Gallus gallus *in reporting Member States and non-Member States, 2006–2010, quantitative data***



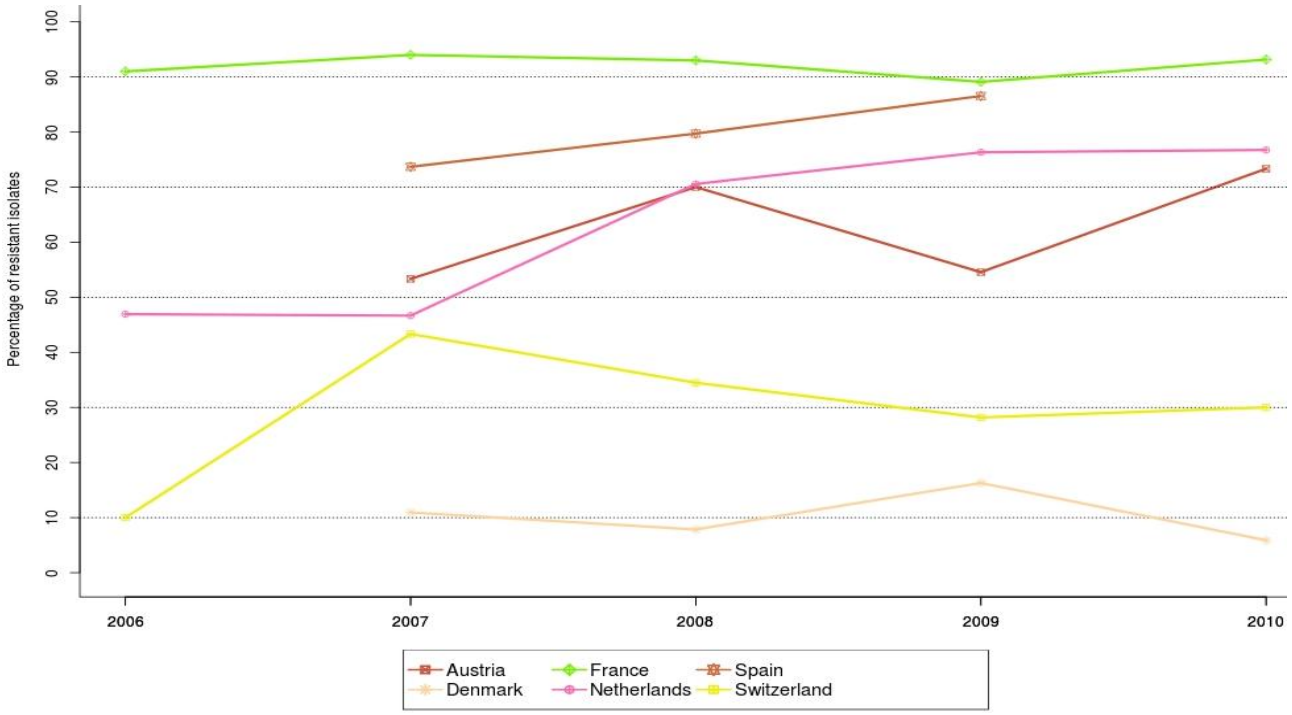

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN3. Trends in streptomycin resistance in* Enterococcus faecium *from* Gallus gallus *in reporting Member States and non-Member States, 2006–2010, quantitative data***



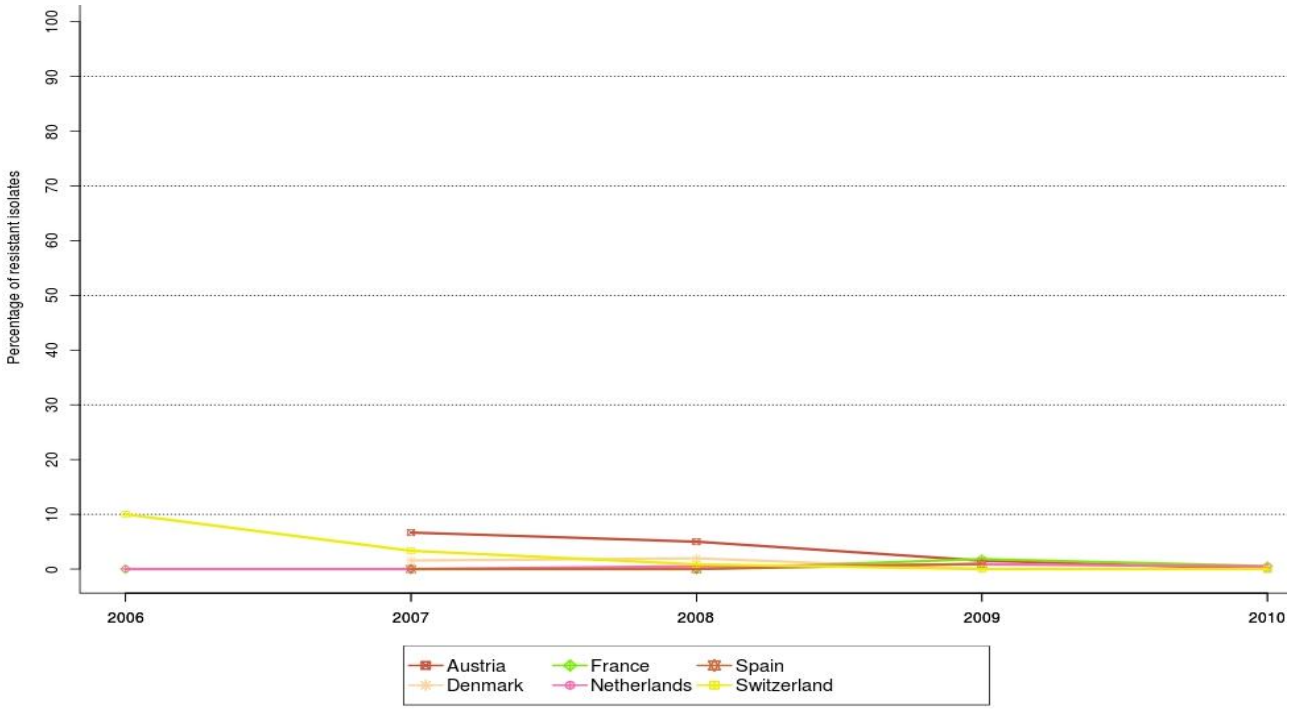

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN4. Trends in tetracycline resistance in* Enterococcus faecium *from* Gallus gallus *in reporting Member States and non-Member States, 2006–2010, quantitative data***



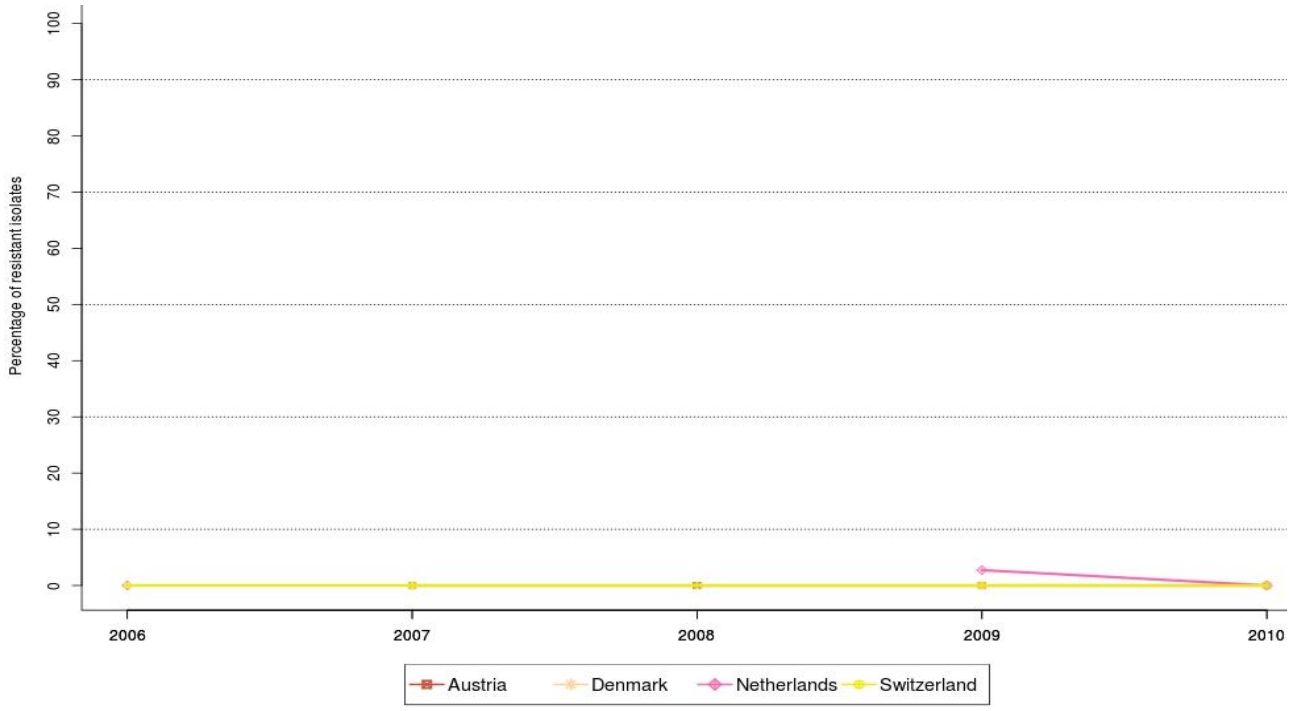

Note: A statistically significant increasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands.

***Figure EN5. Trends in vancomycin resistance in* Enterococcus faecium *from* Gallus gallus *in reporting Member States and non-Member States, 2006–2010, quantitative data***



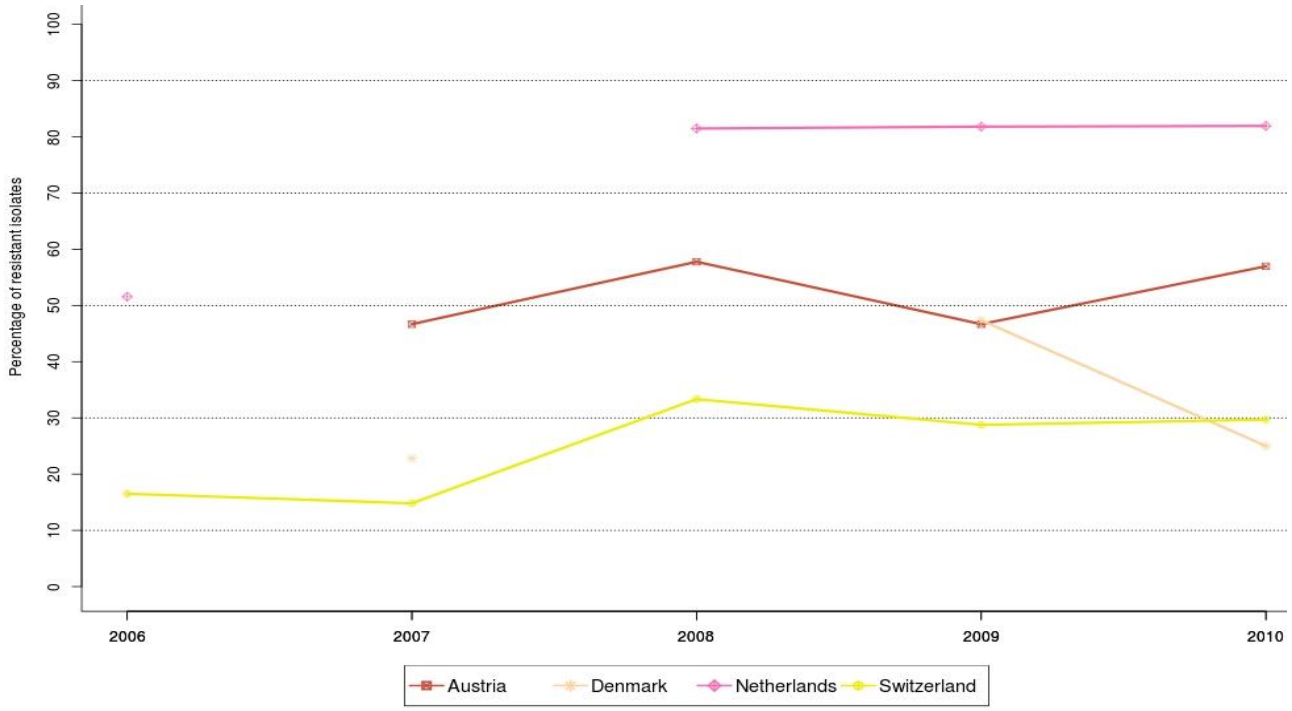

Note: A statistically significant decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Switzerland.

***Figure EN6. Trends in ampicillin resistance in* Enterococcus faecalis *from* Gallus gallus *in reporting Member States and non-Member States, 2006–2010, quantitative data***



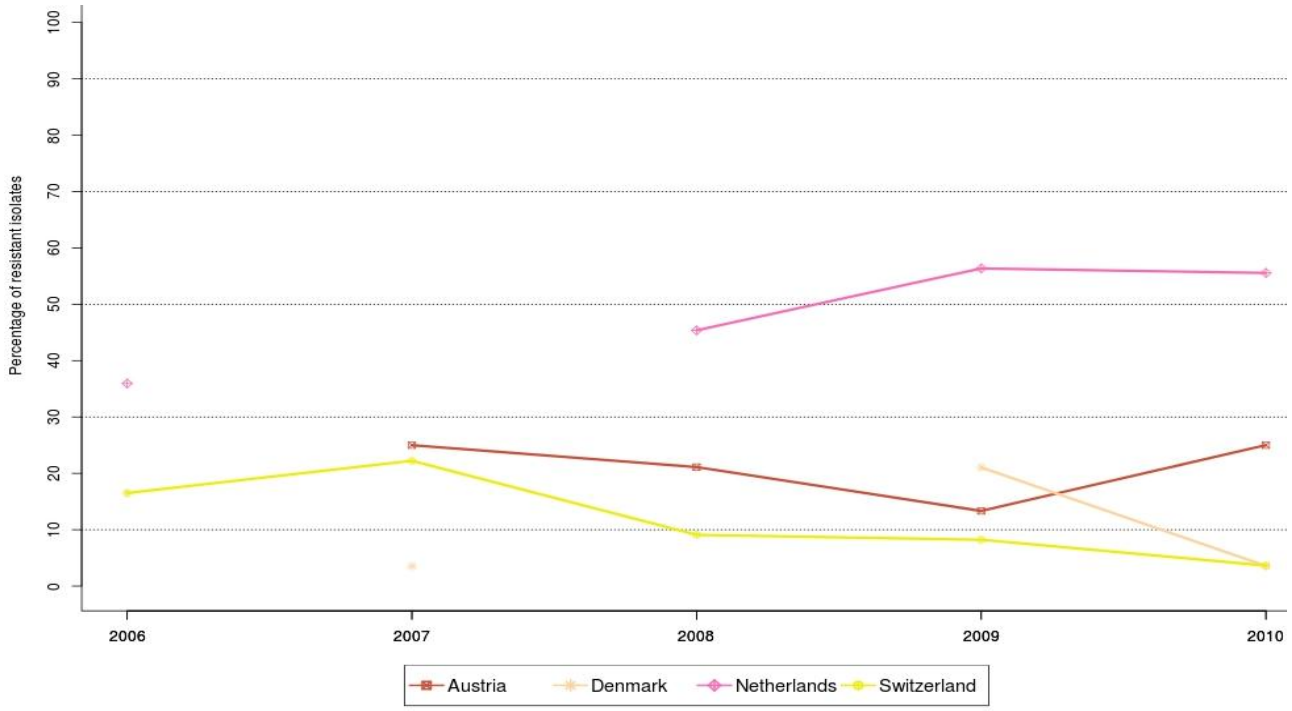

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN7. Trends in erythromycin resistance in* Enterococcus faecalis *from* Gallus gallus *in reporting Member States and non-Member States, 2006–2010, quantitative data***



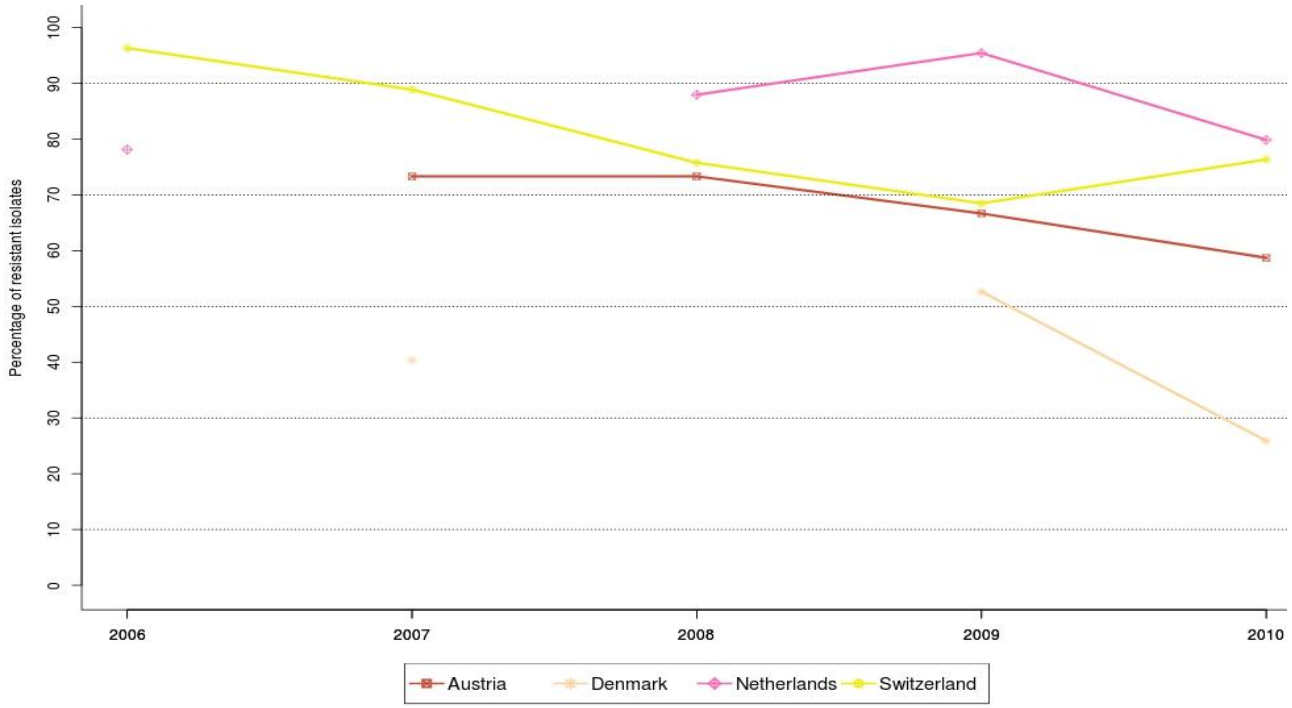

Note: A statistically significant increasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Switzerland.

***Figure EN8. Trends in streptomycin resistance in* Enterococcus faecalis *from* Gallus gallus *in reporting Member States and non-Member States, 2006–2010, quantitative data***



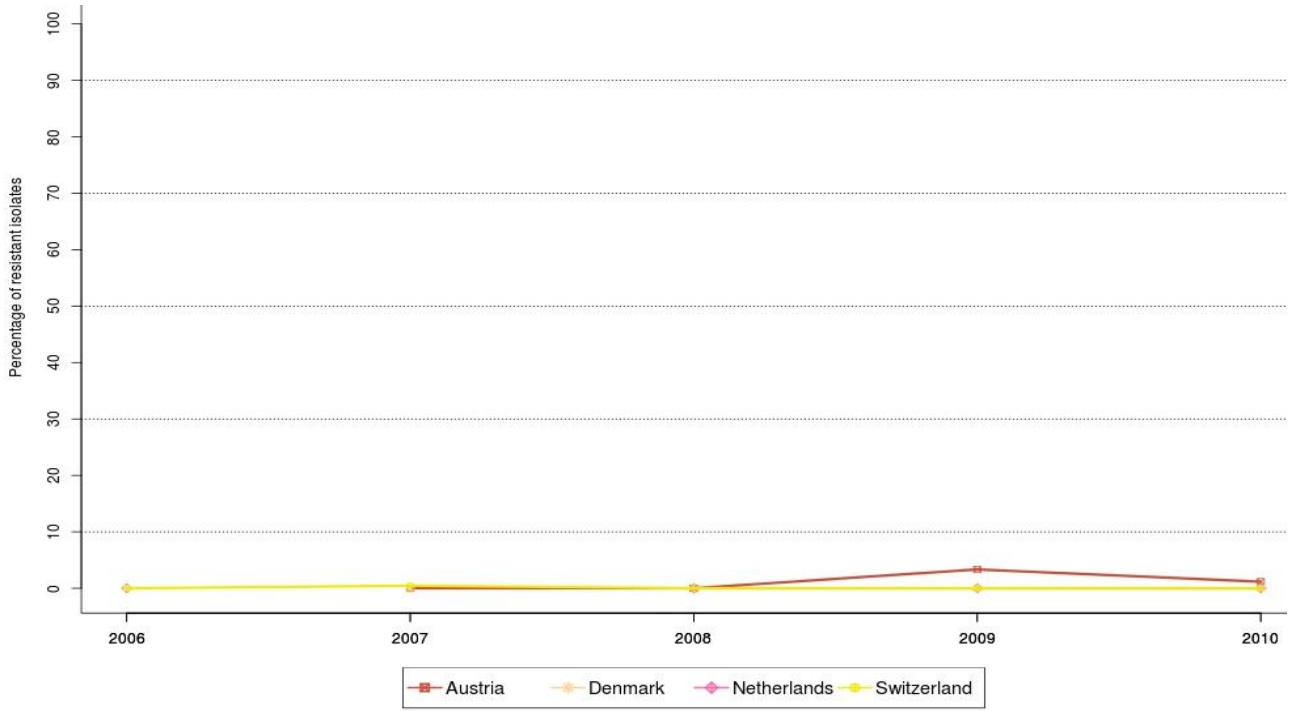

Note: A statistically significant decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Switzerland.

***Figure EN9. Trends in tetracycline resistance in* Enterococcus faecalis *from* Gallus gallus *in reporting Member States and non-Member States, 2006–2010, quantitative data***




Note: A statistically significant decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Switzerland.

***Figure EN10. Trends in vancomycin resistance in* Enterococcus faecalis *from* Gallus gallus *in reporting Member States and non-Member States, 2006–2010, quantitative data***




Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

### 6.2.2.2 Pigs

In the reporting MSs, antimicrobial resistance monitoring in indicator enterococci isolates from pigs was based on active monitoring plans based on random sampling of healthy slaughter pig carcasses at the slaughterhouse. The slaughterhouses included in the monitoring programme accounted for a major proportion, typically 80 % or more, of the total production in the country. The sampling plan was typically stratified by slaughterhouse by allocating the number of samples collected per slaughterhouse proportionally to the annual throughput of the slaughterhouse. An approximately equal distribution of the collected samples over the year enabled the different seasons to be covered. Only one representative faecal sample per epidemiological unit (batch), either derived from a unique carcass or pooled from a number of carcasses, was gathered to account for clustering.

#### Resistance levels in tested isolates

In 2010, six MSs and one non-Ms (Switzerland) submitted quantitative data concerning *E. faecium* isolates from pigs (Table EN5), and five MSs and one non-MS (Switzerland) provided quantitative data on *E. faecalis* isolates from pigs (Table EN6). Similarly to *Gallus gallus,* there were large variations in the resistance levels reported by different countries for several antimicrobials.

The overall level of resistance to tetracyclines in the reporting MS group was very high among *E. faecium* and extremely high among *E. faecalis* (53 % and 71 %, respectively), which is roughly comparable with, although lower than, in 2009 (63 % and 90 %, respectively), and virtually identical to the levels in 2008 (54 % and 71 %, respectively). Among *E. faecium*, resistance levels in the individual MSs ranged between 17 % and 77 % with both France and the Netherlands reporting extremely high resistance levels, while in *E. faecalis*, resistance ranged between 31 % and 84 %, with Denmark, Finland and the Netherlands all reporting extremely high resistance. France was the only country where the level of resistance was higher in *E. faecium* than in *E. faecalis*.

There was a high level of erythromycin resistance in enterococci at the MS reporting group level although, again, the levels were slightly lower than in 2009 (35 % compared with 43 % for *E. faecium* and 38 % compared with 60 % for *E. faecalis*). The levels in individual reporting MSs ranged from 14 % to 53 % in *E. faecium* and from 6 % to 53 % in *E. faecalis*; France had the highest resistance level in *E. faecium* but the lowest in *E. faecalis*. There was also a high level of resistance to streptomycin in both enterococci species at the reporting MS group level. Again, the resistance levels (23 % in *E. faecium* and 21 % in *E. faecalis*) were lower than in 2009 (39 % and 51 %, respectively) and closer to the levels in 2008 (26 % and 17 %, respectively). Among *E. faecium* isolates, resistance levels in the individual countries ranged between 4 % and 37 %, while in *E. faecalis* resistance ranged between 4 % and 33 %; again, France had the highest resistance in the former and close to the lowest in the latter. Finland reported a low level of streptomycin resistance in both enterococci species while Denmark reported a high level of resistance in both species.

No country reported resistance to ampicillin among *E. faecalis*, which was also the case in 2009. The overall level of ampicillin resistance of *E. faecium* in the reporting MS group was 7 % (compared with 20 % in 2009 and 4 % in 2008), with the levels in the individual MSs ranging between 0 % and 22 %, although most countries reported a low level of resistance. In addition, no resistance to vancomycin was recorded among *E. faecalis*. In *E. faecium*, the overall level of resistance to vancomycin within the reporting MS group was very low, with four countries reporting no resistance and the highest level reported being 3 %. This is broadly similar, in both enterococci species, to the situation in 2009.

As for *Gallus gallus*, in 2010 Spain provided no data regarding isolates from pigs, yet this country reported relatively high resistance levels in 2009, and this could be responsible for some of the decreases in overall resistance levels observed in 2010. Furthermore, both Estonia and Finland were included in the analyses for enterococci in pigs in 2010, but neither was included in the 2009 report, as Finland reported no data and Estonia tested fewer than 10 isolates. Regarding individual countries, resistance levels in 2010 were in most countries quite similar to those reported in previous years, although in Denmark and the Netherlands levels of resistance to all antimicrobials in both enterococci species tended to be slightly lower than reported in 2009.

***Table EN5. Resistance (%) to ampicillin, erythromycin, streptomycin, tetracyclines and vancomycin among* Enterococcus faecium *from pigs in countries reporting MIC data in 2010***

| Country | Ampicillin | | Erythromycin | | Streptomycin | | Tetracyclines | | Vancomycin | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 77 | 0 | 77 | 49 | 77 | 4 | 77 | 17 | 77 | 0 |
| Denmark | 133 | 2 | 133 | 27 | 133 | 35 | 133 | 51 | 133 | 1 |
| Estonia | 22 | 5 | 22 | 14 | 22 | 36 | 22 | 41 | 22 | 0 |
| Finland | 36 | 6 | 36 | 22 | 36 | 6 | 36 | 33 | 36 | 0 |
| France | 73 | 4 | 73 | 53 | 73 | 37 | 73 | 77 | 73 | 3 |
| Netherlands | 92 | 22 | 92 | 30 | 92 | 13 | 92 | 76 | 92 | 1 |
| **Total (6 MSs)** | **433** | **7** | **433** | **35** | **433** | **23** | **433** | **53** | **433** | **0.9** |
| Switzerland | 33 | 12 | 33 | 18 | 33 | 12 | 33 | 24 | 33 | 0 |

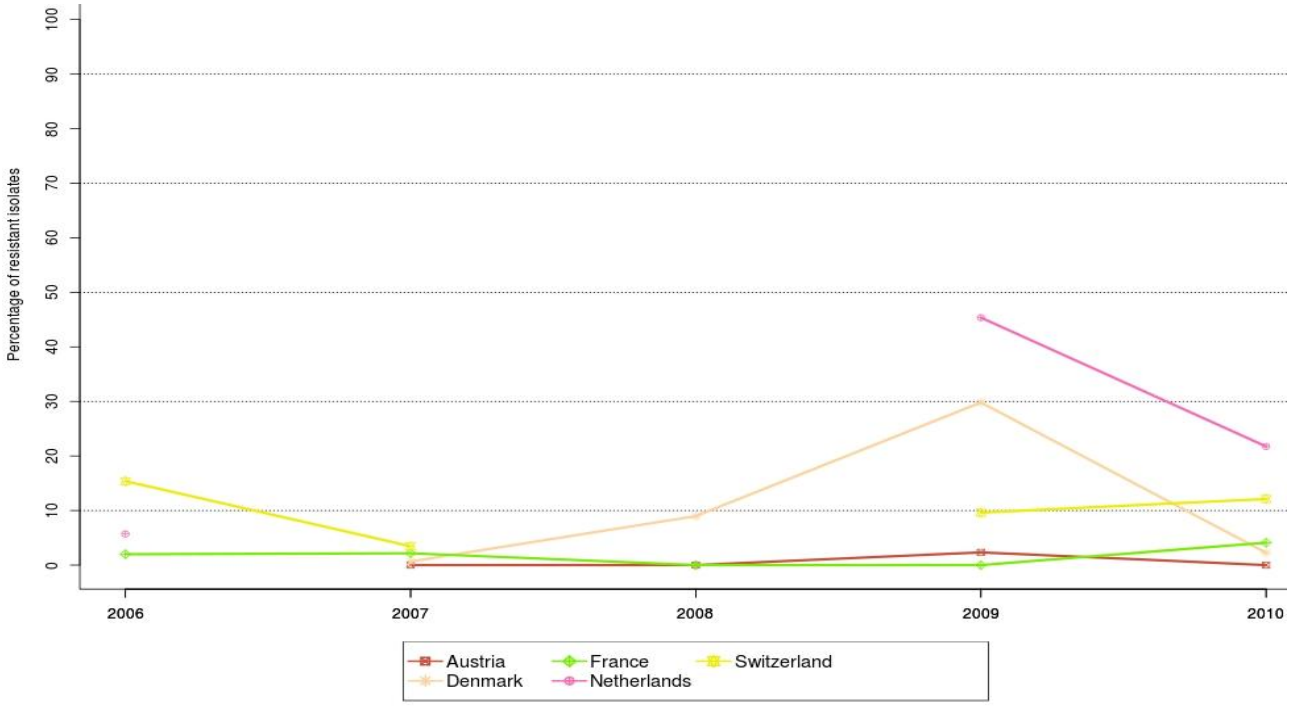
***Table EN6. Resistance (%) to ampicillin, erythromycin, streptomycin, tetracyclines and vancomycin among* Enterococcus faecalis *from pigs in countries reporting MIC data in 2010***

| Country | Ampicillin | | Erythromycin | | Streptomycin | | Tetracyclines | | Vancomycin | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 131 | 0 | 131 | 31 | 131 | 24 | 131 | 62 | 131 | 0 |
| Denmark | 157 | 0 | 157 | 44 | 157 | 28 | 157 | 78 | 157 | 0 |
| Finland | 46 | 0 | 46 | 37 | 46 | 4 | 46 | 74 | 46 | 0 |
| France | 16 | 0 | 16 | 6 | 16 | 6 | 16 | 31 | 16 | 0 |
| Netherlands | 38 | 0 | 38 | 53 | 38 | 13 | 38 | 84 | 38 | 0 |
| **Total (5 MSs)** | **388** | **0** | **388** | **38** | **388** | **21** | **388** | **71** | **388** | **0** |
| Switzerland | 105 | 0 | 105 | 24 | 105 | 33 | 105 | 53 | 105 | 0 |

### Temporal trends in resistance among indicator enterococci

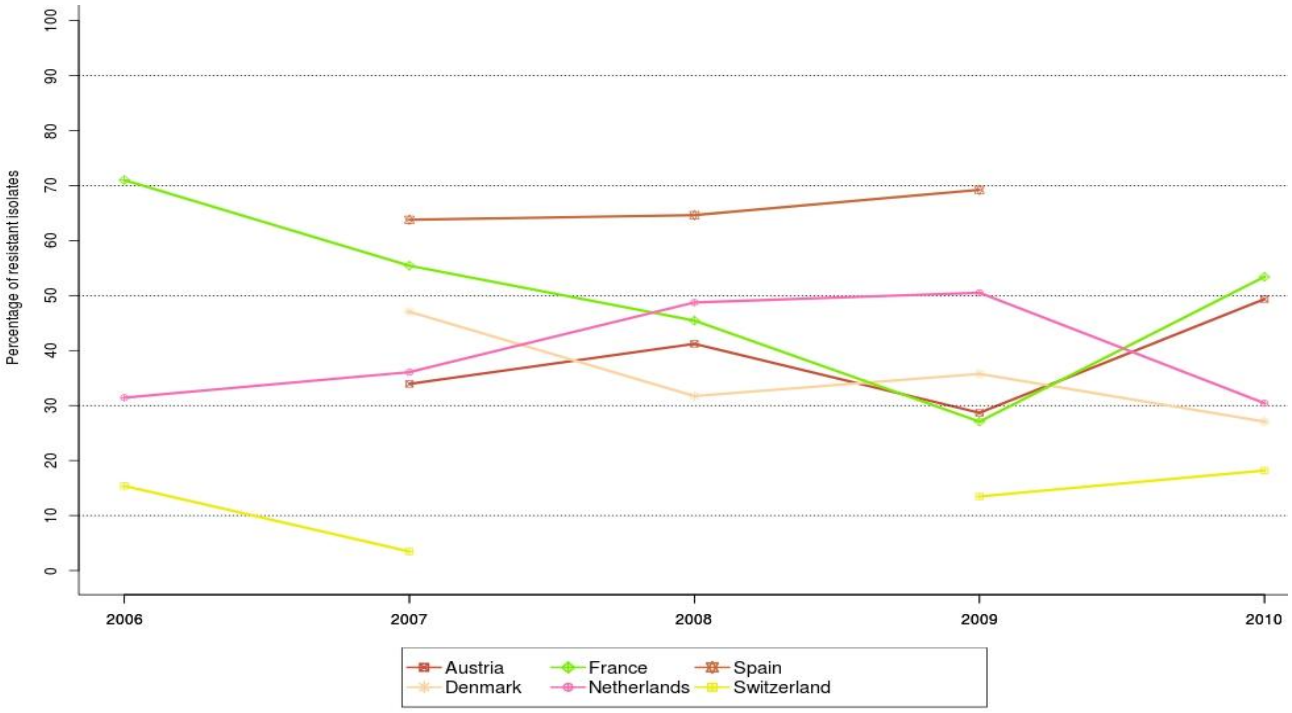
Figures EN11–20 show the trends in resistance to ampicillin, erythromycin, streptomycin, tetracyclines and vancomycin observed in *E. faecium* and *E. faecalis* from pigs over the period 2006–2010. The great variation in resistance levels between countries is clearly shown in the trend figures (e.g. Figure EN14). As in *Gallus gallus*, resistance to ampicillin in *E. faecalis* and to vancomycin in both enterococci species has been stable at low levels since 2006, and no significant trends in any of these were detected (Figures EN15, EN16 and EN20). Both Denmark and the Netherlands showed a decline in resistance for many of the antimicrobials compared to levels reported in 2009 (e.g. Figures EN12, EN13, EN14 and EN19). Tetracycline resistance declined, relative to the levels in 2009, in all countries for *E. faecalis* and for most countries for *E. faecium*. The trends for this antimicrobial over the last three or more reporting years were significantly decreasing for both enterococci species in Denmark (Figures EN14 and EN19) and significantly increasing for *E. faecium* in Spain (Figure EN14). The only other significant trends detected were for erythromycin in *E. faecium* where France showed a significant decreasing trend (over five years) and Denmark (over four years) (Figure EN12). Otherwise, there tended to be no significant trends in resistance over the 2006–2010 period, with often only minor fluctuations in resistance, sometimes in divergent directions in different countries.

***Figure EN11. Trends in ampicillin resistance in* Enterococcus faecium *from pigs in reporting Member States and non-Member States, 2006–2010, quantitative data***



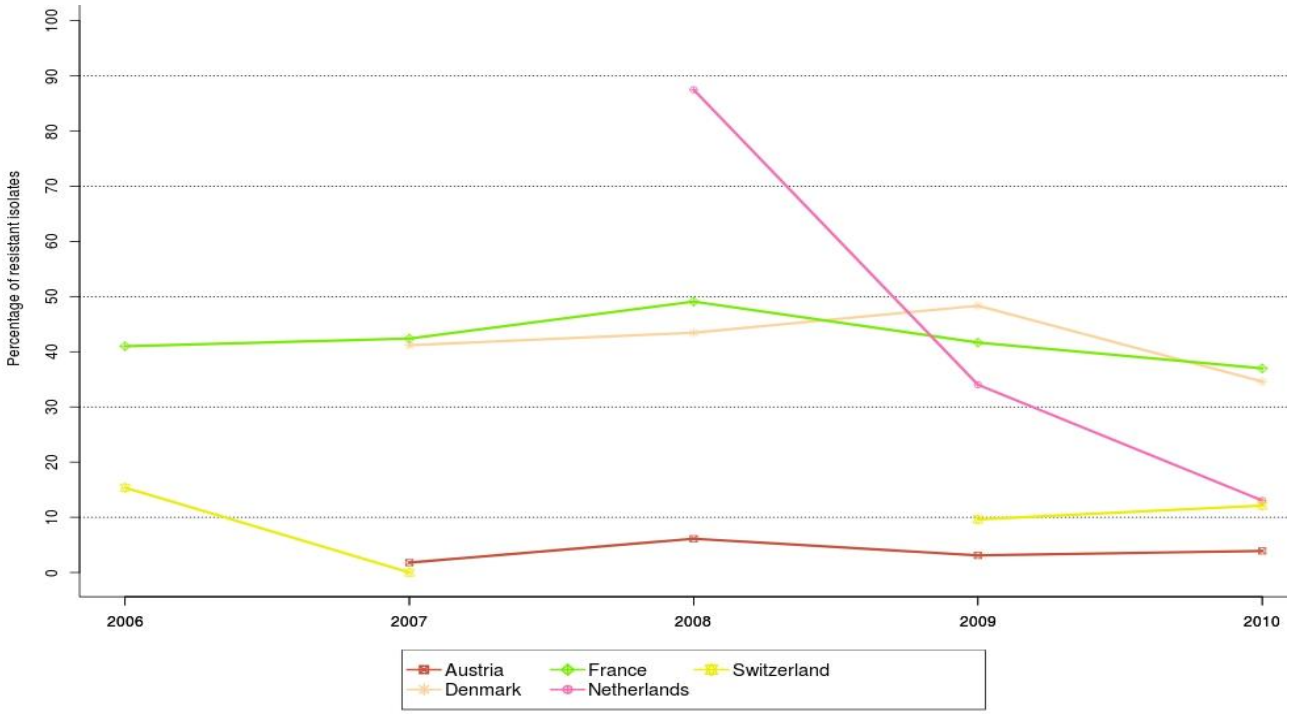

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any reporting country.

***Figure EN12. Trends in erythromycin resistance in* Enterococcus faecium *from pigs in reporting Member States and non-Member States, 2006–2010, quantitative data***



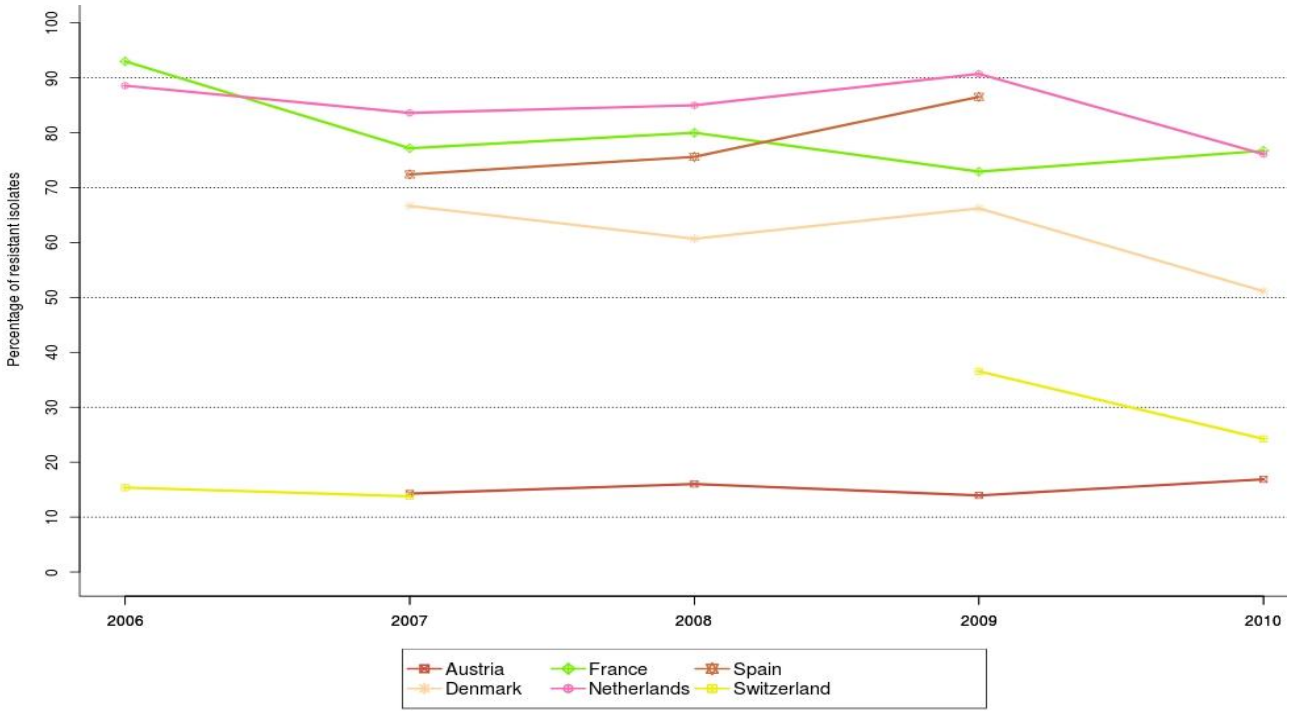

Note: A statistically significant decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in France.

***Figure EN13. Trends in streptomycin resistance in* Enterococcus faecium *from pigs in reporting Member States and non-Member States, 2006–2010, quantitative data***



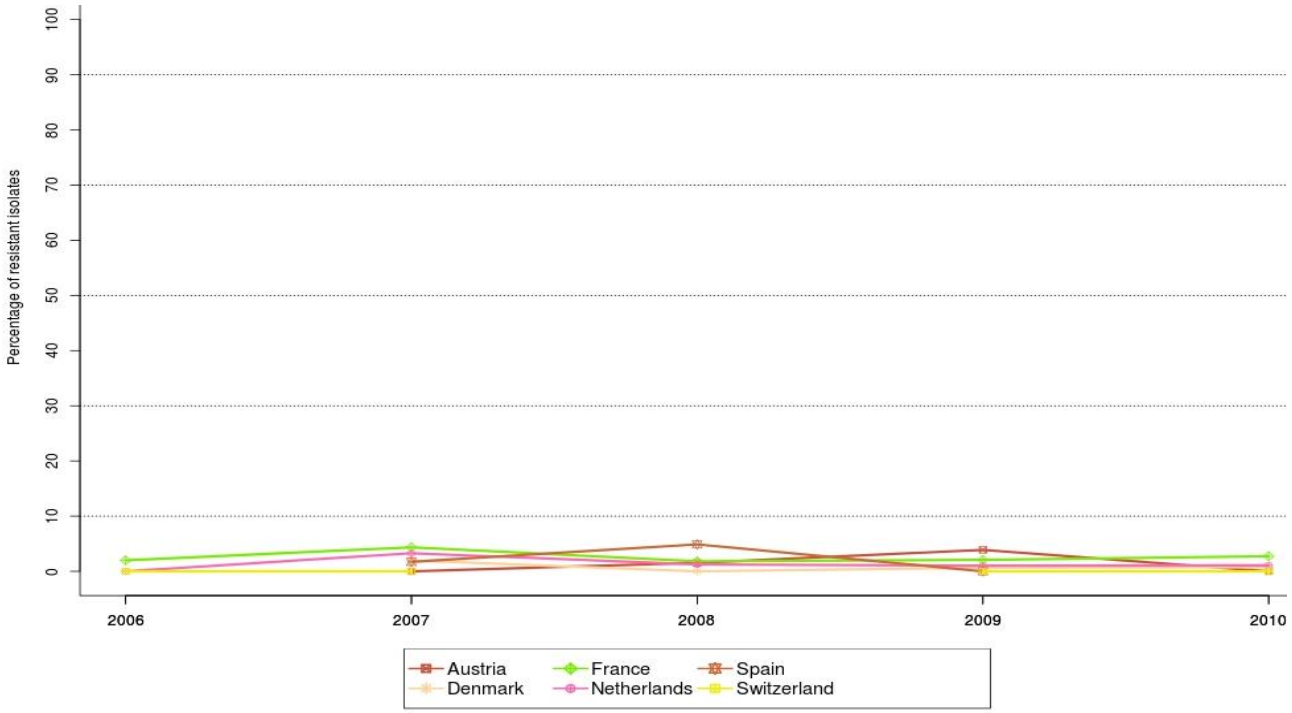

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN14. Trends in tetracycline resistance in* Enterococcus faecium *from pigs in reporting Member States and non-Member States, 2006–2010, quantitative data***



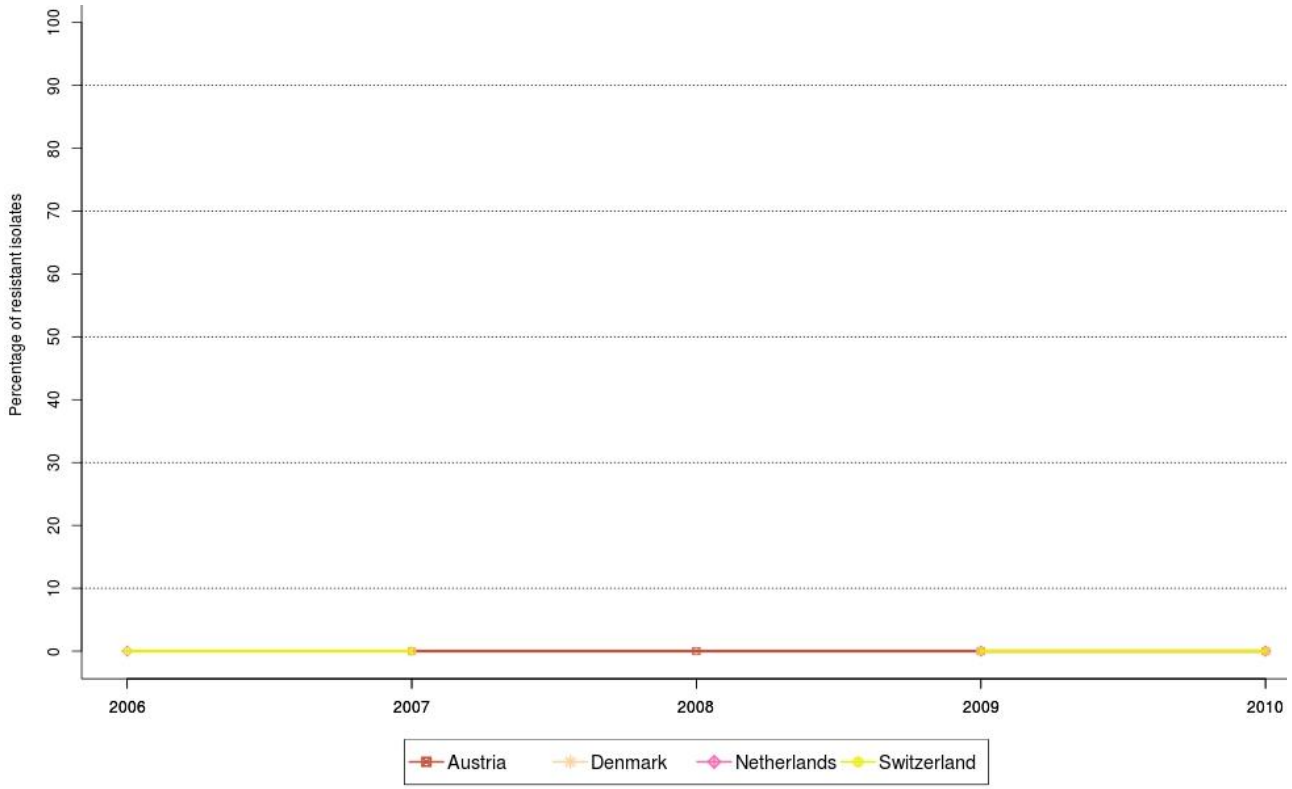

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN15. Trends in vancomycin resistance in* Enterococcus faecium *from pigs in reporting Member States and non-Member States, 2006–2010, quantitative data***



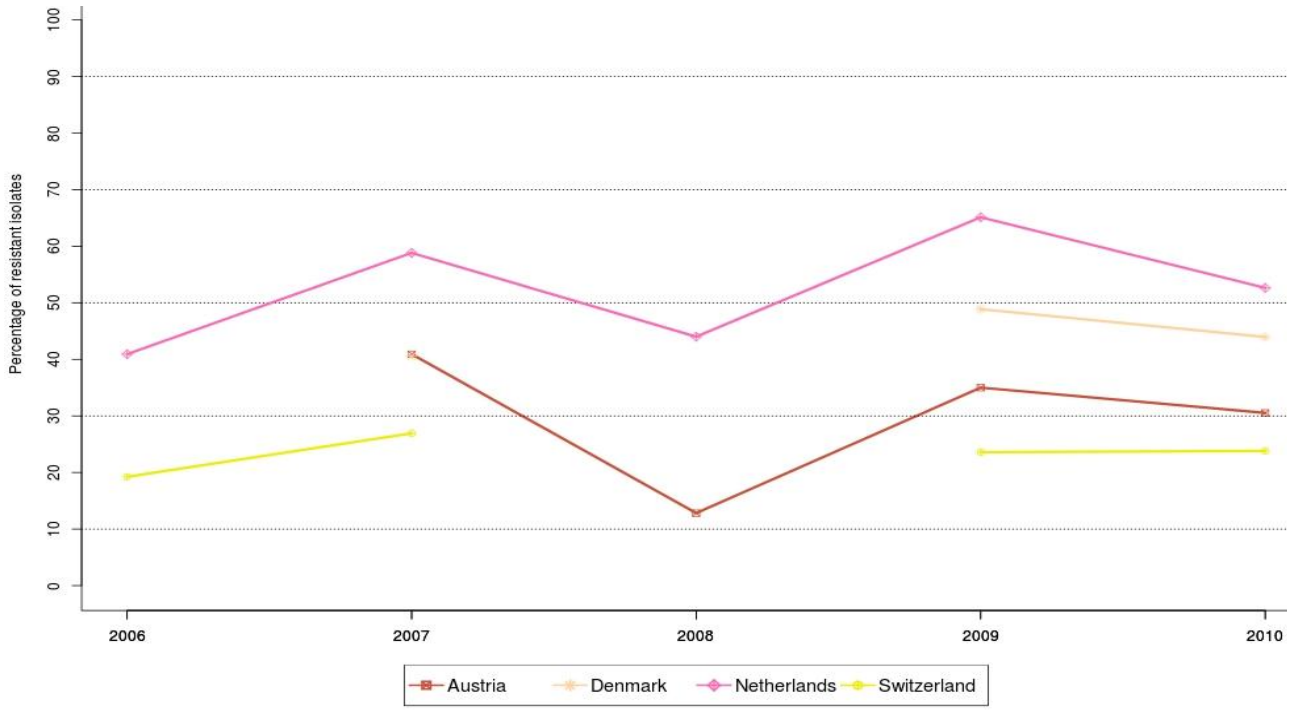

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN16. Trends in ampicillin resistance in* Enterococcus faecalis *from pigs in reporting Member States and non-Member States, 2006–2010, quantitative data***



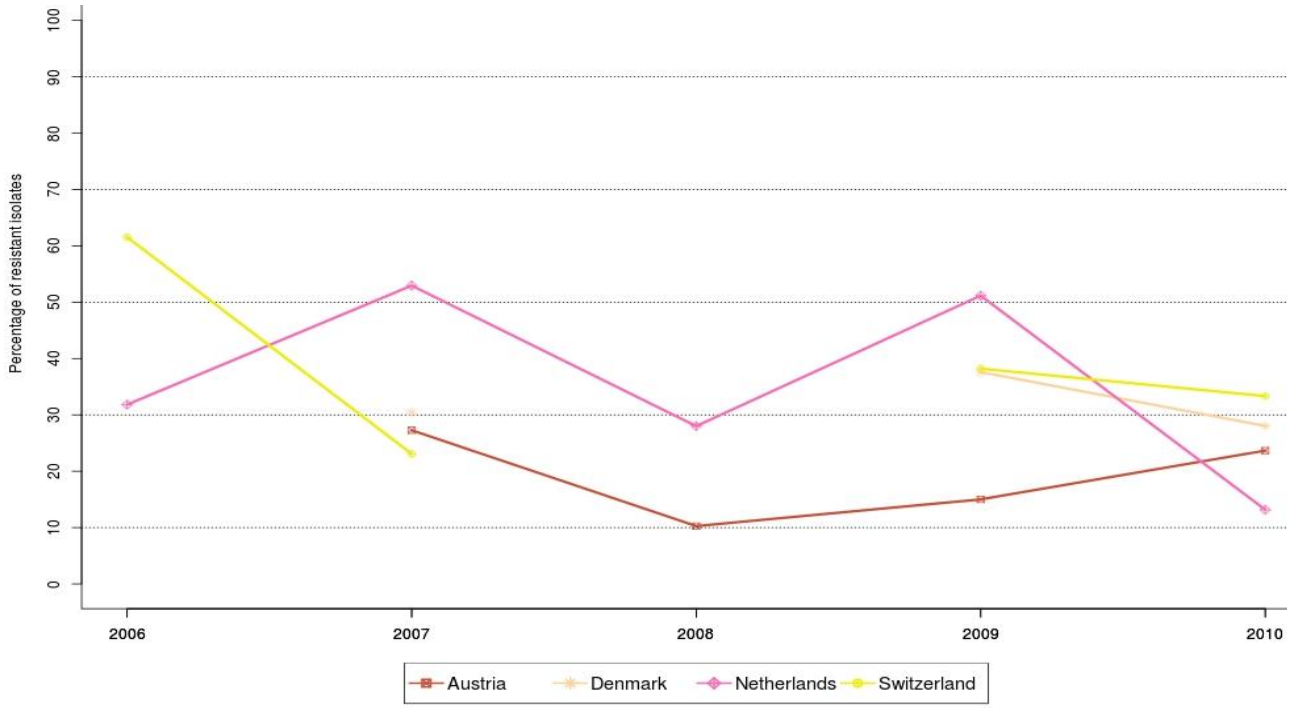

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN17. Trends in erythromycin resistance in* Enterococcus faecalis *from pigs in reporting Member States and non-Member States, 2006–2010, quantitative data***



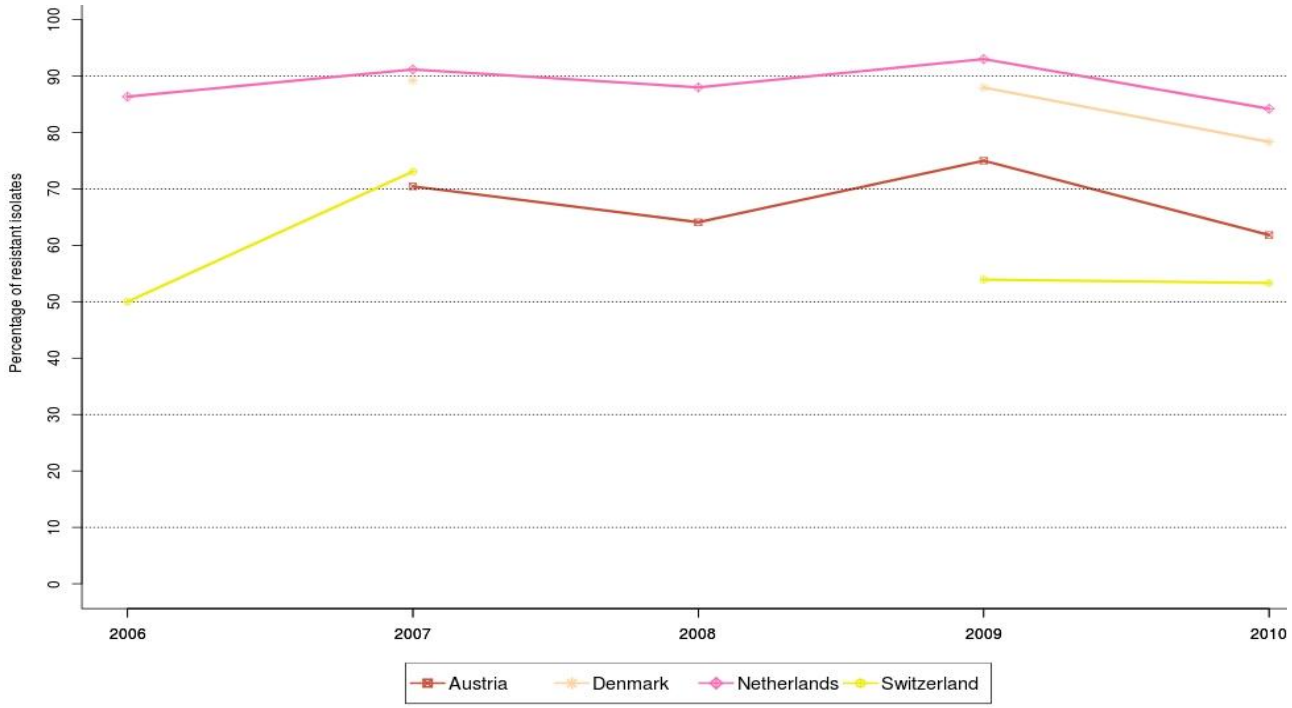

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN18. Trends in streptomycin resistance in* Enterococcus faecalis *from pigs in reporting Member States and non-Member States, 2006–2010, quantitative data***



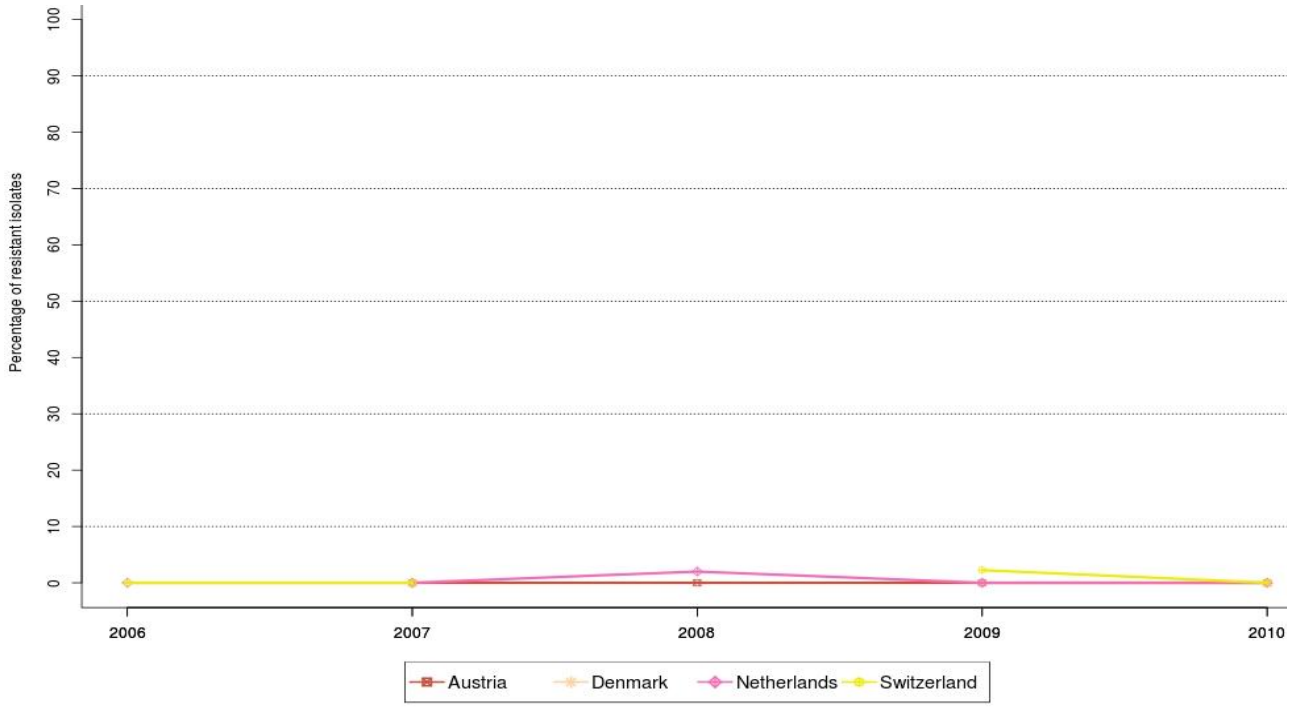

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN19. Trends in tetracycline resistance in* Enterococcus faecalis *from pigs in reporting Member States and non-Member States, 2006–2010, quantitative data***




Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN20. Trends in vancomycin resistance in* Enterococcus faecalis *from pigs in reporting Member States and non-Member States, 2006–2010, quantitative data***




Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

### 6.2.2.3 Cattle (bovine animals)

The data presented are the pooled data of dairy cows, beef animals and veal calves. In the reporting MSs, antimicrobial resistance monitoring in indicator enterococci isolates from cattle was chiefly based on active monitoring plans of healthy bovine animals either sampled from randomly selected herds (the Netherlands) or randomly selected in slaughterhouses (Austria, Switzerland). In both cases, samples are of faecal origin. In the remaining reporting MS, Estonia, the monitoring was passive, based on faecal samples from healthy cattle routinely received at the Veterinary and Food Laboratory. The sampling plans performed at slaughter were stratified by slaughterhouse with proportional allocation of the number of samples to the annual slaughterhouse throughput. In any case, the sampling was evenly distributed throughout the year or a significant part of the year to account for any possible seasonal effect. Only one representative faecal sample was gathered per epidemiological unit, either individual bovine animal or herd, to account for clustering. In Switzerland, the monitoring programme in 2010 focused specifically on calves under 1 year of age or veal calves.

#### Resistance levels in tested isolates

In 2010, only three MSs plus one non-MS (Switzerland) provided quantitative data on *E. faecium* isolates from cattle and only two MSs plus one non-MS (Switzerland) provided quantitative data on *E. faecalis* isolates from cattle. Overall, there was a high level of resistance to tetracyclines within the reporting MS group for both *E. faecium* (21 %) and *E. faecalis* (26 %). The level in *E. faecium* is comparable to 2009 (22 %) while the level in *E. faecalis* represents a decrease relative to 2009 (43 %). In the case of *E. faecium*, Austria reported a low level of resistance (4 %) and Switzerland reported a moderate level of resistance (16 %) while both Estonia and the Netherlands reported high levels of resistance (20 % and 29 %, respectively). Resistance levels were higher in *E. faecalis*: Austria reported 19 % resistance, the Netherlands reported 41 % resistance and Switzerland reported 63 % resistance. Erythromycin resistance at the MS reporting group level was also high in *E. faecium* (20 %) and moderate in *E. faecalis* (13 %). These resistance rates are broadly similar to those reported in 2009 (22 % and 24 % respectively). Considering *E. faecium*, the levels in individual countries ranged from 9 % in Austria to 27 % in the Netherlands, while for *E. faecalis* the levels of resistance ranged between 6 % in Austria and 37 % in Switzerland. The overall level of resistance to streptomycin in the reporting MS group was 14 % for *E. faecium* and 8 % for *E. faecalis*, which is also similar to the levels in 2009 (10 % and 16 %, respectively). Regarding *E. faecium*, Estonia reported no resistance while the other countries reported a proportion between 2 % (Austria) and 22 % (the Netherlands). For *E. faecalis,* the resistance levels ranged between 3 % (Austria) and 42 % (Switzerland). As in 2009, in 2010, no countries reported resistance to ampicillin in *E. faecalis*. The Netherlands was the only country to report ampicillin resistance in *E. faecium* (7 %), giving an overall level of resistance in the reporting MS group of 5 %, which is identical to the level in 2009. No resistance to vancomycin was recorded in *E. faecium*, and the Netherlands was the only country to detect resistance in *E. faecalis* (2 %), giving an overall level in the reporting MS group of 0.6 %.

Fewer MSs reported data in 2010 than in 2009, making the overall trends difficult to interpret. Only Austria, the Netherlands and Switzerland reported data in both years; in Austria and the Netherlands the reported levels of resistance for most antimicrobials tended to be slightly lower in 2010 while the opposite was true for Switzerland.

***Table EN7. Resistance (%) to ampicillin, erythromycin, streptomycin, tetracyclines and vancomycin among* Enterococcus faecium *from cattle in countries reporting MIC data in 2010***

| Country | Ampicillin | | Erythromycin | | Streptomycin | | Tetracyclines | | Vancomycin | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 57 | 0 | 57 | 9 | 57 | 2 | 57 | 4 | 57 | 0 |
| Estonia | 20 | 0 | 20 | 10 | 20 | 0 | 20 | 20 | 20 | 0 |
| Netherlands | 123 | 7 | 123 | 27 | 123 | 22 | 123 | 29 | 123 | 0 |
| **Total (3 MSs)** | **200** | **5** | **200** | **20** | **200** | **14** | **200** | **21** | **200** | **0** |
| Switzerland | 31 | 0 | 31 | 26 | 31 | 19 | 31 | 16 | 31 | 0 |

***Table EN8. Resistance (%) to ampicillin, erythromycin, streptomycin, tetracyclines and vancomycin among* Enterococcus faecalis *from cattle in countries reporting MIC data in 2010***

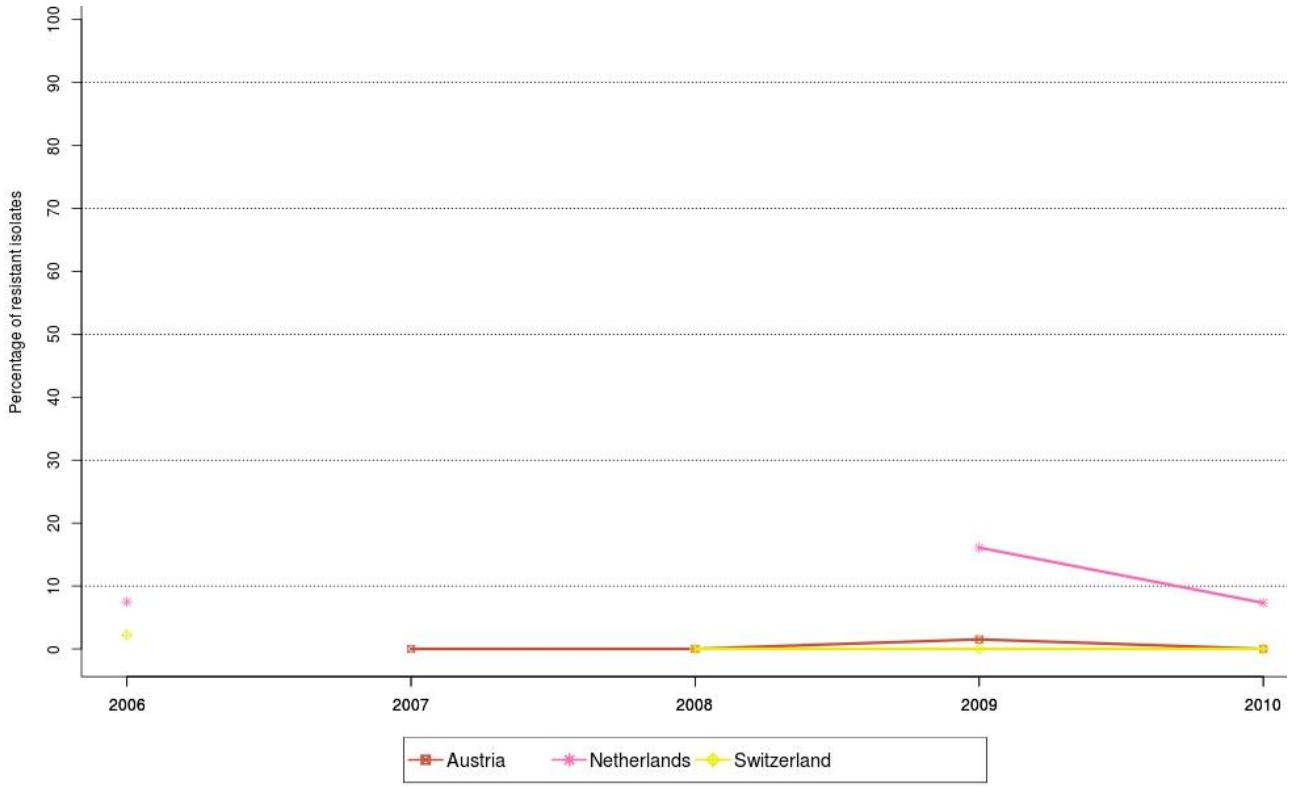
| Country | Ampicillin | | Erythromycin | | Streptomycin | | Tetracyclines | | Vancomycin | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 112 | 0 | 112 | 6 | 112 | 3 | 112 | 19 | 112 | 0 |
| Netherlands | 49 | 0 | 49 | 29 | 49 | 20 | 49 | 41 | 49 | 2 |
| **Total (2 MSs)** | **161** | **0** | **161** | **13** | **161** | **8** | **161** | **26** | **161** | **0.6** |
| Switzerland | 103 | 0 | 103 | 37 | 103 | 42 | 103 | 63 | 103 | 0 |

### Temporal trends in resistance among indicator enterococci

Figures EN21–30 show the trends in resistance to ampicillin, erythromycin, streptomycin, tetracyclines and vancomycin observed in *E. faecium* and *E. faecalis* from cattle from 2006 to 2010. In general, the number of MSs submitting data for at least 3 years for cattle, and thus included in the trend graphs for enterococci, was lower than the number of MSs submitting data for *Gallus gallus* and pigs. Nevertheless, there remained substantial variation in the resistance levels reported by MSs, particularly for erythromycin, streptomycin and tetracycline (Figures EN22–24 and EN27–29). As in *Gallus gallus* and pigs, resistance to ampicillin in *E. faecalis* and to vancomycin in enterococci as a whole has been at a stably low level since 2006 (Figures EN25, EN26 and EN30).

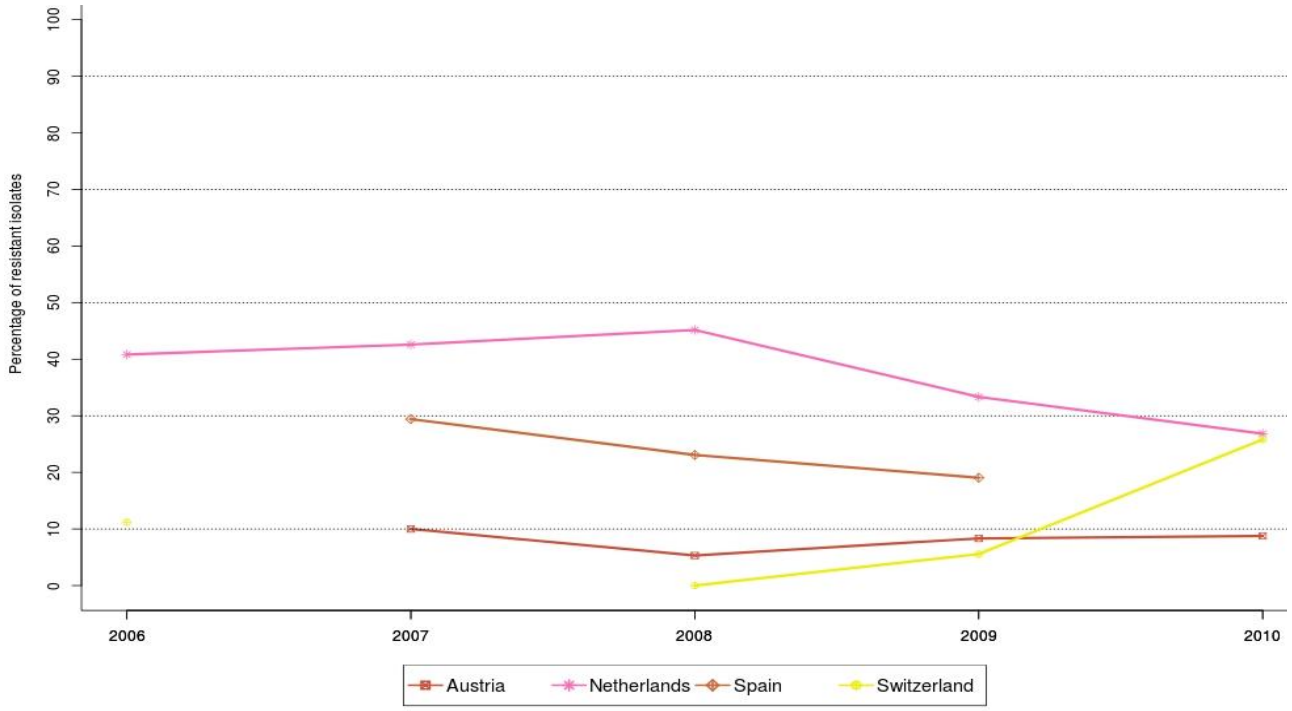
Statistically significant decreasing trends were observed in *E. faecium* in the Netherlands as regards resistance to erythromycin and tetracyclines (Figures EN22 and EN24). A decreasing trend was also observed in Austria for vancomycin in *E. faecium*, limited to the last 4 years (Figure EN25). Otherwise, most countries tended to show only fluctuations in resistance levels with no clear trends.

***Figure EN21. Trends in ampicillin resistance in* Enterococcus faecium *from cattle in reporting Member States and non-Member States, 2006–2010, quantitative data***



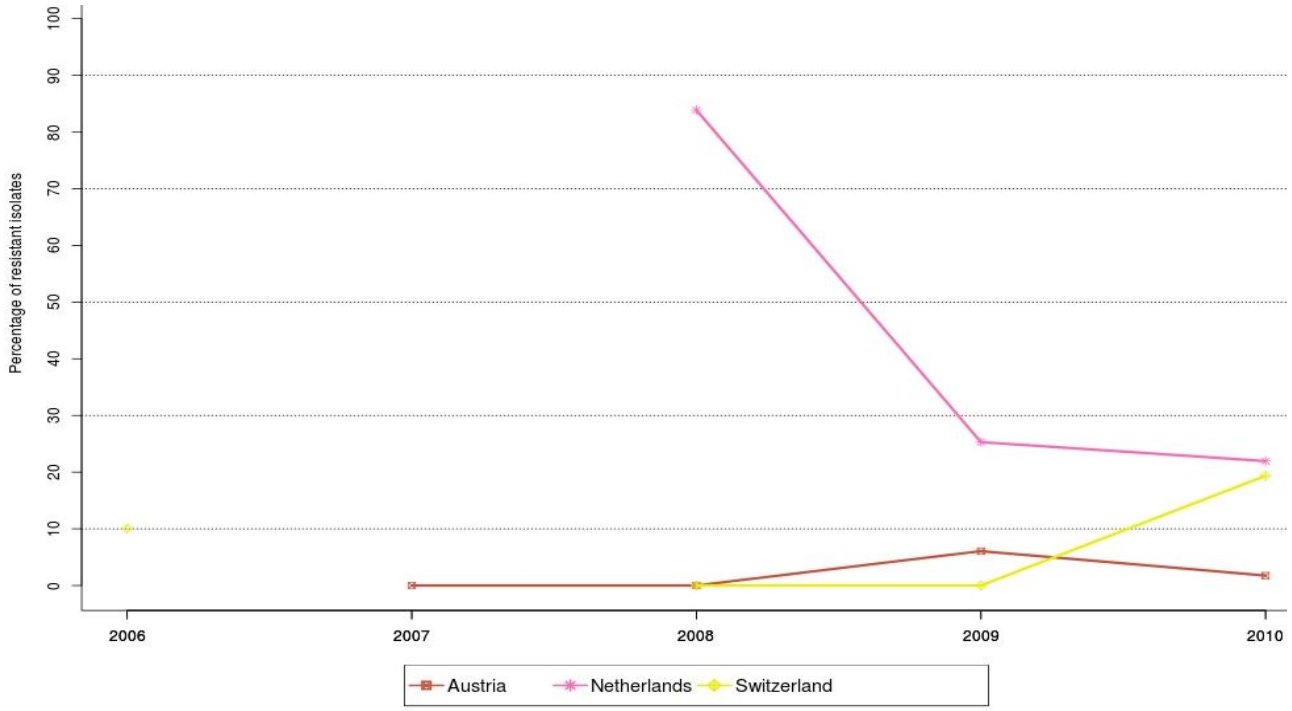

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN22. Trends in erythromycin resistance in* Enterococcus faecium *from cattle in reporting Member States and non-Member States, 2006–2010, quantitative data***



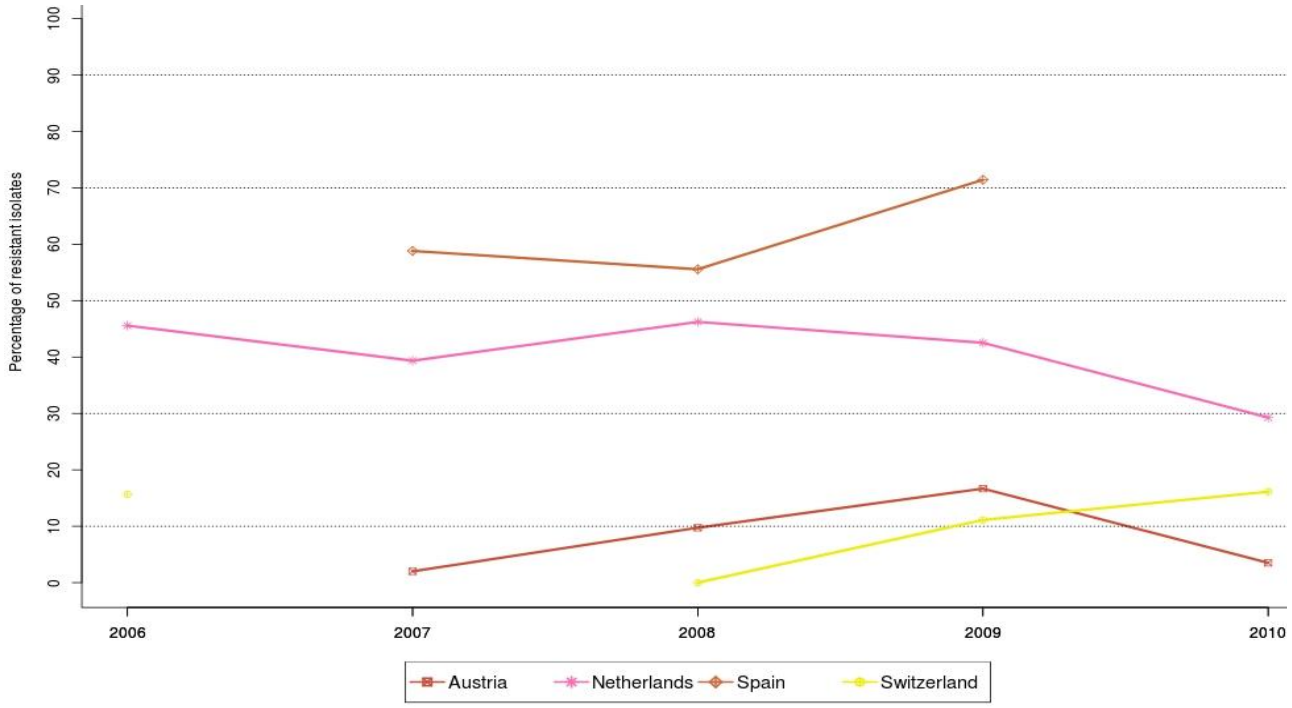

Note: A statistically significant decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands.

***Figure EN23. Trends in streptomycin resistance in* Enterococcus faecium *from cattle in reporting Member States and non-Member States, 2006–2010, quantitative data***



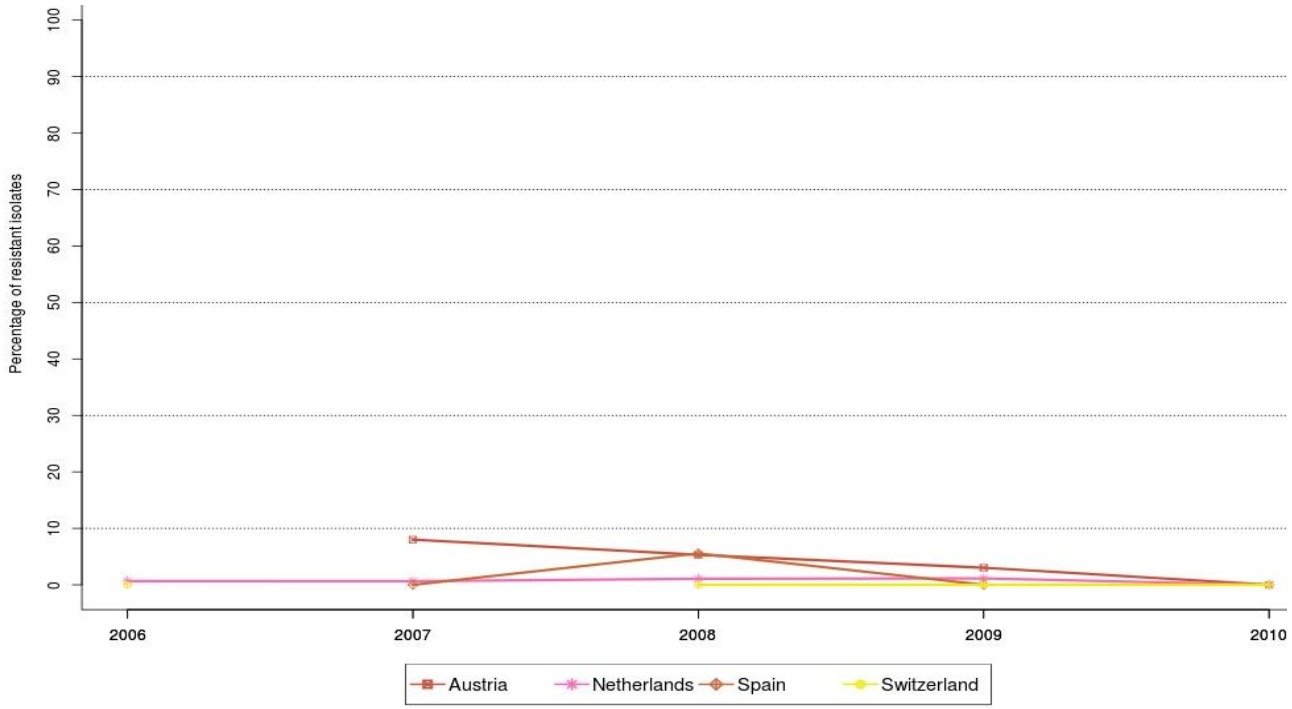

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN24. Trends in tetracycline resistance in* Enterococcus faecium *from cattle in reporting Member States and non-Member States, 2006–2010, quantitative data***



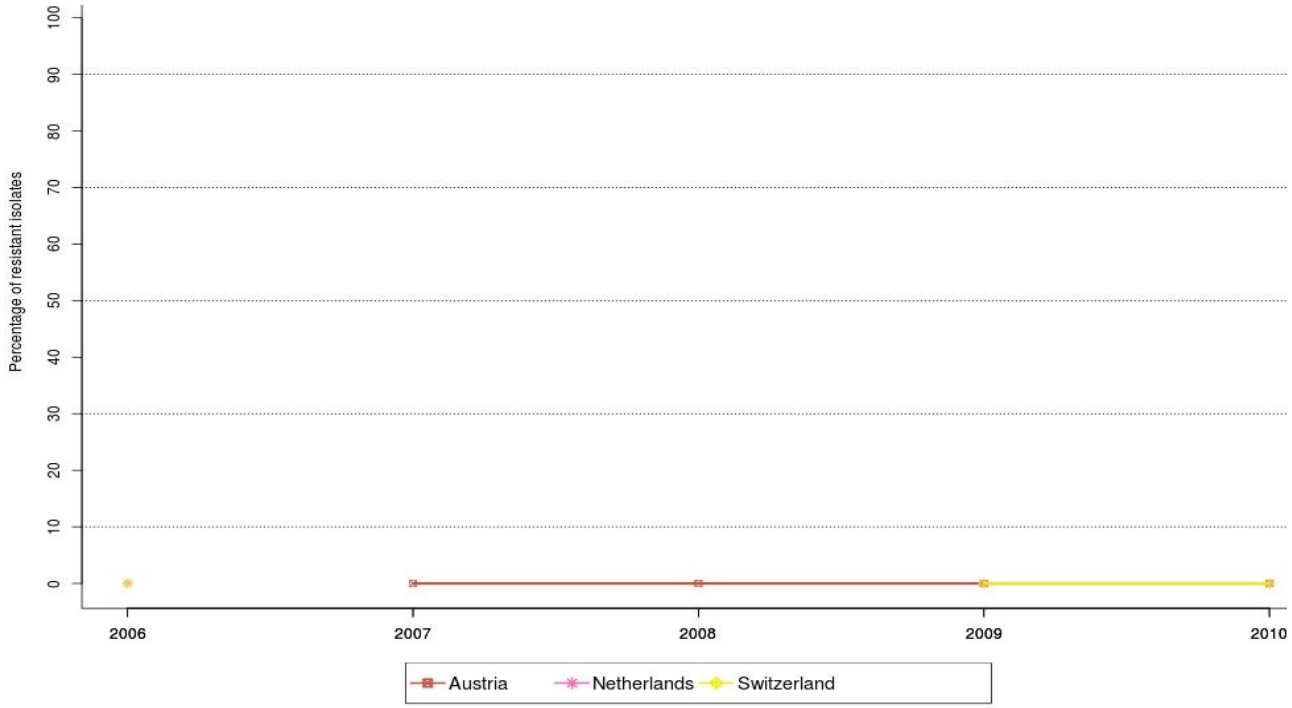

Note: A statistically significant decreasing trend over the last 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands.

***Figure EN25. Trends in vancomycin resistance in* Enterococcus faecium *from cattle in reporting Member States and non-Member States, 2006–2010, quantitative data***



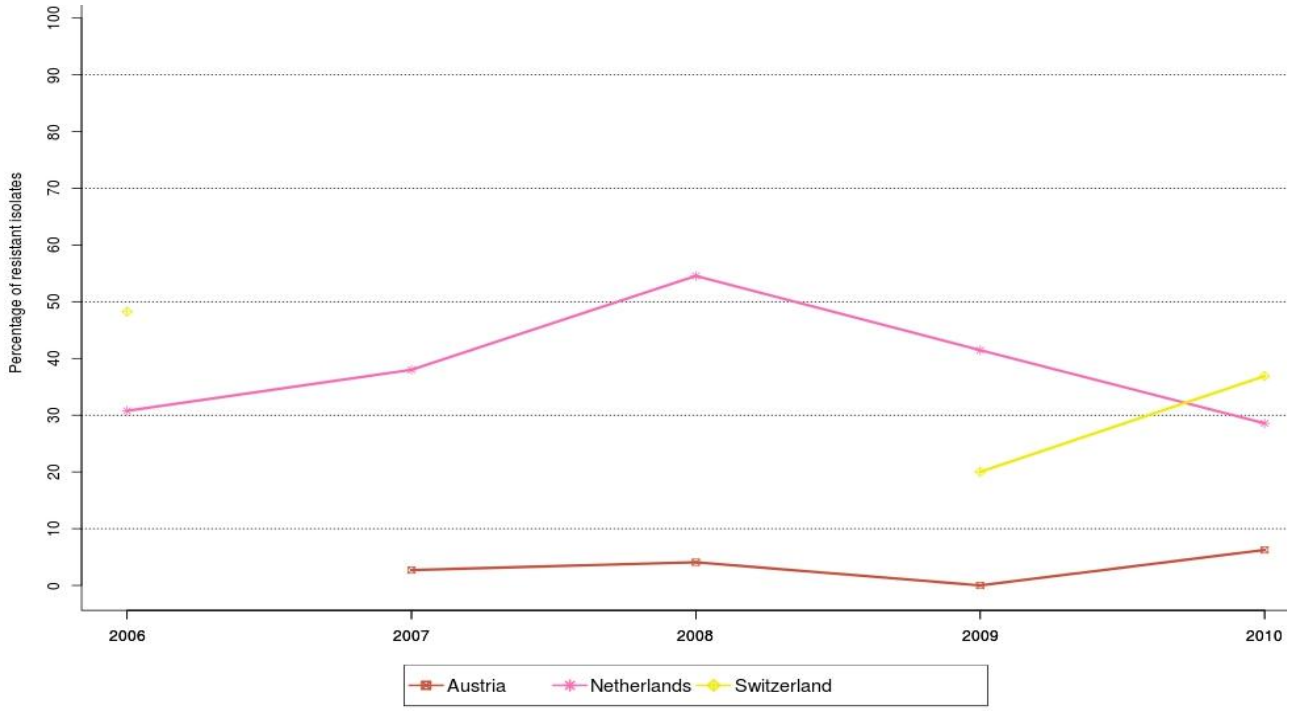

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN26. Trends in ampicillin resistance in* Enterococcus faecalis *from cattle in reporting Member States and non-Member States, 2006–2010, quantitative data***



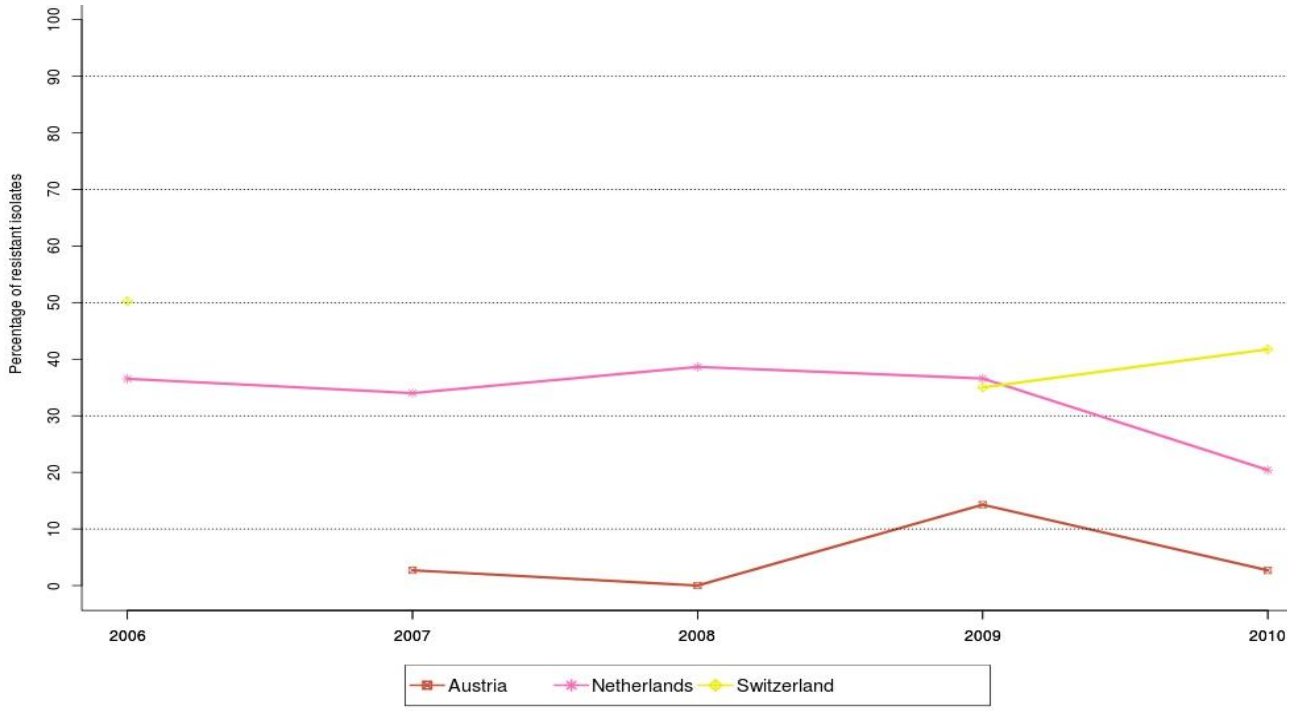

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN27. Trends in erythromycin resistance in* Enterococcus faecalis *from cattle in reporting Member States and non-Member States, 2006–2010, quantitative data***



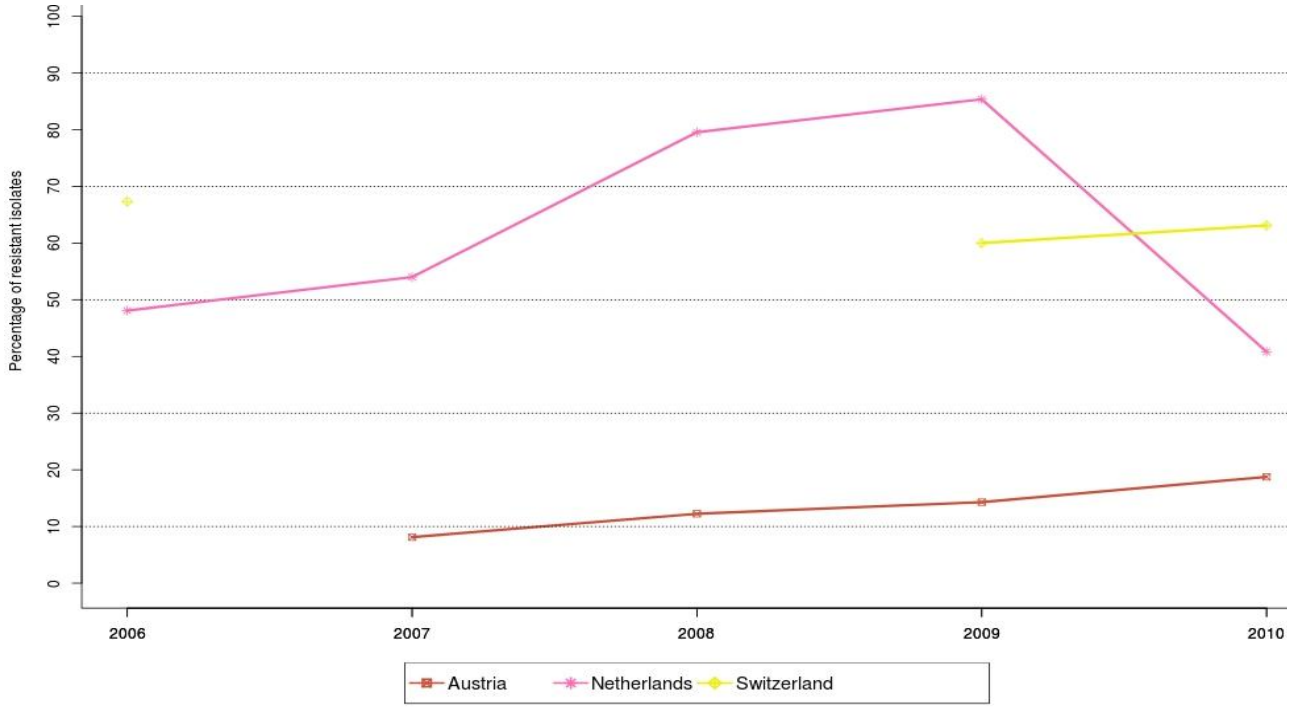

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN28. Trends in streptomycin resistance in* Enterococcus faecalis *from cattle in reporting Member States and non-Member States, 2006–2010, quantitative data***



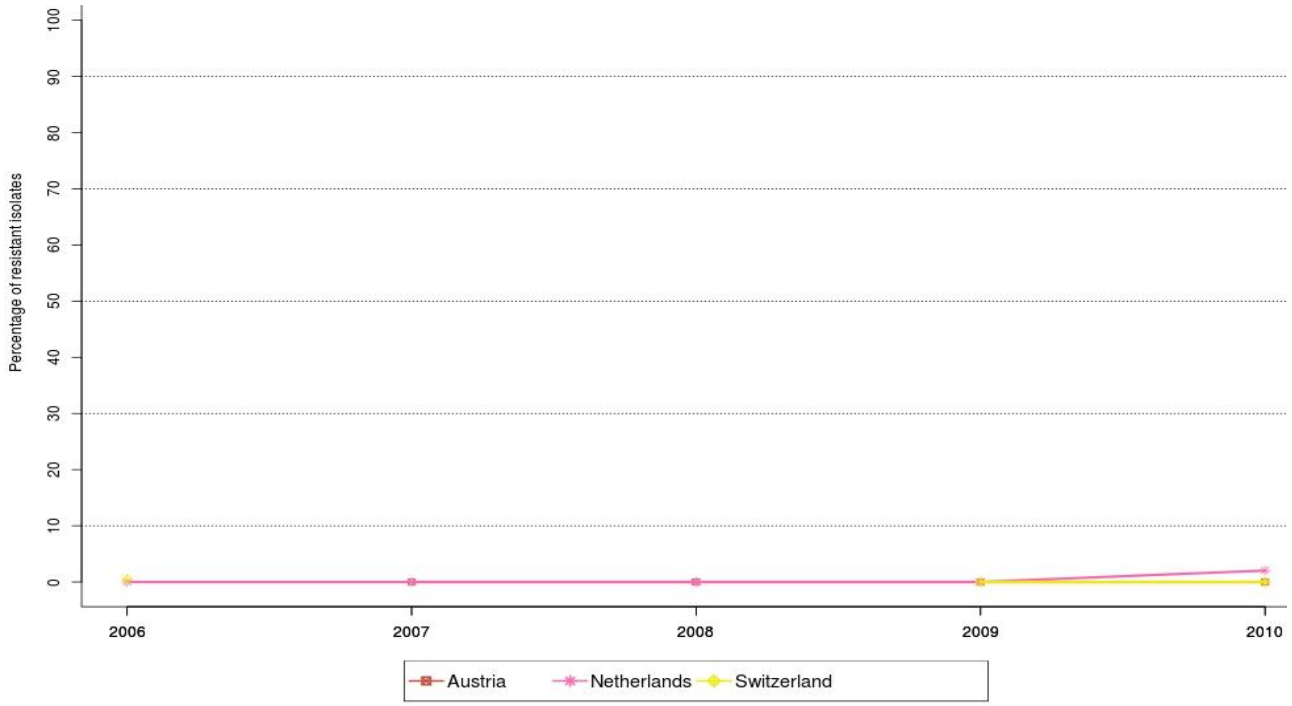

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any reporting country.

***Figure EN29. Trends in tetracycline resistance in* Enterococcus faecalis *from cattle in reporting Member States and non-Member States, 2006–2010, quantitative data***




Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

***Figure EN30. Trends in vancomycin resistance in* Enterococcus faecalis *from cattle in reporting Member States and non-Member States, 2006–2010, quantitative data***



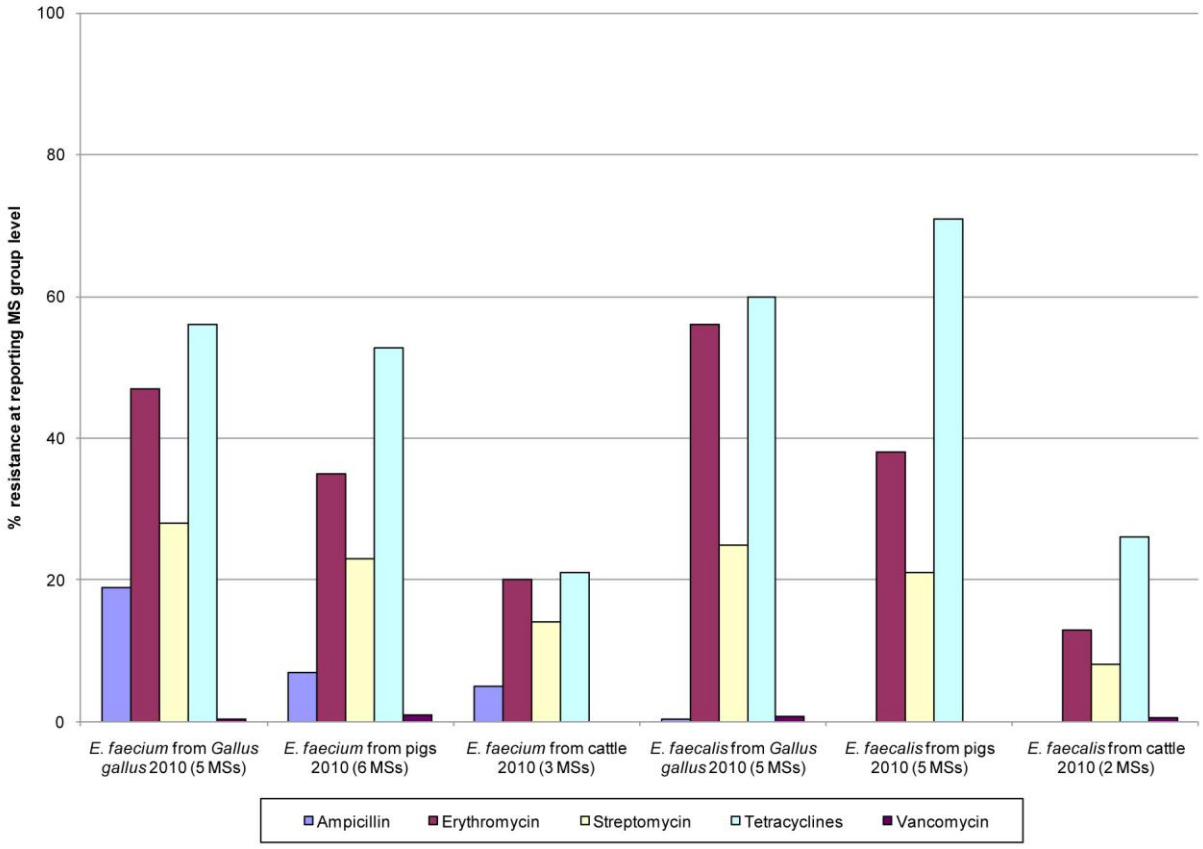

Note: No significant increasing or decreasing trend over 5 years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any reporting country.

## 6.3 Overview of the findings on enterococci resistance at reporting MS group level, 2010

Figure EN31 shows resistance levels in the reporting MS group based on MIC data submitted in 2010 for the various animal species. The fact that data are derived from different numbers and groups of MSs needs to be considered when examining the figure.

As in 2009, resistance to tetracyclines and erythromycin was generally higher among *E. faecalis* isolates than in *E. faecium* isolates, while resistance to ampicillin was substantially lower, with no ampicillin resistance reported in *E. faecalis* isolates from either pigs or cattle in 2010. Unlike in 2009, streptomycin resistance also tended to be slightly higher among *E. faecium* than *E. faecalis* isolates in all three animal species. Vancomycin resistance was very low in both bacterial species. Among both *E. faecium* and *E. faecalis*, the resistance levels were higher in isolates from *Gallus gallus* and pigs than in isolates from cattle.

***Figure EN31. Resistance to ampicillin, erythromycin, streptomycin, tetracyclines and vancomycin in indicator* Enterococcus faecium *and* Enterococcus faecalis *from fowl, pigs and cattle at reporting Member State group level in 2010***



## 6.4. Discussion

Antimicrobial resistance in commensal enterococci isolates from animals and food is used as an indicator of a reservoir of resistance genes in the gram-positive flora which could be transferred to bacteria that are pathogenic to humans. It is recommended that both *E. faecium* and *E. faecalis* are included in any antimicrobial resistance monitoring programme because in some animals one bacterial species is much commoner than the other, and changes in the prevalence of each enterococcal species can also occur with age in some animals. Both enterococcal species can cause human disease, and they differ in the antimicrobials to which they show intrinsic (i.e. naturally occurring) resistance. In fact, one of the most important antimicrobials to monitor in these bacteria is probably vancomycin, and enterococcal species can differ in their propensity to carry resistance to this antimicrobial (see below).

In 2010, information on antimicrobial resistance in enterococcal isolates from animals and food was included in the analysis from seven MSs and one non-MS (Switzerland). Only two MSs (Denmark and Sweden) reported MIC data on isolates collected from food; the former reported results for meat from broilers, pigs and cattle while the latter reported results only for meat from broilers. All reporting MSs used dilution methods to determine MIC values, in accordance with EFSA recommendations (EFSA, 2008b); this is a promising sign that a number of MSs have adopted EFSA's recommendations.

Resistance to several antimicrobials was commonly reported by the MSs in the *E. faecium* and *E. faecalis* isolates from farm animals when using the epidemiological cut-off values. Although there was a wide variation in the levels of resistance observed in reporting MSs, the resistance reported was at a high to extremely high level for many of the antimicrobials. The highest resistance levels were observed among enterococcal isolates from *Gallus gallus* and pigs, whereas resistance was at a lower level in isolates from cattle. However, given the small number of MSs reporting data, especially for cattle, the observed difference between the animal species should be viewed with caution and may not mirror a consistent situation throughout the EU.

Among isolates from fowl, the level of resistance to erythromycin (macrolides) in the reporting group of MSs as a whole was 47 % in *E. faecium* and 56 % in *E. faecalis*. The observed high levels of resistance to macrolides are of particular importance because these substances have been defined as critically important antimicrobials in human medicine. Differences in the occurrence of macrolide resistance in enterococcal isolates from poultry, calves and pigs have been considered to reflect the different levels and patterns of usage of antimicrobials in those different species. This also probably accounts for the widespread occurrence of tetracycline resistance in *Gallus gallus* and pigs, because these species have frequently received treatment with this antimicrobial (van den Bogaard et al., 2000; Cauwerts et al., 2007).

Because cross-resistance occurs between avoparcin and the important human antimicrobial vancomycin (used for treating gram-positive infections in human), the use of avoparcin as an antimicrobial growth promoter was banned in 1997 in the EU. No resistance to vancomycin was detected in reporting MSs in *E. faecalis* isolates from pigs in 2010, whereas two of the six reporting MSs still recorded resistance in *E. faecalis* isolates in fowl. In one reporting MS, a statistically significant decreasing trend in the occurrence of resistance to vancomycin in fowl was observed over the last 5-year period. The overall level of vancomycin resistance in all reporting MSs was 0.7 %. Recent studies have shown that fluctuations, including increases, in the level of vancomycin resistance in *E. faecium* can be related to the spread of single clones of *E. faecium* carrying the *vanA* gene (Nilsson et al., 2009). The results are in agreement with most other studies that have previously been carried out, which show that resistance due to *vanA* is more common in *E. faecium* isolates from animals and meat derived from those animals; *E. faecalis* isolates are more rarely found. In 2010, vancomycin resistance was still detected in *E. faecium* and *E. faecalis* isolates from *Gallus gallus*, pigs or and cattle, although in all cases the occurrence of resistance was low.

# 7. ANTIMICROBIAL RESISTANCE IN *SALMONELLA* – QUALITATIVE DATA

## 7.1 Introduction

In 2010, four MSs reported data on antimicrobial resistance in *Salmonella* from animals and food as quantitative inhibition zone diameter (IZD) data derived from disc diffusion methods. For the purpose of this chapter, these data have been analysed using the breakpoints for resistance specified by the reporting MS and in accordance with the method used and are presented as qualitative data (Tables QSA1–3).

In the case of data reported exclusively as qualitative data, when information on the thresholds used to interpret the resistance was also available, it has been possible to pool the data submitted by MSs and present them in this chapter. It should, however, be noted that countries may not have used the same threshold values or qualitative methods and so direct comparisons between the proportions of resistant isolates in MSs reporting only qualitative data should be interpreted with caution. For this reason, tables do not show the summary figure for the reporting MS group and the spatial distributions of the levels of resistance for *Salmonella* based on qualitative data are not shown here; this is in accordance with previous reports. Furthermore, for those countries that reported quantitative data on antimicrobial resistance as presented in Chapter 3, corresponding qualitative data have been excluded from the analyses presented in this chapter.

The tables displayed below show the occurrence of antimicrobial resistance based on reported disc diffusion data. Tables were generated if three or more countries reported qualitative data per *Salmonella* species and sampling origin. In addition, the report includes only data based on 10 or more isolates per country, per sampling origin, per year.

Resistance to the following antimicrobial agents is described in detail in the tables below: tetracyclines, chloramphenicol, ampicillin, sulfonamides, gentamicin, ciprofloxacin and nalidixic acid.

***Table QSA1. Overview of Member States reporting qualitative data on* Salmonella *spp. from animals and food in 2010***

| Origin | Quantitative disk diffusion data | | Qualitative data | |
|---|---|---|---|---|
| | Total number of MSs reporting | Countries | Total number of MSs reporting | Countries |
| Cattle (bovine animals) | 1 | **MS:** HU | 13 | **MSs:** AT, BE, EE, ES, FI, GR, IE, LU, LV, NL, PL, SE, UK |
| | | | | **Non MS:** NO |
| *Gallus gallus* (fowl) | 4 | **MSs:** CY, ES, HU, RO | 13 | **MSs:** AT, BE, CY, ES, FI, GR, MT, NL, PL, SE, SI, SK, UK |
| | | | | **Non MS:** NO |
| Pigs | 2 | **MSs:** HU, RO | 12 | **MSs:** AT, BE, EE, ES, FI, IE, LV, NL, PL, SE, SI, UK |
| | | | | **Non MS:** NO |
| Meat from bovine animals | 1 | **MS:** RO | 4 | **MSs:** AT, GR, HU, NL |
| Meat from broilers (*Gallus gallus*) | 1 | **MS:** RO | 11 | **MSs:** AT, BE, EE, ES, GR, HU, LT, NL, PL, SI, SK |
| Meat from pig | 2 | **MSs:** ES, RO | 7 | **MSs:** AT, BE, EE, ES, GR, HU, NL |

***Table QSA2. Overview of Member States reporting qualitative data on* Salmonella *Typhimurium from animals and food in 2010***

| Origin | Quantitative disk diffusion data | | Qualitative data | |
|---|---|---|---|---|
| | Total number of MSs reporting | Countries | Total number of MSs reporting | Countries |
| Cattle (bovine animals) | 1 | **MS:** HU | 10 | **MSs:** AT, BE, EE, ES, FI, IE, LU, NL, PL,UK |
| *Gallus gallus* (fowl) | 2 | **MSs:** HU, RO | 11 | **MSs:** AT, BE, ES, GR, MT, NL, PL, SE, SI, SK, UK |
| Pigs | 2 | **MSs:** HU, RO | 11 | **MSs:** AT, BE, EE, ES, FI, IE, NL, PL, SE, SI, UK<br>**Non MS:** NO |
| Meat from bovine animals | 1 | **MS:** RO | 2 | **MSs:** HU, NL |
| Meat from broilers (*Gallus gallus*) | 0 | | 5 | **MSs:** AT, HU, NL, PL, SI |
| Meat from pig | 2 | **MSs:** ES,RO | 6 | **MSs:** AT, BE, EE, GR, HU, NL |

***Table QSA3. Overview of Member States reporting qualitative data on* Salmonella *Enteritidis from animals and food in 2010***

| Origin | Quantitative disk diffusion data | | Qualitative data | |
|---|---|---|---|---|
| | Total number of MSs reporting | Countries | Total number of MSs reporting | Countries |
| Cattle (bovine animals) | 1 | **MS:** HU | 3 | **MSs:** BE, FI, UK |
| *Gallus gallus* (fowl) | 4 | **MSs:** CY, ES, HU, RO | 11 | **MSs:** AT, BE, CY, ES, GR, MT, NL, PL, SI, SK, UK |
| Pigs | 0 | | 2 | **MSs:** GR, HU |
| Meat from bovine animals | 0 | | 4 | **MSs:** BE, EE, LV, SI |
| Meat from broilers (*Gallus gallus*) | 1 | **MS:** RO | 7 | **MSs:** AT, BE, HU, NL, PL, SI, SK |
| Meat from pig | 1 | **MS:** RO | 2 | **MSs:** AT, HU |

## 7.2 Antimicrobial resistance in *Salmonella* isolates from food (qualitative data)

### 7.2.1 Meat from broilers (*Gallus gallus*)

#### Resistance levels among *Salmonella*

Analysis of resistance to the harmonised set of antimicrobials among *Salmonella* spp. isolates from broiler meat tested for antimicrobial susceptibility and reported as qualitative data reveals that an extremely high level of resistance to tetracylines was reported by Austria (72 %), Hungary (79 %) and Romania (73 %). A high level of resistance to nalidixic acid (39 %) was reported by Romania and an extremely high level of resistance by the other reporting MSs. An extremely high level of resistance to ciprofloxacin was reported by Hungary (93 %) and Slovenia (72 %), while Austria and Spain detected no resistance to this antimicrobial. Only Romania reported high levels of resistance to ampicillin (28 %), gentamicin (24 %) and chloramphenicol (23 %), while the other reporting MSs detected no, very low, low or moderate resistance (Table QSA4).

***Table QSA4. Reported resistance (%) to ampicillin, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. from meat from broilers in 2010, using qualitative data***

| Country | Ampicillin | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | |
|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 36 | 8 | 36 | 0 | 36 | 0 | 36 | 0 |
| Hungary | 217 | 1 | 217 | 0.9 | 217 | 93 | 217 | 3 |
| Slovenia | 18 | 17 | 18 | 6 | 18 | 72 | 18 | 6 |
| Spain | 12 | 8 | 12 | 0 | 12 | 0 | 12 | 0 |
| Romania | 97 | 28 | 97 | 23 | 97 | 30 | 97 | 24 |

| Country | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res |
| Austria | 36 | 75 | 36 | 72 | 36 | 72 |
| Hungary | 217 | 93 | 217 | 93 | 217 | 79 |
| Slovenia | 18 | 72 | 18 | 72 | 18 | 61 |
| Spain | 12 | 83 | 12 | 83 | 12 | 8 |
| Romania | 97 | 39 | 97 | 64 | 97 | 73 |

## 7.3 Antimicrobial resistance in *Salmonella* isolates from animals (qualitative data)

### 7.3.1 Fowl (*Gallus gallus*)

#### Resistance levels among *Salmonella*

Tables QSA5 and QSA6 show resistance to the selected antimicrobials among *Salmonella* spp. and *S.* Enteritidis in *Gallus gallus* from the countries reporting qualitative disc diffusion data for this population. In addition to Hungary, Romania and Spain, Cyprus submitted IZD data for three *S.* Enteritidis isolates. No resistance to any of the reported antimicrobials was detected.

***Table QSA5. Reported resistance (%) to ampicillin, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. from* Gallus gallus *in 2010, using qualitative data***

| Country | Ampicillin | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | |
|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res |
| Greece | 60 | 3 | 60 | 2 | 54 | 4 | 60 | 2 |
| Hungary | 199 | 0 | 198 | 0 | 18 | 0 | 199 | 0 |
| Malta | 44 | 23 | 52 | 48 | 52 | 29 | 52 | 77 |
| Romania | 346 | 10 | 347 | 4 | 431 | 9 | 378 | 17 |
| Spain | 40 | 5 | 40 | 0 | 40 | 3 | 40 | 0 |

| Country | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res |
| Greece | 58 | 2 | 60 | 2 | 60 | 5 |
| Hungary | 197 | 0 | 195 | 0 | 198 | 0 |
| Malta | 52 | 0 | 52 | 42 | 52 | 2 |
| Romania | 304 | 58 | 611 | 52 | - | - |
| Spain | 40 | 45 | 40 | 10 | 40 | 15 |

***Table QSA6. Reported resistance (%) to ampicillin, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Enteritidis from* Gallus gallus *in 2010, using qualitative data***

| Country | Ampicillin | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | |
|---|---|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res | N | % Res |
| Hungary | 15 | 0 | 15 | 0 | - | - | 15 | 0 |
| Romania | 32 | 9 | 34 | 3 | 47 | 2 | 38 | 11 |
| Spain | 40 | 5 | 40 | 0 | 40 | 3 | 40 | 0 |

| Country | Nalidixic acid | | Sulfonamides | | Tetracyclines | |
|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res |
| Hungary | 15 | 0 | 15 | 0 | 15 | 0 |
| Romania | 26 | 54 | 73 | 27 | - | - |
| Spain | 40 | 45 | 40 | 10 | 40 | 15 |

### 7.3.2 Pigs

#### Resistance levels among *Salmonella*

In 2010, Hungary and Romania reported qualitative data on antimicrobial resistance among 17 *S.* Typhimurium and 149 *Salmonella* spp. isolates from pigs. In Hungary, no resistance to any of the reported antimicrobials was detected in either *S.* Typhimurium or *Salmonella* spp. isolates.

Romania reported extremely high levels of resistance to nalidixic acid (82 %) among *Salmonella* spp. and to ampicillin (83 %) and sulfonamides (71 %) among *S.* Typhimurium isolates. Among both *S.* Typhimurium and *Salmonella* spp. gentamicin resistance was detected at high levels (40 % and 39 %, respectively). Resistance to sulfonamides in *Salmonella* spp. and to nalidixic acid in *S.* Typhimurium was also detected at high levels (48 % and 20 %, respectively), while resistance to ampicillin among *Salmonella* spp. was detected at a very high level (51 %). Resistance to chloramphenicol and ciprofloxacin was detected at low levels in *Salmonella* spp. (2 % and 1 %, respectively), but no resistance to either antimicrobial was detected among the *S.* Typhimurium isolates analysed.

A monitoring programme in Austria that tested 31 isolates for antimicrobial susceptibility found extremely or very high resistance to sulfonamides (81 %), ampicillin (71 %) and tetracyclines (55 %). Moderate levels of resistance were reported for cefotaxime (10 %) and nalidixic acid (13 %). No or low resistance to ciprofloxacin and gentamicin and chloramphenicol (6 %) was detected.

### 7.3.3 Cattle (bovine animals)

#### Resistance levels among *Salmonella*

Qualitative data on antimicrobial resistance among *Salmonella* spp. isolates in cattle were reported by Hungary in 2010. Between 5 and 24 isolates were tested and no resistance to the panel of antimicrobials analysed in this chapter was detected.

Austria reported information on 43 clinical isolates. Extremely high levels of resistance to streptomycin were reported, and low levels of resistance to ampicillin, chloramphenicol, sulfonamides and tetracyclines. Isolates were fully susceptible to the other antimicrobials of the panel tested (cefotaxime, ciprofloxacin, gentamicin and nalidixic acid).

## 7.4 Discussion

In the framework of this EFSA report, it is difficult to make comparisons between the data collected using disc diffusion techniques and those deriving from dilution methods and collected quantitatively as MIC data. For example, the large difference in the levels of ciprofloxacin and nalidixic acid resistance detected in some animal species in these qualitative results suggests that the ciprofloxacin concentration breakpoint used is rather higher than the ciprofloxacin epidemiological cut-off value applied to the quantitative results. For these reasons and because only a low number of MSs reported qualitative or disc diffusion data, a detailed analysis and interpretation of the results has not been performed.

# 8. METICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS* (MRSA)

## 8.1 Introduction

Meticillin-resistant *Staphylococcus aureus* (MRSA) has been recognised as an important cause of hospital-associated infections in humans for several decades. Treatment of these infections has become an important public health matter owing to the development of resistance to many commonly used antimicrobials. Strains of MRSA have also emerged which are particularly associated with community-acquired infections in humans. Moreover, in recent years, MRSA has also been detected in several animal species, including pigs, pets and other farm animal species. Hospital-associated MRSA and community-associated MRSA are those strains predominantly affecting humans, though livestock-associated MRSA may also be harboured by humans, especially where there is occupational contact with affected livestock.

For instance, it is recognised that pigs are an important source of the MRSA ST398 (MRSA lineage multilocus sequence type 398) strain that has been detected in pig farmers, veterinarians and their families, and that colonisation can arise from direct or indirect contact with pigs. MRSA ST398 has therefore been considered an occupational hazard for humans. This recently recognised strain, which appears to be primarily acquired by occupational exposure, can on occasion be introduced into hospitals. In order to increase awareness and to assess the prevalence of MRSA in pig primary production across the EU, the occurrence and diversity of MRSA and MRSA ST398 in pig holdings in MSs were assessed through a EU-wide baseline survey (EFSA, 2009b, 2010b).

The EFSA's assessment of the public health significance of MRSA in animals and food (EFSA, 2009c) and the Joint scientific report of ECDC, EFSA and EMEA on MRSA in livestock, companion animals and food (EFSA, 2009a) provide more background information and recommendations on MRSA. They notably recommend that monitoring of food-producing animals, in particular intensively reared animals, is carried out periodically, complemented by a systematic surveillance of MRSA in humans so that trends in the spread and evolution of zoonotically acquired MRSA in humans can be identified. In particular, isolate samples representative of various animal and food origins should be analysed for lineage determination, antimicrobial susceptibility and virulence-associated traits.

Molecular typing techniques, such as *spa*-typing and multilocus sequence typing, are commonly used to subtype strains and determine lineages. Using such typing results, often in conjunction with certain other virulence and antimicrobial resistance characteristics, it is possible to subdivide strains of MRSA into groups characterised by differing epidemiology. These techniques are of particular relevance, for instance, in the investigation of outbreaks, such as in the case of hospital-associated MRSA, and of transmission events, for example of livestock-associated MRSA, and in the detection of emergence of strains showing new or multiple resistance patterns.

Livestock-associated MRSAs are the principal focus of this chapter, which summarises the monitoring results of MRSA in various animal species and food reported by MSs to EFSA in 2010 (Table MRSA1). Data on multiple antibiotic resistance of MRSA isolates have been reported by two countries.

***Table MRSA1. Overview of countries reporting data on MRSA in animals and food in 2010***

| Data | Total number of MSs reporting | Countries |
|---|---|---|
| Food | 2 | **MSs:** AT, DE |
| Animals | 7 | **MSs:** DE, ES, FI, HU, IE, NL, SE |
| | | **Non MS:** CH |

## 8.2 Meticillin-resistant *Staphylococcus aureus* – reports from individual MSs

Eleven MSs – Austria (food), Belgium (food), Finland (pigs), Germany (turkeys, veal calves and food), Hungary (*Gallus gallus*, pigs, cattle, turkeys), Ireland (dogs, goats, pigs, sheep, cattle), Italy (*Gallus gallus*, pigs, cattle, sheep, rabbits, goats, pigeons, dogs, cats, alpacas, wild animals, solipeds, water buffalo, ratites and food), Lithuania (food), the Netherlands (dogs, solipeds), Spain (pigs), Sweden (pigs) – and one non-MS, Switzerland (*Gallus gallus*, pigs and cattle), submitted data in relation to the prevalence of *Staphylococcus aureus* in animals and food in their national zoonoses reports for 2010. Among these, a number of countries also provided specific information on MRSA in food, food producing animals, pets and other various domestic animals.

### 8.2.1 Meticillin-resistant *Staphylococcus aureus* in food

In 2010, Austria and Germany were the only MSs reporting information regarding the occurrence of MRSA in food. Austria tested isolates of *S. aureus* while Germany selectively looked for MRSA using enrichment methods.

The results of a representative MRSA monitoring conducted in turkey meat (collected either at the slaughterhouse or at retail) were reported by Germany. Samples were examined using a two-step selective enrichment method, and isolated strains were confirmed as MRSA and *spa*-typed by the national reference laboratory (NRL) using molecular typing methods. Interesting results were reported in turkey carcasses (skin samples) and turkey fresh meat and meat preparation samples, of which 65 % (*n* = 359 carcasses) and 32 % (*n* = 460 meat samples), respectively, tested positive for MRSA. Most confirmed MRSA isolates recovered from carcasses were identified as *spa*-types t011 and t034 assigned to clonal complex CC398, while other isolates belonged to *spa*-types assigned to sequence types ST5 and ST9.

Austria tested a total of 4 447 food samples from different categories (bakery products, beverages, milk and cheeses from different types of milk and other dairy products, cereals and meals, chocolate, cocoa and cocoa preparations, coffee and tea, meat from different animal species, fish, crustaceans and fishery products, fruits and vegetables, juices, infant formula and other food) for coagulase-positive staphylococci. All coagulase-positive staphylococci were subsequently tested for MRSA identification by detecting the *mecA* gene by polymerase chain reaction (PCR). Out of the total samples tested, 169 (3.8 %) yielded coagulase-positive staphylococci, but none of these was MRSA.

### 8.2.2 Meticillin-resistant *Staphylococcus aureus* in animals

Finland, Germany, Hungary, Ireland, Spain, Sweden and Switzerland reported on MRSA prevalence in food-producing animals and/or their immediate breeding environment. The results are summarised in Table MRSA2.

Randomised sampling of fattening pigs at slaughter in abattoirs in several provinces, representing a significant proportion of pigs produced, was performed in Spain. Nasal swabs were taken from one animal per slaughter batch of more than 10 animals or more, with a maximum of 30 batches per slaughterhouse and day of sampling. Chromogenic media (Baird-Parker) were used for isolation of MRSA; suspect isolates were subject to molecular confirmation. Confirmed MRSA isolates were assigned to the CC398, mostly belonging to *spa*-types t011, t108 and t034.

In addition, in Germany, raw milk samples from cows were collected on farm to estimate MRSA prevalence in dairy cow herds. Five per cent of herds of dairy cows (raw milk samples) tested positive for MRSA (*n* = 297), and all MRSA isolates were assigned to CC398.

In 2010, the results of a screening study in pigs conducted in Sweden were reported. In this study, pools of nasal swabs from five pigs at slaughter from the same herd were examined from 191 batches of pigs. MRSA ST398 *spa*-type t011 was isolated in only 1 of 191 samples examined.

In Switzerland, a random sample of 392 fattening pigs, 240 calves and 398 broiler herds was investigated at slaughter using nasal swabs from pigs and calves and cloacal swabs from broilers. The slaughter plants included in the monitoring programme accounted for over 85 % of the total production of pigs, over 80 % of the total production of calves and over 95 % of the total production of broilers in Switzerland. The number of samples to be taken from each plant was determined in proportion to the number of animals slaughtered per year. The suspect samples, which were considered to be MRSA positive following a two-step selective enrichment method and growth on selective chromogenic agar for MRSA, were sent to the NRL for further characterisation. *S. aureus* was identified using Vitek 2 with GP cards (BioMérieux) following the manufacturer recommendations. The MRSA penicillin-binding protein (PBP2a) was detected using the latex agglutination test (Oxoid).

### *Table MRSA2. MRSA in animals, 2010*

| Animal Species/ Country | Production type/description (where specified) | Sample unit | Number of units tested | Number (%) Positive MRSA | *Spa* Types (number of isolates) |
|---|---|---|---|---|---|
| **Poultry** | | | | | |
| Germany | Turkeys, environmental dust | flock | 112 | 22 (20) | Unspecified |
| Hungary | *Gallus gallus* | animals | 154 | 109 (71) | Unspecified |
| | Turkeys | animals | 24 | 11 (46) | Unspecified |
| Switzerland | Broilers, cloacal swabs - 5 pooled swabs per herd | herd | 398 | 0 | not applicable |
| **Pigs** | | | | | |
| Finland | Animal swabs, at farm | holding | 74 | 11 (15) | t108 (5)<br>t127 (5)<br>unspecified (1) |
| Hungary | Unspecified | animals | 14 | 11 (79) | t108 (2) |
| Ireland | Clinical investigations | animals | 327 | 0 | - |
| Spain | Fattening pigs, at slaughter | slaughter batch | 276 | 159 (58) | t011 (121)<br>t108 (17)<br>t034 (3)<br>unspecified (18) |
| Sweden | At slaughter, nasal swabs | slaughter batch | 191 | 1(0.5) | t011 (1) |
| Switzerland | Fattening pigs, at slaughter, nasal swabs | animals | 392 | 23 (6) | ST398:t034 (17)<br>t011 (1)<br>ST49:t208 (5) |
| **Cattle** | | | | | |
| Germany | Veal calves, environmental dust | herd | 296 | 58 (20) | Unspecified |
| | Raw cows milk, at farm | herd | 297 | 14 (5) | Unspecified |
| Hungary | Unspecified | animals | 4,514 | 312 (7) | Unspecified |
| Ireland | Adult, > 2 year-old, clinical investigations | animals | 6,642 | 3 (0.05) | Unspecified |
| Switzerland | Calves < 6 months, nasal swabs | animals | 240 | 5 (2) | t011 (5) |
| **Other animals** | | | | | |
| Hungary | Unspecified | animals | 48 | 31 (65) | Unspecified |
| Ireland | Goats, clinical investigations | animals | 80 | 0 | not applicable |
| | Sheep, clinical investigations | animals | 1,452 | 0 | not applicable |

Data for pets and domestic animals are presented in Table MRSA3. In addition, Sweden reported the isolation of MRSA from four cats, two dogs and five horses in 2010. The isolates from cats and dogs were not ST398 while three out of five equine isolates were *spa*-type t011. In the case of both Ireland and Sweden it was specified that the samples derived from clinical veterinary diagnostic specimens.

***Table MRSA3. MRSA in pets and domestic animals, 2010***

| Animal Species/ Country | Description | Sample unit | Number of units tested | Number (%) Positive MRSA | *Spa* Types |
|---|---|---|---|---|---|
| **Dogs** | | | | | |
| Ireland | Clinical investigations | animals | 308 | 1 (0.3) | unspecified |
| Netherlands | Pet animals | animals | 4,990 | 2 (0.04) | unspecified |
| **Solipeds** | | | | | |
| Netherlands | Domestic | animals | 805 | 32 (4) | unspecified |

### 8.2.3 Susceptibility testing of MRSA isolates

Eleven MRSA isolates from pigs were tested in Finland for antimicrobial susceptibility to tetracyclines, erythromycin, chloramphenicol, enrofloxacin, clindamycin and beta-lactams (oxacillin, penicillin and cefoxitin) using a broth dilution method and Clinical and Laboratory Standards Institute (CLSI) breakpoints. Isolates were resistant to beta-lactams (as expected) and tetracyclines, though susceptible to the other compounds tested.

Five MRSA isolates from calves were tested in Switzerland for antimicrobial susceptibility to tetracyclines, erythromycin, chloramphenicol, ciprofloxacin, trimethoprim, streptomycin, gentamicin, kanamycin, rifampicin, fusidic acid, vancomycin, linezolid, clindamycin, tiamulin, quinupristin/dalfopristin, sulfamethoxazole and beta-lactams (penicillin and cefoxitin) using a broth dilution method and European Committee on Antimicrobial Susceptibility Testing (EUCAST) epidemiological cut-off values (ECOFFs). Isolates were resistant to beta-lactams (as expected), clindamycin, erythromycin and tetracyclines, though susceptible to the other compounds tested, with the exception of single isolates which were resistant to quinupristin/dalfopristin and sulfamethoxazole.

Data from Switzerland also showed that isolates belonging to the most commonly detected genotype, ST398-t034-V, shared an identical resistance profile, except one that was susceptible to streptomycin. They showed resistance to beta-lactams specified by mec(A) and bla(Z), tetracycline [tet(K), tet(M)], macrolide-lincosamide–streptogramin B (MLSB) antibiotics [erm(A)], spectinomycin [ant(9)-Ia], trimethoprim [dfr(G)], and tiamulin.

Among MRSA isolates ($n$ = 23) from pigs in Switzerland, using the same methodology, breakpoints and panel of antimicrobials, resistance was detected to tetracyclines (100 % resistant; $n$ = 23), erythromycin (83 % resistant; $n$ = 19), trimethoprim (74 % resistant; $n$ = 17), streptomycin (74 % resistant; $n$ = 17), clindamycin (91 % resistant; $n$ = 21), tiamulin (96 % resistant; $n$ = 22), quinupristin/dalfopristin (78 % resistant; $n$ = 18), sulfamethoxazole (13 % resistant; $n$ = 3) and confirmed to beta-lactams (penicillin and cefoxitin: 100 % resistant; $n$ = 23).

## 8.3 Discussion

There are currently no EFSA recommendations for sampling and testing for MRSA in livestock or livestock products, apart from those developed for the EU-wide baseline survey of breeding pigs which was performed in 2008 (EFSA, 2009b, 2010b). Therefore, the methods for collecting and testing samples are not harmonised, and as a result MSs may use differing procedures with a concomitant reduction in the comparability of results between MSs. Recently published evidence (see text box in this chapter) will be taken into consideration when drafting technical specifications for the reporting of MRSA.

Seven MSs reported data on MRSA in animals, covering both farm animal species and pets. MRSA was detected in several animal species, including *Gallus gallus* (fowl), turkeys, pigs, cattle, dogs and solipeds. The reported prevalence varied greatly between the investigations, from none to 79 %. However, in many investigations the number of units tested was low, making the results more uncertain. Highest proportions of MRSA-positive animals were reported from *Gallus gallus* and pigs. There seems to be an important variation in the MRSA prevalence between the MSs, since some MSs reported very low prevalence while other MSs detected very high to extremely high prevalence. ST398 was the most often isolated MRSA type, and this type has already been commonly found in pigs in Europe (EFSA, 2009b).

According to BIOHAZ opinion (EFSA, 2009c), persons directly exposed to animals carrying MRSA are likely to be at risk of being colonised by those MRSA strains. However, recent work has shown that in the case of MRSA ST398, which is particularly associated with pigs in some European MSs, although persons in direct contact with affected animals (pigs) are likely to be colonised, transmission to other family members appears to be much less common (Cuny et al., 2009). It has therefore been suggested that person–person transmission of MRSA belonging to CC398 may not be efficient.

Among the 74 pig holdings investigated for MRSA in Finland, 11 (14.8 %) tested positive for MRSA in 2010. The prevalence of MRSA-positive holdings was thus substantially higher than that assessed in the framework of the EU baseline survey performed in 2008, which was 0 % in breeding pig holdings and 0.7 % in production holdings. Switzerland also commented on the changing prevalence of MRSA in pigs. It should, however, be noted that the EU baseline survey conducted in 2008 was based on the collection of environmental dust samples from the breeding holdings, whereas the data reported for 2010 by Finland relate to animal swabs. In Switzerland, the prevalence of MRSA in Swiss slaughter pigs, which in 2009 was assessed at 2.2 %, increased to 5.9 % in 2010, with MRSA recovered from 23 of 392 nasal swabs.

The results from Germany confirm the high prevalence of MRSA in veal calves which has been previously reported by other MSs; Hungary, Ireland (adult cattle) and Switzerland also detected MRSA in bovine animals.

Both Germany and Hungary commonly detected MRSA in turkeys, either live animals or meat. In view of the high prevalence observed, turkeys merit inclusion in future monitoring programmes and when considering potential public health risks of MRSA in the food chain. Considering the isolates from turkey carcasses examined at slaughter from Germany, of those submitted to the NRL and confirmed as harbouring MRSA, most were identified as *spa*-types assigned to CC398 (t011 and t034). However, some isolates were *spa*-types that were assigned to ST5 and ST9. Interestingly, similar *spa*-types were detected in retail turkey meat.

Analysis of the *spa*-types of MRSA reported shows that *spa*-types t011, t034, t108 are all types associated with MRSA ST398, and in most countries, ST398 was the predominant sequence type recorded in pigs, as previously indicated by the EU baseline survey. *spa*-type t127, which was detected in pigs in Finland, is associated with MRSA ST1, which was previously detected in the EU baseline survey of pigs in Italy, Spain and Cyprus.

Switzerland and Finland reported the susceptibility of MRSA isolates, and Switzerland commented that isolates belonging to the most commonly detected *spa*-type (t034) shared an identical resistance profile, with the exception of one isolate, susceptible to streptomycin.

**Detection of *S. aureus* of human and bovine origin carrying a novel *mecA* variant gene**

Meticillin-resistant *Staphylococcus aureus* typically acquires resistance to meticillin (and most other beta-lactam antimicrobials) through possession of the *mecA* gene, which encodes an altered penicillin-binding protein that does not bind most penicillins or cephalosporins. Using this mechanism, the bacterium is able to continue to produce its cell wall in the presence of these compounds. Some strains of *S. aureus* possess an alternative mechanism of resistance, attributable to hyperproduction of the *S. aureus* beta-lactamase enzyme, which hydrolyses the beta-lactam ring of penicillin and cephalosporin compounds, inactivating them (Brown et al., 2005). Recently a novel *mecA* homologue was identified in *S. aureus* isolates from cattle and humans in the United Kingdom and from humans in Denmark, which also confers meticillin resistance. This has been designated $mecA_{LGA251}$ and is approximately 70 % related to the *mecA* gene; the gene $mecA_{LGA251}$ occurs in a previously unidentified genetic element, which has been designated *SCCmec XI* (Garcia-Alvarez et al., 2011). The novel *mecA* homologue has been confirmed in an archived human *S. aureus* isolate from 1975 from Denmark and has also been described in humans in Ireland (Shore et al., 2011) and Germany (Cuny et al., 2011).

Isolates of *S. aureus* carrying the novel *mecA* element are not detected by most methods currently employed to detect 'classical' MRSA. They have been associated with clinical disease in both cattle (mastitis in dairy cows) and humans. *S. aureus* isolates carrying the novel *mecA* homologue identified thus far belong to either clonal complex 130 or sequence type 425 (Garcia-Alvarez et al., 2011; Shore et al., 2011).

The extent to which transfer of these strains may occur between cattle and humans or vice versa is currently unknown. It is also not known whether cattle or humans form the primary host, or the extent to which the populations of bacteria occurring in cattle and humans exist independently of each other. The observation that most previously reported CC130 isolates are from bovine sources has been considered to suggest that CC130 isolates are of bovine origin (Shore et al., 2011).

# 9. THIRD-GENERATION CEPHALOSPORIN RESISTANCE IN *ESCHERICHIA COLI* AND *SALMONELLA*

## 9.1 Introduction

Extended-spectrum beta-lactamases (ESBLs) are considered to be an important emerging issue of public health significance. Bacteria developing ESBL resistance are usually resistant to third-generation cephalosporins, which are critically important antimicrobials for the treatment of systemic or invasive gram-negative infections in humans. These antimicrobials play a critical role in the treatment of certain *Salmonella* infections, particularly in children, in whom the use of fluoroquinolones may not be favoured because of certain potential adverse effects. A low level of resistance may therefore still constitute an important finding. Commensal bacteria, such as indicator *E. coli*, may contribute to the dissemination of ESBL resistance.

*Salmonella* and *E. coli* may develop resistance to third-generation cephalosporins by several different mechanisms. Among these, the most common is the acquisition of beta-lactamase enzymes on plasmids (small covalently closed circles of DNA, which can be transferred between bacteria during bacterial conjugation). There are several different types of beta-lactamase which can confer resistance to third-generation cephalosporins. These are conveniently subdivided into four classes, designated A to D: ESBL enzymes of the TEM, SHV and CTX-M families belong to class A, while class C includes the AmpC beta-lactamases.

No wild-type *Salmonella* isolates possess a beta-lactamase of any class. For beta-lactamases to occur in *Salmonella*, acquisition must have occurred by conjugation, usually with other *Enterobacteriaceae*, and spread on plasmids or other genetic elements. Although all four different classes of beta-lactamase have been described in *Salmonella* globally, within the EU the most important types of beta-lactamase resistance acquired by *Salmonella* are primarily ESBL resistance and, secondly, AmpC resistance. *E. coli* can acquire beta-lactamases from other bacteria, in a similar fashion to *Salmonella*, but it also possesses an endogenous AmpC beta-lactamase, which in some circumstances can be activated, conferring resistance to third-generation cephalosporins.

The EFSA specifications for monitoring resistance in indicator *E. coli* (EFSA, 2008b) state that cefotaxime is a good substrate for what are currently the most common and important ESBLs in humans in Europe, the CTX-M enzymes, and can therefore be used as an indicator for ESBL resistance. Epidemiological cut-off values are given for *Salmonella* and *E. coli* for cefotaxime to facilitate and optimise detection of CTX-M ESBLs, but resistance to cefotaxime may of course be conferred by mechanisms of resistance other than ESBLs, such as certain other types of beta-lactamase, including AmpC beta-lactamases. In this chapter, the occurrence of resistance to cefotaxime and ceftazidime is reported where available. As very few MSs reported data on resistance to ceftiofur, and because this compound is not considered optimal for the detection of ESBL enzymes, results for ceftiofur are not included in this chapter. Furthermore, because this report covers only phenotypic monitoring, it is not possible to determine the class or exact type of beta-lactamase enzyme which is likely to be conferring the resistance detected to third-generation cephalosporins.

The monitoring reported here and performed in accordance with EFSA's technical specifications (EFSA, 2008b) does not utilise selective primary isolation media containing cephalosporins and so the results generally relate to organisms chosen effectively at random from primary culture media. In certain types of monitoring, selective media containing cephalosporins may be used to investigate the presence or absence of cephalosporin-resistant organisms in a particular sample (within the limit of detection) and, in that case, a different type of result would be obtained from such monitoring, which has a greater sensitivity. Ideally, the establishment of optimum phenotypic testing systems for sensitive, specific and rapid detection of ESBLs would be a very important component of antimicrobial resistance monitoring programmes.

## 9.2 Third-generation cephalosporin resistance in *Salmonella* isolates from food and animals

### 9.2.1 Third-generation cephalosporin resistance in *Salmonella* isolates from food

Seven MSs reported resistance to cefotaxime and ceftazidime in *Salmonella* spp. recovered from meat from broilers (Table ESBL1). Overall, in the reporting MSs resistance to third-generation cephalosporins was observed at a low level (4 % for both cefotaxime and ceftazidime). Of the seven reporting MSs, the Czech Republic, Greece and Slovakia reported no resistance to either cefotaxime or ceftazidime while the Netherlands reported the highest occurrence of resistance to both compounds.

***Table ESBL1. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *spp. isolates from meat from broilers tested by Member States in 2010***

| Country | Cefotaxime | | Ceftazidime | |
|---|---|---|---|---|
| | N | % Res | N | % Res |
| Belgium | 182 | 3 | 182 | 3 |
| Czech Republic | 82 | 0 | 82 | 0 |
| Germany | 103 | 3 | 103 | 3 |
| Greece | 17 | 0 | 16 | 0 |
| Ireland | 46 | 2 | 46 | 2 |
| Netherlands | 108 | 11 | 108 | 8 |
| Slovakia | 11 | 0 | 11 | 0 |
| **Total (7 MSs)** | **549** | **4** | **548** | **4** |

The results of testing for third-generation cephalosporin resistance in *Salmonella* spp. isolates recovered from meat from pigs are shown in Table ESBL2. The overall level of resistance to cefotaxime and ceftazidime in all reporting MSs was 0.2 % and 0 %, respectively. Of the 10 MSs that reported the results of testing for cefotaxime resistance in *Salmonella* spp. in meat from pigs, only Ireland reported any resistance among isolates (0.7 %). No resistance to ceftazidime was observed in any of the reporting MSs. In 2009, Belgium reported 4 % cefotaxime resistance and 3 % ceftazidime resistance, while Germany reported 1 % cefotaxime resistance and 0 % ceftazidime resistance.

***Table ESBL2. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *spp. isolates from meat from pigs tested by Member States in 2010***

| Country | Cefotaxime | | Ceftazidime | |
|---|---|---|---|---|
| | N | % Res | N | % Res |
| Belgium | 19 | 0 | 19 | 0 |
| Czech Republic | 29 | 0 | 29 | 0 |
| Denmark | 85 | 0 | - | - |
| Estonia | 22 | 0 | - | - |
| Germany | 150 | 0 | 150 | 0 |
| Greece | 15 | 0 | 13 | 0 |
| Ireland | 138 | 0.7 | 138 | 0 |
| Italy | 18 | 0 | 18 | 0 |
| Netherlands | 15 | 0 | 15 | 0 |
| Portugal | 36 | 0 | - | - |
| **Total (10 and 7 MSs)** | **527** | **0.2** | **382** | **0** |

As shown in Table ESBL3, resistance to cefotaxime in *S.* Typhimurium from meat from pigs was not detected by any of the reporting MSs.

***Table ESBL3. Resistance (%) to cefotaxime in S. Typhimurium isolates from meat from pigs tested by Member States in 2010***

| Country | Cefotaxime | |
|---|---|---|
| | N | % Res |
| Czech Republic | 10 | 0 |
| Denmark | 85 | 0 |
| Germany | 51 | 0 |
| Ireland | 70 | 0 |
| Portugal | 27 | 0 |
| **Total (5 MSs)** | **243** | **0** |

### 9.2.2 Third-generation cephalosporin resistance in *Salmonella* isolates from animals

Resistance to third-generation cephalosporins in *Salmonella* spp. from *Gallus gallus* is shown in Table ESBL4. A low level of resistance to cefotaxime, of 1 %, and to ceftazidime, of 2 %, was reported in *Salmonella* spp. isolates from all reporting MSs. The level of resistance to cefotaxime in *Salmonella* spp. from fowl in Ireland and the Netherlands was 6 % and 5 %, respectively. The figure for the Netherlands represents a decrease from the value of 1 % reported in 2009. Spain detected 26 % resistance to ceftazidime in *Salmonella* spp. in 2009; resistance to neither cefotaxime nor ceftazidime was detected in 2010.

***Table ESBL4. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *spp. isolates from* Gallus gallus *tested by Member States in 2010***

| Country | Cefotaxime | | Ceftazidime | |
|---|---|---|---|---|
| | N | % Res | N | % Res |
| Austria | 192 | 1 | 192 | 1 |
| Cyprus | 12 | 0 | - | - |
| Czech Republic | 375 | 1 | 375 | 0.8 |
| Denmark | 50 | 0 | - | - |
| France | 323 | 0 | - | - |
| Germany | 386 | 2 | 386 | 2 |
| Ireland | 35 | 6 | 35 | 6 |
| Italy | 381 | 3 | 381 | 3 |
| Latvia | 36 | 0 | - | - |
| Netherlands | 193 | 5 | 193 | 4 |
| Poland | 336 | 0.6 | 336 | 0.6 |
| Portugal | 82 | 0 | - | - |
| Slovakia | 86 | 0 | 86 | 0 |
| Slovenia | 29 | 0 | 29 | 0 |
| Spain | 249 | 0 | 248 | 0 |
| Sweden | 15 | 0 | - | - |
| United Kingdom | 282 | 0 | - | - |
| **Total (17 and 10 MSs)** | **3,062** | **1** | **2,261** | **2** |

The occurrence of resistance to cefotaxime and ceftazidime in *S.* Enteritidis isolates from *Gallus gallus* is shown in Table ESBL5. Twelve MSs reported results for cefotaxime and eight MSs reported results for ceftazidime; the overall level of resistance in all reporting MSs was 0.2 % for cefotaxime and 0.3 % for ceftazidime, the Czech Republic being the only MS to report resistance quantitatively. Resistance to third-generation cephalosporin was also detected by Belgium in one *S.* Enteritidis isolate and reported qualitatively.

***Table ESBL5. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *Enteritidis isolates from* Gallus gallus *tested by Member States in 2010***

| Country | Cefotaxime | | Ceftazidime | |
|---|---|---|---|---|
| | N | % Res | N | % Res |
| Austria | 52 | 0 | 52 | 0 |
| Czech Republic | 242 | 0.8 | 242 | 1 |
| France | 36 | 0 | - | - |
| Germany | 179 | 0 | 179 | 0 |
| Italy | 29 | 0 | 29 | 0 |
| Latvia | 35 | 0 | - | - |
| Netherlands | 24 | 0 | 24 | 0 |
| Poland | 230 | 0 | 230 | 0 |
| Portugal | 59 | 0 | - | - |
| Slovakia | 36 | 0 | 36 | 0 |
| Spain | 89 | 0 | 88 | 0 |
| United Kingdom | 23 | 0 | - | - |
| **Total (12 and 8 MSs)** | **1,034** | **0.2** | **880** | **0.3** |

Resistance to cefotaxime and ceftazidime in *S.* Typhimurium isolates from *Gallus gallus* is shown in Table ESBL6. Nine MSs reported results for cefotaxime and four MSs reported results for ceftazidime; the overall level of resistance in all reporting MSs was 0 % for both cefotaxime and ceftazidime, with no MSs reporting resistance.

***Table ESBL6. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *Typhimurium isolates from* Gallus gallus *tested by Member States in 2010***

| Country | Cefotaxime | | Ceftazidime | |
|---|---|---|---|---|
| | N | % Res | N | % Res |
| Austria | 16 | 0 | 16 | 0 |
| Denmark | 11 | 0 | - | - |
| France | 30 | 0 | - | - |
| Germany | 26 | 0 | 26 | 0 |
| Poland | 21 | 0 | 21 | 0 |
| Portugal | 10 | 0 | - | - |
| Spain | 14 | 0 | 14 | 0 |
| Sweden | 12 | 0 | - | - |
| United Kingdom | 13 | 0 | - | - |
| **Total (9 and 4 MSs)** | **153** | **0** | **77** | **0** |

Resistance to cefotaxime and ceftazidime in *Salmonella* spp. isolates from pigs is shown in Table ESBL7. Ten MSs reported results for cefotaxime and seven MSs reported results for ceftazidime; the overall level of resistance in all reporting MSs was 0.8 % for cefotaxime and 1 % for ceftazidime, similar to the figures obtained in 2009. Only one MS reported resistance to third-generation cephalosporins; Germany reported a level of resistance to cefotaxime and ceftazidime of 2 %, which was the same as the figure reported in 2009.

***Table ESBL7. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *spp. isolates from pigs tested by Member States in 2010***

| Country | Cefotaxime | | Ceftazidime | |
|---|---|---|---|---|
| | N | % Res | N | % Res |
| Czech Republic | 13 | 0 | 13 | 0 |
| Denmark | 455 | 0 | - | - |
| Estonia | 19 | 0 | - | - |
| Germany | 489 | 2 | 489 | 2 |
| Ireland | 19 | 0 | 19 | 0 |
| Italy | 37 | 0 | 37 | 0 |
| Netherlands | 96 | 0 | 96 | 0 |
| Slovenia | 34 | 0 | 34 | 0 |
| Spain | 38 | 0 | 21 | 0 |
| Sweden | 14 | 0 | - | - |
| **Total (10 and 7 MSs)** | **1,214** | **0.8** | **709** | **1** |

Resistance to third-generation cephalosporins in *S.* Typhimurium from pigs is shown in Table ESBL8. Five MSs tested *S.* Typhimurium isolates for cefotaxime and/or ceftazidime resistance. The overall level of resistance for all reporting MSs was 0.2 % for cefotaxime and 0 % for ceftazidime. Among reporting MSs, Germany was the only country to report cefotaxime resistance in *S.* Typhimurium, at a level of 0.6 %.

***Table ESBL8. Resistance (%) to cefotaxime and ceftazidime in S. Typhimurium isolates from pigs tested by Member States in 2010***

| Country | Cefotaxime | | Ceftazidime | |
|---|---|---|---|---|
| | N | % Res | N | % Res |
| Denmark | 455 | 0 | - | - |
| Germany | 173 | 0.6 | 173 | 0 |
| Ireland | 15 | 0 | 15 | 0 |
| Slovenia | 11 | 0 | 11 | 0 |
| Spain | 17 | 0 | - | - |
| **Total (5 and 3 MSs)** | **671** | **0.2** | **199** | **0** |

Seven MSs tested *Salmonella* spp. isolates from cattle for third-generation cephalosporin resistance and the results are shown in Table ESBL9. Germany was the only country to report cefotaxime or ceftazidime resistance in *Salmonella* spp. isolates from cattle, which was found at a very low level of 0.5 %, similar to the figure of 0.9 % obtained in 2009.

***Table ESBL9. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *spp. isolates from cattle tested by Member States and non-Member States in 2010***

| Country | Cefotaxime | | Ceftazidime | |
|---|---|---|---|---|
| | N | % Res | N | % Res |
| Denmark | 18 | 0 | - | - |
| Finland | 13 | 0 | - | - |
| Germany | 220 | 0.5 | 220 | 0.5 |
| Ireland | 30 | 0 | 30 | 0 |
| Netherlands | 36 | 0 | 36 | 0 |
| Spain | 30 | 0 | 30 | 0 |
| Sweden | 28 | 0 | - | - |
| **Total (7 and 4 MSs)** | **375** | **0.3** | **316** | **0.3** |
| Switzerland | 34 | 0 | 34 | 0 |

Resistance to cefotaxime and ceftazidime in *Salmonella* Typhimurium isolates from cattle is shown in Table ESBL10. Six MSs reported results for cefotaxime and three MSs reported results for ceftazidime; the overall level of resistance in all reporting MSs was 0.8 % for cefotaxime and 1 % for ceftazidime. Germany was the only MS reporting resistance.

***Table ESBL10. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *Typhimurium isolates from cattle tested by Member States and non-Member States in 2010***

| Country | Cefotaxime | | Ceftazidime | |
|---|---|---|---|---|
| | N | % Res | N | % Res |
| Denmark | 18 | 0 | - | - |
| Finland | 10 | 0 | - | - |
| Germany | 60 | 2 | 60 | 2 |
| Ireland | 18 | 0 | 18 | 0 |
| Netherlands | 14 | 0 | 14 | 0 |
| Sweden | 12 | 0 | - | - |
| **Total (6 and 3 MSs)** | **132** | **0.8** | **92** | **1** |
| Switzerland | 27 | 0 | 27 | 0 |

Third-generation cephalosporin resistance was identified in a range of *Salmonella* serovars in 2010. Reporting MSs do not necessarily list all of the *Salmonella* serovars identified, and so the list of affected serovars is likely to be incomplete. Among the serovars that were identified as resistant to third-generation cephalosporins are the monophasic *Salmonella* 4,12:i:- and 4,5,12:i:-, which were identified in pigs from Germany. In comparison, in 2009, monophasic isolates with third-generation resistance were detected in pigs, *Gallus gallus* and cattle in several MSs. Other third-generation cephalosporin-resistant serovars identified from one or more sources (pigs, *Gallus gallus* and/or cattle) and from one or more MSs included: *S.* Blockley, *S.* Derby, *S.* Enteritidis (PT4b, PT6c and PT8), *S.* Infantis, *S.* Kedougou, *S.* Kentucky, *S.* Livingstone, *S.* London, *S.* Mbandaka, *S.* Java and *S.* Typhimurium. In addition, some isolates from turkeys (*S.* Derby from France and *S.* Kentucky from Poland) expressed resistance to third-generation cephalosporins in 2010.

## 9.3 Third-generation cephalosporin resistance in indicator *E. coli* isolates from food and animals

### 9.3.1 Third-generation cephalosporin resistance in indicator *E. coli* isolates from food

The number of indicator *E. coli* isolates recovered from meat from animals in 2010 and tested by MSs for inclusion in the report was extremely low and so these data did not qualify for the inclusion in this report.

### 9.3.2 Third-generation cephalosporin resistance in indicator *E. coli* isolates from animals

Table ESBL11 summarises data on resistance in indicator *E. coli* isolates from *Gallus gallus* tested by six reporting MSs. All reporting countries tested isolates for cefotaxime resistance and, in addition, three reporting MSs also tested isolates for ceftazidime resistance. Overall, for the reporting MS group, the observed resistance to cefotaxime was 5 % and to ceftazidime was 7 %.

***Table ESBL11. Resistance (%) to cefotaxime and ceftazidime in indicator* E. coli *isolates from* Gallus gallus *tested by Member States and non-Member States in 2010***

| Country | Cefotaxime | | Ceftazidime | |
|---|---|---|---|---|
| | N | % Res | N | % Res |
| Austria | 171 | 0.6 | - | - |
| Denmark | 118 | 0 | - | - |
| France | 201 | 4 | 201 | 3 |
| Germany[1] | 200 | 14 | 200 | 14 |
| Germany[2] | 1,001 | 3 | 1,001 | 3 |
| Netherlands | 284 | 18 | 284 | 18 |
| Sweden | 181 | 1 | - | - |
| **Total (6 and 3 MSs)** | **2,156** | **5** | **1,686** | **7** |
| Switzerland | 183 | 1 | 183 | 1 |

1. Isolates from broilers.

2. Isolates from laying hens.

Denmark did not detect third-generation cephalosporin resistance (cefotaxime) in indicator *E. coli* isolates from *Gallus gallus*, while the level of resistance in Austria, France and Germany (isolates from laying hens) was low, ranging from 0.6 % to 3 %. A moderate level of cefotaxime resistance was noted in the Netherlands (18 %) and in Germany (isolates from broilers, 14 %). France, Germany and the Netherlands also tested isolates for ceftazidime resistance, which was again found to be approximately the same as cefotaxime resistance. This may result from the involvement of particular cefotaximase (CTX-M) enzymes, which can, in some cases, confer resistance to cefotaxime but slightly less so to ceftazidime.

Table ESBL12 shows resistance to cefotaxime and ceftazidime in indicator *E. coli* from pigs. The overall level of resistance for all reporting MSs was 1 % to cefotaxime and 2 % to ceftazidime, with three MSs reporting results for ceftazidime. Finland did not detect cefotaxime resistance while in all other reporting MSs the occurrence of resistance was low or very low, at 0.7 % to 5 %. However, Estonia also tested ceftazidime resistance and found a level that was higher than that for cefotaxime, at 10 %.

***Table ESBL12. Resistance (%) to cefotaxime and ceftazidime in indicator* E. coli *isolates from pigs tested by Member States and non-Member States in 2010***

| Country | Cefotaxime | | Ceftazidime | |
|---|---|---|---|---|
| | N | % Res | N | % Res |
| Austria | 169 | 1 | - | - |
| Denmark | 160 | 1 | - | - |
| Estonia | 40 | 5 | 40 | 10 |
| Finland | 250 | 0 | - | - |
| France | 158 | 3 | 158 | 0.6 |
| Netherlands | 282 | 0.7 | 282 | 0.7 |
| **Total (6 and 3 MSs)** | **1,059** | **1** | **480** | **2** |
| Switzerland | 179 | 0 | 179 | 0 |

The results of examinations for third-generation cephalosporin resistance in indicator *E. coli* from cattle are shown in Table ESBL13. Five MSs tested indicator *E. coli* isolates from cattle for cefotaxime and/or ceftazidime resistance. The overall occurrence of resistance to cefotaxime was 3 % and to ceftazidime was 4 % in all reporting MSs, an increase on the figures of 0.7 % and 2 % reported in 2009. Austria and Denmark did not detect cefotaxime resistance in indicator *E. coli* from cattle, and in the remaining MSs a low or very low level (0.9–2 %) of resistance to both antimicrobials was detected, except in Germany, where all isolates came from veal calves and the occurrence of resistance to cefotaxime and ceftazidime was 10 % and 8%, respectively.

***Table ESBL13. Resistance (%) to cefotaxime and ceftazidime in indicator* E. coli *isolates from cattle tested by Member States and non-Member States in 2010***

| Country | Cefotaxime | | Ceftazidime | |
|---|---|---|---|---|
| | N | % Res | N | % Res |
| Austria | 181 | 0 | - | - |
| Denmark | 106 | 0 | - | - |
| Estonia | 44 | 2 | 44 | 2 |
| Germany[1] | 272 | 10 | 272 | 8 |
| Netherlands | 436 | 1 | 436 | 0.9 |
| **Total (5 and 3 MSs)** | **1,039** | **3** | **752** | **4** |
| Norway | 209 | 0.5 | - | - |
| Switzerland | 184 | 1 | 184 | 1 |

1. All isolates were from veal calves.

## 9.4 Discussion

In 2010, resistance to third-generation cephalosporins was generally detected at only low levels in *Salmonella* and indicator *E. coli* isolates recovered from food and animals. However, low levels of resistance should still be considered important owing to the critical role these antimicrobials play in human medicine. Among reporting MSs overall, the occurrence of resistance to third-generation cephalosporins, as determined by resistance to cefotaxime in *Salmonella* spp. from *Gallus gallus*, pigs and cattle, was 1 %, 0.8 % and 0.3 %, respectively, very similar to the figures of 2 %, 0.7 % and 0.4 %, respectively, obtained in 2009. In *E. coli* the corresponding figures were 5 %, 1 % and 3 %, compared with 9 %, 2 % and 0.7 % obtained in 2009. Among *Salmonella* spp. in broiler and pig meat, the level of resistance was 4 % and 0.2 %, respectively.

A number of factors probably contribute to the observed occurrence of resistance to third-generation cephalosporins in *Salmonella* and indicator *E. coli* isolates. One of the principal factors is likely to have been the use of third-generation cephalosporins in animals; the use of other antimicrobials through the mechanism of genetic linkage and co-selection may also have contributed to the appearance of such resistance. The indicator *E. coli* population in healthy animals may constitute a reservoir of resistance genes which can be transferred to zoonotic organisms such as *Salmonella*, and this process may be particularly enhanced in some circumstances (for example, under selection pressure resulting from antimicrobial usage). Once *Salmonella* isolates have acquired plasmids which carry genes conferring resistance to third-generation cephalosporins (either ESBL or AmpC resistance genes) then dissemination of such resistant *Salmonella* clones will also play a major part in influencing the occurrence of third-generation cephalosporin resistance.

It should be noted, however, that in some cases only low numbers of tested isolates were reported by MSs, thus not enabling firm conclusions on the proportions of resistance to be drawn. There may also be differences between MSs relating to the population of animals sampled; for example, the category *Gallus gallus* may contain different proportions of laying hens and broilers while the cattle category could contain different proportions of veal calves, dairy cattle and beef cattle. Differences in the sample population might, of course, account for some of the differences in the level of resistance observed.

It is noteworthy that among those *Salmonella* serovars reported by MSs as exhibiting third-generation cephalosporin resistance were some isolates of monophasic *Salmonella* serovars 4,12:i:- and 4,5,12:i:-, which are currently increasing in prevalence in Europe. However, only one MS reported resistance in these serovars, and only in pigs, whereas in 2009 monophasic isolates exhibiting third-generation cephalosporin resistance were recorded in pigs, *Gallus gallus* and cattle in several MSs.

There were substantial differences in the levels of resistance in different MSs, suggesting that the potential for movement to higher resistance levels probably exists in a number of MSs. As third-generation cephalosporin resistance can have important potential consequences for public health, the situation requires active and detailed monitoring. In particular, it may be useful in future EU Summary Reports to trace the occurrence of particular serovars of *Salmonella* that have acquired resistance to third-generation cephalosporins. Detailed molecular examination of these *Salmonella* serovars and indicator *E. coli* isolates to determine the resistance mechanism involved would assist in identifying the principal resistances and the main clonal types possessing such resistance. The data presented in Chapter 3 of this report on the occurrence of cefotaxime resistance in *S*. Enteritidis in humans (Table SA2) and *Gallus gallus* (Table SA11) show that resistance to third-generation cephalosporins seems to occur only at low or very low levels. Such resistance appears to be a relatively new and emerging phenomenon in Europe in this serovar.

The description of *Salmonella* serovars showing third-generation cephalosporin resistance in different categories of farm animals or food will be useful in tracing the spread from animals to humans of such *Salmonella* isolates and also in identifying clones of *Salmonella* exhibiting such resistance, which may be increasing in prevalence in MSs. The relation between the level of third-generation cephalosporin resistance in indicator *E. coli* and the occurrence of third-generation cephalosporin resistance in *Salmonella* isolates also needs further investigation. Correlation of results between countries and the evaluation of trends would require further characterisation of the type of third-generation cephalosporin resistance carried by these organisms in order to ensure that comparisons were appropriate and valid.

# 10. FARM-TO-FORK ANALYSIS

## 10.1 Introduction

A number of MSs reported the occurrence of antimicrobial resistance in *Salmonella* and *Campylobacter* in humans, animals and food products derived from those animals in 2010. This chapter collates and summarises the available data, showing the occurrence of resistance which was reported along the food chain and in humans. This is the second year in which this type of analysis has been included in the EU Summary Report on Antimicrobial Resistance. The aim is to highlight potential connections or associations which may exist between resistance occurring in the bacterial isolates from animals, foods derived from those animals and humans. The direct comparison of the figures along the food chain for a MS is likely to simplify the complexity of the inputs which determine the occurrence of resistance observed in human isolates (for example, no account may have been taken of imported foods or infections resulting from foreign travel). Also, because the breakpoints used to assess the resistance of human isolates have not yet been fully harmonised, inter-country comparisons may not always be valid. For this reason, this analysis should perhaps best be viewed as an exploratory investigation, which will hopefully stimulate harmonisation of data reporting.

In addition to differences in the methodology and breakpoints used, direct comparison of the occurrence of resistance in animal food and humans may also be problematic because of some differences in the methods by which isolates have been collected. For example, in the case of food-producing animals, isolates were collected during routine surveillance, random sampling of carcasses at slaughterhouses, or through diagnostic clinical work. In the case of humans, similar considerations apply, relating to whether the isolate has been examined and typed for treatment purposes or as part of antimicrobial resistance surveillance. Ideally, the methodology and breakpoints used for the testing of isolates from humans, food and animals should be standardised and systematic screening of representative strains (i.e. involving a random sample of isolates and an appropriate sample size) undertaken. In relation to isolates from food, a further difficulty in interpreting data is the relative importance of antimicrobial-resistant organisms in imported food in relation to human infection, compared with the contribution of domestically produced food. The relative quantities of imported and domestically produced food may therefore be relevant in relation to human infections for a particular MS. Many of these concerns have previously been addressed in the joint opinion on antimicrobial resistance focused on zoonotic infections, published in November 2009 (EFSA, 2009b). In some circumstances, even though the results obtained for humans, animals and food may not be directly comparable, they may indicate emerging and/or consistent trends between the different types of samples examined. In this chapter, results from humans, animals and food have been included only where representative numbers of isolates are available from each sampling category for each country.

In this section of the report, antimicrobial resistance data from humans, animals and foodstuffs (meat) are described for the following antimicrobial–microorganism combinations:

- **Erythromycin** and **ciprofloxacin** in *C. jejuni* and *C. coli* from humans, poultry (*Gallus gallus*) and from food products derived from poultry, where relevant data are available.

Data for these combinations of antimicrobials from humans, animals and food were available from only a few MSs. Human data are generally qualitative and cannot therefore be re-interpreted using an appropriate revised breakpoint. The majority of MSs reporting human data used Clinical and Laboratory Standards Institute (CLSI) methods and clinical breakpoints and, in order to harmonise the farm-to-fork analysis for the above antimicrobial–microorganism combinations, the quantitative MIC data from animals and food have been re-interpreted using the recent clinical breakpoints defined by CLSI and listed in the tables. Therefore, the levels of resistance reported in this chapter for bacterial isolates from animals and food may differ from those reported in other chapters. This chapter analyses the data using clinical breakpoints, whereas in the other, quantitative, chapters epidemiological cut-off are used for the interpretation of results values. All MSs submitting quantitative data for animals or food for the selected antimicrobial–organism combinations have been included in the tables; the corresponding data for humans from MSs for the relevant categories in animals and/or food has been included wherever these are available. The human, animal and food data in this chapter have therefore been analysed for most MSs after applying CLSI clinical breakpoints; those breakpoints were selected to enable the inclusion of the largest number of available data. For the optimal detection of emerging resistance, analysis using the epidemiological cut-off values would have been preferable.

## 10.2 Breakpoints used for the farm-to-fork analysis

The clinical breakpoints defined by CLSI (*Campylobacter* CLSI document M45-A) were used to re-analyse the quantitative MIC susceptibility data submitted by MSs for bacterial isolates obtained from animals and food for the analysis performed in this chapter. The CLSI clinical breakpoints are shown in Table FFA1.

***Table FFA1. CLSI clinical breakpoints used for the farm-to-fork analysis***

| Organism | Antimicrobial | CLSI MIC Breakpoint in mg/L (R ≥) | EUCAST/EFSA Epidemiological Cut-off Value in mg/L (R >) |
|---|---|---|---|
| *Campylobacter* spp. | Ciprofloxacin | ≥ 4 | > 1 |
| *C. coli* | Erythromycin | ≥ 32 | > 16 |
| *C. jejuni* | Erythromycin | ≥ 32 | > 4 |

Human isolates were tested mainly in accordance with CLSI disc diffusion recommendations. The breakpoints used to interpret human data are listed in Table FFA2 for the MSs that are included in this analysis.

***Table FFA2. Breakpoints (mg/l) used for the analysis of human data for Member States also submitting data for animals or food***

| Member State | *Campylobacter coli* and *Campylobacter jejuni* | |
|---|---|---|
| | Ciprofloxacin | Erythromycin |
| Austria | NS | NS |
| France | NS | NS |
| Netherlands | ≥ 1.0-1.5 | ≥ 1.5-2.0 |
| Slovenia | ≥ 4 | ≥ 32 |

NS = Equivalent breakpoint concentration not stated in disc diffusion method.

## 10.3 *Campylobacter jejuni* and *C. coli*

Erythromycin and ciprofloxacin resistance were analysed in isolates of *C. jejuni* and *C. coli* from humans, animals and from food products derived from poultry, where relevant data were available. The data are shown in Tables FFCA3–5.

***Table FFA3. Resistance (%) to erythromycin in* C. coli *from* Gallus gallus*, food derived from poultry, pigs and humans in 2010, interpreted using CLSI clinical breakpoints for animals and food***

| Country | Erythromycin Resistance (CBP ≥ 32 mg/L) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Humans | | *Gallus gallus* | | Broiler Meat | | Pigs | |
| | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 76 | 4 | 46 | 9(9) | 24 | 0(0) | - | - |
| Belgium | - | - | - | - | 118 | 18(18) | - | - |
| Denmark | - | - | - | - | 20 | 0(0) | 103 | 16(16) |
| Finland | - | - | - | - | - | - | 87 | 0 (0) |
| France | 581 | 14 | 59 | 10(10) | - | - | - | - |
| Hungary | - | - | 41 | 0(0) | - | - | 114 | 15(15) |
| Ireland | - | - | - | - | 70 | 1(1) | - | - |
| Netherlands | 224 | 8 | 21 | 5(5) | 61 | 39(39) | 106 | 26(26) |
| Poland | - | - | - | - | 81 | 0(0) | 22 | 9(9) |
| Spain | - | - | 76 | 34(34) | - | - | 105 | 67(67) |
| **Total MSs*** | **881** | **12** | **243** | **15(15)** | **374** | **12(12)** | **537** | **25(25)** |
| Switzerland | - | - | 19 | 11(11) | - | - | 192 | 7(7) |

*Total MSs represents all MSs contributing to each column in this table.

Note: Figures in parentheses indicate the occurrence of resistance determined using EUCAST epidemiological cut-off values. Table FFA2 shows the breakpoints used for human isolates.

***Table FFA4. Resistance (%) to ciprofloxacin in C. jejuni from Gallus gallus, food derived from poultry, cattle and humans in 2010, interpreted using CLSI clinical breakpoints for animals and food***

| Country | Ciprofloxacin Resistance (CBP ≥ 4 mg/L) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Humans | | *Gallus gallus* | | Broiler Meat | | Cattle | |
| | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 1,120 | 54 | 134 | 56(56) | 16 | 69(69) | 159 | 39(39) |
| Belgium | - | - | - | - | 274 | 42(43) | - | - |
| Denmark | - | - | 41 | 20(20) | 52 | 15(17) | 98 | 20(20) |
| Finland | - | - | 84 | 2(2) | - | - | - | - |
| France | 3,275 | 46 | 49 | 51(51) | - | - | - | - |
| Hungary | - | - | 55 | 84(89) | - | - | - | - |
| Ireland | - | - | - | - | 51 | 28(28) | - | - |
| Netherlands | 2,977 | 52 | 97 | 51(54) | 171 | 56(56) | 101 | 33(33) |
| Poland | - | - | - | - | 46 | 80(83) | - | - |
| Slovenia | 913 | 63 | 30 | 83(83) | 60 | 78(78) | - | - |
| Spain | - | - | 48 | 92(92) | - | - | 88 | 59(59) |
| Sweden | - | - | 100 | 20(21) | - | - | - | - |
| **Total MSs*** | **8,285** | **51** | **638** | **46(47)** | **670** | **49(50)** | **446** | **37(37)** |
| Norway | - | - | | | - | - | 11 | 9(9) |
| Switzerland | - | - | 107 | 29(29) | - | - | 24 | 33(33) |

* Total MSs represents all MSs contributing to each column in this table.

Note: Figures in parentheses indicate the occurrence of resistance determined using EUCAST epidemiological cut-off values. Table FFA2 shows the breakpoints used for human isolates.

***Table FFA5. Resistance (%) to ciprofloxacin in Campylobacter coli from Gallus gallus, food derived from poultry, pigs and humans in 2010, interpreted using CLSI clinical breakpoints for animals and food***

| Country | Ciprofloxacin Resistance (CBP ≥ 4 mg/L) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Humans | | *Gallus gallus* | | Broiler Meat | | Pigs | |
| | N | % Res | N | % Res | N | % Res | N | % Res |
| Austria | 99 | 74 | 46 | 76(80) | 24 | 79(79) | - | - |
| Belgium | - | - | - | - | 118 | 68(69) | - | - |
| Denmark | - | - | - | - | 20 | 0(0) | 103 | 8(8) |
| Finland | - | - | - | - | - | - | 87 | 26(26) |
| France | 581 | 71 | 59 | 66(66) | - | - | - | - |
| Hungary | - | - | 41 | 80(83) | - | - | 113 | 49(52) |
| Ireland | - | - | - | - | 70 | 54(56) | - | - |
| Netherlands | 249 | 53 | 21 | 86(86) | 50 | 100(100) | 106 | 8(8) |
| Poland | - | - | - | - | 81 | 90(90) | 22 | 68(68) |
| Spain | - | - | 76 | 100(100) | - | - | 106 | 95(95) |
| **Total MSs*** | **929** | **67** | **243** | **83(84)** | **363** | **72(72)** | **537** | **39(40)** |
| Switzerland | - | - | 19 | 47(47) | - | - | 192 | 38(38) |

* Total MSs represents all MSs contributing to each column in this table.

Note: Figures in parentheses indicate the occurrence of resistance determined using EUCAST epidemiological cut-off values. Table FFA2 shows the breakpoints used for human isolates.

## 10.4 Resistance data from the Netherlands on verotoxigenic *E. coli* O157

In 2010, the Netherlands voluntarily submitted data on the occurrence of resistance in verotoxigenic *E. coli* (VTEC) isolates from cattle, cattle hides and humans. The results provide a good illustration of how AMR results may be used to investigate possible relationships between bacteria occurring in different epidemiological niches and whether organisms are being shared between those different niches. Use of AMR data in this way provide a means by which potential sources of human infection can be identified or eliminated from investigations.

In this case, the striking similarity in the resistance of isolates from cattle, cattle hides and humans supports the view that cattle, via the food chain, are a likely source of at least some human infections. In combination with other secondary typing methods, AMR data therefore provide a powerful investigatory screening tool and can support (as in this case) or refute current thinking on the likely epidemiology of infection. The figures are broadly similar; however, particular resistances (for example to third-generation cephalsoporins in the human isolates) might assist further tracing in case investigations.

***Table FFA6. Resistance (%) to multiple antimicrobials in verotoxigenic* E. coli *O157 from cattle, cattle hides and humans from the Netherlands in 2010, interpreted using epidemiological cut-off values***

| Antimicrobial | Humans | | Cattle Hides | | Calves < 1 Year | |
|---|---|---|---|---|---|---|
| | N | % Res | N | % Res | N | % Res |
| Chloramphenicol | 58 | 2 | 35 | 6 | 67 | 4 |
| Tetracyclines | 58 | 5 | 35 | 11 | 67 | 15 |
| Ciprofloxacin | 58 | 0 | 35 | 0 | 67 | 0 |
| Nalidixic acid | 58 | 0 | 35 | 0 | 67 | 0 |
| Trimethoprim | 58 | 2 | 35 | 6 | 67 | 6 |
| Streptomycin | 58 | 10 | 35 | 11 | 67 | 12 |
| Gentamicin | 58 | 0 | 35 | 0 | 67 | 0 |
| Ampicillin | 58 | 5 | 35 | 6 | 67 | 7 |
| Cefotaxime | 58 | 2 | 35 | 0 | 67 | 0 |
| Ceftazidime | 58 | 3 | 35 | 0 | 67 | 0 |
| Sulphonamides | 58 | 10 | 35 | 11 | 67 | 16 |

## 10.5 Discussion

This chapter reports the occurrence of resistance observed in isolates of *Campylobacter jejuni, C. coli* and VTEC from humans, animals and food. Results have been included wherever these are available from the reporting MSs, subject to certain criteria relating to minimum numbers of isolates tested. There are numerous gaps in the data available reported by MSs in relation to the reporting of isolates from humans or from the various animal or food categories. In addition, for some of these combinations, data were available for only a small number of isolates. The relative importance of imported foods (for example in relation to pathogen prevalence, occurrence of resistance and relative quantity of food imported) within a given MS for human infections occurring in that MS has not been considered and will play a role in the resistance figures obtained for isolates of *Campylobacter* originating from humans. Likewise, the impact on the results of travel-acquired human infections from other countries where antimicrobial resistance can differ from that in the EU has not been considered as such information is not available for most countries.

The usefulness of reporting quantitative resistance values for isolates from animals and food, in accordance with EFSA's recommendations (EFSA, 2007), is emphasised in that this has enabled the occurrence of resistance to be re-evaluated in accordance with the relevant CLSI breakpoints (which have been used to generate the results for human isolates in many MSs). Some data gaps remain in relation to certain methodological aspects (for example, the methods used to collect some samples may not have been reported), and this will influence the overall degree of harmonisation attained.

Based on the analyses of the data on erythromycin and ciprofloxacin resistance in *Campylobacter* isolates from humans, food and animals, it appears that, at the country level, when resistance is observed in human isolates, resistant isolates are also found in animals and food. In most cases, the levels of resistance observed in human, food and animal isolates are the same as or higher than in animal isolates. These findings indicate a possible association between the occurrence of resistance in *Campylobacter* isolates from human cases and the occurrence of resistance in *Campylobacter* isolates from food and animals. The data on antimicrobial resistance in VTEC isolates from humans and animals provided by one MS reveal similar findings.

This is the second joint analysis of data by ECDC and EFSA in the series of Summary Reports on Antimicrobial Resistance, and as such provided an opportunity to critically evaluate aspects of the data collection and analysis and the degree of harmonisation so far attained between the medical, veterinary and food testing sectors. Though the analysis was limited to a small number of MSs, the results are encouraging, particularly in relation to the collection of quantitative data, which enables much better comparison and interpretation of results according to different breakpoints. However, there is still much room for improvement of the harmonisation attained by reporting MSs procedures to optimise the outputs and their comparability. Further inclusion of harmonised data, particularly from humans is desirable. EFSA and ECDC would also encourage more MSs to provide data to make this analysis more representative for the EU.

# 11. MATERIALS AND METHODS

## 11.1 Antimicrobial susceptibility data from humans available in 2010

Member States (MSs) report results from antimicrobial susceptibility testing (AST) to ECDC through the European Surveillance System (TESSy). The data used in this report were submitted in connection with the annual data collection for the Summary Report of Trends and Sources of Zoonoses and Zoonotic Agents in the EU.

### 11.1.1 Human *Salmonella* data

Nineteen MSs and Iceland provided data for 2010. The antimicrobials reported for *Salmonella* are ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, kanamycin, nalidixic acid, streptomycin, sulfonamides, tetracyclines and trimethoprim. Some countries reported all of these and some only a few. Countries reported qualitative data, i.e. interpreted AST results for tested isolates (susceptible (S), intermediate (I) or resistant (R)), but no minimum inhibitory concentration (MIC) values or zone diameters.

The reference laboratories were asked by e-mail to provide an update on which guidelines were being used for testing and interpretation. It should be noted that the reference laboratories in many countries type only a fraction of the isolates. The remaining isolates are typed by hospital or local laboratories and the methods used by these are often unknown. The guidelines used for the AST method and interpretation differed between countries (Table MM1). Fifteen countries primarily used guidelines from the Clinical and Laboratory Standards Institute (CLSI), where these were available, while two countries used guidelines with generally more sensitive breakpoints (i.e. lower threshold to classify an isolate as resistant) or even epidemiological cut-off values (ECOFFs) from the European Committee on Antimicrobial Susceptibility Testing (EUCAST), which compares the isolates with the wild-type population. For only four of the 12 antimicrobials tested (chloramphenicol, nalidixic acid, sulfonamide and tetracycline) are the CLSI MIC breakpoints and EUCAST ECOFFs equivalent (i.e. classification of resistance expressed as ≥ 32 mg/l in CLSI and as > 16 mg/l in EUCAST guidelines; see Table MM1). In the case of the remaining eight antimicrobials, CLSI MIC breakpoints and ECOFFs are not equivalent, and the results for these antimicrobials must therefore be interpreted with caution.

Results are shown only for countries reporting > 20 isolates for the antimicrobial in question. Trend lines for 2007–2010 are shown for those countries for which data were available for all four years. Countries reporting 0 % resistance during this period are mentioned but are not shown in the table.

### 11.1.2 Human *Campylobacter* data

Thirteen MSs and Iceland provided data for 2010. The antimicrobials reported for *Campylobacter* were amoxicillin, ampicillin, ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracycline. Some countries reported all of these and some only a few. Countries reported the qualitative data, i.e. interpreted AST results for tested isolates (S, I or R), but no MIC values or zone diameters.

National reference laboratories were asked to provide the guidelines used for local testing and interpretation. As for *Salmonella*, the methods and guidelines used for AST in local laboratories are often unknown, but could represent a high proportion of the data submitted to TESSy. Six countries primarily used disc diffusion or E-test® for their routine testing while three countries used dilution. Three countries used both disc diffusion and dilution, depending on the circumstances. The few guidelines that were used by several countries were the CLSI M45-A criteria (covering the three most clinically important antimicrobials) and recommendations from the French Society for Microbiology (CA-SFM).

Results are shown only for countries reporting the results of testing > 20 isolates for the antimicrobial in question. Trend lines for 2008–2010 are shown for those countries for which data were available for all three years. Countries reporting 0 % resistance during this period are mentioned but are not shown in the table.

***Table MM1. Breakpoints used for the interpretation of 2007–2009 susceptibility data on* Salmonella *of human origin, according to a survey performed by Member States on 22–26 November 2010***

| Country | Ampicillin | | Cefotaxime | | Chloramphenicol | | Ciprofloxacin | | Gentamicin | | Kanamycin | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MIC | mm | MIC | mm | MIC | mm | MIC | mm | MIC | mm | MIC | mm | |
| Austria | ≥ 32 | ≤ 13 | ≥ 64 | ≤ 14 | ≥ 32 | ≤ 12 | ≥ 4 | ≤ 15 | ≥ 16 | ≤ 12 | ≥ 64 | ≤ 13 | CLSI M100-S17 and S19. |
| Denmark | > 8 | - | > 0.5 | - | > 16 | - | > 0.06 | - | > 2 | - | > 4 | - | EUCAST ECOFFS. KAN is NEO. |
| Estonia | ≥ 32 | ≤ 13 | ≥ 64 | ≤ 14 | ≥ 32 | ≤ 12 | ≥ 4 | ≤ 15 | ≥ 16 | ≤ 12 | ≥ 64 | ≤ 13 | CLSI |
| France | > 8 | < 16 | > 2 | < 23 | > 8 | < 23 | > 1 | < 22 | > 4 | < 16 | > 16 | < 15 | CA-SFM (www.sfm.fr). |
| Germany | > 8 | - | > 8 | - | na | na | > 2 | - | > 4 | - | > 16 | - | German standard. For NAL CLSI. |
| Hungary | ≥ 32 | ≤ 13 | ≥ 4 | ≤ 22 | ≥ 32 | ≤ 12 | ≥ 4 | ≤ 15 | ≥ 16 | ≤ 12 | ≥ 64 | ≤ 13 | CLSI M100-S20. |
| Ireland | > 8 | - | > 2 | - | > 8 | - | > 1 | - | > 4 | - | ≥ 64 | - | EUCAST (where available, otherwise CLSI). |
| Italy | ≥ 32 | ≤ 13 | ≥ 64 | ≤ 14 | ≥ 32 | ≤ 12 | ≥ 4 | ≤ 15 | ≥ 16 | ≤ 12 | ≥ 64 | ≤ 13 | CLSI |
| Latvia | ≥ 32 | ≤ 13 | ≥ 64 | ≤ 14 | ≥ 32 | ≤ 12 | ≥ 4 | ≤ 15 | ≥ 16 | ≤ 12 | na | na | CLSI |
| Lithuania | ≥ 32 | ≤ 13 | ≥ 64 | ≤ 14 | ≥ 32 | ≤ 12 | ≥ 4 | ≤ 15 | ≥ 16 | ≤ 12 | ≥ 64 | ≤ 13 | CLSI M100-S17-S19. |
| Luxemburg | - | ≤ 13 | - | ≤ 22 | - | ≤ 12 | - | ≤ 15 | - | ≤ 12 | - | ≤ 13 | CLSI M100-S20. |
| Malta | ≥ 32 | - | na | na | na | na | ≥ 4 | - | ≥ 16 | na | na | na | Trimethoprin is Trim/Sulphat. Biomerieux Vitek system. |
| Netherlands | > 4 | - | > 0.5 | - | > 16 | - | > 0.06 | - | > 2 | - | na | - | EUCAST ECOFFS. For Streptomicin EFSA ECOF and for sulfonamides CLSI. |
| Romania | ≥ 32 | ≤ 13 | ≥ 64 | ≤ 14 | ≥ 32 | ≤ 12 | ≥ 4 | ≤ 15 | ≥ 16 | ≤ 12 | ≥ 64 | ≤ 13 | CLSI for disc diffusion and E-test. |
| Slovakia | ≥ 32 | ≤ 13 | ≥ 64 | ≤ 14 | ≥ 32 | ≤ 12 | ≥ 4 | ≤ 15 | ≥ 16 | ≤ 12 | na | na | CLSI M100-S19. For kanamycin and STR 2003 (STR MIC from Sensitrite). |
| Slovenia | - | ≤ 13 | - | ≤ 22 | - | ≤ 12 | - | ≤ 15 | - | ≤ 12 | - | ≤ 13 | CLSI |
| Spain | - | ≤ 13 | - | ≤ 14 | - | ≤ 12 | - | ≤ 15 | - | ≤ 12 | - | ≤ 13 | CLSI M100-S17. |
| United Kingdom | 8 | - | 1 | - | 8 | - | 0.125 | - | 4 | - | 16 | - | HPA methodology based on Frost (1994). |
| Iceland | - | ≤ 13 | na | na | - | ≤ 12 | - | ≤ 15 | na | na | na | na | CLSI for disc diffusion. |

***Table MM1 (continued). Breakpoints used for the interpretation of 2007–2009 susceptibility data on* Salmonella *of human origin, according to a survey performed by Member States on 22–26 November 2010***

| Country | Naladixic acid | | Streptomycin | | Sulfonamides | | Tetracyclines | | Trimethoprim | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MIC | mm | MIC | mm | MIC | mm | MIC | mm | MIC | mm | |
| Austria | ≥ 32 | ≤ 13 | - | ≤ 11 | ≥ 512 | ≤ 12 | ≥ 16 | ≤ 11 | ≥ 16 | ≤ 10 | CLSI M100-S17 and S19. |
| Denmark | > 16 | - | > 16 | - | > 256 | - | > 8 | - | > 2 | - | EUCAST ECOFFS. KAN is NEO. |
| Estonia | ≥ 32 | ≤ 13 | - | ≤ 11 | ≥ 512 | ≤ 12 | ≥ 16 | ≤ 11 | ≥ 16 | ≤ 10 | CLSI |
| France | > 16 | < 15 | - | - | > 256 | < 12 | > 8 | < 17 | > 4 | < 16 | CA-SFM (www.sfm.fr). |
| Germany | > 16 | - | > 16 | - | na | na | na | na | n.d. | - | German standard. For NAL CLSI. |
| Hungary | ≥ 32 | ≤ 13 | - | ≤ 11 | ≥ 512 | ≤ 12 | ≥ 16 | ≤ 11 | ≥ 16 | ≤ 10 | CLSI M100-S20. |
| Ireland | > 16 | - | > 32 | - | ≥ 512 | - | ≥ 16 | - | > 4 | - | EUCAST (where available, otherwise CLSI). |
| Italy | ≥ 32 | ≤ 13 | - | ≤ 11 | ≥ 512 | ≤ 12 | ≥ 16 | ≤ 11 | ≥ 16 | ≤ 10 | CLSI |
| Latvia | na | na | na | na | na | na | na | na | ≥ 16 | ≤ 10 | CLSI |
| Lithuania | ≥ 32 | ≤ 13 | - | ≤ 11 | ≥ 512 | ≤ 12 | ≥ 16 | ≤ 11 | ≥ 16 | ≤ 10 | CLSI M100-S17-S19. |
| Luxemburg | - | ≤ 13 | - | ≤ 11 | - | ≤ 12 | - | ≤ 11 | - | ≤ 10 | CLSI M100-S20. |
| Malta | na | na | na | na | na | na | na | - | ≥ 320 | - | Trimethoprin is Trim/Sulphat. Biomerieux Vitek system. |
| Netherlands | > 16 | - | > 32 | - | na | na | > 8 | - | na | na | EUCAST ECOFFS. For Streptomicin EFSA ECOF and for sulfonamides CLSI. |
| Romania | ≥ 32 | ≤ 13 | - | ≤ 11 | ≥ 512 | ≤ 12 | ≥ 16 | ≤ 11 | ≥ 16 | ≤ 10 | CLSI for disc diffusion and E-test. |
| Slovakia | na | na | ≥ 32 | ≤ 11 | ≥ 512 | ≤ 12 | ≥ 16 | ≤ 14 | na | na | CLSI M100-S19. For kanamycin and STR 2003 (STR MIC from Sensitrite). |
| Slovenia | - | ≤ 13 | - | ≤ 11 | - | ≤ 12 | - | ≤ 11 | - | ≤ 10 | CLSI |
| Spain | - | ≤ 13 | - | ≤ 11 | - | ≤ 12 | - | ≤ 11 | - | - | CLSI M100-S17. |
| United Kingdom | 16 | - | 16 | - | 64 | - | 8 | - | 2 | - | HPA methodology based on Frost (1994). |
| Iceland | - | ≤ 13 | na | na | na | na | na | na | - | ≤ 10 | CLSI for disc diffusion. |

***Table MM2. Breakpoints used for the interpretation of 2007–2009 susceptibility data on Campylobacter of human origin according to a survey performed by Member States on 22 November to 3 December 2010***

| Country | Amoxicillin | | Ampicillin | | Ciprofloxacin | | Erythromycin | | Comment |
|---|---|---|---|---|---|---|---|---|---|
| | MIC | mm | MIC | mm | MIC | mm | MIC | mm | |
| Austria | na | na | na | na | - | ≤ 15 | - | ≤ 13 | National guideline for disc diffusion. |
| Estonia | na | na | na | na | ≥ 4 | ≤ 20 | - | ≤ 19 | SRGA-M for disc diffusion and dilution. CLSI for ciprofloxacin MIC. |
| France | - | - | - | 19 | - | < 22 | - | < 22 | |
| Italy | na | na | - | ≤ 6 | - | ≤ 6 | - | ≤ 6 | CLSI M45-A vol.26 no 19 for ciprofloxacin and erthromycin Local labs adapted same criteria for remaining ab. Disc diffusion. |
| Lithuania | na | na | na | na | - | ≤ 17 | - | ≤ 19 | BSAC for disc diffusion. Local laboratories providing data for some antimicrobials now closed down, so impossible to get information. |
| Luxembourg | na | na | na | na | ≥ 1 | - | ≥ 4 | - | CA-SFM – E-test method. |
| Malta | na | na | na | na | ≥ 1 | - | ≥ 4 | - | E-test (CA-SFM in the 2009 report) |
| Netherlands | na | na | na | na | ≥ 1.0–1.5 | ≤ 19–20 | ≥ 1.5–2.0 | < 13–≤ 23 | Survey in 12 clinical labs in NL. 10 use disc diffusion, 2 dilution. |
| Romania | na | na | na | na | - | - | - | - | No reply. |
| Slovakia | na | na | na | na | ≥ 4 | - | ≥ 32 | - | CLSI for dilution test. |
| Slovenia | - | < 14 | - | < 14 | ≥ 4 | < 22 | ≥ 32 | < 17 | Amoxicillinis amoxicillin+clavulanic acid. CA-SFM 2010 for disc diffusion. CLSI M45-A for ciprofloxacin and erythromycin (dilution for *C. jejuni* in one clin. lab. and E-tests in two clinical labs). |
| United Kingdom | na | na | ≥ 8 | - | ≥ 2 | - | ≥ 4 | - | At HPA, BSAC guidelines adapted to Thwaites and Frost (1999). CLSI for erythromycin modified to same ref. dilution. Unknown breakpoint for AMC since not done at HPA. |
| Iceland | na | na | na | na | ≥ 4 | | ≥ 32 | | No reply 2010-2011. In other survey mention CLSI for E-test. |

***Table MM2 (continued). Breakpoints used for the interpretation of 2007–2009 susceptibility data on* Campylobacter *of human origin according to a survey performed by Member States on 22 November to 3 December 2010***

| Country | Gentamicin | | Nalidixic acid | | Tetracyclines | | Comment |
|---|---|---|---|---|---|---|---|
| | MIC | mm | MIC | mm | MIC | mm | |
| Austria | na | na | - | ≤ 13 | - | ≤ 14 | National guideline for disc diffusion. |
| Estonia | na | na | - | ≤ 19 | - | ≤ 21 | SRGA-M for disc diffusion and dilution. CLSI for ciprofloxacin MIC. |
| France | - | < 16 | - | < 20 | - | < 17 | |
| Italy | - | ≤ 6 | - | ≤ 6 | - | ≤ 6 | CLSI M45-A vol.26 no 19 for ciprofloxacin and erthromycin Local labs adapted same criteria for remaining ab. Disc diffusion. |
| Lithuania | na | na | na | na | na | na | BSAC for disc diffusion. Local laboratories providing data for some antimicrobials now closed down, so impossible to get information. |
| Luxembourg | na | na | > 16 | - | na | na | CA-SFM – E-test method. |
| Malta | na | na | na | na | na | na | E-test (CA-SFM in the 2009 report). |
| Netherlands | na | na | na | na | ≥ 2–8 | ≤ 17–28 | Survey in 12 clinical labs in NL. 10 use disc diffusion, 2 dilution. |
| Romania | - | - | - | - | - | - | No reply. |
| Slovakia | na | na | na | na | ≥ 16 | - | CLSI for dilution test. |
| Slovenia | - | < 16 | - | < 15 | - | < 17 | Amoxicillinis amoxicillin+clavulanic acid. CA-SFM 2010 for disc diffusion. CLSI M45-A for ciprofloxacin and erythromycin (dilution for *C. jejuni* in one clin. lab. and E-tests in two clinical labs). |
| United Kingdom | > 4 | - | > 16 | - | ≥ 8 | - | At HPA, BSAC guidelines adapted to Thwaites and Frost (1999). CLSI for erythromycin modified to same ref. dilution. Unknown breakpoint for AMC since not done at HPA. |
| Iceland | na | na | na | na | na | na | No reply 2010-2011. In other survey mention CLSI for E-test. |

## 11.2 Antimicrobial susceptibility data from animals and food available in 2010

For the year 2010, 26 MSs and two non-MSs reported data on antimicrobial resistance in tested *Salmonella* and *Campylobacter*, commensal *E. coli* and commensal enterococcal or meticillin-resistant *Staphylococcus aureus* isolates from food-producing animals and/or food. Dilution and disc diffusion testing methods were used by reporting countries for susceptibility testing; both quantitative and qualitative data were reported. Quantitative data reported as MIC (measured in mg/l) comprised the number of isolates with a specific MIC value considering the total number of isolates tested, for each antimicrobial agent and in each specific food/animal category. Quantitative data reported as inhibition zone diameters (IZDs, measured in millimetres) comprised the number of isolates with a specific zone diameter of inhibition considering the total number of isolates tested, for each antimicrobial agent and in each food/animal category. Qualitative data were reported as the number of resistant isolates out of the total number of isolates that were tested against each antimicrobial agent, in each food/animal category; qualitative data can be generated either from MIC or from disc diffusion testing. For the purpose of this report, primarily quantitative dilution and disc diffusion data have been considered.

An overview of the MSs and non-MSs reporting antimicrobial resistance data in 2010 is shown in Table MM3.

***Table MM3. Member States and non-Member States reporting data in 2010 and description of data included in the report (no of isolates)***

| Bacteria | Number of MSs and non-MSs reporting quantitative or qualitative data | Data included in the report (no of isolates) | |
|---|---|---|---|
| | | MIC Dilution | Diffusion |
| *Salmonella* | 26 MSs + 2 non-MSs | 93,087 | 15,290 |
| *Campylobacter* | 19 MSs + 2 non-MSs | 36,109 | - |
| Indicator *E. coli* | 13 MSs + 2 non-MSs | 80,033 | 6,584 |
| Indicator *Enterococci* | 8 MSs + 1 non-MS | 42,248 | - |
| Methicillin-resistant *Staphylococcus aureus*[1] | 1 MS + 1 non-MS | 592 | - |

1. In 2010, eight MSs and one non-MS reported data on the occurrence of MRSA.

In this report, quantitative results generated by dilution MIC methods, including those methods recommended by EFSA, are reported and analysed together; quantitative disc diffusion results, which constitute a relatively small fraction of the total data (14 % of the quantitative *Salmonella* data are disc diffusion data), have not been included in the analysis of quantitative data and are described separately in this report. As few countries reported them, and to refine further the reporting of the quantitative dilution data, quantitative disc diffusion data are analysed for *Salmonella* in the qualitative chapter for that organism (see Chapter 7). Data generated from the antimicrobial susceptibility testing and reported as qualitative by MSs are described separately in this report.

The antimicrobial resistance data reported by MSs for *Salmonella*, *Campylobacter*, indicator *E. coli* and enterococcal isolates from *Gallus gallus*, pigs and cattle are presented and analysed in this report. The report also includes data on *Salmonella* from meat from *Gallus gallus,* pigs and cattle. Also, for the first time, data on *Salmonella* from turkeys and turkey meat have been included in the report. For *Campylobacter*, *Gallus gallus,* pigs, cattle, and meat from broilers are included. These comprise the animal and food categories most frequently reported on by most MSs. Data are included only if quantitative MIC data were provided by more than four MSs or disc diffusion data were provided by more than two MSs for the bacterium/animal/food category combination. Data based on fewer than 10 tested isolates per combination and per MS are not included. In order to present a complete overview of the animal populations and food categories in which specific *Salmonella* serovars of public health importance have been recovered, data based on the testing of fewer than 10 isolates and data reported by fewer than four countries have been included.

### 11.2.1 Data reported under Directive 2003/99/EC in 2010

MSs generated data on antimicrobial susceptibility through the testing of bacteria from animal/food samples collected through a number of different national schemes. Often the isolates tested constituted a subsample of the total isolates available at the national reference laboratory (NRL). Isolates may have been collected by different monitoring approaches, either by active monitoring of animals and foods or, in some cases, by passive monitoring based on diagnostic submissions of samples from clinical cases of disease in animals, or from foods sampled as part of investigatory work.

In 2010, MSs reported the results of antimicrobial susceptibility testing of isolates from various animal species and from various food categories. Antimicrobial resistance was measured by MIC determination or, in some cases, by disc diffusion methods. In 2010, 14 % of quantitative *Salmonella* antimicrobial resistance data from animals and/or food included in the report were submitted by reporting MSs as disc diffusion data; for 2009 the figure was 4 %. In the case of *E. coli,* 8 % of quantitative data were obtained by disc diffusion, although these data were not included in the report as they were submitted by only two MSs.

For this report, quantitative data regarding resistance to a number of antimicrobials, determined by the dilution method recommended by EFSA, were analysed using harmonised epidemiological cut-off values, and are reported in separate chapters dedicated to each microorganism. Some MSs reported antimicrobial resistance data as both quantitative and qualitative data; in such cases, only the quantitative data are included in this report.

### 11.2.2 Methods used by reporting Member States

In 2010, quantitative (MIC) results on antimicrobial resistance in *Salmonella* isolates from animals and food were reported by 23 MSs and two non-MSs (Norway and Switzerland). The information collected by these countries was in accordance with EFSA's recommendations (EFSA, 2007); these data are described in Chapter 3. Norway reported results for only small numbers of isolates (fewer than 10); these data have been excluded from the analysis. Cyprus, Hungary, Romania and Spain reported quantitative or qualitative disc diffusion results obtained using CLSI methods and applying CLSI breakpoints. All disc diffusion data are reported in Chapter 7 together with qualitative reported data on *Salmonella*.

In 2010, 15 MSs and two non-MSs (Norway and Switzerland) reported data on antimicrobial resistance in *Campylobacter.* All *Campylobacter* results were reported as MIC values in accordance with EFSA's recommendations (EFSA, 2007). These data are described in Chapter 4.

For indicator (commensal) *E. coli*, a total of 10 MSs and two non-MSs (Norway and Switzerland) reported quantitative dilution (MIC) results from animals or meat derived from those animals; these data are described in Chapter 5. Some countries reported results for only small numbers of isolates (fewer than 10); these data have been excluded from the analysis. Hungary reported quantitative results for indicator *E. coli* isolates, tested according to CLSI recommendations and using the CLSI disc diffusion method.

For indicator enterococci (*E. faecalis* and *E. faecium*), in total seven MSs and one non-MS (Switzerland) reported quantitative MIC data; these are described in Chapter 6. All countries reporting quantitative MIC data used the methods recommended by EFSA (EFSA, 2008b).

In relation to third-generation cephalosporin resistance in *E. coli* and *Salmonella* spp., EFSA's recommendations suggest the use of cefotaxime alone to detect important types of resistance (EFSA, 2007). Most MSs reported results for cefotaxime; some also reported results for ceftazidime. Cefotaxime is likely to detect the presence of most cefotaximases (CTX-M enzymes), which currently appear to be the most prevalent type of extended-spectrum beta-lactamase (ESBL) enzymes found in food-producing animals in the EU. The use of cefotaxime will also detect the presence of AmpC enzymes in *Salmonella* or *E. coli*. Some ESBLs are ceftazidimases rather than cefotaximases (particularly enzymes in the TEM and SHV families of ESBLs). Thus, although testing of both cefotaxime and ceftazidime is optimal for the detection of all ESBLs and AmpC enzymes, EFSA's guidelines recommend testing only cefotaxime to detect all CTX-M enzymes, mainly for reasons of affordability.

Data relating to the occurrence of MRSA were reported by eight MSs and one non-MS (Switzerland). Among these, Finland and Switzerland reported data on multiresistance in MRSA isolates from pigs and cattle. The methods for collecting and testing samples for MRSA are not harmonised between MSs, and as a result MSs may use differing procedures. Owing to the variety of methods employed by MSs, these are explained in detail within Chapter 8 to enable readers to better follow the procedures carried out by individual countries.

There is an important difference between the methods used to isolate *Salmonella*, *Campylobacter, E. coli* and enterococci and that used to isolate MRSA. In the case of the former group of organisms, there is no selective medium used to isolate organisms possessing a particular resistance from primary samples, whereas, for MRSA, antimicrobials are used to selectively isolate only those *Staphylococcus aureus* isolates which are resistant to meticillin. Some MSs may have sampled particular production types of animals (for example laying hens in *Gallus gallus* or veal calves in cattle) and this introduces another source of possible variation which may account for observed differences between MSs.

## 11.3 Antimicrobials for susceptibility testing

The antimicrobials incorporated in this summary analysis were selected based on their relative public health importance and as representatives of different antimicrobial classes, taking into account EFSA's reports and recommendations on the harmonised monitoring and reporting of antimicrobial susceptibility data (EFSA, 2007; EFSA, 2008b).

### 11.3.1 Antimicrobials for susceptibility testing of *Salmonella*

In 2010, MSs used both dilution and disc diffusion methods to test the susceptibility of *Salmonella* isolates from animals and food. Tables MM4 and MM5 show the antimicrobials selected by the different countries for susceptibility testing. Quantitative dilution results allowed MIC distributions to be reported for *Salmonella* for the following antimicrobials: ampicillin, apramycin, cefotaxime, ceftazidime, ceftiofur, chloramphenicol, ciprofloxacin, colistin, florfenicol, gentamicin, kanamycin, nalidixic acid, neomycin, spectinomycin, streptomycin sulfonamide, tetracycline and trimethoprim. For further information on reported MIC distributions and data on the number of resistant isolates, refer to the level 3 tables published on the EFSA website.

Data on *Salmonella* which were reported as disc diffusion data are presented in Chapter 7. Although results may not be directly comparable between MSs, it is anticipated that in most cases procedures will not have changed markedly over time within a country, and therefore comparisons of the proportion of resistance isolates over time in that country may be possible.

***Table MM4. Antimicrobials selected for susceptibility testing of* Salmonella *isolates by Member States and non-Member States reporting quantitative data as MIC distributions, in 2010***

| Country | Ampicillin | Apramycin | Cefotaxime | Ceftazidime | Ceftiofur | Chloramphenicol | Ciprofloxacin | Colistin | Florfenicol | Gentamicin | Kanamycin | Nalidixic acid | Neomycin | Spectinomycin | Streptomycin | Sulfonamides | Tetracyclines | Trimethoprim |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | ● | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Belgium | ● | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Cyprus | ● | | ● | | | ● | ● | | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Czech Republic | ● | | ● | ● | | ● | ● | | | ● | | ● | | | ● | ● | ● | ● |
| Denmark | ● | ● | ● | | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● |
| Estonia | ● | | ● | | | ● | ● | | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Finland | ● | | ● | | | ● | ● | | | ● | | ● | | | ● | ● | ● | ● |
| France | ● | | ● | | | ● | ● | | | ● | | ● | | | ● | ● | ● | ● |
| Germany | ● | | ● | ● | | ● | ● | | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Greece | ● | | ● | ● | ● | ● | ● | | | ● | | ● | | | ● | ● | ● | ● |
| Ireland | ● | | ● | ● | | ● | ● | | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Italy | ● | | ● | ● | | ● | ● | | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Latvia | ● | | ● | | | ● | ● | | ● | ● | | ● | | | ● | ● | ● | ● |
| Netherlands | ● | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Norway | ● | | ● | | | ● | ● | | | ● | | ● | | | ● | ● | ● | ● |
| Poland | ● | | ● | ● | | ● | ● | | ● | ● | | ● | | | ● | ● | ● | ● |
| Portugal | ● | | ● | | | ● | ● | | ● | ● | | ● | | | ● | ● | ● | ● |
| Slovakia | ● | | ● | ● | | ● | ● | | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Slovenia | ● | | ● | ● | | ● | ● | | | ● | | ● | | | ● | ● | ● | ● |
| Spain | ● | | ● | ● | | ● | ● | | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Sweden | ● | | ● | | | ● | ● | | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Switzerland | ● | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | | ● | ● | ● | ● |
| United Kingdom | ● | | ● | | | ● | ● | | | ● | | ● | | | ● | ● | ● | ● |

Note: Sulfonamides may include a variety of substances.

***Table MM5. Antimicrobials selected for susceptibility testing of* Salmonella *isolates by Member States reporting quantitative data as disc inhibition zones, in 2010***

| Country | 3rd generation cephalosporins | Amoxicillin Clavulanic acid | Ampicillin | Cefazolin | Cefepime | Cefotaxime | Ceftazidime | Ceftiofur | Chloramphenicol | Ciprofloxacin | Enrofloxacin | Florfenicol | Gentamicin | Imipenem | Kanamycin | Nalidixic acid | Piperacillin | Streptomycin | Sulfonamides | Tetracyclines | Trimethoprim |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cyprus | | | ● | | | ● | ● | | ● | ● | | ● | ● | | ● | ● | | ● | ● | ● | ● |
| Hungary | | | ● | | | ● | ● | ● | ● | ● | ● | ● | ● | | | ● | | ● | ● | ● | |
| Romania | | | ● | | | ● | ● | | ● | ● | ● | | ● | | ● | ● | | ● | ● | ● | ● |
| Spain | ● | ● | ● | ● | ● | ● | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

Note: Sulfonamides may include a variety of substances.

### 11.3.2 Antimicrobials for susceptibility testing of *Campylobacter*

In 2010, all quantitative *Campylobacter* data were reported as MIC values, generated by dilution methods. Table MM6 shows the antimicrobials selected by the different countries for susceptibility testing.

MIC distributions were obtained for the following antimicrobials: ciprofloxacin, chloramphenicol, erythromycin, gentamicin, nalidixic acid, streptomycin, and tetracyclines. For further information on reported MIC distributions and data on the number of resistant isolates, refer to the level 3 tables published on the EFSA website.

These antimicrobials were selected based on public health relevance and as representatives of different classes of antimicrobial. In this report, antimicrobial resistance is reported separately for *C. jejuni* and *C. coli*. All qualitative information data on antimicrobial resistance in *Campylobacter* were also reported as quantitative data.

***Table MM6. Antimicrobials selected for susceptibility testing of* Campylobacter *isolates by Member States and non-Member States reporting quantitative data as MIC distributions, in 2010***

| Country | Amoxicillin Clavulanic acid | Ampicillin | Chloramphenicol | Ciprofloxacin | Clarithromycin | Colistin | Erythromycin | Gentamicin | Imipenem | Nalidixic acid | Neomycin | Streptomycin | Sulfonamides | Tetracyclines | Tulathromycin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | ● | |
| Belgium | | | ● | ● | | | ● | ● | | ● | | ● | | ● | |
| Denmark | | | ● | ● | | | ● | ● | | ● | | ● | | ● | |
| Estonia | | | | ● | | | ● | ● | | ● | | ● | | ● | |
| Finland | | | | ● | | | ● | ● | | ● | | ● | | ● | |
| France | | | | ● | | | ● | ● | | ● | | ● | | ● | |
| Germany | | | ● | ● | | | ● | ● | | ● | | ● | | ● | |
| Hungary | | | | ● | | | ● | ● | | ● | | | | ● | |
| Ireland | | | ● | ● | | | ● | ● | | ● | | ● | | | |
| Netherlands | | ● | ● | ● | ● | | ● | ● | | ● | ● | ● | ● | ● | ● |
| Norway | | | | ● | | | ● | ● | | ● | | ● | | ● | |
| Poland | | | | ● | | | ● | ● | | ● | ● | ● | ● | ● | |
| Portugal | | ● | | ● | | | ● | ● | | ● | | ● | | ● | |
| Slovenia | | | ● | ● | | | ● | ● | | ● | | ● | | ● | |
| Spain | | | ● | ● | | | ● | ● | | ● | | ● | | ● | |
| Sweden | | | | ● | | | ● | ● | | ● | | ● | | ● | |
| Switzerland | | | ● | ● | | | ● | ● | | ● | | ● | | ● | |

Note: Sulfonamides may include a variety of substances.

### 11.3.3 Antimicrobials for susceptibility testing of *Escherichia coli*

In 2010, both dilution and disc diffusion methods were used to test the susceptibility of *E. coli* isolates from animals and food. Tables MM7 and MM8 show the antimicrobials selected by the different countries for susceptibility testing. In this report, susceptibility data from animal isolates are presented. The number of countries reporting susceptibility data from food isolates was very low, and thus the data described in the text come from only two MSs.

MIC distributions were made for the following antimicrobials: ampicillin, apramycin, cefotaxime, ceftazidime, ceftiofur, chloramphenicol, ciprofloxacin, colistin, florfenicol, gentamicin, kanamycin, nalidixic acid, neomycin, spectinomycin, streptomycin, sulfonamide, tetracycline and trimethoprim. For further information on reported MIC distributions and data on the number of resistant isolates, refer to the level 3 tables published on the EFSA website.

These antimicrobials were selected based on their public health relevance and as representatives of different antimicrobial classes.

***Table MM7. Antimicrobials selected for susceptibility testing of* Escherichia coli *isolates by Member States and non-Member States reporting quantitative data as MIC distributions, in 2010***

| Country | Ampicillin | Apramycin | Cefotaxime | Ceftazidime | Ceftiofur | Chloramphenicol | Ciprofloxacin | Colistin | Florfenicol | Gentamicin | Kanamycin | Nalidixic acid | Neomycin | Spectinomycin | Streptomycin | Sulfonamides | Tetracyclines | Trimethoprim |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | ● | | ● | | | ● | ● | | | ● | | ● | | | ● | ● | ● | ● |
| Denmark | ● | ● | ● | | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● |
| Estonia | ● | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Finland | ● | | ● | | | ● | ● | | ● | ● | ● | ● | | | ● | ● | ● | ● |
| France | ● | | ● | ● | | ● | ● | | ● | ● | | ● | | | ● | ● | ● | ● |
| Germany | ● | | ● | ● | | ● | ● | | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Netherlands | ● | | ● | ● | | ● | ● | | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Norway | ● | | ● | | | ● | | | | ● | | ● | | | ● | ● | ● | ● |
| Sweden | ● | | ● | | | ● | | ● | ● | ● | ● | ● | | | ● | ● | ● | ● |
| Switzerland | ● | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | | ● | ● | ● | ● |

Note: Sulfonamides may include a variety of substances.

***Table MM8. Antimicrobials selected for susceptibility testing of* Escherichia coli *isolates by Member States reporting quantitative data as disc inhibition zones, in 2010***

| Country | Ampicillin | Cefotaxime | Ceftazidime | Ceftiofur | Chloramphenicol | Enrofloxacin | Florfenicol | Gentamicin | Nalidixic acid | Streptomycin | Sulfonamides | Tetracyclines |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hungary | • | • | • | • | • | • | • | • | • | • | • | • |

Note: Sulfonamides may include a variety of substances.

### 11.3.4 Antimicrobials for susceptibility testing of enterococci

In 2010, for enterococci, only susceptibility data obtained by dilution methods were reported by MSs. Table MM9 shows the antimicrobials selected by the different countries for susceptibility testing. Only susceptibility data from animal isolates are presented as very few countries reported susceptibility data for enterococcal isolates from food. Data were available from only two MSs and are described in the text.

For the following antimicrobials, MIC distributions were analysed in detail: tetracycline, chloramphenicol, ampicillin, erythromycin, streptomycin, vancomycin, quinupristin/dalfopristin, avilamycin and linezolid. For further information on reported MIC distributions and data on the number of resistant isolates, refer to the level 3 tables published on the EFSA website.

***Table MM9. Antimicrobials selected for susceptibility testing of isolates of* Enterococcus faecium *and* Enterococcus faecalis*, by Member States and non-Member States reporting quantitative data as MIC distributions, in 2010***

| Country | Amoxicillin Clavulanic acid | Ampicillin | Avilamycin | Bacitracin | Chloramphenicol | Ciprofloxacin | Daptomycin | Erythromycin | Florfenicol | Gentamicin | Kanamycin | Linezolid | Narasin | Neomycin | Nitrofurantoin | Penicillin | Quinupristin Dalfopristin | Salinomycin | Streptomycin | Teicoplanin | Tetracyclines | Tigecycline | Vancomycin | Virginiamycin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | | ● | | | ● | ● | ● | ● | | ● | | ● | | | | | ● | | ● | | ● | | ● | |
| Denmark | | ● | ● | | ● | ● | | ● | | ● | ● | ● | | | | ● | ● | ● | ● | ● | ● | ● | ● | |
| Estonia | | ● | | ● | ● | | | ● | | ● | ● | ● | ● | | | | | | ● | | ● | | ● | ● |
| Finland | | ● | | ● | ● | | | ● | | ● | ● | ● | ● | | | | | | ● | | ● | | ● | ● |
| France | | ● | | | ● | ● | ● | ● | | ● | | ● | | | | | ● | | ● | | ● | ● | ● | |
| Netherlands | | ● | | | ● | ● | | ● | ● | ● | | ● | | | | | ● | ● | ● | | ● | | ● | |
| Sweden | | ● | | ● | ● | | | ● | | ● | ● | ● | ● | | | | | | ● | | ● | | ● | ● |
| Switzerland | ● | ● | | ● | ● | ● | | ● | ● | ● | | ● | | ● | ● | | ● | ● | ● | | ● | | ● | |

### 11.3.5 Antimicrobials for susceptibility testing of MRSA

In 2010, Finland and Switzerland reported data on susceptibility testing of MRSA isolates from cattle and pigs. Table MM10 shows the antimicrobials selected by the two countries. For further information on reported MIC distributions and data on the number of resistant isolates, refer to the level 3 tables published on the EFSA website.

***Table MM10. Antimicrobials selected for susceptibility testing of MRSA isolates by Member States and non-Member States reporting quantitative data as MIC distributions, in 2010***

| Country | Cefoxitin | Chloramphenicol | Ciprofloxacin | Clindamycin | Enrofloxacin | Erythromycin | Fusidic acid | Gentamicin | Kanamycin | Linezolid | Oxacillin | Penicillin | Quinupristin Dalfopristin | Rifampicin | Streptomycin | Sulfamethoxazol | Tetracyclines | Tiamulin | Trimethoprim | Vancomycin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Finland | ● | ● | | ● | ● | ● | | | | | ● | ● | | | | | ● | | | |
| Switzerland | ● | ● | ● | ● | | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● |

## 11.4 Data description and analysis

Methods to interpret describe and analyse antimicrobial resistance data were presented in detail in the 2004–2007 Community Summary Report on Antimicrobial Resistance (EFSA, 2010c). Typically, quantitative data were interpreted using epidemiological cut-off values as presented in Decision 2007/407/EC MIC data (corresponding to those published by EUCAST at the time of publication of the Decision); inhibition zone diameter (IZD) data reported by MSs under Directive 2003/99/EC for the years 2004–2007 were interpreted as described in previous Community Summary Reports. Epidemiological cut-off values for MIC distributions are given in Table MM11. Resistance levels reported for reporting MS groups were calculated as totals – the total number of resistant isolates out of the total number of tested isolates across reporting MSs – and not as the weighted means.

In this report, data on antimicrobial resistance in tested *Salmonella* isolates were aggregated to give a value for *Salmonella* spp. for each country and food/animal category for 2010. In addition, whenever sufficient data had been transmitted by MSs for the different food/animal categories, the most prevalent *Salmonella* serovars, *S.* Enteritidis and *S.* Typhimurium, were also reported separately for each food/animal category. An additional section is included in this year's report to describe the occurrence of antimicrobial resistance among *Salmonella* serovars of public health importance. This includes monophasic *S.* Typhimurium in various animals and meat products thereof, *S.* Java in *Gallus gallus*, *S.* Kentucky in poultry and *S.* Saintpaul in turkeys.

For quantitative MIC data, an isolate was defined as 'resistant' for a selected antimicrobial when its MIC value was above the epidemiological cut-off value as indicated in Table MM11. A more sensitive MIC breakpoint or epidemiological cut-off value (i.e. a lower MIC breakpoint or epidemiological cut-off value) might be expected to result in more isolates being defined as clinically or microbiologically resistant, respectively; the number of isolates affected in this way will, of course, depend on the distribution of MIC results.

Throughout the report, the following definitions apply:

- **level or occurrence of antimicrobial resistance** means the percentage of resistant isolates as a proportion of the isolates tested of that microorganism.
- **MS reporting group** means the MSs that provided data and were included in the relevant table for antimicrobial resistance data for the bacteria/food or animal category/antimicrobial combination.

Terms used to describe the antimicrobial resistance levels are:

- rare: ..... < 0.1 %
- very low: ..... 0.1 % to 1 %
- low: ..... > 1 % to 10 %
- moderate: ..... > 10 % to 20 %
- high: ..... > 20 % to 50 %
- very high: ..... > 50 % to 70 %
- extremely high: ..... > 70 %

These terms are applied to all antimicrobials. However, the significance of a given level of resistance will depend on the particular antimicrobial and its importance in human and veterinary medicine.

MIC distributions are presented as frequency tables, giving the number of isolates tested with a given MIC at each test dilution (mg/l) of the antimicrobial. For each combination of microorganism, antimicrobial and food or animal category tested, a summary figure was calculated giving the number of isolates resistant out of those tested.

Where data met the minimum criteria for inclusion in this report (i.e. more than 10 isolates tested by a MS and more than four MSs reporting results for that antimicrobial, microorganism, food or animal category), temporal trend graphs were generated showing the resistance to different antimicrobials over the period

2005–2010, by plotting the level of resistance for each year of sampling. Only countries that reported data for three or more years in the period 2005–2010 were included.

In order to assess the statistical significance of temporal trends, the proportions of resistance were modelled against time in a logistic regression. Results were provided only if data for five years or more were available to use in the model, and if the likelihood ratio test suggested that the model was meaningful. This analysis was carried out in SAS9.2 using the PROC LOGISTIC function for each country, where temporal trend data were presented in the report. The PROC LOGISTIC function used a logit transform to model proportion of prevalence against year, and provided estimates for both intercepts and slope. Models resulting in a *p*-value of less than 0.05 were considered to be significant.

For ciprofloxacin and nalidixic acid, resistance trends over time were visually explored for *Salmonella*, *Campylobacter*, indicator *E. coli* and enterococci by *trellis* graphs, using the *lattice* package in the R software (http://www.r-project.org). Graphs were created for those countries for which resistance data were available for three or more years, for at least one of the two antimicrobials. MS-specific resistance levels trend graphs use a unique scale and countries are shown in alphabetical order.

MS-specific antimicrobial resistance levels for selected bacteria/food or animal category combinations were plotted in maps for 2010, using ArcGIS 9.3. Where resistance levels were not available for 2010, the 2009 level of resistance was used instead and this is indicated by a footnote to the map. In the maps, resistance levels are presented with colours, reflecting the continuous scale of resistance to the antimicrobial of interest among reporting MSs; thus, there might be some apparent discrepancies between the colours and resistance levels between maps. Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2010. When quantitative 2010 data were not available, 2009 data were used instead. The countries labelled as ‘qualitative data’ therefore include those reporting IZD data, MIC data for fewer than 10 isolates or purely qualitative data (as proportion of resistant isolates).

***Table MM11. Epidemiological cut-off values[1] used to interpret MIC distributions (mg/l) for bacteria from animals and food – the given values define the microbiologically resistant isolates***

| Antimicrobial agent | *Salmonella* | *E. coli* | *E. faecium* | *E. faecalis* | *C. jejuni* | *C. coli* |
|---|---|---|---|---|---|---|
| | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| Ampicillin | > 4 | > 8 | > 4 | > 4 | | |
| Apramycin | > 16 | > 16 | | | | |
| Avilamycin | | | > 16 | > 8 | | |
| Cefotaxime | > 0.5 | > 0.25 | | | | |
| Ceftazidime | > 2 | > 0.5 | | | | |
| Ceftiofur | > 2 | > 1 | | | | |
| Chloramphenicol | > 16 | > 16 | > 32 | > 32 | > 16 | > 16 |
| Ciprofloxacin | > 0.06 | > 0.03 | | | > 1 | > 1 |
| Erythromycin | | | > 4 | > 4 | > 4 | > 16 |
| Florfenicol | > 16 | > 16 | | | | |
| Gentamicin | >2 | >2 | > 32 | > 32 | > 1 | > 2 |
| Linezolid | | | > 4 | > 4 | | |
| Nalidixic acid | > 16 | > 16 | | | > 16 | > 32 |
| Neomycin | > 4 | > 8 | | | | |
| Spectinomycin | | > 64 | | | | |
| Streptomycin | > 32 | > 16 | > 128 | > 512 | > 2 | > 4 |
| Sulfonamide | > 256[1] | > 256[1] | | | | |
| Quinupristin/dalfopristin | | | >1 | | | |
| Tetracycline | > 8 | > 8 | > 2 | > 2 | > 2 | > 2 |
| Trimethoprim | > 2 | >2 | | | | |
| Vancomycin | | | > 4 | > 4 | | |

1. Cut-off values were not defined by EUCAST; instead cut-off values defined by the EU-RL were used.

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# APPENDIX 1.

## List of abbreviations and definitions

| Abbreviation | Definition |
|---|---|
| AHVLA | Animal Health and Veterinary Laboratories Agency |
| AMR | Antimicrobial Resistance |
| AST | Antimicrobial susceptibility testing |
| BIOHAZ | EFSA Panel on Biological Hazards |
| CA-SFM | French Society for Microbiology |
| CBPs | Clinical Breakpoints |
| CIAs | Critically Important Antimicrobials |
| CLSI | Clinical and Laboratory Standards Institute |
| CTX-M | Cefotaximase |
| DNA | Desoxyribonucleic Acid |
| EC | European Commission |
| ECDC | European Centre for Disease Prevention and Control |
| ECOFFS | Epidemiological cut-off values |
| EFSA | European Food Safety Authority |
| EMA | European Medicines Agency |
| ESBLs | Extended spectrum beta-lactamases |
| ETEC | Enterotoxigenic *E. coli* |
| EU | European Union |
| EUCAST | European Committee on Antimicrobial Susceptibility Testing |
| EURL | European Union Reference Laboratory |
| HACCP | Hazard Analysis and Critical Control Point |
| IZD | Inhibition Zone Diameter |
| MIC | Minimum Inhibitory Concentration |
| MLSB | Macrolide-lincosamide-streptogramin B |
| MRSA | Methicillin-resistant *Staphylococcus aureus* |
| MS | Member State |
| NRL | National Reference Laboratory |
| PBP | Penicillin-binding protein |
| PCR | Polymerase Chain Reaction |
| spp. | Species |
| TESSy | The European Surveillance System |
| VLA | Veterinary Laboratories Agency |
| VTEC | Vero(cyto)toxigenic *E. coli* |
| WHO | World Health Organization |

## Member States of the European Union and other reporting countries in 2010

### Member States of the European Union, 2010

| Member State | Country Abbreviations |
|---|---|
| Austria | AT |
| Belgium | BE |
| Bulgaria | BG |
| Cyprus | CY |
| Czech Republic | CZ* |
| Denmark | DK |
| Estonia | EE |
| Finland | FI |
| France | FR |
| Germany | DE |
| Greece | GR |
| Hungary | HU |
| Ireland | IE |
| Italy | IT |
| Latvia | LV |
| Lithuania | LT |
| Luxembourg | LU |
| Malta | MT |
| Netherlands | NL* |
| Poland | PL |
| Portugal | PT |
| Romania | RO |
| Slovakia | SK |
| Slovenia | SI |
| Spain | ES |
| Sweden | SE |
| United Kingdom | UK* |

* In text, referred to as the Czech Republic, the Netherlands and the United Kingdom

### Non-Member States reporting, 2010

| Country | Country Abbreviations |
|---|---|
| Iceland | IS |
| Norway | NO |
| Switzerland | CH |

## Definitions

| Term | Definition and description |
|---|---|
| 'Antimicrobial resistant isolate'. | In the case of quantitative data, an isolate was defined as 'resistant' for a selected antimicrobial when its MIC value (in mg/L) was above the cut-off value or the disk diffusion diameter (in mm) was below the cut-off value. The cut-off values for both MIC are indicated in Table MM10.<br>In the case of qualitative data, an isolate was regarded resistant when the country reported it as resistant using their own cut-off value or break point. |
| 'Level of antimicrobial resistance': | The percentage of resistant isolates from the tested isolates. |
| 'Reporting MS group': | Member States (MSs) that provided data and were included in the relevant table for antimicrobial resistance data for the bacteria -food/animal category- antimicrobial combination. |
| Terms used to describe the antimicrobial resistance levels: | Rare: <0.1 %<br>Very low: 0.1 % to 1 %<br>Low: >1 % to 10 %<br>Moderate: >10 % to 20 %<br>High: >20 % to 50 %<br>Very high: >50 % to 70 %<br>Extremely high: >70 % |

# APPENDIX 2.

## List of institutions contributing to AMR monitoring in animals and food

| Member State | Institution |
|---|---|
| Austria | • Austrian Agency for Health and Food Safety, Graz |
| Belgium | • Veterinary and Agrochemical Research Centre (CODA-CERVA), Uccle<br>• Institute of public Health, Brussels<br>• Federal Agency for the Safety of the Food Chain, Brussels |
| Bulgaria | • National Diagnostic and Research Veterinary Institute, Sofia<br>• Bulgarian Food Safety Agency, Sofia |
| Cyprus | • Veterinary Services, Nicosia<br>• Ministry of Agriculture, Nicosia |
| Czech Republic | • State Veterinary Institute, Prague and Olomouc<br>• State Veterinary Administration of the Czech Republic, Prague |
| Denmark | • National Food Institute, Technical University of Denmark<br>• Danish Veterinary and Food Administration |
| Estonia | • Estonian Veterinary and Food Laboratory, Tartu<br>• Veterinary and Food Board, Tallinn |
| Finland | • EVIRA, Finnish Food Safety Authority, Helsinki |
| France | • Anses, French Agency for Food, Environmental Occupational Health and Safety: Fougères Laboratory, Maisons-Alfort Laboratory, Ploufragan/Plouzané Laboratory<br>• Ministère de l´agriculture, de l'alimentation, de la pêche, de la ruralité et de l'aménagement du terriroire, Direction Générale de l'Alimentation, Paris |
| Germany | • Federal Institute for Risk Assessment (BfR), Berlin |
| Greece | • Veterinary Laboratory, Chalkis<br>• Ministry of Rural Development and Food, Athens |
| Hungary | • Central Agricultural Office, Veterinary Diagnostical Directorate, Budapest<br>• Ministry of Rural Agriculture, Budapest |
| Ireland | • Central Veterinary Research Laboratory, Celbridge<br>• Food Safety Authority of Ireland, Dublin |
| Italy | • Istituto Zooprofilattico Sperimentale delle Regioni Lazio e Toscana, Rome<br>• Ministry of Health, Rome |
| Latvia | • Institute of Food Safety, Animal Health and Enviroment "BIOR", Animal Disease Diagnostic Laboratory, Riga<br>• Food and Veterinary Service of Latvia, Riga |
| Lithuania | • National Food and Veterinary Risk Assessment Institute, Vilnius<br>• State Food and Veterinary Service, Vilnius |
| Luxembourg | • Laboratoire de Médecine Vétérinaire, Luxembourg |
| Malta | • Ministry for Resources and Rural Affairs |

Table continued overleaf.

## List of institutions contributing to AMR monitoring in animals and food (continued)

| Member State | Institution |
|---|---|
| Netherlands | • Central Veterinary Institute, part of Wageningen UR (CVI), Lelystad<br>• National Institute of Public Health and the Environment (RIVM), Bilthoven<br>• Ministry of of Agriculture, Nature and Food Quality<br>• Animal Health Service, Deventer |
| Poland | • National Veterinary Research Institute, Pulawy<br>• General Veterinary Inspectorate, WARSAW |
| Portugal | • Laboratório Nacional de Investigação Veterinária, Lisboa<br>• Direcção Geral de Veterinária, Lisboa |
| Romania | • Institute for Diagnostic and Animal Heath, Bucharest<br>• Institute for Hygiene and Veterinary Public Heath, Bucharest<br>• National Sanitary Veterinary and Food Safety Authority, Bucharest |
| Slovakia | • State Veterinary and Food Institute, Dolny Kubin and Bratislava<br>• State Veterinary and Food Administration of the Slovak Republic |
| Slovenia | • National Veterinary Institute, Veterinary Faculty, Ljubljana<br>• Ministry for Agriculture and Environment, Veterinary Administration, Ljubljana |
| Spain | • Laboratorio Central de Sanidad Animal de Santa Fe, Granada<br>• Laboratorio Central de Veterinaria de Algete, Madrid<br>• VISAVET Health Surveillance Center, Complutense University, Madrid<br>• Ministerio de Agricultura, Alimentación y Medio Ambiente<br>• Agencia Española de Seguridad Alimentaria y Nutrición |
| Sweden | • National Veterinary Institute (SVA), Department of Animal Health and Antimicrobial Strategies, Uppsala<br>• National Food Administration, Uppsala |
| United Kingdom | • Animal Health and Veterinary Laboratories Agency (AHVLA) |

| Other reporting country | Institution |
|---|---|
| Norway | • Norwegian Veterinary Institute |
| Switzerland | • ZOBA - Centre for Zoonoses, Bacterial Animal Diseases and Antimicrobial Resistance - Institute of Veterinary Bacteriology, Vetsuisse Faculty, University of Bern<br>• Swiss Federal Veterinary Office |

# APPENDIX 3

## LEVEL 3 TABLES

Level 3 tables containing information on reported MIC distributions and data on the number of resistant isolates, are available at the following address: http://www.efsa.europa.eu/en/efsajournal/pub/2598.htm