Overview of Antimicrobial Usage and Bacterial Resistance in Selected Human and Animal Pathogens in the UK:2004

A Joint Report from:

Communicable Disease Surveillance Centre Northern Ireland
Department for Environment Food and Rural Affairs
Department of Agriculture and Rural Development, Northern Ireland
Department of Health
Food Standards Agency
Health Protection Agency
Health Protection Scotland
Scottish Agricultural College
Scottish Executive Environment and Rural Affairs Department
Veterinary Laboratories Agency
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FOREWORD

1. Antimicrobials, including antibiotics, are a very important factor in maintaining the health of humans and animals. The development of antimicrobial resistance makes the treatment of some significant diseases of humans and animals more difficult. There is also concern that antimicrobial resistant bacteria in animals may transfer to humans in particular in the food we eat.

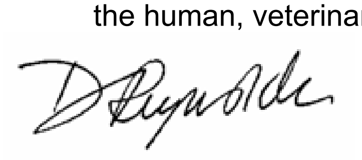
2. Across Government the issue of antimicrobial resistance and the long term maintenance of the efficacy of antimicrobials is taken very seriously. Our policy is, therefore, to support precautionary measures such as appropriate antimicrobial use in all sectors and the banning of antimicrobial growth promoters in animals.

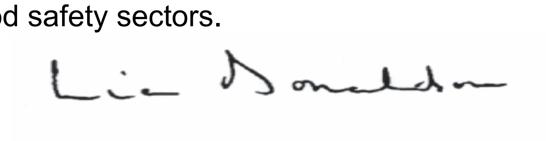
3. For the first time, this new report brings together information on antimicrobial usage and antimicrobial resistance from both humans and animals in the UK into a single document. By presenting these data in this way we hope to help inform the discussion on antimicrobial resistance in both humans and animals.

4. In 1999, the Government's Advisory Committee on the Microbial Safety of Food (ACMSF) produced a report entitled 'Microbial Antibiotic Resistance in Relation to Food Safety' (ACMSF 1999). A key recommendation of this report was that the organisations responsible for monitoring antimicrobial resistance in animals, people and food should work together to produce a report summarising antibiotic resistance in the food chain, in the UK.

5. This report fulfils this recommendation and we hope agencies in the public and animal health fields will find it useful. The Report has been produced through close co-operation between a range of UK Government departments and scientific agencies working in partnership.

6. This Report highlights the important work to monitor the occurrence of antimicrobial resistance that has been going on over many years in the UK. This integrated approach is a key element of modern Government and the work reported here is a good example of collaboration between the human, veterinary and food safety sectors.





Dr Debbie Reynolds
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EXECUTIVE SUMMARY

This is the first joint report in the UK compiled by the various agencies dealing with public health or the health of animals raised for food. It brings together data on antimicrobial consumption, significant pathogens and their antimicrobial susceptibilities across both fields. Readers from either public health or animal health fields may well be familiar with data which relates to their particular interests; but they may not usually be familiar with both.

This is the first such report and although it is not yet a fully harmonised document this is not unexpected as methods of surveillance and analysis and the geographical areas covered differ. However, it is anticipated that future reports will reflect greater integration between the public and animal health sectors as methods and other aspects become more harmonised. The aim of this report is to develop an overview of significant pathogens affecting both animals and humans to help identify where interventions in one field impact on the other, so that appropriate preventive measures can then be taken. Although information on food surveys is included, it is not possible at this stage to give a full picture of potential pathogens in food derived from animals to which the human population may be exposed.

In producing this report we have inevitably come across some difficulties in bringing together data produced originally for different purposes. For instance some information is available from the human side but not the animal side and *vice versa*, different methods of measurement and analysis were used, different reporting periods and different units, different terminology between organisations and different antimicrobials tested for each organism between countries. All of these factors, from the population of humans or animals examined, the bacterial population sampled, to susceptibility methods, mean that caution should be exercised when comparing results obtained from different sources.

The report is prefaced with an introduction, followed by information on the sources of resistance and population data. This is followed by data on antimicrobial consumption, which shows that over half of the total tonnage of antimicrobials used in 2004 was used in animals. Approximately 80% of antimicrobial prescribing in humans was for patients in the community while 87% of antimicrobial use in animals was in food-producing animals. In humans, β-lactams were the most commonly prescribed antimicrobial agents comprising 64% of antimicrobials used in the community and 76% of antimicrobials used in hospitals in England. In contrast, tetracyclines accounted for 54% of total antimicrobial use in animals, while β-lactams accounted for 14%.

Campylobacter

Campylobacter is a common cause of food-poisoning in humans. Following a 3 year surveillance project in England, Wales and Scotland it was shown that

C. jejuni accounted for 90% of infections in humans. This survey also showed that 22-24% of *C. jejuni* and 28-29% of *C. coli* were resistant to ciprofloxacin. In contrast the prevalence of resistance to ciprofloxacin in *C. coli* and *C. jejuni* in cattle, sheep and pigs at slaughter as seen in a statistically based survey was lower than in humans in England, Wales and Scotland. For *C. jejuni*, the prevalence of resistance seen in humans approximates to the prevalence detected in retail chicken. However, a simple comparison of the prevalence of resistance may be misleading, because the role of other factors such as foreign travel and the proportion of home-produced versus imported retail chicken is not taken into account.

Enterococcus faecium

In humans vancomycin resistance was higher in *E. faecium (13-45%)* than in *E. faecalis* (0-7%). This trend was evident from isolates identified to the species level, but a significant proportion of isolates were not identified to species level.

In animals there were only two isolates amongst the 223 strains of *E. faecium* tested from pigs in Great Britain that were resistant to vancomycin and teicoplanin. This resistance indicates a *vanA* phenotype and likely possession of the *vanA* resistance gene. The low number of vancomycin-resistant strains detected in pigs probably reflects the fact that glycopeptides have not been permitted for use in this species for several years in EU countries.

Escherichia coli

In humans *E. coli* is one of the two most important bacterial pathogen causing bacteraemia in the UK. Cephalosporin resistance in *E. coli* from bacteraemia is increasing, probably reflecting the spread of *E. coli* strains producing extended-spectrum ß-lactamase (ESBLs) since 2003. Over half of the *E. coli* bacteraemia isolates were resistant to ampicillin or amoxicillin, and up to 9-19% were resistant to ciprofloxacin.

The prevalence of resistance to fluoroquinolone antimicrobials such as enrofloxacin in veterinary *E. coli* isolates is interesting, because there are differences in the prevalence of resistance between England and Wales, Scotland and Northern Ireland. The methods used for susceptibility testing have not yet been harmonised and this may possibly account for some of the variation.

Escherichia coli O157

The majority of *E. coli* O157 isolates from humans were susceptible to all antimicrobials tested, although resistance to some antimicrobials was occasionally identified. Some human isolates from England and Wales showed resistance to tetracyclines, sulphonamides and streptomycin, though interestingly Scottish isolates were susceptible to sulphonamides, with only low numbers resistant to tetracyclines.

All *E. coli* O157 isolates from sheep were fully susceptible to all of the antimicrobials tested. Tetracycline resistance was the commonest resistance detected in *E. coli* O157 from pigs; streptomycin and sulphonamide resistances were the next most frequently observed. Resistance to tetracyclines, sulphonamides or streptomycin were also the commonest resistances observed in *E. coli* isolates from cattle, though the prevalence of resistance was low.

Listeria monocytogenes

All human and animal isolates of *L. monocytogenes* were susceptible to penicillin and/or ampicillin. Antimicrobial resistance continues to be extremely rare in *L. monocytogenes*.

Mycobacterium tuberculosis and *Mycobacterium bovis*

The prevalence of tuberculosis (TB) in humans is increasing in the UK with disease concentrated among population sub-groups in major urban centres. More than 99% of human TB is accounted for by *M. tuberculosis* and 8.5% of human isolates were resistant to one or more first-line drugs.

In the UK in 2004, bovine TB in cattle was controlled by a programme of statutory testing followed by slaughter of positive animals. Similar rules were applied to farmed deer. It was illegal to treat for the presence of either the bacterium or the disease and so *M. bovis* isolates were not tested for their sensitivity to antimicrobials.

Salmonella

S. Enteritidis is the most common serovar in cases of human infection in England and Wales and Scotland with *S*. Typhimurium the second most common. In Northern Ireland *S*. Typhimurium is the most common serovar. Resistance to more than one drug is common in *S*. Typhimurium. *S.* Enteritidis, particularly phage type 1, commonly has resistance to nalidixic acid.

Salmonella is one of the bacterial organisms that can cause disease in both humans and animals and infected animals can provide a source of infection for humans via the food chain. There can be differences in the prevalence of *Salmonella* in food-produced within the UK and imported food; human infections can also be related to foreign travel or contact with other infected humans. Untreated human sewage can also provide a source of *Salmonella* infection for animals. There was no resistance detected to amikacin, cefotaxime, ceftazidime or ciprofloxacin in *Salmonella* isolates of animal origin from England and Wales. Similarly, no resistance was detected to cefotaxime or ciprofloxacin in animal *Salmonella* isolates from Northern Ireland or Scotland.

Staphylococcus aureus

S. aureus is a common pathogen of humans, being one of the two commonest causes of bacteraemia. Surveillance of *S. aureus* bacteraemia is mandatory in the UK, as a result of the increased incidence of meticillin-resistant *S. aureus* (MRSA) bacteraemia throughout the 1990's. The increased incidence of MRSA bacteraemia now appears to be levelling out at around 40% of all *S. aureus* bacteraemia. There were no reports of vancomycin or teicoplanin resistance in 2004.

Isolates of *S. aureus* from clinical disease in animals remain relatively less resistant to antimicrobials than their human counterparts. For example, the majority (more than 50%) of *S. aureus* isolates from England, Wales and Northern Ireland were susceptible to penicillin and / or ampicillin.

INTRODUCTION

This is the first joint report in the UK between the various agencies dealing with public health and food-producing animal health. It brings together data on antimicrobial consumption, significant pathogens and their antimicrobial susceptibilities across both fields. It includes data that might be familiar to readers in one or other field, but the data will not usually be familiar to both.

This is the first step in creating a joint report and so cannot yet be a fully harmonised document. As might be expected, methodologies and the geographical areas covered differ, but it is anticipated that future reports will be able to integrate the approach on the public and animal health further. The aim of this report is to develop the overview of significant pathogens affecting both animals and humans to identify where interventions in one field impact on the other, so that appropriate preventive measures can then be taken. Although information on food surveys is included, it is not possible at this stage to give a full picture of potential pathogens in food derived from animals to which the human population may be exposed.

This Report summarises the antimicrobial resistance data collected in 2004 (or for the most recent previous year if there are no 2004 data) for a range of bacterial organisms of medical and veterinary importance in the UK. This information has been collated from different sources including surveys of healthy people, animals and food, as well as the results of tests performed on medical or veterinary clinical diagnostic samples, which will mostly have been obtained from people or animals who were ill. Bringing together data from different sources has benefits, but there are also caveats which need to be recognised. The particular group of humans or animals that have been sampled and the method of sampling may also have influenced the final results. Consequently caution should be exercised when comparing results obtained from different sources. As far as possible, information that is relevant to these sorts of considerations has been included in the report.

BACKGROUND

Concern about increasing antimicrobial resistance in various pathogens has been growing over recent years. This has been reflected in the publication of numerous reports on the topic, with recommendations on further action to control antimicrobial use and monitor resistance. In 1999, the Government's Advisory Committee on the Microbial Safety of Food (ACMSF) produced a report entitled 'Microbial Antibiotic Resistance in Relation to Food Safety' (ACMSF 1999). A key recommendation of this report was that the organisations responsible for monitoring antimicrobial resistance in animals, people and food should work together to produce a report summarising antibiotic resistance in the food chain, in the UK. In addition, the 1998 Report by the House of Lords Select Committee (HoLSC) on Science and

Technology on Resistance to Antibiotics and Other Antimicrobial Agents, recommended that a multi-disciplinary Government committee to oversee all aspects of antimicrobial use should be set up. Development of this report works towards achieving the recommendation as above. This report has been produced through close co-operation between a range of UK Government departments and independent scientific organisations working in partnership. This approach is a key theme of the Government's Animal Health and Welfare Strategy for Great Britain, launched in 2004. The Specialist Advisory Committee on Antimicrobial Resistance (SACAR) (www.advisorybodies.doh.gov.uk/sacar/) and Defra Antimicrobial Resistance Coordination (DARC) Group (www.vmd.gov.uk under the General Infor/DARC Group tabs) have been supportive of the initiative to produce this publication and have monitored its progress.

Much work has been done in the UK over many years to address antimicrobial resistance in both humans and animals. For the purposes of this report antimicrobials include antibiotics but do not include disinfectants, preservatives and other substances (see definition in the Glossary at Annex 3). This report brings together information from a number of sources (some already published) into a single publication. The aims of summarising these data into a single report are to:

- Provide an overview of antimicrobial resistance in selected human and animal pathogens across the UK to strengthen future policy development;
- Summarise antimicrobial usage for both humans and animals;
- Reveal any geographical variation of these parameters between England, Wales, Scotland and Northern Ireland;
- Highlight trends and emerging issues that will provide information to aid optimal use of antimicrobials;
- Identify areas for further harmonisation of approaches that could be beneficial; and
- Highlight the different ways in which data are collected to lead towards a more harmonised approach across the UK.

CAVEATS TO THE REPORT

As mentioned in the Executive Summary to this report, in producing this report we have inevitably come across some difficulties in bringing together data produced originally for different purposes. For instance some information is available from the human side but not the animal side and *vice versa*, different methods of measurement and analysis were used, different reporting periods and different units, different terminology between organisations and different antimicrobials tested for each organism between countries. All of these factors, from the population of humans or animals examined, the bacterial population sampled, to susceptibility methods, mean that caution should be exercised when comparing results obtained from different sources.

WHAT THE REPORT DOES

This report takes existing top-level information from published reports and unpublished data of antimicrobial resistance in the UK for analyses of trends.

WHAT THE REPORT DOES NOT DO

This report does not attempt to replace the current practice of publishing full reports of antimicrobial resistance surveillance work and antimicrobial use by the individual agencies contributing to this report. The previously published detailed reports provide the information that forms the basis of this report and each of the fuller reports is crossed referenced so that more detailed information can be obtained if required.

COMMENTS PLEASE

We would very much welcome comments from readers about the value of this report and, in particular, any ways in which the report could be improved. Please forward your comments to Dr. Kay Goodyear at the VMD:

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SOURCES OF DATA

RESISTANCE DATA

Humans

England and Wales

Hospitals in England and Wales have submitted, on a voluntary basis, reports of clinically significant infections to the Health Protection Agency (HPA), and before that, to the Public Health Laboratory Service (PHLS) over many years. Most hospital-based laboratories participate in this surveillance. More recently, submission of data on some infections has become mandatory, for instance for *Staphylococcus aureus* and glycopeptide-resistant enterococcal bacteraemias and *Clostridium difficile* disease. The collection of information from hospital reports of infections and from samples referred to Reference Laboratories is the basis of surveillance in England, Wales and Northern Ireland. In addition to this, sometimes enhanced surveillance systems have been established to gather additional information on cases of infections, as for tuberculosis (TB). These data are collated nationally by the HPA Centre for Infection (CfI). Hospital laboratories are required to participate in the National External Quality Assurance Scheme (NEQAS) as part of accreditation. Information is also gathered on samples submitted to the HPA's Reference Laboratories. These may be submitted for identification purposes, for susceptibility testing or for further microbiological investigations, such as typing of strains in an outbreak. The bulk of information on salmonella infections comes from the relevant Reference Laboratory, the HPA Laboratory of Enteric Pathogens, as the great majority of isolates from cases of human infection are referred to this laboratory for confirmation of identity and typing.

Data on TB were obtained from the Mycobacterial Surveillance Network (MycobNet), established in 1994 to monitor drug resistance trends in newly diagnosed bacteriologically confirmed cases of TB. This system collects data from a network of collaborating centres in England and Wales. Drug susceptibility data on new cases are supplemented with demographic and clinical information from the Enhanced TB Surveillance (ETS) data set at national level, through a computerised matching process based on patient identifiers common to both systems. For the purposes of this report, the proportion of resistance was calculated among initial isolates with known drug susceptibility testing results reported from MycobNet. Further data including drug susceptibility among reported cases is available in the ETS report for 2003 (Anon 2005c).

Lastly, special studies may be undertaken to monitor the situation in particular pathogens, as in the survey of *Campylobacter* infections undertaken between 2000 and 2003.

Scotland

All human-disease surveillance data in Scotland are based on voluntary laboratory reporting to Health Protection Scotland (HPS). The relevant reference laboratory carried out laboratory identification and characterisation. Resistance data on *Salmonella* (human and animal) and TB (human) are held at HPS and are obtained from the *Salmonella* and Mycobacterial Reference Laboratories. Resistance data on meticillin-resistant *S. aureus* (MRSA) are held at the Scottish MRSA Reference Laboratory.

Resistance data on *E. coli* O157 are held at the Scottish *E. coli* O157 Reference Laboratory.

Resistance data on *S. aureus* (bacteraemia isolates) are held at HPS and are obtained through the European Antimicrobial Resistance Surveillance System (EARSS). (http://www.rivm.nl/earss).

Northern Ireland

Human communicable disease data including antimicrobial susceptibilities are based on voluntary reporting to the Communicable Disease Surveillance Centre (Northern Ireland) (CDSC(NI)), part of the HPA. These data are then forwarded to CfI.

As in other parts of the UK there is mandatory Trust reporting of *S. aureus* bacteraemia and *C. difficile*. Both surveillance programmes are managed by CDSC(NI). A pilot study with the HPA anaerobe reference laboratory to type a subset of *C. difficile* cultures is underway.

Recruitment to EARSS continues with currently seven of the ten hospital bacteriology laboratories submitting data via CDSC(NI) to EARSS.

The Northern Ireland Mycobacterial Reference Laboratory is a contributor to MycobNet.

Animals

England and Wales

The Veterinary Laboratories Agency (VLA), as part of its surveillance role for zoonotic and other diseases in animals, monitors antimicrobial resistance in many bacteria of veterinary or public health importance. The VLA surveillance programme for antimicrobial resistance in bacteria can be divided into three broad areas, providing different and complementary information on antimicrobial resistance in farm animals:

- Surveillance for antimicrobial resistance in bacteria recovered from animals after slaughter for human consumption. This surveillance is statistically-based (i.e. has been performed on a statistical sample of the animal population under consideration), covers the whole of Great Britain and has involved surveys of pigs, cattle and sheep in 1999/

2000, which were repeated in 2003 (summary data are available at http://www.defra.gov.uk/animalh/diseases/zoonoses/abattoir-survey.htm) The surveillance methods used in these studies are described in detail in the paper by Davies *et al*. published in 2004.

- The VLA *Salmonella* surveillance programme covers England and Wales and captures data from *Salmonella* incidents reported under statute (the Zoonoses Order 1989). A new incident of *Salmonella* is defined as the first occurrence of a given serotype (or phage type) of *Salmonella* at a premises during a three-month period. Only the first *Salmonella* isolate from each new incident is subjected to susceptibility testing and this avoids bias that might occur in relation to the intensity of sampling at a given location, if all isolates were tested. All *Salmonella* isolates from new incidents of *Salmonella* infection in farm animals are examined for their antimicrobial susceptibility. Results are published annually (Anon 2004).
- Surveillance of clinical veterinary diagnostic samples. Data have been collected and published since 1998 from all of the sensitivity tests that are performed on veterinary clinical diagnostic samples at a network of fourteen VLA regional laboratories situated throughout England and Wales. The VLA Regional Laboratories mainly deal with samples and specimens from food-producing animals but other animals may be examined on occasion, particularly if there are zoonotic aspects to a particular incident. Results are available at http://www.defra.gov.uk/animalh/diseases/zoonoses/reports.htm

Internal and external auditing procedures are in place at VLA to manage quality standards to ISO900:2000. VLA is implementing a strategy and action plan to develop and maintain quality assurance in all Departments through third party certification to ISO900:2000; this is the minimum standard which is to be achieved by 2006. The disc diffusion susceptibility tests performed at VLA laboratories to determine the antimicrobial susceptibility of veterinary micro-organisms are accredited by the United Kingdom Accreditation Service (UKAS).

Scotland

The Scottish Agricultural College (SAC) receives financial support from the Scottish Executive Environment and Rural Affairs Department (SEERAD) to provide a network of eight Disease Surveillance Centres (DSCs) across Scotland. This network provides a veterinary investigation service for veterinary practitioners analogous to that provided by the VLA Regional Laboratories in England and Wales. SAC DSCs receive submissions from veterinary surgeons in practice principally for animal disease diagnosis and investigation. The antimicrobial sensitivity results are derived from the routine samples received by all eight DSCs.

Aerobic bacterial isolates recovered during the course of the DSC's laboratory work are a reflection of those occurring in cases of clinical disease and of the material submitted through this scanning surveillance system. The results have been extracted from the more comprehensive report "SAC Antimicrobial

Sensitivity Report 2000 to 2004" (Anon, 2005b). In the case of animal *Salmonella* isolates, these are sent to the Scottish *Salmonella* Reference Laboratory (SSRL) for confirmation, typing and antimicrobial resistance testing. The methods for animal salmonellae is thus identical to that used for human *Salmonella* isolates (see previously).

The antimicrobial resistance results for the bacterial isolates are recorded at each DSC in the SAC Laboratory Information Management System (LIMS). The SAC antimicrobial resistance results and sample details recorded in LIMS were exported from the eight DSC data sets to allow collation and interrogation.

The overall laboratory operations of the DSCs within SAC Veterinary Services Group organised to comply with the requirements of ISO17025:2005 and UKAS. The disc diffusion antimicrobial susceptibility tests are carried out according to Standard Operating Procedures (SOPs) and are subject to internal and external audit.

Northern Ireland

Data on antimicrobial resistance for animal isolates in Northern Ireland are derived from the animal disease surveillance activities undertaken by the Veterinary Sciences Division (VSD) of the Department of Agriculture and Rural Development (DARD). These surveillance activities include statutory and other monitoring programmes, as well as a veterinary investigation service. VSD has two diagnostic laboratories, which receive samples from private veterinary practitioners and provide a service comparable to that of the VLA Regional Laboratories in England and Wales, and the SAC DSCs in Scotland.

Similarly to the rest of the UK, the information presented in this report is derived from a combination of complementary surveillance activities covering statutory and industry *Salmonella* monitoring programmes, clinical diagnostic submissions and the most recent data available from abattoir surveys.

Antimicrobial resistance tests in relation to *Salmonella* are carried out in accordance with Clinical and Laboratory Standards Institute (CLSI) requirements and operate to a standard equivalent to ISO17025:2005. Other antimicrobial resistance tests are carried out in accordance with in-house SOP’s. Results of antimicrobial sensitivity testing in both disease surveillance laboratories are recorded on a LIMS, from which the data in this report have been collated.

POPULATION DATA

Humans

Table 1 shows the Office of National Statistics (ONS) mid-year population estimate for the UK. Further details on the collection of census data and production of population estimates for England and Wales are available at www.statistics.gov.uk/. The Scottish data are taken from the General Register Office for Scotland and further details on these data can be found at www.gro-scotland.gov.uk/index.html. Northern Ireland data are taken from the Northern Ireland Statistics and Research Agency. Further details on these data can be obtained from www.nisra.gov.uk/.

Animals

Food animal population data were taken from Defra's June census (www.defa.gov.uk/), see Table 1. Non-food-producing animal data were provided by the Pet Food Manufacturers Association (PFMA) and the Agricultural Census Division of Defra, see Table 2. Further information about numbers of non food-producing animals in the UK can be found at www.pfma.com/public/welcome.htm.

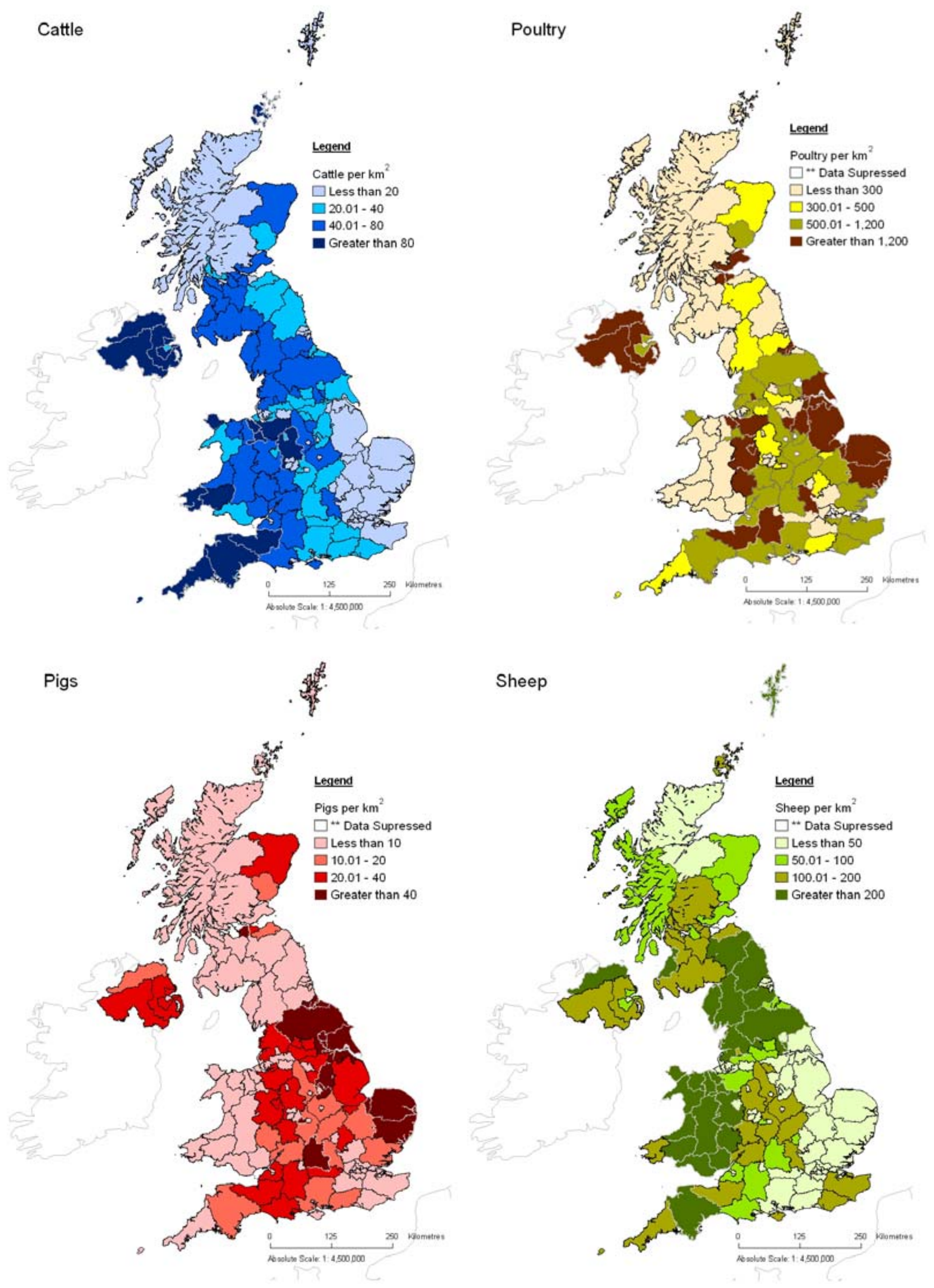
Details of how these data are collected and collated can be found in the Veterinary Medicine Directorates (VMD) Annual Reports on Sales of Veterinary Medicines (www.vmd.gov.uk/ under the publications and antibiotic related tabs) (VMD 2000-2005).

Table 1: Numbers of people in the UK and livestock in the national herd in the UK on 1st June 2004

	People*	Cattle	Pigs	Sheep	Poultry**
England	50,093,762	5,679,934	4,236,342	15,873,166	136,697,734
Wales	2,952,462	1,281,359	30,657	9,736,836	8,688,428
Scotland	5,078,400	1,959,920	471,550	8,045,770	15,895,000
Northern Ireland	1,710,322	1,677,583	424,058	2,225,407	20,509,231
UK Total	59,834,946	10,598,796	5,162,607	35,881,179	181,790,393

* Source data: Crown Copyright

** The term 'Poultry' in this table refers to the total number of birds kept on agricultural premises that are specified as poultry and recorded as such by the June Agricultural Censuses in the UK. Among others, these are: chickens, bantams, ducks, geese, turkeys, guinea fowl, and ostriches.



N.B. **The white category represents those areas where data has been suppressed by the Census departments due to the area represented containing five or fewer holdings and therefore open to disclosure of information about individual holdings.

Figure 1: Maps showing the density (number per km²) of cattle, poultry, pigs and sheep in UK Census areas on the 1st of June 2004. Dark colours denote areas of high population density and light colours represent areas with lower densities. Data obtained from June Agricultural Census, 2004

Table 2: Numbers of key companion animals in the UK for 2003 (the last calendar year for which data are available)

	2003
Cats	9,200,000
Dogs	6,500,000
Fish	2,700,000
Rabbits*	1,600,000
Hamsters*	980,000
Guinea Pigs*	700,000
Horses**	330,083
Total	22,010,083

* = data are for 2001 and were provided by PFMA via *pers.comms*.
** = data are for 2004 taken from the Agricultural Census Divisions in the UK.

Food

Pathogenic, commensal and environmental bacteria can be present in food and some of these are resistant to antimicrobials. Infectious intestinal diseases can be transmitted through several routes, one of which is the consumption of contaminated food i.e. from food animals. It is thought that in the UK, the consumption of contaminated food is a common route of infection. Food animals such as cattle, sheep, pigs and poultry are major reservoirs of *Salmonella* spp., *Campylobacter* spp., and *E. coli*. Observing the 4C's: cleaning, cooking, cooling and avoiding cross-contamination are important in preventing food poisoning. Contamination of ready-to-eat foods can be a significant problem for some pathogens.

The Food Standards Agency (FSA) undertakes national surveys and in recent years focus has been on fresh eggs and poultry. The HPA currently holds an archive of foodborne pathogens that were isolated from food as part of the FSA food surveys. These isolates have been subtyped and screened for antimicrobial resistance.

The use of antimicrobials for treatment may be reflected in the antimicrobial profiles of isolated bacteria and may even indicate whether the food sampled was of non-UK origin. Through the commissioning of food surveillance and the gathering of antimicrobial resistance data, the prevalence and the resistance status of the bacteria entering the kitchen could be reviewed.

Poultry is the commonest fresh meat type consumed, followed by beef, veal and pork (see Table 3).

Table 4 shows the amount of meat, eggs and milk produced in or imported into the UK. The majority of beef and veal, mutton and lamb, poultry, eggs and milk were produced in the UK whereas a significant proportion of bacon and ham was imported.

Table 3: The amount of meat, eggs and dairy produce bought per person per week in an average household in the UK in 2000-2004

	Consumption g/person/week (unless otherwise stated)
Milk and cream (ml/person/week)*	2,024
Other meat products	316
Poultry	248
Ready meal and convenience meat products	155
Beef and veal	119
Bacon and Ham	117
Cheese (natural and processed)*	113
Pork	56
Mutton and Lamb	49
Eggs (Number)	1.6

* data are for the year 2003/04
Data source: Department of Environmental Food and Rural Affairs. 2006. Family Food

Table 4: The amount in tonnes of meat, eggs and milk produced in the UK and imported into the UK in 2004

	2004
Beef and veal	
Home produced	235,000
Imported	88,000
Mutton and lamb	
Home produced	313,000
Imported	142,000
Pork	
Home produced	575,000
Imported	428,000
Bacon and ham	
Home produced	211,000
Imported	302,000
Poultry and poultry meat	
Home produced	410,000
Imported	67,000
Eggs**	
Home produced	778
Imported	150
Milk	
*Home produced**	14,215
*Imported**	69
Cheese	
Home produced	373,000
Imported	335,000

(*measured in million litres)
(**measured in million dozen)
Source: Department of Environment Food and Rural Affairs http://statistics.defra.gov.uk/esg/publications/auk/default.asp

Table 5 shows the amounts of foods of animal origin purchased and eaten out in the UK.

Table 5: The amount of food and drink purchased and eaten out in the UK per person per week in 2003-2004

	Purchases g/persons/week
Meat and meat products	97
Cheese and egg dishes and pizza	26
Soft drinks including milk drinks	384*

*measured in ml/person/week

Data source: Department of Environmental Food and Rural Affairs. 2006. Family Food – A Report on the 2004-5 Expenditure and Food Survey. TSO, London.

From 1996 to 2000 an estimated 1,724,315 cases of indigenous food borne disease per annum in England and Wales resulted in 21,997 hospitalisations and 687 deaths (Adak *et al.* 2005). The greatest impact on the healthcare sector arose from *Campylobacter* infection (160,788 primary care visits and 15,918 hospitalisations), whilst salmonellosis was associated with the most deaths (209). The most important cause of indigenous food borne disease was contaminated chicken (398,420 cases, 141 deaths). More deaths (164) were attributed to red meat (beef, lamb and pork) than chicken, although there were fewer cases of illness per million servings.

ANTIMICROBIAL USE

Humans

- 80% of antimicrobial prescribing for humans was for patients in the community.
- β-lactams accounted for 64% of antimicrobials used in humans in the community and 76% of antimicrobials used in hospitals in England.

Community Prescribing

United Kingdom

Prescription Analysis and Cost (PACT) data are collated from all prescriptions dispensed in the community: i.e. by community pharmacists, appliance contractors, dispensing doctors and items personally administered by doctors. PACT data are currently based on the therapeutic grouping used in the British National Formulary (BNF). Further information can be found at the Prescriptions Pricing Authority (PPA) website at www.ppa.org.uk/index.htm

PACT data were obtained from all prescriptions dispensed in the community. Data were collated for 2004 by the following for England, Wales, Scotland and Northern Ireland respectively: the Prescribing Support Unit, Health and Social Care Information Centre; Health Solutions Wales, Prescribing Services Unit; Information Services Division, National Services, Scotland; and Information and Research Unit, Central Services Agency. All data were analysed by HPA.

Table 6 shows the gross quantities of antimicrobial active ingredient (a.i.) derived from prescriptions dispensed in the community in England, Wales, Scotland and Northern Ireland in 2004. All data are expressed as tonnes of active compound. Further information about how this information is collected and derived can be found at the Prescription Cost Analysis Unit website of the Department of Health.
http://www.dh.gov.uk/PublicationsAndStatistics/Statistics/StatisticalWorkAreas

Hospital Prescribing

England

Data are not routinely published on hospital prescribing of antimicrobials. The reason for this is that, unlike in primary care, electronic prescribing and related information technology is in place in less than 5% cent of UK hospitals. For the purposes of this report national aggregated data were obtained from IMSHealth covering about 97% of Trusts in England (Table 7). As in the community, the majority of antimicrobial prescribing in hospitals is for β-lactams.

Table 6: Total tonnage by selected chemical groupings of base active ingredient (a.i.) derived from prescriptions dispensed in the community in UK in 2004

Antimicrobial	Tonnes a.i.				
	England	Wales	Scotland*	Northern Ireland	Total
Tetracyclines	33.1	1.9	4.7	0.9	40.6
Sulphonamides/Trimethoprim	1.1	0.1	0.1	<0.1	1.3
Sulphonamides	<0.1	<0.1	<0.1	<0.1	<0.1
Trimethoprim	7.4	0.5	0.9	0.3	9.1
β-Lactams	170.1	11.4	20.6	8.8	210.9
*Cephalosporins**	23.8	1.4	2.7	1.0	28.9
*Penicillins***	146.3	10.0	17.9	7.8	182.0
*Others****	<0.1	<0.1	<0.11	<0.1	<0.1
Aminoglycosides	<0.1	<0.1	<0.1	<0.1	<0.1
Macrolides	36.5	2.2	4.3	1.4	44.4
Quinolones	7.5	0.5	1.2	0.4	9.6
Other****	12.9	0.8	1.3	0.5	15.5
Total	**268.7**	**17.4**	**33.2**	**12.4**	**331.7**

* all generations of cephalosporins are included in this group.
** includes penicillinase resistant and broad spectrum penicillins.
*** includes mecillinams and carbapenems.
**** includes chloramphenicol, clindamycin, dapsone, ethambutol, fusidic acid, isoniazid, metronidazole, nitrofurantoin, rifampicin, vancomycin.
Source: Prescription Cost Analysis 2004 Crown Copyright. Data are for the year April 2004 – March 2005.

Table 7: Total tonnage by selected chemical groupings of base active ingredient (a.i.) derived from prescriptions dispensed in hospitals in England in 2004

Antimicrobial	Tonnes a.i.
Tetracyclines	**1.4**
Sulphonamides/Trimethoprim	**1.3**
β-Lactams	**52.3**
*Cephalosporins**	10.9
*Penicillins***	41.4
Mecillinams	<0.1
Aminoglycosides	**0.3**
Macrolides	**5.5**
Quinolones	**5.1**
Other***	**2.8**
Total	**68.8**

* includes all generations of cephalosporins and carbapenems.
** includes penicillinase resistant, broad spectrum and antipseudomonal penicillins.
*** details of drugs included in this category were not available.

Animals

- Tetracyclines accounted for 54% of total antimicrobial use in animals, while β-lactams accounted for 14%.
- 87% of antimicrobial use in animals was in food-producing animals.

United Kingdom

Data on total veterinary antimicrobial product sales for 2004 were collected from the veterinary pharmaceutical companies early in 2005 (VMD 2006). The veterinary pharmaceutical companies marketing these products in the UK voluntarily provided the data. Further information about these data can be found in the VMD Annual Reports on Sales of Antimicrobial Products Authorised for Use as Veterinary Medicines, Antiprotozoals, Antifungals, Growth Promoters and Coccidiostats, in the UK (www.vmd.gov.uk/ under the publications and antibiotic related tabs) (VMD 2000-2006).

All data about the amounts of antimicrobials sold for use in animals are available only on a UK basis and cannot be divided by each country.

Table 8 shows the sales of total therapeutic veterinary antimicrobials in the UK in 2004 divided by chemical grouping. All data are expressed as tonnes of base active ingredient. Where it is possible within the bounds of company confidentiality, the larger classes of antimicrobials have been sub-divided, to give a more detailed picture of use in the UK. Further details about these data can be found in the VMD Annual Sales Data Reports (www.vmd.gov.uk/ under the publications and antibiotic related tabs).

Table 8: Sales of total therapeutic veterinary antimicrobial products by chemical grouping in the UK in 2004, in tonnes of base active ingredient (a.i.)

Antimicrobial	**Tonnes a.i.**
Tetracyclines	**243**
Sulphonamides/ Trimethoprim	**77**
Trimethoprims	13
Sulphonamides	64
β-Lactams	**63**
*Cephalosporins**	3
*Penicillins***	14
*Others****	46
Aminoglycosides	**22**
Streptomycins	6
Neomycin and Framycetin	6
*Others*****	11
Macrolides	**37**
Quinolones	**1**
Other*****	**11**
UK Total	**454**

* all generations of cephalosporins are included in this group.
** includes potassium penicillin, benzyl penicillin, procain penicillin, benzathine penicillin.
*** includes cloxacillin, amoxicillin, ampicillin, nafcillin, penethamate hydriodide.
**** includes gentamicin, apramycin and spectinomycin.
***** includes chloramphenicol, clindamycin, colistin, diethanolamine fusidate, florfenicol, fusidic acid, lincomycin, metronidazole, nitrofuazone, novobiocin, pirlimycin, polymixin B, tiamulin, valnemulin.

Table 9 shows the gross quantities of antimicrobial active ingredients in therapeutic products in 2004 sold for use in animals. These sales are divided into those sold for use in food-producing animals only, non food-producing animals only and those sold for use in a combination of both food and non food-producing animals. All data are expressed as tonnes of base active ingredient. Further details about these data can be found in the VMD Annual Reports on Sales of Veterinary Medicines (www.vmd.gov.uk/ under the publications and antibiotic related tabs) (VMD 2000-2006). There are currently no data available on the amount of antimicrobials given to animals, but it is assumed that there is a close correlation between those antimicrobials sold for use and those used.

Table 9: Sales of therapeutic antimicrobials 2004, in the categories of food animals only, non food animals only and combined food and non food animals

Animal	**Tonnes a.i.**
Food-Producing animals	**393**
Cattle only	10
Pig only	63
Poultry only	11
Sheep only	<1
Fish only	4
Pig and Poultry only*	282
Multi-Food-Producing-animals only**	22
Companion animals	**29**
Dog only	5
Horse only	14
Multi-companion-animals only	10
Combination of Food and Non food producing animals	**32**
UK Total	**454**

* This category is antimicrobials that are authorised for use in pigs and poultry only.
** This category is antimicrobials that are authorised for use in a combination of 2 or more food-producing animals.

Figure 2 shows the relative proportions of total antimicrobials given to food producing animals, companion animals, a combination of food-producing and non food-producing animals and humans in the UK in 2004. It is noted that the total human figure is lower than the full picture for the UK as data for hospital prescribing were only available for England, rather than the UK.

Figure 3 shows the relative proportions of each class of antimicrobials used in people and animals in the UK in 2004. The figure clearly illustrates different patterns of antimicrobial use for people and animals, with β-Lactams mainly being prescribed for people and tetracyclines for animals.

A list of all antimicrobial ingredients authorised for use in humans and different key animal species was developed by the VMD and DH and is available on the VMD web site (www.vmd.gov.uk/ under the General Information / DARC Group tabs) (Anon 2003).

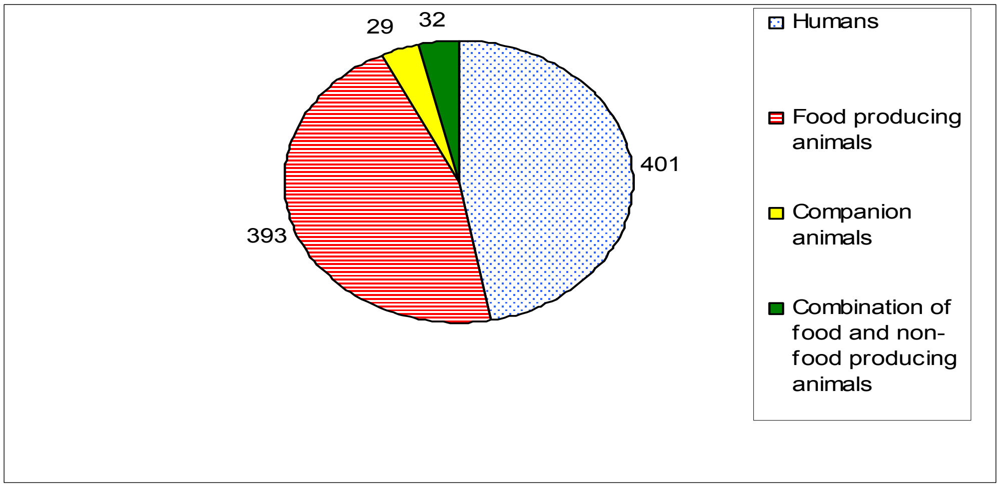


Figure 2: Graph to show the relative proportions of antimicrobials used in food producing animals, companion animals, a combination of food-producing and non food-producing animals in the UK and in humans (community data from the UK and hospital data from England only) in 2004

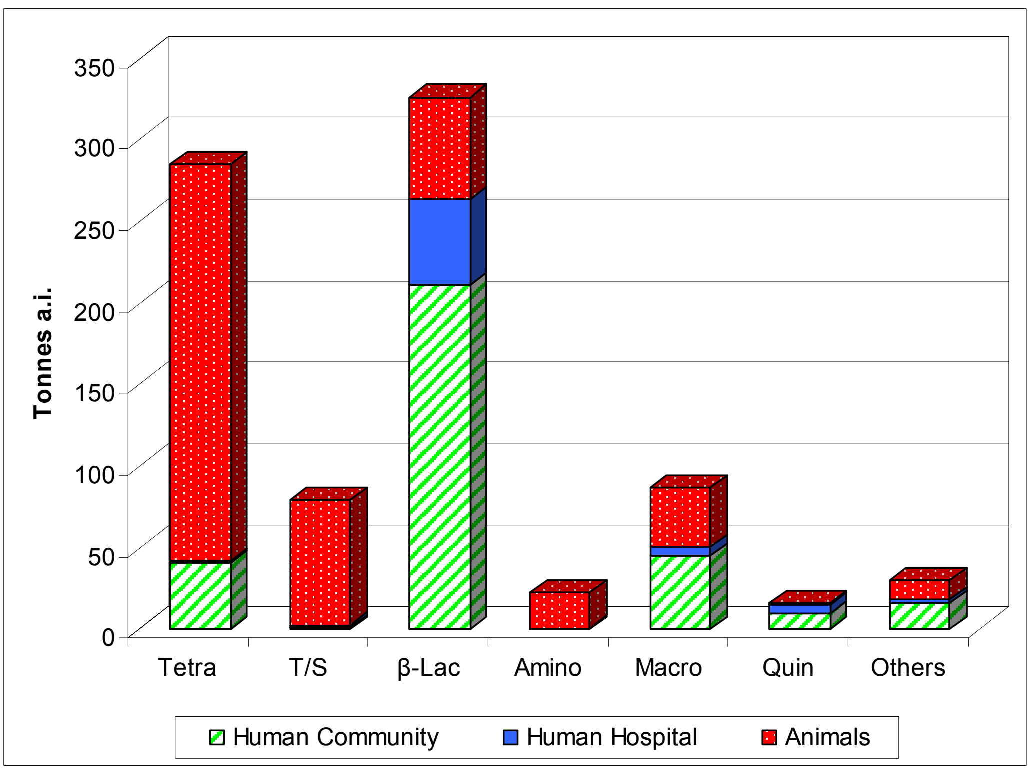


Figure 3: Graph to show the relative proportions of each class of antimicrobials used in humans in the community in the UK and hospitals in England only and used in animals in the UK in 2004[1]

[1]On Figure 3 the abbreviations mean: - Tetra – Tetracyclines, T/S Trimethoprim/Sulphonamide, ß-Lac - ß-Lactams, Amino – Aminoglycosides, Macro – Macrolides, Quin – Quinolones.

BACTERIAL RESISTANCE DATA

CAMPYLOBACTER

Humans

- 3 year sentinal surveillance undertaken in England, Wales and Scotland showed that *C. jejuni* accounted for 90% of infections.

- 22-24% of *C. jejuni* and 28-29% of *C. coli* were resistant to ciprofloxacin.

For surveillance of *Campylobacter* infection, 22 sentinel health authorities in England and Wales, covering a population of approximately 12.5 million people, participated in a three-year Sentinal Surveillance Scheme (April 2000-March 2003). Under the scheme, isolates from infected patients were referred to the Reference Unit and completed questionnaires providing clinical and epidemiological information were sent to the CfI. Data are not available for 2004 as the scheme did not cover this year.

England and Wales

A total of 3,520 isolates were obtained for identification and tested for antimicrobial susceptibility testing in 2003. *C. jejuni* accounted for the majority of infections (3,165; 90%), with *C. coli* comprising 9.3% of the total, see Table 10. All other species (*C. lari, C. fetus, C. upsaliensis* and C. *hyointestinalis*) were represented by less than 1% of isolates examined.

Table 10: Resistance of *Campylobacter jejuni* and *Campylobacter coli* to two antimicrobials in 2003 in humans in England and Wales

Antimicrobial	*C. jejuni*	*C. coli*
	No. isolates 3,165	No. isolates 328
	%R	%R
Ciprofloxacin (1mg/L)	24	28
Erythromycin (4mg/L)	3	17

Scotland

Resistance data are not routinely available in Scotland for *Campylobacter*. However, resistance data are available for isolates from Lothian NHS Board from May 2001 to April 2003, which comprised the Scottish component of the *Campylobacter* Sentinel Study. These data are summarised in Table 11.

Table 11: Resistance of *Campylobacter jejuni* and *Campylobacter coli* to selected antimicrobials from May 2001 to April 2003 in humans in Lothian NHS Board, Scotland

Antimicrobial	*C. jejuni*	*C. coli*
	No. isolates 1,254	No. isolates 122
	%R	%R
Ampicillin 32mg/L	34	21
Chloramphenicol 8mg/L	2	2
Ciprofloxacin 1mg/L	22	29
Gentamicin 4mg/L	0	3
Erythromycin 4mg/L	0	8
Kanamycin 16mg/L	2	3
Nalidixic acid 16mg/L	35	30
Neomycin 8mg/L	2	2
Tetracycline 8mg/L	31	34

Northern Ireland

No *Campylobacter* data are available for Northern Ireland.

Animals

- The prevalence of resistance to ciprofloxacin in *C. coli* and *C. jejuni* in cattle, sheep and pigs at slaughter as seen in a statistically-based survey was lower than in humans in England, Wales and Scotland.

Great Britain

The *Campylobacter* susceptibility data recorded in this report are taken from the most recent survey, which was performed in 2003.

The *Campylobacter* isolates referred to in Tables 12 and 13, were isolated from animals after slaughter at abattoirs throughout Great Britain in a statistically-based, national abattoir survey, performed in 2003. A detailed description of the sampling methods has already been published (Davies *et al*. 2004). Antimicrobial resistances were determined using an agar-dilution breakpoint method; the method was identical to that performed by the HPA in the routine susceptibility testing of human *Campylobacter* isolates.

Table 12: Resistance of *Campylobacter coli* to selected antimicrobials in 2003 in food-producing animals in Great Britain

Antimicrobial	*C. coli*		
	Cattle	Sheep	Pig
	No. isolates 33	No. isolates 105	No. isolates 328
	%R	%R	%R
Ampicillin (32mg/L)	48	26	24
Chloramphenicol (8mg/L)	9	3	46
Ciprofloxacin (1mg/L)	3	1	16
Erythromycin (4mg/L)	18	24	21
Furazolidone (8mg/L)	0	0	0
Kanamycin (16mg/L)	0	1	3
Nalidixic acid (16mg/L)	15	3	27
Tetracycline (8mg/L)	0	10	70
Tetracycline (128mg/L)	0	1	32

Table 13: Resistance of *Campylobacter jejuni* to selected antimicrobials in 2003 in food-producing animals in Great Britain

Antimicrobial	*C. jejuni*		
	Cattle	Sheep	Pig
	No. isolates 284	No. isolates 199	No. isolates 15
	%R	%R	%R
Ampicillin (32mg/L)	14	19	33
Chloramphenicol (8mg/L)	5	6	7
Ciprofloxacin (1mg/L)	3	2	0
Erythromycin (4mg/L)	3	6	13
Furazolidone (8mg/L)	0	0	0
Kanamycin (16mg/L)	1	1	0
Nalidixic acid (16mg/L)	8	4	0
Tetracycline (8mg/L)	6	6	53
Tetracycline (128mg/L)	1	3	40

Northern Ireland

Included below (Table 14) is the most recently available information on antimicrobial resistance in animal isolates of *Campylobacter*, which is derived from an abattoir survey of pigs carried out in 2002. Antimicrobial resistances were determined using an agar-dilution breakpoint method, with the relevant antimicrobial concentrations included in table below.

Table 14: Resistance of *Campylobacter* species from slaughtered pigs, to selected antimicrobials in 2002 in Northern Ireland

Antimicrobial	*Campylobacter* species
	No. isolates 257
	%R
Ampicillin (32mg/L)	21
Chloramphenicol (8mg/L)	0
Ciprofloxacin (1mg/L)	21
Erythromycin (4mg/L)	55
Furazolidone (8mg/L)	0
Kanamycin (16mg/L)	11
Nalidixic acid (16mg/L)	25
Neomycin (8mg/L)	7
Tetracycline (8mg/L)	69

Food

Tables 15 and 16 contain data from retail surveys carried out by the FSA in 2001 and in 2004. The 2004 survey was in partnership with the National Health Protection Service Wales and local authorities to monitor the prevalence of *Campylobacter* and *Salmonella* in raw retail chicken. A proportion of the *Campylobacter* isolates were subjected to resistance profiling.

Table 15: Antimicrobial resistance of *Campylobacter jejuni* and *Campylobacter coli* from retail sourced raw chicken in England, Scotland, Wales and Northern Ireland in April and May 2001

	England		Scotland		Wales		Northern Ireland	
Antimicrobial	*C. jejuni* No. isolates 417	*C. coli* No. isolates 147	*C. jejuni* No. isolates 304	*C. coli* No. isolates 63	*C. jejuni* No. isolates 133	*C. coli* No. isolates 54	*C. jejuni* No. isolates 356	*C. coli* No. isolates 157
	% R	%R	%R	%R	%R	%R	%R	%R
Ampicillin (32mg/L)	42	30	45	29	41	22	20	13
Chloramphenicol (8mg/L)	0	0	0	0	0	0	0	0
Ciprofloxacin (1mg/L)	9	14	17	16	18	15	13	17
Erythromycin (4mg/L)	0	6	0	10	0	6	0	4
Gentamicin (4mg/L)	0	0	0	2	0	0	0	0
Kanamycin (16mg/L)	8	3	5	5	6	2	2	4
Nalidixic acid (16mg/L)	14	16	18	17	21	19	14	18
Neomycin (4mg/L) for *C. jejuni* (8mg/L) for *C. coli*	8	3	5	3	6	2	2	4
Tetracycline (8mg/L)	10	27	28	24	36	28	17	24

Table 16: Antimicrobial resistance of *Campylobacter jejuni* and *Campylobacter coli* from retail sourced raw chicken in Wales and Northern Ireland in 2004

	Wales		Northern Ireland	
Antimicrobial	*C. jejuni* No. isolates 77	*C. coli* No. isolates 39	*C. jejuni* No. isolates 39	*C. coli* No. isolates 25
	%R	%R	%R	%R
Ampicillin (32mg/L)	73	64	64	84
Chloramphenicol (8mg/L)	3	5	5	0
Ciprofloxacin (1mg/L)	19	23	21	0
Erythromycin (4mg/L)	0	3	3	12
Gentamicin (4mg/L)	0	0	0	0
Kanamycin (16mg/L)	0	3	0	0
Nalidixic acid (16mg/L)	23	26	23	0
Neomycin (4mg/L) for *C. jejuni* (8mg/L) for *C. coli*	0	3	3	0
Tetracycline (8mg/L)	29	13	41	20

Data source: : Meldrum RJ, Smith, SM, Wilson I.G (2006)

ENTEROCOCCI

Humans

- Reported resistance to vancomycin was higher in *E. faecium* (13 - 44%) than in *E. faecalis* (0 – 7%).
- A significant proportion of isolates were not identified to the species level.

England, Wales and Northern Ireland

The data in Tables 17-19 are for the key clinically-relevant agents tested against this genus. As expected, the prevalence of resistance to glycopeptides was higher in *E. faecium* than in *E. faecalis*. Reports of resistance to ampicillin/amoxicillin in *E. faecalis* may reflect mis-identification of isolates of *E. faecium*. The inclusion of Table 19 showing data for other enterococci reflects that many laboratories do not routinely identify isolates to the species level.

Table 17: Resistance of *Enterococcus faecium* from human blood culture to selected antimicrobials in 2004 in England, Wales and Northern Ireland

Antimicrobial	England		Wales		Northern Ireland	
	No. isolates	%R	No. isolates	%R	No. isolates	%R
Ampicillin/Amoxicillin	907	87	67	79	18	89
Erythromycin	461	95	16	88	20	100
High level Gentamicin	177	21	0	0	7	71
Penicillin	421	99	30	100	15	100
Teicoplanin	567	16	39	51	22	0
Tetracycline	253	50	17	41	22	41
Vancomycin	853	20	68	44	23	13

Table 18: Resistance of *Enterococcus faecalis* isolated from human blood culture to selected antimicrobials in 2004 in England, Wales and Northern Ireland

Antimicrobial	England		Wales		Northern Ireland	
	No. isolates	%R	No. isolates	%R	No. isolates	%R
Ampicillin/Amoxicillin	2,203	4	84	4	27	0
Erythromycin	1,039	79	44	75	29	86
High level Gentamicin	397	40	1	100	4	100
Penicillin	962	93	36	100	20	45
Teicoplanin	1,276	3	53	8	31	0
Tetracycline	584	76	34	79	34	71
Vancomycin	2,001	2	70	7	29	0

Table 19: Resistance of other enterococci isolated human blood culture to selected antimicrobials in 2004 in England, Wales and Northern Ireland

Antimicrobial	England		Wales		Northern Ireland	
	No. isolates	%R	No. isolates	%R	No. isolates	%R
Ampicillin/Amoxicillin	1,657	31	54	19	5	80
Erythromycin	728	82	11	82	5	60
High level Gentamicin	186	30	0	0	0	0
Penicillin	671	95	10	90	2	100
Teicoplanin	1,028	10	7	43	6	0
Tetracycline	416	63	10	60	5	20
Vancomycin	1,554	11	52	6	7	14

Scotland

No data are available for Scotland.

Animals

- In animals there were only two isolates amongst the 223 strains of *E. faecium* tested from pigs in Great Britain that were resistant to vancomycin and teicoplanin. This resistance indicates a *vanA* phenotype and likely possession of the *vanA* resistance gene. The low number of vancomycin-resistant strains detected in pigs probably reflects the fact that glycopeptides have not been permitted for use in this species for several years in EU countries.

Great Britain

The *E. faecium* susceptibility data recorded in this report were taken from the most recent survey, which was performed in 2003.

The *E. faecium* isolates referred to in Table 20, were isolated from pigs after slaughter at abattoirs throughout Great Britain in a statistically-based, national abattoir survey, performed in 2003. The minimum inhibitory concentration (MIC) was determined for each isolate using a broth microdilution method.

Table 20: Resistance of *Enterococcus faecium* isolated from pigs to selected antimicrobials in 2003 in Great Britain

Antimicrobial (MIC breakpoint)	Great Britain
	No. isolates 227
	% R
Ampicillin (8mg/L)	0
Avilamycin (32mg/L)	13
Bacitracin (32mg/L)	66
Erythromycin (4mg/L	68
Flavomycin (8mg/L)	98
Gentamicin (>512mg/L)	0
Salinomycin (8mg/L)	3
Quinupristin/ Dalfopristin (2mg/L)	76
Teicoplanin (16mg/L)	0
Tetracycline (8mg/L)	90
Tylosin (4mg/L)	79
Vancomycin (16mg/L)	0

The prevalence of resistance to some antimicrobials reported for *E. faecium* in pigs in Great Britain is different from that recently reported (MARAN, 2002, DANMAP, 2003), in certain other European countries. However, consideration of the distribution of the MIC values obtained (not shown) and the breakpoint used to discriminate between susceptible and resistant strains is necessary to fully evaluate the results. When this is done, it becomes apparent that the results are in fact much more similar than initially appear the case.

Northern Ireland

No data are available for Northern Ireland.

ESCHERICHIA COLI AND *ESCHERICHIA COLI O157*

Humans

- *E. coli* is one of the two commonest bacterial causes of bacteraemia in the UK.
- The number of reports of cephalosporin resistance in *E. coli* isolates from bacteraemia is increasing. This probably reflects the spread of strains producing extended-spectrum β-lactamases (ESBLs) since 2003.
- Over half the blood culture isolates tested were resistant to ampicillin or amoxicillin (57-62%).
- Resistance to ciprofloxacin was a significant problem with 9-20% of isolates resistant.
- In contrast to *E. coli* isolates from blood culture, the vast majority of isolates of *E. coli* O157 have remained susceptible to a range of antimicrobials.

England, Wales and Northern Ireland.

E. coli is the commonest cause of urinary tract infection and one of the two commonest bacterial pathogens responsible for septicaemia in humans the other being *S. aureus*. Surveillance focuses on serious infections caused by *E. coli*, notably bacteraemias. There were 16,690 reports of *E. coli* bacteraemia in 2004 in England and Wales. Antimicrobial susceptibilities are shown in Table 21. An increase in the prevalence of ciprofloxacin resistant *E. coli* from bacteraemias in England and community and hospital spread of *E. coli* producing ESBLs in the UK have been described (Livermore *et al.* 2003; Woodford *et al*. 2003). Apparent differences in the rates of resistance seen between England, Wales and Northern Ireland may reflect the small numbers tested in some cases.

Table 21: Resistance of *Escherichia coli* isolated from human blood culture to selected antimicrobials in 2004 in England, Wales and Northern Ireland

Antimicrobial	England		Wales		Northern Ireland	
	No. Isolates	%R	No. Isolates	%R	No. Isolates	%R
Amoxicillin/Clavulanic acid	8,182	19	544	18	213	20
Ampicillin/Amoxicillin	12,510	57	742	58	250	62
Cefotaxime	5,460	6	461	2	126	2
Ceftazidime	8,419	6	289	2	135	2
Ciprofloxacin	12,320	16	661	9	188	20
Gentamicin	13,150	7	750	4	244	5
Piperacillin/Tazobactam	7,287	6	461	3	150	1
Trimethoprim	8,433	35	409	28	148	34

Less commonly, certain strains of *E. coli*, such as *E. coli* O157, cause diarrhoeal disease in people and, infrequently, haemorrhagic colitis and haemolytic uraemic syndrome. The antimicrobial susceptibilities of all isolates of *E. coli* O157 submitted to the HPA Laboratory of Enteric Pathogens in 2004 (faecal isolates) are shown in Table 22.

Table 22: Resistance of *Escherichia coli* O157 to selected antimicrobials in 2004 in England and Wales

Antimicrobial	No. isolates 701
	%R
Ampicillin	2
Chloramphenicol	0
Ciprofloxacin	0
Furazolidone	0
Gentamicin	0
Kanamycin	1
Nalidixic Acid	0
Streptomycin	19
Sulphonamides	20
Tetracyclines	18
Trimethoprim	1

Scotland

The *E. coli* Reference Laboratory tests all *E. coli* O157 isolates in Scotland against a panel of 11 antimicrobials, see Table 23. MICs were determined according to the 2005 guidelines of the CLSI.

Table 23: Resistance of *Escherichia coli* O157 to selected antimicrobials in 2004 in humans in Scotland

Antimicrobial	No. isolates 202
	%R
Ampicillin (32mg/L)	0
Cefotaxime (64mg/L)	0
Ceftazidime (32mg/L)	0
Chloramphenicol (32mg/L)	0
Ciprofloxacin (4mg/L)	0
Fosfomycin (256mg/L)	0
Nalidixic acid (32mg/L)	0
Sulphonamide (512mg/L)	0
Tetracycline (16mg/L)	1
Trimethoprim (16mg/L)	1

Animals

- Resistance to cephalosporins remains low in all four countries in all species.
- Resistance to tetracyclines is high in pigs in all four countries.
- There is a variable resistance pattern for all species in all countries.
- In pigs Verotoxigenic *E. coli* O157 (VTEC O157) was resistant to streptomycin 23%, sulphonamides 31%, tetracyclines 46% and apramycin 15%.
- For the remaining antimicrobials tested in pigs and all those in cattle and sheep resistance was low.

England and Wales

Data on *E. coli* are obtained from three complementary data sets: data outbreaks on farms submitted by diagnostic laboratories; data from abattoir surveys which provide information at the point at which animals from a number of farms enter the food chain and data from the national antimicrobial sensitivity database (Teale *et al.* 2003). The latter includes information on all susceptibility tests undertaken on veterinary clinical diagnostic samples submitted to the network of fourteen VLA Regional Laboratories in England and Wales since 1998.

The majority of *E. coli* isolates referred to in Table 24, originate from samples referred to VLA Regional Laboratories as part of investigations into outbreaks of clinical disease in food-producing animals; many of these isolates may come from animals already undergoing antimicrobial treatment. Isolates from cattle, sheep and pigs are predominantly from cases of enteritis and / or septicaemia in young animals; the isolates from chickens and turkeys also include isolates from cases of colisepticaemia and other clinical conditions. Isolates were tested using a disc diffusion method; disc concentrations are shown in the table of results.

Scotland

The isolates summarised in Table 25 originate from samples referred to SAC DSCs as part of investigations into outbreaks of clinical disease in domestic animals: many may come from animals already undergoing antimicrobial treatment. The majority of samples described as “all sources” are faecal samples from diarrhoeic animals. “Avian” includes domestic fowl, gamebirds and wildfowl.

Northern Ireland

The antimicrobial resistance data on *E. coli* isolates from animals in Northern Ireland are derived from clinical submissions to the VSD disease surveillance and investigation service, see Table 26. In the case of sheep, pigs and cattle – other sources, isolates are predominantly from cases of enteritis and / or septicaemia in young animals. The sources in the avian category are mainly cases of colisepticaemia and other clinical conditions in chickens, but also include isolates from other species of poultry and gamebirds, as well as some wild bird species.

Table 24: Resistance of *Escherichia coli* isolated from food-producing animals in England and Wales to selected antimicrobials in 2004

Antimicrobial	Cattle Mastitis		Cattle Other		Sheep		Pig		Chicken		Turkeys all sources	
	No. isolates	%R	No. isolates	%R	No. isolates	%R	No. isolates	%R	No. isolates	%R	No. isolates	%R
Amoxicillin/Clavulanic acid (30µg)	977	5	3576	19	446	4	-	-	-	-	4	0
Ampicillin (10µg)	977	15	3,576	53	446	30	313	47	176	38	23	57
Apramycin (15µg)	-	-	3,576	3	446	2	313	8	174	1	23	0
Ceftiofur (30µg)	-	-	5	0	6	0	140	<1	27	0	14	0
Cephalexin (30µg)	977	3	56	12	12	8	44	0	12	0	-	-
Enrofloxacin (5µg)	-	-	3,576	0	446	0	313	2	175	6	23	4
Neomycin (10µg)	977	6	3,576	30	446	12	313	11	175	9	23	0
Penicillin/Streptomycin (25µg)	977	6	3,576	28	446	13	313	55	175	28	23	35
Tetracycline (10µg)	977	14	3,576	57	446	42	313	82	175	65	23	74

Table 25: Resistance of *Escherichia coli* isolated from food-producing animals in Scotland to selected antimicrobials in 2004

Antimicrobial	Cattle Mastitis		Cattle Other		Sheep		Pig		Avian all sources	
	No. isolates	%R	No. isolates	%R	No. isolates	%R	No. isolates	%R	No. isolates	%R
Amoxicillin (25µg)	-	-	325	67	80	35	27	52	187	32
Amoxicillin/Clavulanic acid (30µg)	194	4	331	17	82	7	31	3	194	2
Ampicillin (10µg)	191	18	331	66	82	35	31	61	194	33
Apramycin (15µg)	-	-	331	18	81	6	31	13	194	2
Cefoperazone (75µg)	212	2	-	-	-	-	-	-	-	-
Cephalexin (30µg)	212	6	326	12	80	4	27	15	187	3
Enrofloxacin (5µg)	212	0	326	10	80	1	27	7	187	4
Neomycin (10µg)	191	6	326	35	80	23	27	19	187	8
Penicillin/Streptomycin (60µg)	162	6	-	-	-	-	-	-	-	-
Sulphisoxazole (300µg)	-	-	326	76	80	55	30	63	187	42
Sulphonamide/trimethoprim (25µg)	28	93	331	44	82	20	31	52	194	24
Tetracycline (10µg)	37	41	331	77	82	50	31	87	193	55

Table 26: Resistance of *Escherichia coli* isolated from food-producing animals in Northern Ireland to selected antimicrobials in 2004

Antimicrobial	Cattle Mastitis		Cattle Other		Sheep		Pig		Avian	
	No. isolates	%R	No. isolates	%R	No. isolates	%R	No. isolates	%R	No. isolates	%R
Amoxicillin (25µg)	112	21	415	97	24	88	39	95	221	65
Amoxicillin/Clavulanic acid (30µg)	398	14	886	30	85	9	83	18	-	-
Ampicillin (10µg)	400	74	896	92	84	71	84	88	2	0
Apramycin (15µg)	287	13	892	32	82	11	84	25	101	15
Cefoperazone (75µg)	2	0	465	6	61	2	43	5	-	-
Enrofloxacin (5µg)	287	2	892	37	84	14	84	15	220	2
Florfenicol (30µg)	-	-	407	46	20	30	38	21	-	-
Neomycin (10µg)	111	21	411	76	23	43	38	71	220	37
Spectinomycin (25µg)	395	60	409	80	21	67	38	95	220	47
Sulphonamide/trimethoprim (25µg)	398	17	894	77	85	48	84	80	217	37
Tetracycline (10µg)	401	22	896	92	85	78	84	92	221	48

Great Britain

The VTEC O157 isolates referred to in Table 27, were isolated from the intestinal contents of healthy cattle, pigs and sheep after slaughter at abattoirs throughout Great Britain in a statistically-based national abattoir survey, performed in 2003. Antimicrobial resistances were determined using a disc diffusion method; disc concentrations are shown in the table of results.

The prevalence of resistance is generally much lower than that observed in clinical veterinary *E. coli* isolates from animals in England, Wales and Scotland.

Table 27: Resistance of Verotoxigenic *Escherichia coli* O157 (VTEC O157) isolated from cattle, sheep and pigs in Great Britain to selected antimicrobials in 2003

Antimicrobial	Cattle	Pig	Sheep
	No. isolates 133	No. isolates 13	No. isolates 38
	%R	%R	%R
Amikacin (30µg)	0	0	0
Amoxicillin/ clavulanic acid (30µg)	0	0	0
Ampicillin (10µg)	1	8	0
Apramycin (15µg)	0	15	0
Cefoperazone (30µg)	0	0	0
Ceftazidime (30µg)	0	0	0
Chloramphenicol (10µg)	0	0	0
Colistin (25µg)	0	0	0
Furazolidone (15µg)	0	0	0
Gentamicin (10µg)	0	0	0
Nalidixic Acid (30µg)	0	0	0
Neomycin (10µg)	0	0	0
Streptomycin (25µg)	4	23	0
Sulphonamides (300µg)	6	31	0
Tetracyclines (10µg)	6	46	0
Trimethoprim/sulphonamides (25µg)	0	8	0

LISTERIA MONOCYTOGENES

L. monocytogenes can be detected in the faeces of healthy humans and animals and is also widely distributed in the environment and especially in sites with decaying vegetable matter. It can under certain circumstances infect humans and animals, resulting in a range of clinical diseases including abortion in pregnant animals, ocular infections and encephalitis or meningoencephalitis. The principal reservoir for human infections is unclear. Infections in ruminant animals are often associated with feeding poorly fermented silage, which has been contaminated with soil.

Humans

- Antimicrobial resistance continues to be extremely rare in *L. monocytogenes.*

United Kingdom

All 77 isolates tested were found to be susceptible to ampicillin/amoxicillin. Some of these isolates were also tested against erythromycin, tetracycline, vancomycin and teicoplanin. Of the 39 isolates tested against tetracyclines, one was resistant. Resistance to the other antimicrobials was not seen.

Animals

- All veterinary isolates of *L. monocytogenes* were susceptible to penicillin and / or ampicillin.

England and Wales

The antimicrobial susceptibility of 29 *L. monocytogenes* isolates from sheep (n=19) and cattle (n=10) has been determined. These isolates originated from samples referred to VLA Regional Laboratories as part of investigations into outbreaks of clinical disease in domestic animals; many of these isolates will have originated from animals already undergoing antimicrobial treatment. The panel of antimicrobials tested included penicillin, ampicillin, amoxicillin/ clavulanate and tetracyclines. Twenty eight isolates were tested against all of these antimicrobials using a disc diffusion method and no resistance was detected. The disc diffusion method used was that currently described by the British Society for Antimicrobial Chemotherapy, though historical veterinary breakpoint criteria were applied. A variable number of the available isolates from sheep and cattle were tested for susceptibility to florfenicol, erythromycin, tylosin, trimethoprim/sulphonamides and cephalexin. The isolates were fully susceptible to all compounds tested, except cephalexin, where 32% of isolates from sheep and cattle were resistant. This resistance is not unexpected, because *L. monocytogenes* is innately resistant to cephalosporins.

Scotland

Three cattle and ten sheep *L. monocytogenes* isolates were tested in Scotland in 2004 for antimicrobial susceptibility. All isolates were susceptible to penicillin and ampicillin, though one apparently ampicillin susceptible isolate was resistant to amoxicillin/clavulanate and this is an anomalous result. All isolates were susceptible to neomycin, enrofloxacin and tylosin, though a single isolate of 12 tested was resistant to tilimicosin. A single sheep isolate was resistant to tetracyclines, whilst resistance to sulphonamides was 58%, for combined cattle and sheep isolates (n=12 tested). A single cattle isolate was also resistant to trimethoprim/sulphonamides. 23% of all isolates tested were resistant to cephalexin, again reflecting the innate resistance of *L. monocytogenes* to cephalosporins.

Northern Ireland

Four *L. monocytogenes* isolates were reported from Northern Ireland - all derived from clinical submissions to the VSD (DARD) disease surveillance and investigation service and all originated from cases of encephalitis or septicaemia in sheep. All four isolates were tested for susceptibility to amoxicillin, amoxicillin/clavulanate, trimethoprim/sulphonamides, tetracyclines and erythromycin. All isolates were fully susceptible apart from one isolate, which was resistant to erythromycin. Single isolates were tested for enrofloxacin and neomycin susceptibility and proved susceptible.

MYCOBACTERIUM TUBERCULOSIS AND MYCOBACTERIUM BOVIS

Humans

- The prevalence of TB is increasing in humans in the UK, with disease concentrated among population sub-groups in major urban centres.
- More than 99% of TB in humans in England and Wales is due to *M. tuberculosis*, with *M. bovis* accounting for 0.3%.
- 8.5% of isolates were resistant to one or more first-line drugs and 1.1% were multi-resistant.
- 2% of isolates from Northern Ireland were multi-resistant.

England and Wales

The prevalence of TB in England and Wales has increased annually since 1988. The overall incidence in 2003 was 12.8 per 100,000 population with disease concentrated among certain population sub-groups and in major urban centres. In London, rates of TB have doubled over the last 10 years and in 2003 the capital accounted for 45% of reported cases and had the highest prevalence (41.3 per 100,000 population). Data on the prevalence of TB in England and Wales have previously been summarised (Anon 2005c, 2005d). Most TB in the UK is not animal-associated. *M. bovis* only accounted for 0.3% of human isolates in 2004.

The emergence of drug resistance is a threat to the control of TB. While TB patients with susceptible strains are effectively treated with standard four-drug regimens, patients with drug resistant disease, especially multi-drug resistance (MDR, resistance to at least isoniazid and rifampicin), may be more difficult to treat and less likely to be cured. The MycobNet, established in 1994 to monitor drug resistance trends in newly diagnosed bacteriologically-confirmed cases of TB, collects data from a network of collaborating centres in England and Wales. Drug susceptibility data on new cases are supplemented with demographic and clinical information from the ETS data set at national level, through a computerised matching process based on patient identifiers common to both systems.

For the purposes of this report, the proportion of resistance is calculated among initial isolates with known drug susceptibility testing results reported from MycobNet. Further analysis on drug resistance, including drug susceptibility among reported cases is available in the ETS report for 2003 (Anon 2005c).

Isoniazid, rifampicin, ethambutol and pyrazinamide are considered first line drugs in the UK for treatment of *M. tuberculosis* complex (which includes *M. tuberculosis, M. africanum* and *M. bovis*). However *M. bovis* is known to be inherently resistant to pyrazinamide and so when calculating susceptibility to this agent *M. bovis* isolates are excluded. Streptomycin is not routinely included in drug sensitivity testing, and so is not included as a measure of first line resistance.

Susceptibility test results for both isoniazid and rifampicin were available for 4,801 (98%) of the 4,885 isolates of *M. tuberculosis* obtained from cases in England and Wales in 2004 (Table 28). Of these isolates, 408 (8.5%) were resistant to one or more of the first line drugs, 326 isolates (6.8%) were isoniazid resistant, and 52 (1.1%) were MDR. Compared to the previous year, resistance to one or more first line drugs increased (from 8.1% in 2003), while a decrease was seen in both isoniazid resistance (7.2% in 2003) and MDR (1.5% in 2003).

Table 28: First line drug resistance in initial isolates of *Mycobacterium tuberculosis*, England and Wales, 2004

Antimicrobial	Resistance		Monoresistance*	
	No. isolates	%R	No. isolates	%R
Ethambutol	4,801	0	4,816	0
Isoniazid	4,801	7	4,801	6
Pyrazinamide**	4,801	1	4,816	0
Rifampicin	4,801	3	4,801	1
At least one first line drug	4,801	9	4,816	7
More than one first line drug	4,801	1	-	-

Total number of isolates (with drug susceptibility testing results for isoniazid and rifampicin) = 4,829
*Without known resistance to others from the following group: isoniazid, rifampicin, ethambutol and pyrazinamide
**denominator = 4,816 (excluding 13 *M. bovis*)
Source: MycobNet as of 19/12/05

Three of the 8 *M. africanum* isolates reported had results for isoniazid and rifampicin susceptibility testing, all 3 being sensitive to both of these drugs and ethambutol. In 2004, 13 *M. bovis* isolates were identified and reported through MycobNet in England and Wales. One of these was isoniazid mono-resistant, and one was resistant to rifampicin only (Table 29).

Table 29: First line drug resistance in initial isolates of *Mycobacterium bovis*, England and Wales, 2004

Antimicrobial	Resistance		Mono-resistance*	
	No. isolates	%R	No. isolates	%R
Ethambutol	13	0	13	0
Isoniazid	13	8	13	8
Rifampicin	13	8	13	8
At least one first line drug	13	15	13	15
More than one first line drug	13	0	-	-

Total number of *M. bovis* isolates (with drug susceptibility testing results for isoniazid and rifampicin) = 13
*Without known resistance to others from the following group: isoniazid, rifampicin and ethambutol
Source: MycobNet as of 01/02/06

Scotland

The surveillance of TB in Scotland is based on the Enhanced Surveillance of Mycobacterial Infections (ESMI). The Mycobacteria Reference Laboratory carries out breakpoint sensitivity testing on all isolates. A summary of the 2004 testing is in Table 30.

Table 30: Resistance of *Mycobacterium tuberculosis* and *Mycobacterium bovis* to selected antimicrobials in 2004 in humans in Scotland

Antimicrobial	*M. tuberculosis*		*M. bovis*	
	Human sources		Human sources	
	No. isolates	%R	No. isolates	%R
Amikacin (2mg/L)	282	0	4	0
Ciprofloxacin (2mg/L)	282	0	4	0
Clarythromycin (4mg/L)	282	0	4	0
Ethambutol (2mg/L)	282	0	4	0
Isoniazid (0.1mg/L)	282	4	4	25
Pyrazinamide (100mg/L)	282	1	4	100
Rifabutin (0.2mg/L)	282	0	4	0
Rifampicin (2mg/L)	282	0	4	0
Streptomycin (2mg/L)	282	2	4	0

Northern Ireland

Susceptibility test results for both isoniazid and rifampicin were available for 63 (98%) of the 64 *M. tuberculosis* isolates obtained from cases in Northern Ireland in 2004 (Table 31). Three were mono-resistant (1 to isoniazid, and 2 to pyrazinamide), and 1 isolate was MDR. Two *M. bovis* isolates were reported by Northern Ireland in 2004, which were susceptible to isoniazid, rifampicin and ethambutol.

Table 31: First line drug resistance in initial isolates of *Mycobacterium tuberculosis*, Northern Ireland, 2004

Antimicrobial	Resistance		Mono-resistance*	
	No. isolates	%R	No. isolates	%R
Ethambutol	63	0	63	0
Isoniazid	63	3	63	2
Rifampicin	63	2	63	0
Pyrazinamide	63	3	63	3
At least one first line drug	63	6	63	5
More than one first line drug	63	2	-	-

Total number of *M. tuberculosis* isolates (with drug susceptibility testing results for isoniazid and rifampicin) = 63
*Without known resistance to others from the following group: isoniazid, rifampicin and ethambutol
Source: MycobNet as of 01/02/06

Animals

- In the UK in 2004, bovine TB in cattle was controlled by a programme of statutory testing followed by slaughter of positive animals.

United Kingdom

In the UK in 2004, bovine TB in cattle was controlled by a programme of statutory testing followed by slaughter of positive animals. Similar rules were applied to farmed deer. It was illegal to treat for the presence of either the bacterium or the disease and so *M. bovis* isolates were not tested for their sensitivity to antimicrobials.

Bovine TB can affect cats and dogs, but the apparent incidence is low. Any *M. bovis* strains isolated from cases in companion animals are held at the VLA, but similarly to the isolates from farmed animals, they are not typed according to their resistance to antimicrobials. It is not illegal to treat cases of *M. bovis* in companion animals.

SALMONELLA

The 10 most frequently confirmed *Salmonella* serotypes isolates from humans in the UK in 2004 are summarised in Table 32. These can be compared with the 10 most frequent *Salmonella* serotypes isolated from livestock incidents in the UK in 2004 Table 33. These data are taken from the UK Zoonoses Report: 2004 (Anon 2004).

Table 32: The 10 most frequently confirmed *Salmonella* serotypes isolates from humans in the UK in 2004 in descending order

Humans England and Wales	Humans Scotland	Humans Northern Ireland
S. Enteritidis	*S*. Enteritidis	*S*. Typhimurium
S. Typhimurium	*S*. Typhimurium	*S*. Newport
S. Newport	*S*. Newport	*S*. Enteritidis
S. Virchow	*S*. Virchow	*S*. Virchow
S. Stanley	*S*. Hadar	*S*. Dublin
S. Braenderup	*S*. Montevideo	*S*. Infantis
S. Hadar	*S*. Braenderup	*S*. Ohio
S. Agona	*S*. Agona	*S*. Braenderup
S. Infantis	*S*. Java	*S*. Kottbus
S.Thompson	*S*. Infantis	*S*. Montevideo

Table 33: The 10 most frequently isolated *Salmonella* serotypes in incidents and livestock infection in the UK in 2004 in descending order

Cattle UK		Sheep UK		Chicken UK		Pig UK	
Serotype	%	Serotype	%	Serotype	%	Serotype	%
S. Dublin	81	*S*. Enterica Diarizonae	66	*S*. Livingstone	21	*S*. Typhimurium	64
S. Typhimurium	12	*S*. Montevideo	13	*S*. Senftenberg	11	*S*. Derby	17
S. Anatum	3	*S*. Dublin	8	*S*. Liverpool	6	*S*. Reading	4
S. Montevideo	1	*S*. Typhimurium	4	*S*. Kedougou	5	*S*. Goldcoast	3
S. Agama	1	*S*. Derby	4	*S*. Ohio	4	*S*. Kedougou	3
S. Vejle	1	*S*. Agama	2	*S*. Thompson	4	*S*. London	2
S. Agona	1	*S*. Newport	1	*S*. Virchow	4	*S*. Give	2
S. Schwarzengrund	1	*S*. Indiana	1	*S*. Give	4	*S*. Dublin	1
S. Newport	1	*S*. Ajiobo	1	*S*. Mbandaka	4	*S*. Infantis	1
S. London	1	*S*. Anatum	1	*S*. Brandenburg	3	*S*. Brandenburg	<1

Humans

- *S.* Enteritidis is the most common serovar in cases of human infection in England and Wales, and Scotland, with *S.* Typhimurium the most common serovar in Northern Ireland.

- *S*. Typhimurium is the second most common serovar in cases of human infection in England and Wales, and Scotland.

- Resistance to more than one drug is common in *S*. Typhimurium.

- Resistance to nalidixic acid is very common in *S.* Enteritidis, particularly phage type 1.

England and Wales

All salmonellae isolated from cases of human infection are submitted to the HPA Laboratory of Enteric Pathogens for full identification and susceptibility testing. A small number were from asymptomatic infections in contacts of cases. There were 13,119 laboratory-confirmed cases of salmonellas in England and Wales in 2004. Antimicrobial susceptibility testing was subjected to internal quality assurance (QA) in accordance with the published methods, and to external QA in collaboration with laboratories within the EU Enter-Net Group. The antimicrobials to which isolates were resistant are summarised in Table 34.

Scotland

The surveillance of *Salmonella* in Scotland is based on laboratory reports of human and animal isolates to HPS from the SSRL. Isolates from routine diagnostic and veterinary laboratories are sent to SSRL for confirmation and typing. Data presented in Table 35 include reports from all sites of isolation including faeces, blood, urine etc. Breakpoint sensitivity testing is the method of choice for resistance typing. This involves the antimicrobials being dissolved in agar and poured into Petri-plates. Suspensions of *Salmonella* are inoculated onto the surface of the plates and the presence of vegetative growth following incubation is taken to indicate resistance to the antimicrobial at this concentration.

Northern Ireland

Isolates from patients in Northern Ireland are referred to the HPA laboratory of enteric pathogens for identification and typing, and for determination of antimicrobial resistance. The methods used are identical to those for isolates from patients in England and Wales. Data summarising the isolates of salmonellae in humans from Northern Ireland are in Table 36.

Table 34: Antimicrobial resistance of salmonellae causing human infection in 2004 in England and Wales

Human	*S*. Enteritidis	*S*. Enteritidis PT1	*S*. Enteritidis PT4	*S*. Typhimurium	*S*. Typhimurium DT104
Antimicrobial	No. isolates 8,549	No. isolates 1,968	No.isolates 2,385	No. isolates 1,687	No. isolates 509
	%R	%R	%R	%R	%R
Ampicillin (8mg/L)	8	1	1	44	66
Chloramphenicol (8mg/L)	0	0	0	34	62
Furazolidone (8mg/L)	0	0	0	3	0
Gentamicin (4mg/L)	0	0	0	3	0
Kanamycin (16mg/L)	0	0	0	4	0
Nalidixic acid/Ciprofloxacin $_{(L)}$ (0.125mg/L)	26	76	0	10	13
Streptomycin (16mg/L)	<3	1	1	56	87
Sulphonamide (64mg/L)	<2	1	1	62	90
Tetracycline (8mg/L)	4	0	1	54	64
Trimethoprim (2mg/L)	2	1	1	19	11

PT = Phage Type

Table 35: Antimicrobial resistance of salmonellae causing human infection in 2004 in Scotland

Human	*S*. Enteritidis	*S*. Enteritidis PT1	*S*. Enteritidis PT4	*S*. Newport	*S*. Typhimurium	*S*. Typhimurium DT104
Antimicrobial	No. isolates 607	No. isolates 160	No. isolates 155	No. isolates 35	No. isolates 214	No. isolates 79
	% R	%R	%R	%R	%R	%R
Ampicillin (50mg/L)	5	4	0	0	51	68
Cefotaxime (1mg/L)	0	0	0	0	1	0
Chloramphenicol (20mg/L)	1	0	0	0	35	65
Ciprofloxacin (0.5mg/L)	3	1	4	0	1	0
Furazolidone (20mg/L)	0	0	0	0	3	0
Gentamicin (20mg/L)	0	0	1	0	3	0
Kanamicin (20mg/L)	0	1	0	0	1	1
Nalidixic acid (40mg/L)	31	69	10	0	9	17
Netilmicin (20mg/L)	0	0	0	0	1	0
Spectinomycin (100mg/L)	2	0	2	0	49	96
Streptomycin (20mg/L)	2	0	1	0	56	96
Sulphonamide (100mg/L)	4	2	3	3	63	100
Tetracycline (10mg/L)	4	3	2	3	51	65
Trimethoprim (2mg/L)	3	2	2	0	14	10
Ciprofloxacin $_{(L)}$ (0.125mg/L)	31	70	11	0	9	17

PT = Phage Type

Table 36: Antimicrobial resistance of salmonellae causing human infection in 2004 in Northern Ireland

Human	*S.* Enteritidis	*S.* Enteritidis PT1	*S.* Enteritidis PT4	*S.* Typhimurium	*S.* Typhimurium DT104
Antimicrobial	No. isolates 111	No. isolates 33	No. isolates 19	No. isolates 160	No. isolates 130
	%R	%R	%R	%R	%R
Ampicillin (8mg/L)	5	0	0	10	6
Chloramphenicol (8mg/L)	0	0	0	1	4
Furazolidone (8mg/L)	0	0	0	0	0
Gentamicin (4mg/L)	0	0	0	0	0
Kanamycin (16mg/L)	0	0	0	1	0
Nalidixic acid/Ciprofloxacin $_{(L)}$ (0.125mg/L)	24	48	9	2	1
Streptomycin (16mg/L)	5	0	0	85	98
Sulphonamide (64mg/L)	5	0	0	86	98
Tetracycline (8mg/L)	7	3	0	10	38
Trimethoprim (2mg/L)	3	0	0	1	0

PT = Phage Type

Animals

- There was no resistance detected to amikacin, cefotaxime, ceftazidime or ciprofloxacin in *Salmonella* isolates of animal origin from England and Wales. Similarly, no resistance was detected to cefotaxime or ciprofloxacin in animal *Salmonella* isolates from Northern Ireland or Scotland.

England and Wales

The VLA *Salmonella* surveillance programme covers England and Wales and captures susceptibility data from *Salmonella* incidents reported under statute (the Zoonoses Order 1989); isolates may originate from healthy or diseased animals. A new incident of *Salmonella* is defined as the first occurrence of a given serotype (or phage type) of *Salmonella* at a premises during a three-month period. Only the first *Salmonella* isolate from each new incident is subjected to susceptibility testing and this avoids bias that might occur in relation to the intensity of sampling at a given location, if all isolates were tested. The susceptibility testing of *Salmonella* isolates was performed using a disc diffusion method; the disc concentrations used are as stated in the tabled results. Results of the surveillance are published annually by Defra (Anon 2005a). Summaries of the results for cattle, pigs, sheep, chickens and turkeys are given in Tables 37, 38, 39, 40 and 41 respectively.

Scotland

These results relate to isolates sent to the SSRL, including those reported under the Zoonoses Order 1989; isolates may originate from healthy or diseased animals. Results of the surveillance are published annually by SEERAD (Anon 2005b). Summaries of the results for cattle, pigs, sheep and chickens are given in Tables 42, 43, 44 and 45 respectively.

Northern Ireland

The information on antimicrobial resistance in *Salmonella* isolates from animals in Northern Ireland is derived from a combination of surveillance activities. Isolates from cattle and sheep are almost entirely from clinical diagnostic submissions to the VSD disease surveillance and investigation service, while the information for farmed poultry and pigs also includes isolates from targeted surveillance work such as statutory and industry surveillance programmes. Tests were carried out using disc-diffusion methods performed to CLSI standards and interpretation criteria. For the antimicrobials furazolidone, framycetin, apramycin, and spectinomycin, for which no CLSI criteria existed, in-house breakpoints were used to classify isolates as resistant or sensitive. Summaries of the results for cattle, pigs, sheep, chickens and pigeons are given in Tables 46, 47, 48, 49 and 50 respectively.

Food

The Salmonellae are a diverse group of organisms capable of infecting mammals, birds, fish and reptiles. Investigations have shown that *Salmonella* can be acquired through the consumption of a variety of contaminated foods of animal or plant origin. These foods may be contaminated at source or during production and handling through the food chain. Epidemiological and microbiological studies have shown that poultry is the main source of *S*. Enteritidis and *S*. Typhimurium.

Retail Chicken

Data were summarised from a UK wide Survey of *Salmonella* and *Campylobacter* Contamination of Fresh and Frozen Chicken on Retail Sale (FSA 2003) and are presented in Table 51. The survey was undertaken in April and May 2001 and involved testing 4,866 samples of fresh, frozen, whole and portioned chicken purchased from over 1,500 retail outlets throughout the UK.

All *Salmonella* isolates obtained during this survey were subjected to antimicrobial resistance testing at the HPA's Laboratory of Enteric Pathogens.

A twelve month FSA study in partnership with the Local Authorities from Wales and Northern Ireland was carried out to produce an estimate of the *Salmonella* contamination of raw whole chickens available to consumers through retail outlets in Wales and Northern Ireland in 2004. A summary of the results is provided in Table 52.

Table 37: Resistance of salmonellae in cattle to selected antimicrobials in 2004 in England and Wales

Cattle	*S.* Dublin	*S.* Agama	*S.* Anatum	*S.* Enteritidis	*S.* Typhimurium	*S.* Typhimurium DT104	*S.* Typhimurium U302	*S.* Typhimurium DT 195
Antimicrobial	No. isolates 479	No. isolates 16	No. isolates 14	No. isolates 7	No. isolates 90	No. isolates 44	No. isolates 7	No. isolates 6
	%R	%R	%R	%R	%R	%R	%R	%R
Amikacin (30µg)	0	0	0	0	0	0	0	0
Amoxicillin/Clavulanic acid (30µg)	0	0	0	0	0	0	0	0
Ampicillin (10µg)	0	0	0	0	69	82	100	0
Apramycin (15µg)	0	0	0	0	0	0	0	0
Ceftazidime (30µg)	0	0	0	0	0	0	0	0
Cefotaxime (30µg)	0	0	0	0	0	0	0	0
Chloramphenicol (10µg)	0	0	0	0	62	82	100	0
Ciprofloxacin (1µg)	0	0	0	0	0	0	0	0
Furazolidone (15µg)	0	0	0	0	0	0	0	0
Gentamicin (10µg)	0	0	0	0	0	0	0	0
Nalidixic acid (30µg)	0	0	0	0	1	0	0	0
Neomycin (10µg)	0	0	0	0	0	0	0	0
Streptomycin (25µg)	1	0	0	0	68	93	86	0
Sulphonamide (300µg)	0	0	0	0	76	93	100	0
Sulphonamide/trimethoprim (25µg)	0	0	0	0	30	34	43	0
Tetracycline (10µg)	0	0	0	0	84	86	100	0

Table 38: Resistance of salmonellae in pigs to selected antimicrobials in 2004 in England and Wales

Pig	*S.* Derby	*S.* Gold coast	*S.* Kedougou	*S.* Enteritidis	*S.* Typhimurium	*S.* Typhimurium U288	*S.* Typhimurium DT 193	*S.* Typhimurium DT 104
Antimicrobial	No. isolates 24	No. isolates 12	No. isolates 6	No. isolates 0	No. isolates 147	No. isolates 71	No. isolates 19	No. isolates 10
	%R	%R	%R	%R	%R	%R	%R	%R
Amikacin (30µg)	0	0	0	-	0	0	0	0
Amoxicillin/Clavulanic acid (30µg)	0	0	0	-	1	3	0	0
Ampicillin (10µg)	0	0	0	-	82	92	79	100
Apramycin (15µg)	8	0	0	-	4	6	5	0
Ceftazidime (30µg)	0	0	0	-	0	0	0	0
Cefotaxime (30µg)	0	0	0	-	0	0	0	0
Chloramphenicol (10µg)	4	0	0	-	71	93	58	70
Ciprofloxacin (1µg)	0	0	0	-	0	0	0	0
Furazolidone (15µg)	0	0	0	-	2	0	5	0
Gentamicin (10µg)	8	0	0	-	3	4	5	0
Nalidixic acid (30µg)	8	0	0	-	4	1	5	10
Neomycin (10µg)	4	0	0	-	10	7	11	0
Streptomycin (25µg)	25	0	0	-	80	92	68	90
Sulphonamide (300µg)	42	17	50	-	90	97	95	90
Sulphonamide/trimethoprim (25µg)	21	17	33	-	72	97	79	10
Tetracycline (10µg)	100	0	50	-	93	94	89	100

Table 39: Resistance of salmonellae in sheep to selected antimicrobials in 2004 in England and Wales

Sheep	*S.* Diarizonae	61:-:1,5,7*	*S.* Dublin	*S.* Enteritidis	*S.* Typhimurium	*S.* Typhimurium U288	*S.* Typhimurium DT 104	*S.* Typhimurium DT 193
Antimicrobial	No. isolates 124	No. isolates 44	No. isolates 15	No. isolates 0	No. isolates 7	No. isolates 2	No. isolates 2	No. isolates 1
	%R	%R	%R	%R	%R	%R	%R	%R
Amikacin (30µg)	0	0	0	-	0	0	0	0
Amoxicillin/Clavulanic acid (30µg)	0	0	0	-	0	0	0	0
Ampicillin (10µg)	1	0	0	-	71	100	100	100
Apramycin (15µg)	0	0	0	-	0	0	0	0
Ceftazidime (30µg)	0	0	0	-	0	0	0	0
Cefotaxime (30µg)	0	0	0	-	0	0	0	0
Chloramphenicol (10µg)	0	0	0	-	71	100	100	100
Ciprofloxacin (1µg)	0	0	0	-	0	0	0	0
Furazolidone (15µg)	0	0	0	-	0	0	0	0
Gentamicin (10µg)	0	0	0	-	0	0	0	0
Nalidixic acid (30µg)	0	0	0	-	0	0	0	0
Neomycin (10µg)	0	0	0	-	0	0	0	0
Streptomycin (25µg)	0	2	0	-	71	100	100	100
Sulphonamide (300µg)	1	0	0	-	86	100	100	100
Sulphonamide/trimethoprim (25µg)	0	0	0	-	0	100	50	0
Tetracycline (10µg)	0	0	0	-	86	100	100	100

*i.e Salmonella enterica subspecies diarizonae serovar 61:k:1,5,7 (and associated incomplete antigenic structures).

Table 40: Resistance of salmonellae in chickens to selected antimicrobials in 2004 in England and Wales

Chicken	*S*. Livingstone	*S*. Senftenberg	67:-:-*	*S*. Enteritidis	*S*. Typhimurium	*S*. Typhimurium DT104	*S*. Typhimurium DT 120	*S*. Typhimurium DT 193
Antimicrobial	No. isolates 289	No. isolates 128	No. isolates 75	No. isolates 13	No. isolates 11	No. isolates 6	No. isolates 1	No. isolates 1
	%R	%R	%R	%R	%R	%R	%R	%R
Amikacin (30µg)	0	0	0	0	0	0	0	0
Amoxicillin/Clavulanic acid (30µg)	0	0	0	0	0	0	0	0
Ampicillin (10µg)	1	0	3	0	45	67	100	0
Apramycin (15µg)	0	0	0	0	0	0	0	0
Ceftazidime (30µg)	0	0	0	0	0	0	0	0
Cefotaxime (30µg)	0	0	0	0	0	0	0	0
Chloramphenicol (10µg)	2	2	3	8	45	67	100	0
Ciprofloxacin (1µg)	0	0	0	0	0	0	0	0
Furazolidone (15µg)	0	0	0	0	0	0	0	0
Gentamicin (10µg)	0	0	0	0	0	0	0	0
Nalidixic acid (30µg)	0	3	0	0	0	0	0	0
Neomycin (10µg)	0	0	0	0	0	0	0	0
Streptomycin (25µg)	1	0	9	8	64	100	100	0
Sulphonamide (300µg)	3	2	37	8	64	100	100	0
Sulphonamide/trimethoprim (25µg)	2	2	29	0	0	0	0	0
Tetracycline (10µg)	1	0.8	4	8	55	67	100	100

* A Salmonella isolate with the antigenic structure 67:-:- and for which there is no serovar name, because the antigenic structure is incomplete.

Table 41: Resistance of salmonellae in turkeys to selected antimicrobials in 2004 in England and Wales

Turkey	*S*. Kottbus	*S*. Newport	*S*. Enteritidis	*S*. Typhimurium	*S*. Typhimurium DT 104	*S*. Typhimurium DT120	*S*. Typhimurium DT 56
Antimicrobial	No. isolates 55	No. isolates 53	No. isolates 1	No. isolates 55	No. isolates 39	No. isolates 2	No. isolates 1
	%R	%R	%R	%R	%R	%R	%R
Amikacin (30µg)	0	0	0	0	-	0	0
Amoxicillin/Clavulanic acid (30µg)	0	0	0	0	-	0	0
Ampicillin (10µg)	0	9	0	80	100	0	0
Apramycin (15µg)	0	0	0	0	-	0	0
Ceftazidime (30µg)	0	0	0	0	-	0	0
Cefotaxime (30µg)	0	0	0	0	-	0	0
Chloramphenicol (10µg)	0	4	0	62	77	0	0
Ciprofloxacin (1µg)	0	0	0	0	-	0	0
Furazolidone (15µg)	0	0	0	0	-	0	0
Gentamicin (10µg)	0	0	0	0	-	0	0
Nalidixic acid (30µg)	2	21	0	60	74	0	0
Neomycin (10µg)	-	0	0	0	-	0	0
Streptomycin (25µg)	2	6	0	64	77	0	0
Sulphonamide (300µg)	2	66	0	80	100	0	0
Sulphonamide/trimethoprim (25µg)	0	64	0	2	0	0	0
Tetracycline (10µg)	4	51	0	71	79	0	0

Table 42: Resistance of salmonellae in cattle to selected antimicrobials in 2004 in Scotland

Cattle	*S*. Dublin	*S*. Montevideo	*S*. Enteritidis	*S*. Typhimurium	*S*. Typhimurium DT104
Antimicrobial	No. isolates 179	No. isolates 16	No. isolates 0	No. isolates 39	No. isolates 20
	%R	%R	%R	%R	%R
Ampicillin (50mg/L)	0	0	0	62	100
Cefotaxime (1mg/L)	0	0	0	0	0
Chloramphenicol (20mg/L)	1	0	0	56	95
Ciprofloxacin (0.5mg/L)	2	0	0	0	0
Furazolidone (20mg/L)	0	0	0	0	0
Gentamicin (20mg/L)	0	0	0	5	0
Kanamicin (20mg/L)	0	0	0	5	0
Nalidixic acid (40mg/L)	2	0	0	5	10
Netilmicin (20mg/L)	0	0	0	3	0
Spectinomycin (100mg/L)	0	0	0	59	100
Streptomycin (20mg/L)	0	0	0	59	100
Sulphonamide (100mg/L)	0	0	0	62	100
Tetracycline (10mg/L)	0	0	0	74	100
Trimethoprim (2mg/L)	1	0	0	3	0
Ciprofloxacin $_{(L)}$ (0.125mg/L)	2	0	0	5	10

Table 43: Resistance of salmonellae in pigs to selected antimicrobials in 2004 in Scotland

Pig	*S*. Derby	*S*. Enteritidis	*S*. Typhimurium	*S*. Typhimurium DT208
Antimicrobial	No. isolates 4	No. isolates 0	No. isolates 12	No. isolates 8
	%R	%R	%R	%R
Ampicillin (50mg/L)	0	0	0	0
Cefotaxime (1mg/L)	0	0	0	0
Chloramphenicol (20mg/L)	0	0	0	0
Ciprofloxacin (0.5mg/L)	0	0	0	0
Furazolidone (20mg/L)	0	0	0	0
Gentamicin (20mg/L)	0	0	0	0
Kanamicin (20mg/L)	0	0	0	0
Nalidixic acid (40mg/L)	0	0	0	0
Netilmicin (20mg/L)	0	0	0	0
Spectinomycin (100mg/L)	25	0	0	0
Streptomycin (20mg/L)	25	0	0	0
Sulphonamide (100mg/L)	50	0	0	0
Tetracycline (10mg/L)	75	0	58	75
Trimethoprim (2mg/L)	50	0	0	0
Ciprofloxacin $_{(L)}$ (0.125mg/L)	0	0	0	0

Table 44: Resistance of salmonellae in sheep to selected antimicrobials in 2004 in Scotland

Sheep	*S*. Montevideo	*S*. Diarizonae	*S*. Enteritidis
Antimicrobial	No. isolates 28	No. isolates 7	No. isolates 0
	%R	%R	%R
Ampicillin (50mg/L)	0	0	0
Cefotaxime (1mg/L)	0	0	0
Chloramphenicol (20mg/L)	0	0	0
Ciprofloxacin (0.5mg/L)	0	0	0
Furazolidone (20mg/L)	0	0	0
Gentamicin (20mg/L)	0	0	0
Kanamicin 20(mg/L)	0	0	0
Nalidixic acid (40mg/L)	0	0	0
Netilmicin (20mg/L)	0	0	0
Spectinomycin (20mg/L)	0	0	0
Streptomycin (20mg/L)	0	0	0
Sulphonamide (100mg/L)	4	0	0
Tetracycline (10mg/L)	0	0	0
Trimethoprim (2mg/L)	4	0	0
Ciprofloxacin $_{(L)}$ (0.125mg/L)	0	0	0

Table 45: Resistance of salmonellae in chickens and the chicken environment (e.g. litter) to selected antimicrobials in 2004 in Scotland

Chicken and the chicken environment	GpC4 (non motile)	*S.* Liverpool	*S.* Thomson	*S.* Typhimurium	*S.* Enteritidis
Antimicrobial	No. isolates 141	No. isolates 87	No. isolates 83	No. isolates 3	No. isolates 1
	%R	%R	%R	%R	%R
Ampicillin (50mg/L)	1	8	18	67	0
Cefotaxime (1mg/L)	0	0	0	0	0
Chloramphenicol (20mg/L)	1	0	6.0	67	0
Ciprofloxacin (0.5mg/L)	0	0	2	0	0
Furazolidone (20mg/L)	0	0	0	0	0
Gentamicin (20mg/L)	0	0	0	0	0
Kanamicin (20mg/L)	0	0	0	0	0
Nalidixic acid (40mg/L)	0	0	27	0	0
Netilmicin (20mg/L)	0	0	0	0	0
Spectinomycin (100mg/L)	2	10	10	67	0
Streptomycin (20mg/L)	2	10	7	67	0
Sulphonamide (100mg/L)	6	51	92	67	0
Tetracycline (10mg/L)	1	9	0	100	0
Trimethoprim (2mg/L)	6	51	92	0	0
Ciprofloxacin $_{(L)}$ (0.125mg/L)	0	0	28	0	0

Table 46: Resistance of salmonellae in cattle to selected antimicrobials in 2004 in Northern Ireland

Cattle	*S*. Dublin	*S*. Enteritidis	*S*. Typhimurium	*S*. Typhimurium 104b	*S*. Typhimurium 104	*S*. Typhimurium 193	Other Serotypes
Antimicrobial	No. isolates 295	No isolates 0	No. isolates 12	No. isolates 4	No. isolates 1	No. isolates 1	No. isolates 6
	%R	%R	%R	%R	%R	%R	%R
Amoxicillin/Clavulanic acid (30µg)	0	-	0	0	0	0	0
Ampicillin (10µg)	0	-	58	75	100	100	0
Apramycin (15µg)	0	-	0	0	0	0	0
Cefotaxime (30µg)	0	-	0	0	0	0	0
Chloramphenicol (30µg)	0	-	58	75	0	100	0
Ciprofloxacin (5µg)	0	-	0	0	0	0	0
Framycetin (100µg)	0	-	0	0	0	0	0
Furazolidone (50µg)	0	-	0	0	0	0	0
Gentamicin (10µg)	0	-	0	0	0	0	0
Kanamycin (30µg)	0	-	0	0	0	0	0
Nalidixic acid (30µg)	1	-	8	25	0	0	0
Spectinomycin (100µg)	0	-	83	100	0	0	0
Streptomycin (10µg)	15	-	75	100	100	100	0
Sulphonamides (300µg)	0	-	75	100	0	100	0
Tetracycline (30µg)	0	-	58	50	100	100	0
Trimethoprim (5µg)	0	-	50	50	0	100	0

Table 47: Resistance of salmonellae in pigs to selected antimicrobials in 2004 in Northern Ireland

Pig	*S*. Typhimurium	*S*. Typhimurium 104b	*S*. Typhimurium 104	*S*. Typhimurium 193	*S*. Derby	Other Serotypes
Antimicrobial	No. isolates 20	No. isolates 7	No. isolates 3	No. isolates 2	No. isolates 3	No. isolates 5
	%R	%R	%R	%R	%R	%R
Amoxicillin/Clavulanic acid (30µg)	5	0	0	0	0	0
Ampicillin (10µg)	70	57	100	100	0	20
Apramycin (15µg)	0	0	0	0	0	0
Cefotaxime (30µg)	0	0	0	0	0	0
Chloramphenicol (30µg)	65	57	100	50	0	0
Ciprofloxacin (5µg)	0	0	0	0	0	0
Framycetin (100µg)	0	0	0	0	0	0
Furazolidone (50µg)	0	0	0	0	0	0
Gentamicin (10µg)	0	0	0	0	0	0
Kanamycin (30µg)	5	14	0	0	0	0
Nalidixic acid (30µg)	0	0	0	0	33	20
Spectinomycin (100µg)	70	57	100	50	0	0
Streptomycin (10µg)	55	57	100	50	0	40
Sulphonamides (300µg)	70	57	100	100	33	60
Tetracycline (30µg)	70	57	67	100	67	60
Trimethoprim (5µg)	20	0	0	100	33	60

Table 48: Resistance of salmonellae in sheep to selected antimicrobials in 2004 in Northern Ireland

Sheep	*S.* Dublin	*S.* Enteritidis	*S.* Typhimurium	*S.* Typhimurium U312
Antimicrobial	No. isolates 6	No. isolates 0	No. isolates 1	No. isolates 1
	%R	%R	%R	%R
Amoxicillin/Clavulanic acid (30µg)	0	-	0	0
Ampicillin (10µg)	0	-	0	0
Apramycin (15µg)	0	-	0	0
Cefotaxime (30µg)	0	-	0	0
Chloramphenicol (30µg)	0	-	0	0
Ciprofloxacin (5µg)	0	-	0	0
Framycetin (100µg)	0	-	0	0
Furazolidone (50µg)	0	-	0	0
Gentamicin (10µg)	0	-	0	0
Kanamycin (30µg)	0	-	0	0
Nalidixic acid (30µg)	0	-	0	0
Spectinomycin (100µg)	0	-	0	0
Streptomycin (10µg)	17	-	0	0
Sulphonamides (300µg)	0	-	0	0
Tetracycline (30µg)	0	-	100	100
Trimethoprim (5µg)	0	-	0	0

Table 49: Resistance of salmonellae in chickens to selected antimicrobials in 2004 in Northern Ireland

Chicken	*S*. Mbandaka	*S*. Typhimurium	*S*. Typhimurium DT 104	*S*. Enteritidis	*S*. Enteritidis PT4	Other Serotypes
Antimicrobial	No. isolates 8	No. isolates 1	No. isolates 1	No. isolates 2	No. isolates 2	No. isolates 9
	%R	%R	%R	%R	%R	%R
Amoxicillin/Clavulanic acid (30µg)	0	0	0	0	0	0
Ampicillin (10µg)	0	0	0	0	0	0
Apramycin (15µg)	0	0	0	0	0	0
Cefotaxime (30µg)	0	0	0	0	0	0
Chloramphenicol (30µg)	0	0	0	0	0	0
Ciprofloxacin (5µg)	0	0	0	0	0	0
Framycetin (100µg)	0	0	0	0	0	0
Furazolidone (50µg)	0	0	0	0	0	0
Gentamicin (10µg)	0	0	0	0	0	0
Kanamycin (30µg)	0	0	0	0	0	0
Nalidixic acid (30µg)	0	0	0	0	0	0
Spectinomycin (100µg)	0	0	0	0	0	0
Streptomycin (10µg)	0	100	100	0	0	33
Sulphonamides (300µg)	0	100	100	0	0	0
Tetracycline (30µg)	0	0	0	0	0	0
Trimethoprim (5µg)	0	0	0	0	0	0

PT = Phage Type

Table 50: Resistance of salmonellae in pigeons to selected antimicrobials in 2004 in Northern Ireland

Pigeon	*S.* Enteritidis	*S.* Typhimurium	*S.* Typhimurium PT2
Antimicrobial	No. isolates 0	No. isolates 3	No. isolates 3
	%R	%R	%R
Amoxicillin/Clavulanic acid (30µg)	-	0	0
Ampicillin (10µg)	-	0	0
Apramycin (15µg)	-	0	0
Cefotaxime (30µg)	-	0	0
Chloramphenicol (30µg)	-	0	0
Ciprofloxacin (5µg)	-	0	0
Framycetin (100µg)	-	0	0
Furazolidone (50µg)	-	0	0
Gentamicin (10µg)	-	0	0
Kanamycin (30µg)	-	0	0
Nalidixic acid (30µg)	-	0	0
Spectinomycin (100µg)	-	0	0
Streptomycin (10µg)	-	100	100
Sulphonamides (300µg)	-	0	0
Tetracycline (30µg)	-	0	0
Trimethoprim (5µg)	-	0	0

PT = Phage Type

Table 51: Antimicrobial resistance of salmonellae isolates from retail sourced raw chicken in the UK in April and May 2001

Antimicrobial	*S.* Typhimurium	*S.* Typhimurium DT104	*S.* Heidelberg	*S.* Infantis	*S.* Enteritidis	*S.* Enteritidis PT4	*S.* Java PT Dundee Var.1
	No. isolates 38	No. isolates 28	No. isolates 34	No. isolates 21	No. isolates 20	No. isolates 10	No. isolates 10
	%R	%R	%R	%R	%R	%R	%R
Ampicillin (8mg/L)	95	93	47	10	10	0	60
Chloramphenicol (8mg/L)	92	89	6	0	0	0	0
Ciprofloxacin (0.125mg/L)	0	0	0	5	10	10	20
Colistinmethate (8mg/L)	3	4	0	0	0	0	0
Furazolidone (8mg/L)	0	0	0	24	0	0	100
Kanamycin (16mg/L)	3	0	0	0	0	0	0
Nalidixic acid (16mg/L)	0	0	0	5	10	10	20
Neomycin (4mg/L)	3	4	0	0	0	0	0
Spectinomycin (64mg/L)	100	100	3	10	0	0	100
Streptomycin (16mg/L)	100	100	12	14	0	0	100
Sulphonamides (64mg/L)	100	100	24	19	0	0	40
Tetracycline (8mg/L)	95	93	12	5	0	0	10
Trimethoprim (2mg/L)	13	14	24	10	0	0	100

PT = Phage Type

Table 52: Antimicrobial resistance of salmonellae isolates from retail sourced raw chicken in Wales in 2004

Antimicrobial	*S*. Typhimurium*	*S*. Kentucky	*S*. Indiana	*S*. unnamed I4, 12:d:-
	No. isolates 4	No. isolates 5	No. isolates 5	No. isolates 5
	%R	%R	%R	%R
Ampicillin (8mg/L)	75	0	0	0
Chloramphenicol (8 mg/L)	50	0	0	0
Ciprofloxacin (0.125mg/L)	0	0	0	0
Colistinmethate (8mg/L)	0	0	0	0
Furazolidone (8mg/L)	0	0	20	67
Kanamycin (16mg/L)	0	0	0	0
Nalidixic acid (16mg/L)	0	0	0	0
Neomycin (4mg/L)	0	0	0	0
Spectinomycin (64mg/L)	75	20	20	0
Streptomycin (16mg/L)	75	20	20	0
Sulphonamides (64mg/L)	75	20	20	17
Tetracycline (8mg/L)	50	0	0	0
Trimethoprim (2mg/L)	0	20	20	17

* single isolates of phage types DT56, 104, 195 and unspecified type

STAPHYLOCOCCUS AUREUS

Humans

- The increase in meticillin resistance among *S. aureus* isolates from bacteraemia seen during the 1990's levelled off in 2004 with the proportion of isolates reported as resistant being 40%, 38%, 40%, and 46%, for England, Wales, Scotland and Northern Ireland respectively.
- There were no reports of a vancomycin or teicoplanin resistance.
- Resistance to ciprofloxacin and erythromycin was also common (42-56% and 33-47% respectively).
- Gentamicin remains active against the majority (>95%) of isolates.

United Kingdom

S. aureus is ubiquitous in humans, often colonising people with no untoward effects, but also causing a range of infections from boils and abscesses to severe life-threatening sepsis. Surveillance of *S. aureus* bacteraemia has become mandatory in most parts of the UK, as a result of rising incidences of MRSA bacteraemia in the 1990s. Mandatory surveillance data are published regularly. Table 53 shows that amongst *S. aureus* causing bacteraemia in 2004, 40% in England and 38% in Wales were resistant to meticillin. The proportion of *S. aureus* resistant to meticillin (MRSA) has plateaued over the last few years, following the marked increase seen during the 1990s (Johnson, Pearson, Duckworth, 2005). Resistance to vancomycin or teicoplanin was not reported.

Table 53: Resistance of *Staphylococcus aureus* isolated from human blood culture to selected antimicrobials in 2004 in UK

Antimicrobial	England		Wales		Scotland		Northern Ireland	
	No. isolates	%R	No. isolates	%R	No. isolates	%R	No. isolates	%R
Ciprofloxacin	6,075	51	267	57	1,686	42	88	58
Erythromycin	11,943	37	664	34	1,686	35	216	48
Fusidic Acid	10,406	9	710	11	1,686	4	203	6
Gentamicin	10,991	4	656	2	1,426	4	214	2
Meticillin	14,779	40	798	38	1,686	40	523	46
Penicillin	9,216	90	639	92	-	-	183	95
Teicoplanin	6,004	0	86	0	1,224	0	155	0
Tetracycline	6,727	4	387	2	1,686	5	90	4
Vancomycin	10,426	0	678	0	1,674	0	113	0

Animals

- Isolates of *S. aureus* from clinical disease in animals remain relatively less resistant to antimicrobials than their human counterparts. As example, more than 50% of *S. aureus* isolates from England, Wales and Northern Ireland were susceptible to penicillin/ampicillin.

England and Wales

The antimicrobial susceptibility data on *S. aureus* have been compiled from information provided by the VLA's Regional Diagnostic Laboratories and relate to isolates from clinical veterinary diagnostic samples (Teale *et al.* 2003).

The majority of *S. aureus* isolates referred to in Table 54, originate from samples referred to VLA Regional Laboratories as part of investigations into outbreaks of clinical disease in food-producing animals; many of these isolates may have come from animals already undergoing antimicrobial treatment. Most *S. aureus* isolates from cattle were from cases of cattle mastitis; sheep isolates originated from a range of conditions including mastitis, whilst avian isolates were also from a range of conditions including arthritis and air-sacculitis/septicaemia.

Table 54: Resistance of *Staphylococcus aureus* isolated from food-producing animals in England and Wales to selected antimicrobials in 2004

Antimicrobial	Cattle Mastitis		Sheep		Avian*	
	No. isolates	%R	No. isolates	%R	No. isolates	%R
Amoxicillin/Clavulanic acid (30µg)	340	3	38	0	1	0
Ampicillin (10µg)	340	38	39	3	13	46
Cephalexin (30µg)	226	0	35	0	1	0
Erythromycin (15µg)	340	2	27	4	6	50
Neomycin (10µg)	340	0	27	0	-	-
Novobiocin (30µg)	115	0	5	0	-	-
Penicillin (10iu)	340	38	38	0	13	46
Tetracycline (10µg)	340	4	39	10	13	62
Trimethoprim/sulphonamide (25µg)	67	0	28	0	13	8
Tylosin (30µg)	59	2	11	0	7	14

*avian = chicken, turkey and game birds. [Does not include geese]

Scotland

These isolates (Table 55) originate from samples referred to SAC DSCs as part of investigations into outbreaks of clinical disease in domestic animals; many of these isolates may come from animals already undergoing antimicrobial treatment. Isolates from ovine and avian sources derive from skin, milk and other tissues.

Table 55: Resistance of *Staphylococcus aureus* isolated from food-producing animals in Scotland to selected antimicrobials in 2004

Antimicrobial	Cattle Mastitis		Sheep		Avian*	
	No. isolates	%R	No. isolates	%R	No. isolates	%R
Amoxicillin (25µg)	-	-	12	0	17	18
Amoxicillin/Clavulanic acid (30µg)	251	2	16	0	19	11
Ampicillin (10µg)	249	56	16	6	19	21
Apramycin (15µg)	-	-	16	13	19	11
Cefoperazone (75µg)	256	3	-	-	-	-
Cephalexin (30µg)	258	2	12	0	17	0
Enrofloxacin (5µg)	256	1	12	0	17	0
Erythromycin (15µg)	258	1	-	-	-	-
Neomycin (10µg)	249	2	12	0	17	0
Novobiocin (30µg)	256	2	-	-	-	-
Penicillin (10µg)	255	55	12	0	17	24
Penicillin/Streptomycin (60µg)	230	2	-	-	-	-
Sulphisoxazole (300µg)	-	-	13	23	17	6
Sulphonamide/trimethoprim (25µg)	45	7	16	6	19	11
Tetracycline (10µg)	66	12	16	0	19	63
Tilimicosin (15µg)	-	-	16	6	19	47
Tylosin (30µg)	250	8	16	0	19	58

* = domestic fowl and gamebirds

Northern Ireland

The isolates in Table 56 are derived from clinical submissions to VSD (DARD) disease surveillance and investigation service. Tests were carried out by the disc-diffusion method, in accordance with an in-house operating procedure. The majority of isolates were from cases of mastitis in cattle with the remaining isolates predominantly from cases of septicaemia or joint infections in sheep and poultry.

Table 56: Resistance of *Staphylococcus aureus* isolated from food-producing animals in Northern Ireland to selected antimicrobials in 2004

Antimicrobial	Cattle Mastitis		Sheep		Avian	
	No. isolates	%R	No. isolates	%R	No. isolates	%R
Amoxicillin (25µg)	5	0	2	0	49	51
Amoxicillin/Clavulanic acid (30µg)	175	2	3	0	-	-
Ampicillin (10µg)	179	25	5	20	2	0
Apramycin (15µg)	-	-	1	0	29	21
Cefoperazone (75µg)	84	2	4	0	1	0
Enrofloxacin (5µg)	3	0	2	0	49	2
Erythromycin (15µg)	-	-	5	0	1	0
Neomycin (10µg)	4	0	1	0	49	0
Novobiocin (30µg)	172	13	3	0	1	0
Penicillin (10µg)	-	-	4	25	20	90
Tetracycline (10µg)	179	10	6	17	49	24

Meticillin-Resistant *S. aureus*

The scale of the problem of MRSA infections in humans has caused considerable concern over the last few years.

MRSA has not yet been detected in food producing animals in the UK, but there are reports of infections in companion animals and horses. In light of these reports and the increasing focus on MRSA in the public health sector, Defra is currently considering how best the Department can contribute to the knowledge and understanding of the role of MRSA in animals. This process is being facilitated by a multi-disciplinary MRSA sub-group of the DARC Group, which contains representatives from the veterinary profession, universities, animal owners, Defra, DH, HPS and the HPA. More information about MRSA in animals is available on Defra's website at:
http://www.defra.gov.uk/animalh/diseases/zoonoses/mrsa.htm

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Acknowledgments

Thanks are extended to the following:

Veterinary Pharmaceutical Companies.

Pet Food Manufacturers Association.

Office of National Statistics.

Specialist Advisory Committee on Antimicrobial Resistance (SACAR).

Advisory Committee of the Microbiological Safety of Food (ACMSF).

Professor Jonathan Cooke (South Manchester University Hospitals NHS Trust Wythenshawe Hospital Manchester) for providing data from IMSHealth on hospital antibiotic usage.

Charlotte Anderson and Pam Sonnenburg, (Respiratory Diseases Department, HPA Centre for Infections) for data on *M. tuberculosis* in humans.

Annex 3: Glossary

ACMSF	Advisory Committee on Microbiological Safety of Food.
AFBI	Agri-food and Biosciences Institute (Formally known as the Department of Agriculture and Rural Development).
AGP	Antimicrobial Growth Promoter.
AHWDG	Animal Health and Welfare Directorate General, Defra.
Aminoglycosides	A closely related group of bactericidal antibiotics derived from bacteria of the order Actinomycetales. Polycationic compounds that contain an aminocyclitol with cyclic amino-sugars attached by glycoside linkages. Sulphate salts are generally used. They have broadly similar toxicological features.
AMR	Antimicrobial Resistance.
AMRAP	Antimicrobial Resistance Action Plan, Northern Ireland.
Antibiotic	A substance produced by or derived from a microorganism, which selectively destroys or inhibits the growth of other microorganisms.
Antimicrobial	A compound, which at low concentrations, exerts an action against microorganisms and exhibits selective toxicity towards them. The term includes any substance of natural, synthetic or semi-synthetic origin that is used to kill, or inhibit the growth of, microorganisms (bacteria, fungi, protozoa and viruses). Antimicrobials include antibiotics, disinfectants, preservatives and other substances, but for the purposes of this report, disinfectants, preservatives and other substances are not included.
β-Lactams	Naturally occurring or semi-synthetic antibiotics characterised by the presence of a β-lactam ring. This class of antibiotics include penicillins, cephalosporins, carbapenems and monobactams. β-Lactams work by inhibiting synthesis of the bacterial cell wall.
BSAC	British Society for Antimicrobial Chemotherapy.
BNF	British National Formulary.
CDSCNI	Communicable Disease Surveillance Centre Northern Ireland.
CEFAS	Centre for Environment, Fisheries and Aquaculture Sciences, Defra.
CfI	Centre for Infection.
CGMP	Chemicals and GM Policy, Defra.
CLSI	Clinical and Laboratory Standards Institute, formally the NCCLS.

Colisepticaemia	A systemic infection with the bacterium *Escherichia coli* where *E. coli* can usually be isolated from blood and internal organs.
CSL	Central Science Laboratory.
DARC	Defra Antimicrobial Resistance Coordination Group.
DARD	Department of Agriculture and Rural Development.
Defra	Department for Environment, Food and Rural Affairs.
DH	Department of Health.
DSCs	Disease Surveillance Centres of the Scottish Agricultural College.
EARSS	European Antimicrobial Resistance Surveillance System.
EPC	Welsh Assembly Government Department for Environment, Planning and Countryside.
ESAC	European Surveillance of Antimicrobial Consumption.
EST	Enhanced TB Surveillance.
EU	European Union.
FAO	Food and Agriculture Organisation.
FDA	Food and Drug Administration, United States.
Fluoroquinolone	A sub-group of the quinolone compounds, having the addition of a fluorine atom and the 7-piperazinyl group. Broad-spectrum antibacterials with properties more suited to the treatment of systemic infections.
FSA	Food Standards Agency.
GRO	General Register Office.
HPA	Health Protection Agency (formerly PHLS).
HPS	Health Protection Scotland (formerly SCIEH).
LIMS	Laboratory Information Management System.
Macrolides	A large group of antibiotics mainly derived from *Streptomyces* spp. Weak bases that are only slightly soluble in water. They have low toxicity and similar antimicrobial activity with cross-resistance between individual members of the group. Thought to act by interfering with bacterial protein synthesis.
MDR	Multi Drug Resistant.
MIC	Minimum Inhibitory Concentration.
MRSA	Meticillin Resistant *Staphylococcus aureus*.
NCCLS	National Committee for Clinical Laboratory Standards.
NCTC	National Collection of Type Cultures.

NEQAS	National External Quality Assurance Scheme.
NHS	National Health Service.
NISRA	Northern Ireland Statistics and Research Agency.
ONS	Office for National Statistics.
PACT	Prescribing Analysis and Cost.
PFMA	Pet Food Manufacturers Association.
PHLS	Public Health Laboratory Service.
PPA	Prescription Prescribing Authority.
PSD	Pesticides Safety Directorate, Defra.
PT	Phage Type.
R&D	Research and Development.
SAC	Scottish Agricultural College.
SACAR	Specialist Advisory Committee on Antimicrobial Resistance.
SEERAD	Scottish Executive Environment and Rural Affairs Department.
SOP	Standard Operating Procedure.
SSRL	Scottish Salmonella Reference Laboratory.
Sulphonamides	A group of bacteriostatic compounds that interfere with folic acid synthesis of susceptible organisms. They all have similar antimicrobial activity but different pharmacokinetic properties. See also trimethoprims.
SVS	State Veterinary Service.
SZEID	Surveillance, Zoonoses and Emerging Issues Division.
Tetracycline	A group of antibiotics derived from *Streptomyces* spp. They are usually bacteriostatic at concentrations achieved in the body, and act by interfering with protein synthesis in susceptible organisms. All have a broad spectrum of activity.
TB	Tuberculosis.
Therapeutic Product	A product that treats or prevents disease.
Trimethoprims	Compounds with a similar action to sulphonamides, acting by interfering with folic acid synthesis, but at a different stage in the metabolic pathway. Display a similar spectrum of activity to, and are often used in combination with, sulphonamides. Due to synergistic effects between these classes of drugs, lower doses can achieve the same effect.
UK	United Kingdom.
UKAS	United Kingdom Accreditation Service.

VLA	Veterinary Laboratories Agency, Defra.
VMD	Veterinary Medicines Directorate, Defra.
VPC	Veterinary Products Committee.
VEROD	Veterinary Exotic Diseases, Research and Official Controls Division.
VSS	Veterinary Surveillance Strategy.