# A baseline survey of antimicrobial resistance in bacteria from selected New Zealand foods, 2009–2010

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**A baseline survey of**
**antimicrobial resistance in bacteria**
**in selected New Zealand foods,**
**2009-2010**

Prepared for the New Zealand Food Safety Authority
under Agreement for Services 11451
Antimicrobial Resistance Surveillance -
baseline survey in selected New Zealand foods

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# Summary


There is a lack of published data on antimicrobial resistance among bacteria associated with livestock in New Zealand. Comprehensive and current information on resistance among these bacteria is required to guide policy decisions on the use of antimicrobials in animal husbandry in this country. Therefore in 2005, the New Zealand Food Safety Authority's (NZFSA's) Expert Panel on Antibiotic Resistance recommended a programme of surveillance and monitoring of antimicrobial resistance among animal bacteria should be implemented as soon as practicable. A later Working Group developed the methodology for a baseline survey of antimicrobial resistance which was undertaken in 2009-2010 in accordance with the Working Group's recommended methods and scope. The results of this survey are presented in this report.

*Campylobacter* and *Salmonella*, representative of pathogenic bacteria, and *Escherichia coli* and Enterococci (*Enterococcus faecalis* and *E. faecium*), representative of commensal bacteria, were included in the survey. The isolates were sourced, in various ways, from specimens routinely collected from freshly dressed carcasses of very young calves, pigs and broiler poultry as part of the National Microbiological Database (NMD) programme. Isolates from NMD programme specimens taken between 5 October 2009 and 3 October 2010 were included in the survey. In addition, *Salmonella* (n=2) and *E. coli* (n=90) isolated during a Fresh Produce Survey conducted in 2008-2009 were included.

Antimicrobial susceptibility testing was performed by microbroth dilution (MBD) using the methods of the Clinical and Laboratory Standards Institute and commercially prepared MBD plates. The aim was to test the antimicrobial susceptibility of 300 isolates of each of the bacterial groups from each of the animal groups, and all isolates available from the Fresh Produce Survey. These targets were not met for all bacteria from all animal groups. During the 12-month survey period only 56 and 11 *Campylobacter* isolates were isolated from very young calves and pigs, respectively, and only 19, 6 and 3 *Salmonella* were isolated from calves, pigs and poultry, respectively.

Resistance was uncommon among *Campylobacter.* The majority (94.5%) of the *Campylobacter* isolates were *C. jejuni.* Among isolates of this species, 91.8% and 95.9% from very young calves and poultry, respectively, were susceptible to all antimicrobials tested. The only resistances identified among the *C. jejuni* isolates were ciprofloxacin/nalidixic acid resistance (2.7%) in poultry isolates, and streptomycin resistance in calf (8.2%) and poultry (1.0%) isolates. No *C. jejuni* were isolated from pigs.

In total only 30 *Salmonella* isolates were included in this survey. Two isolates from very young calves were resistant to streptomycin, and two isolates from pigs were sulphonamide resistant and one had additional resistance to trimethoprim.

*E. coli* from animals were more resistant than isolates from fresh produce. Ninety percent of *E. coli* from fresh produce were susceptible to all antimicrobials tested compared with 55.6% of isolates from poultry, 48.0% from very young calves and 35.0% from pigs. There was no resistance to cefotaxime, ciprofloxacin or gentamicin among *E. coli* from any of the animal groups or fresh produce. None of the isolates produced extended-spectrum or AmpC β-lactamase.


*continued*

Rates of ampicillin, chloramphenicol, neomycin, spectinomycin, streptomycin, sulphonamide and tetracycline resistance were relatively high among *E. coli* from some animals. Compared with isolates from the other sources, *E. coli* from very young calves were significantly ($P \leq 0.05$) more resistant to ampicillin, neomycin and sulphonamides. *E. coli* from pigs were more resistant to chloramphenicol and spectinomycin, whereas poultry isolates were more resistant to nalidixic acid. Streptomycin and tetracycline resistance was higher in calf and pig isolates than those from poultry.

Among the *E. faecalis* isolates, 53.1% of those from pigs and 42.2% from very young calves were susceptible to all the antimicrobials tested (excluding quinupristin/dalfopristin to which *E. faecalis* is intrinsically resistant) compared with 17.9% of isolates from poultry. Among the *E. faecium* isolates, 31.6% of those from pigs were fully susceptible compared with 20.3% of isolates from poultry and 5.4% from calves. There was no resistance to ampicillin or vancomycin among *E. faecalis* or *E. faecium* from any of the animal groups.

Compared with *E. faecalis* from the other sources, isolates from very young calves were significantly more resistant to streptomycin, whereas isolates from pigs were more resistant to chloramphenicol and gentamicin, and isolates from poultry were more resistant to erythromycin and tetracycline. Compared with *E. faecium* from the other sources, isolates from calves were significantly more resistant to ciprofloxacin and tetracycline, whereas isolates from pigs were more resistant to streptomycin, and isolates from poultry were more resistant to nitrofurantoin. While the bacitracin MICs were not interpreted, the MICs for poultry isolates were high, with 95.0% of *E. faecalis* and 98.7% of *E. faecium* isolates having bacitracin MICs ≥512 mg/L.

There were some significant differences in rates of resistance among *E. coli* and Enterococci according to whether the animals they were isolated from were processed at plants in the North Island or the South Island. There were also some significant differences in resistance at different time periods during the 12 months of the survey.

The prevalence of resistance among bacteria from the food animals and fresh produce included in this survey was usually less than that reported for human isolates of the same bacterial species isolated in New Zealand in 2009, especially for the antibiotics of most importance in human medicine. Moreover, comparison of the results from this survey with the limited data available from earlier New Zealand studies on animal isolates does not suggest a trend of increasing resistance among bacteria from animals in New Zealand.

Finally, comparison of the results of this survey with 2009 data from the Danish DANMAP surveillance system, which uses similar methodology to that used in this survey but does not include an animal category of very young calves, showed that, with the exception of sulphonamide resistance in *E. coli* from poultry, resistance was either lower in pigs and poultry in New Zealand or not significantly different for the antibiotics that were commonly tested in both this survey and the DANMAP system. A similar comparison with 2008 data from the NARMS surveillance system in the United States for retail chicken breast and pork chop meat indicated that resistance was lower among bacteria from New Zealand poultry than American chicken breast meat, but higher among *E. faecalis* from New Zealand pigs than American pork chop meat.

# 1 Introduction

There is a lack of published data on the prevalence of antimicrobial resistance among bacteria associated with livestock in New Zealand. Comprehensive and current information on resistance among these bacteria is required to guide policy decisions on the use of antimicrobials in animal husbandry in this country. In 2005 the New Zealand Food Safety Authority's (NZFSA's) Expert Panel on Antibiotic Resistance recommended a programme of surveillance and monitoring of antimicrobial resistance among animal bacteria should be implemented as soon as practicable.[1] The Expert Panel's recommendation was subsequently endorsed by the Antimicrobial Resistance Steering Group.

The Expert Panel proposed that any surveillance programme be pragmatic and utilise existing sampling systems within the National Microbiological Database (NMD) programme. The NZFSA accepted the Expert Panel and Steering Group recommendations,[2] and, as part of the overall NZFSA Antimicrobial Resistance Implementation Project, established a Working Group, with external expert input, to develop, scope and recommend a surveillance programme. This Working Group recommended a baseline survey with the following components:

- The survey should focus on antimicrobial resistance among bacteria from food-producing animals.
- The bacteria of interest should be *Campylobacter, Salmonella, Escherichia coli, Enterococcus faecalis* and *Enterococcus faecium.*
- The food animals and locations to be surveyed should be very young calves (carcasses), culled dairy cattle (carcasses), pigs (carcasses) and broiler poultry (caeca and carcasses).
- The NMD programme should be utilised as the sampling framework, but additional isolation, identification and susceptibility testing of bacteria would be required.
- The baseline survey should cover all the bacteria of interest in all the identified food animal species.
- The panels of antimicrobials to be tested for each bacterial group should be those listed in Section 9 of the Working Group's report (see **Table 5** in the Appendix).
- ESR's current programme of antimicrobial resistance among *Salmonella* should be utilised and, if possible, expanded to include all *Salmonella* isolated as part of the NMD programme.
- An evaluation, utilising standard criteria for public health surveillance programmes, of the baseline survey should occur to inform decisions on future NZFSA surveillance of antimicrobial resistance.
- Isolates included in the baseline survey should be retained for future use.

The Institute of Environmental Science and Research (ESR) was contracted by the NZFSA to undertake the baseline survey in accordance with the Working Group's recommendations with a few notable changes:

- Bacteria from culled dairy cows were not to be included, as dairy and beef cows are not distinguished in the NMD programme.
- Bacteria from poultry caeca were not to be included as these samples are no longer available as part of the NMD programme.

In addition to the bacteria recovered from the NMD programme, *E. coli* and *Salmonella* isolated as part of a national Fresh Produce Survey conducted in 2008 and 2009 by ESR for the NZFSA were to be included in this baseline survey.[3]

# 2 Methods

## 2.1 SOURCE OF BACTERIAL ISOLATES AND SAMPLES FOR ISOLATION OF BACTERIA

The *Campylobacter, Salmonella, E. coli, E. faecalis* and *E. faecium* isolates included in the survey were from two sources:

1. The National Microbiological Database (NMD) programme

   Presumptive *Campylobacter* and *E. coli* isolates, and samples for the isolation of *Campylobacter, E. faecalis* and *E. faecium*, were obtained from the LAS-approved laboratories[1] that perform NMD programme testing for abattoirs processing very young calves and pigs and for plants processing broiler poultry. The samples used were rinsates of swabs of calf and pig carcasses and poultry whole carcass rinsates.

   The laboratories were requested to refer a specified number of isolates or samples from each processing plant to ESR each week, fortnight or quarter over a 12-month period, 5 October 2009 to 3 October 2010. The 5 October 2009 start was chosen to coincide with the date that the NMD programme was extended to include pig processing. The collection period for isolates and samples from plants processing very young calves was confined to the months that these calves are being processed, that is, the ‘bobby calf’ season (5 October – 5 November 2009 and 7 July – 3 October 2010). The number of isolates and samples specified for each processing plant was proportional to the plant’s throughput.

   *Salmonella* isolated as part of the NMD programme from very young calves, pigs and poultry during the 12-month survey period were identified from the NMD database. These *Salmonella* isolates were obtained from ESR’s Enteric Reference Laboratory, as all *Salmonella* isolated as part of the NMD programme are referred to this laboratory. For the survey, the NMD database was upgraded to include the ESR laboratory numbers for the *Salmonella* isolates. This upgrade facilitated the identification and retrieval of the *Salmonella* isolates that were to be included in the survey.

2. The 2008-2009 Fresh Produce Survey

   All *E. coli* and *Salmonella* isolated during the 2008-2009 Fresh Produce Survey and that had been stored were obtained from the ESR laboratory which conducted the survey. The isolates had been stored at -80ºC in cryogenic media.

[1] The Laboratory Approval Scheme (LAS) is an integral part of NZFSA official assurances for market access. The LAS is designed specifically to encompass laboratory requirements for regulatory samples for New Zealand official assurances. LAS-approved laboratories that carry out microbiological and chemical or any other specified laboratory testing for market access assurances must follow standards and requirements specified by LAS.

## 2.2 ISOLATION AND IDENTIFICATION OF *CAMPYLOBACTER*, *E. COLI*, *E. FAECALIS* AND *E. FAECIUM* FROM NMD PROGRAMME SAMPLES

The NMD programme protocols specify that only *Salmonella* are definitively identified. In addition the protocols specify that *Campylobacter* isolated from poultry are confirmed as *Campylobacter* species by oxidase and latex agglutination (Microgen Bioproducts Ltd, Camberley, Surrey, UK) tests, and that *E. coli* are presumptively identified on the basis of characteristic growth on *E. coli* petrifilms. Therefore, for this survey, additional work was required to isolate *Campylobacter* from very young calves and pigs, to speciate all *Campylobacter* isolates, to purify and confirm presumptive *E. coli* isolates, and to isolate and identify *E. faecalis* and *E. faecium*. This isolation and identification work was undertaken by ESR's Food Group at the Christchurch Science Centre using the following methods.

### 2.2.1 *Campylobacter*

To obtain *Campylobacter* from very young calves and pigs, 2 mL of carcass swab rinsate was added to 18 mL of Bolton broth (Lab M, Bury, Lancashire, UK) in the LAS-approved laboratory. The Bolton broths were kept chilled and transported to ESR in an insulated container. At ESR, the broths were incubated in a microaerobic environment (provided in a dedicated microaerobic incubator) at 37ºC for at least 4 hours to resuscitate any *Campylobacter* present, followed by further incubation at 42ºC microaerobically for 44 hours. A loopful (10 µL) of the broth culture was streaked on modified charcoal cefoperazone desoxycholate agar (mCCDA, Lab M) and incubated at 42ºC microaerobically for 48 hours to obtain single colonies.

To obtain *Campylobacter* from poultry, *Campylobacter* species from whole carcass rinsates isolated on mCCDA plates in LAS-approved laboratories were picked onto Amies charcoal swabs (one swab per positive carcass). These swabs were transported chilled to ESR. At ESR, culture from each swab was streaked on mCCDA and incubated at 42ºC microaerobically for 48 hours to obtain single colonies.

Typical *Campylobacter*-like colonies on mCCDA were purified by culturing on sheep blood agar (Columbia Blood Agar base by Difco, Becton Dickinson, Sparks, MD, USA) at 42ºC microaerobically for 48 hours, and then tested for oxidase and, if positive, definitively identified and speciated by PCR.[4] All speciated isolates were stored at -80ºC in cryogenic media until subcultured for susceptibility testing.

### 2.2.2 *E. coli*

To obtain *E. coli* from very young calves, pigs and poultry, the LAS-approved laboratories submitted the *E. coli* Petrifilms that had been used to enumerate *E. coli* in calf and pig carcass swab rinsates and poultry whole carcass rinsates. The Petrifilms were transported chilled to ESR. At ESR, blue colonies typical of *E. coli* were picked and streaked on eosin methylene blue agar (EMB, Merck, Darmstadt, Germany) and tested for indole production in tryptone broth (Becton Dickinson).[5] Colonies which were indole positive and produced a characteristic metallic sheen on EMB agar were purified on sheep blood agar and stored at -80ºC in cryogenic media until subcultured for susceptibility testing.

### 2.2.3 *E. faecalis* and *E. faecium*

To obtain *E. faecalis and E. faecium* from very young calves, pigs and poultry, the LAS-approved laboratories submitted calf and pig carcass swab rinsates and poultry whole carcass rinsates. The rinsates were transported chilled to ESR. At ESR, 2 mL of each rinsate was added to 18 mL of azide dextrose broth (Oxoid, Basingstoke, England) and incubated at 35ºC for 18-24 hours. The broths were streaked on Slanetz & Bartley agar (Oxoid) and incubated at 44ºC for 48 hours. Reddish-pink to reddish-brown colonies were picked and purified on sheep blood agar. Colonies were confirmed as *Enterococcus* by testing for growth in brain heart infusion broth (Becton Dickinson) at 45°C and in 6.5% salt broth at 35°C for 48 hours. *Enterococcus* isolates were speciated by PCR.[6] All *E. faecalis* and *E. faecium* isolates were stored at -80ºC in cryogenic media until subcultured for susceptibility testing.

## 2.3 SELECTION OF ISOLATES FOR ANTIMICROBIAL SUSCEPTIBILITY TESTING

### 2.3.1 *Campylobacter*, *E. coli*, *E. faecalis* and *E. faecium* from the NMD programme

For operational purposes and to achieve even sampling over the 12-month survey period, the 12 months were divided into four quarterly periods: 5 October-31 December 2009, 1 January-31 March 2010, 1 April-30 June 2010 and 1 July-3 October 2010. The aim was to select for antimicrobial susceptibility testing a total of 300 isolates, 75 per quarter, of each bacterial group (ie, *Campylobacter*, *E. coli* and Enterococci) from each animal group (ie, very young calves, pigs and poultry). When selecting Enterococci, equal numbers of *E. faecalis* and *E. faecium* were selected, where available.

Individual target numbers of isolates were set for each processing plant and were proportional to the plant’s historical throughput. Except for isolates from very young calves, isolates were selected for susceptibility testing with the aim of obtaining the quarterly target number of isolates of each bacterial group from each processing plant. When the number of isolates recovered from samples from a plant was less than the target number, the shortfall was made up by selecting a greater number of isolates from that plant in another quarter. If there were insufficient isolates from a plant to do this, then, at the end of the survey when all samples had been processed, any remaining shortfalls in isolate numbers was made up by selecting isolates from other plants with the aim of achieving the quarterly target totals of 75 isolates.

Due to the limited ‘bobby calf’ season, isolates from very young calves were only available from some (South Island) processing plants in the 5 October-31 December 2009 quarter and all plants in the 1 July-3 October 2010 quarter. For those plants still processing in the 5 October-31 December 2009, isolates were selected for susceptibility testing with the aim of obtaining about one-third of the total number of isolates required from these plants. This strategy was based on the assumption that approximately one-third of these plants’ annual processing occurred during this quarter. The balance for these plants and the total numbers required from the other plants were selected from isolates recovered in the 1 July-3 October 2010 quarter.

### 2.3.2 *Salmonella* from the NMD programme

All *Salmonella* isolated from very young calves (n=19), pigs (n=9) and poultry (n=3) as part of the NMD programme during the 12-month survey period were included for susceptibility testing.

### 2.3.3 *E. coli* and *Salmonella* from the 2008-2009 Fresh Produce Survey

All available *E. coli* (n=90) and *Salmonella* (n=2) isolated during the 2008-2009 Fresh Produce Survey were included for susceptibility testing.

## 2.4 ANTIMICROBIAL SUSCEPTIBILITY TESTING

The antimicrobial susceptibility testing was undertaken by ESR's Antibiotic Reference Laboratory at the Kenepuru Science Centre.

All susceptibility testing was performed by broth microdilution using Sensititre plates (Trek Diagnostic Systems, East Grinstead, England). Three plate types were used: one for *Campylobacter* (code EUCAMP), one for *E. coli* and *Salmonella* (code NZFSAN), one for Enterococci (code NZFSAP). The plate for *Campylobacter* was standard, however, the *E. coli*/*Salmonella* plate and Enterococci plate were customised for this survey. The antibiotics included in each plate, the concentration ranges and plate configurations are detailed in Table 6 in the Appendix.

The inoculum preparation, inoculum standardisation, incubation conditions, and determination of minimum inhibitory concentration (MIC) end points, were according to the Clinical and Laboratory Standard Institute's (CLSI's) microbroth dilution method.[7] The MICs were interpreted using the CLSI interpretive standards for human isolates.[8,9] For veterinary-specific antibiotics, the MICs were interpreted using the CLSI standards for bacteria isolated from animals.[10] Where none of the CLSI standards contained interpretive standards for a particular antibiotic, the epidemiological cut-off values used in the DANMAP surveillance system were applied.[11] The interpretive standards used are summarised in Table 7 in the Appendix. Neither CLSI nor DANMAP have bacitracin or tylosin interpretive standards for Enterococci. Therefore the MICs of these antibiotics were not interpreted.

*E. coli* and *Salmonella* that screened positive for extended spectrum β-lactamases (ESBLs) by growing at a concentration of 1 mg/L cefotaxime and/or 1 mg/L ceftazidime were further tested by the CLSI ESBL disc confirmatory method to confirm the presence of an ESBL.[8] Cefoxitin-resistant *E. coli* and *Salmonella* were screened for AmpC β-lactamase with a boronic acid double-disc synergy test.[12] Any screen-positive isolates were tested by PCR for plasmid-mediated AmpC β-lactamase.[13]

Vancomycin-resistant or intermediate Enterococci were further tested by PCR to confirm the presence of the *vanA* or *vanB* gene.[14]

### 2.4.1 Quality control

All susceptibility testing was fully controlled according to the CLSI protocols and the prescribed quality control strains were used:

- *E. coli* ATCC 25922
- *E. coli* ATCC 35218
- *Enterococcus faecalis* ATCC 29212
- *Enterococcus faecalis* ATCC 51299
- *Campylobacter jejuni* ATCC 33560

The quality control testing included the prerequisite 30 consecutive days' testing of each of the three types of Sensititre plates. Each lot of Sensititre plates was controlled by one day of testing. During routine testing, quality control strains were run weekly.

The divalent cation content of all lots of Mueller-Hinton broth (Difco) used was adjusted, if necessary, and then tested for satisfactory performance as specified in the CLSI standards.[7] Each lot of Mueller-Hinton broth was also tested for acceptable thymidine and thymine content, that is, suitability for trimethoprim and sulphonamide susceptibility testing, as specified in the CLSI standards.[7]

## 2.5 DATA ANALYSIS

Statistical analyses were performed with SAS software v.9.1.3 (SAS Institute Inc, Cary, NC, USA). The chi-square test or Fisher's exact test, as appropriate, were used to determine the significance of any observed differences. Chi-square for trend was used to determine the significance of any changes over the four quarters of the survey period. An associated P value $\leq 0.05$ was used to identify whether a difference or trend was significant.

The comparison of resistance among bacteria isolated in the North Island with those isolated in the South Island was confined to isolates from the NMD programme as the geographic origin of the fresh produce isolates was not available.

The analysis of full susceptibility among Enterococci excluded bacitracin and tylosin as the MICs of these antibiotics were not interpreted.

# 3 Results

## 3.1 RECOVERY OF *CAMPYLOBACTER*, *E. COLI* AND ENTEROCOCCI ISOLATES FROM NMD PROGRAMME SAMPLES AND NUMBERS OF ISOLATES SELECTED FOR ANTIMICROBIAL SUSCEPTIBILITY TESTING

The numbers of NMD programme samples received for processing from each of the animal groups; the numbers of *Campylobacter*, *E. coli* and Enterococci recovered from these samples; and the numbers of *Campylobacter*, *Salmonella*, *E. coli*, and *E. faecalis* or *E. faecium* selected or available for antimicrobial susceptibility testing from isolates recovered and fully identified from the NMD programme and the Fresh Produce Survey are summarised in Table 1. This information is shown in more detail for individual processing plants on a quarterly basis in Table 8, Table 9 and Table 10 in the Appendix, respectively, for *Campylobacter*, *E. coli* and Enterococci from NMD programme samples.

Table 1. Number of NMD samples received, recovery of *Campylobacter*, *E. coli* and Enterococci isolates from NMD samples, and the numbers of isolates selected or available for antimicrobial susceptibility testing

| | ***Campylobacter***[1] | ***Salmonella*** | ***E. coli*** | **Enterococci**[2] |
|---|---|---|---|---|
| **Very young calves** | | | | |
| Number of samples | 1159 | NA[3] | 1028 | 1143 |
| Number of isolates recovered | 56 | NA | 547 | 576 |
| Number selected/available for susceptibility testing | 56 | 19 | 300 | 277 |
| **Pigs** | | | | |
| Number of samples | 1661 | NA | 698 | 1636 |
| Number of isolates recovered | 11 | NA | 481 | 381 |
| Number selected/available for susceptibility testing | 11 | 6 | 303 | 285 |
| **Poultry** | | | | |
| Number of samples | 445 | NA | 610 | 871 |
| Number of isolates recovered | 420 | NA | 501 | 627 |
| Number selected/available for susceptibility testing | 297 | 3 | 306 | 298 |
| **Fresh produce** | | | | |
| Number available for susceptibility testing | NA | 2 | 90 | NA |

1 All *Campylobacter* recovered from very young calves and pigs were susceptibility tested.

2 Not all Enterococci recovered were speciated, but all those from very young calves and pigs that were speciated were susceptibility tested.

3 NA, not applicable

## 3.2 *CAMPYLOBACTER* ANTIMICROBIAL SUSCEPTIBILITY

The antimicrobial susceptibility of 56 *Campylobacter* isolates from very young calves, 11 isolates from pigs, and 297 isolates from poultry was tested (Table 1) and is reported in Table 2. The species distribution of the *Campylobacter* isolates is also given in Table 2. The full MIC distributions among *C. jejuni* and *C. coli* are shown in **Table 11** and **Table 12**, respectively, in the Appendix.

Table 2. Resistance among *Campylobacter* from very young calves, pigs and poultry

| Antimicrobial | Percent resistance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *C. jejuni* | | | *C. coli* | | | | *C. lari* |
| | Very young calves n=49 | Poultry n=295 | Total n=344 | Very young calves n=7 | Pigs n=10 | Poultry n=2 | Total n=19 | Pigs n=1 |
| Chloramphenicol | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Ciprofloxacin | 0.0 | 2.7 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 |
| Erythromycin | 0.0 | 0.0 | 0.0 | 0.0 | 20.0 | 0.0 | 10.5 | 0.0 |
| Gentamicin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nalidixic acid | 0.0 | 2.7 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 |
| Streptomycin | 8.2 | 1.0 | 2.0 | 0.0 | 20.0 | 0.0 | 10.5 | 0.0 |
| Tetracycline | 0.0 | 0.3 | 0.3 | 0.0 | 30.0 | 0.0 | 15.8 | 100.0 |

Resistance was uncommon among *Campylobacter.* Among the *C. jejuni* isolates, 91.8% and 95.9% of those from very young calves and poultry, respectively, were susceptible to all antimicrobials tested. The only significant difference in resistance among the *Campylobacter* from the different animal groups was higher streptomycin resistance among *C. jejuni* from calves compared with poultry. The small number of *C. coli* isolates precludes any meaningful comparison of resistance among this species in the different animal groups.

Ciprofloxacin and nalidixic acid resistance, which is conferred by the same mechanism, was significantly higher among *C. jejuni* from poultry processed in the South Island compared with that processed in the North Island (Table 13 in the Appendix). The ciprofloxacin/nalidixic acid-resistant isolates from poultry processed in the South Island were all isolated in the third and fourth quarters and accounted for the significantly higher rates of resistance to these two antibiotics in these quarters among poultry (Table 14 in the Appendix).

## 3.3 *SALMONELLA* ANTIMICROBIAL SUSCEPTIBILITY

There were only 30 *Salmonella* isolated during the survey period and from the Fresh Produce Survey: 19 isolates from very young calves, 6 from pigs, 3 from poultry and 2 from fresh produce. The serotypes of the isolates are shown in Table 15 in the Appendix.

The full MIC distributions are shown in Table 16 in the Appendix. All *Salmonella* were susceptible to all the antibiotics tested except for two isolates from calves and two from pigs. Both resistant isolates from calves were *S*. Typhimurium phage type 9 and both had mono-resistance to streptomycin. One of the resistant isolates from pigs was *S*. Brandenburg resistant to sulphamethoxazole and trimethoprim, and the other was *S*. Derby resistant to sulphamethoxazole.

## 3.4 *ESCHERICHIA COLI* ANTIMICROBIAL SUSCEPTIBILITY

The antimicrobial susceptibility of 300 *E. coli* isolates from very young calves, 303 isolates from pigs, 306 isolates from poultry, and 90 from fresh produce was tested (Table 1) and is reported in (Table 3). The full MIC distributions are shown in **Table 17** in the Appendix.

Table 3. Resistance among *Escherichia coli* from very young calves, pigs, poultry and fresh produce

| Antimicrobial | Percent resistance | | | | |
|---|---|---|---|---|---|
| | Very young calves n=300 | Pigs n=303 | Poultry n=306 | Fresh produce n=90 | Total n=999 |
| Ampicillin | 23.7 | 8.9 | 4.9 | 2.2 | 11.5 |
| Apramycin | 0.0 | 0.3 | 0.3 | 0.0 | 0.2 |
| Cefotaxime | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Cefoxitin | 1.0 | 1.3 | 0.3 | 2.2 | 1.0 |
| Ceftiofur | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Cephalothin | 4.0 | 2.0 | 2.0 | 2.2 | 2.6 |
| Chloramphenicol | 3.3 | 10.2 | 0.7 | 1.1 | 4.4 |
| Ciprofloxacin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Co-amoxiclav | 1.0 | 0.7 | 0.0 | 3.3 | 0.8 |
| Gentamicin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nalidixic acid | 0.3 | 0.7 | 5.6 | 0.0 | 2.0 |
| Neomycin | 28.3 | 2.6 | 2.9 | 0.0 | 10.2 |
| Spectinomycin | 8.7 | 24.4 | 5.9 | 0.0 | 11.8 |
| Streptomycin | 44.3 | 32.3 | 10.1 | 1.1 | 26.3 |
| Sulfamethoxazole | 45.0 | 32.7 | 30.7 | 1.1 | 32.9 |
| Tetracycline | 40.7 | 48.5 | 12.1 | 6.7 | 31.2 |
| Trimethoprim | 12.7 | 8.3 | 6.7 | 1.1 | 8.5 |

There was no resistance to cefotaxime, ceftiofur, ciprofloxacin or gentamicin among *E. coli* from any of the animal groups or fresh produce. None of the isolates produced ESBL or AmpC β-lactamase. The rates of resistance to apramycin, cefoxitin, cephalothin, co-amoxiclav and nalidixic acid were relatively low among isolates from all animals groups and fresh produce.

*E. coli* from animals were more resistant than isolates from fresh produce. Ninety percent of *E. coli* from fresh produce were susceptible to all antimicrobials tested compared with 55.6% of isolates from poultry, 48.0% from calves and 35.0% from pigs. Compared with isolates from other sources, *E. coli* from calves were significantly more resistant to ampicillin, neomycin and sulphonamides. Isolates from pigs were more resistant to chloramphenicol and spectinomycin, whereas poultry isolates were more resistant to nalidixic acid. Streptomycin and tetracycline resistance was higher in calf and pig isolates than those from poultry and fresh produce.

There were some significant differences in rates of resistance among *E. coli* from pigs and poultry, but not very young calves, processed in the North Island compared with those processed in the South Island. Isolates from pigs processed in the North Island were more resistant to chloramphenicol, spectinomycin, streptomycin and sulphonamides, but less resistant to tetracycline. Isolates from poultry processed in the South Island were more resistant to cefoxitin, spectinomycin, streptomycin and trimethoprim (**Table 18** in the Appendix)

There were also some significant differences in rates of resistance among *E. coli* from very young calves and pigs, but not poultry, in the different quarters of the survey period (Table 19).

## 3.5 *ENTEROCOCCUS FAECALIS* AND *E. FAECIUM* ANTIMICROBIAL SUSCEPTIBILITY

The antimicrobial susceptibility of 277 *E. faecalis* or *E. faecium* isolates from very young calves, 285 *E. faecalis* or *E. faecium* isolates from pigs, and 298 *E. faecalis* or *E. faecium* from poultry was tested (Table 1) and is reported in (Table 4). The full MIC distributions among each species are shown in Table 20 and Table 21 in the Appendix.

Table 4. Resistance among *Enterococcus faecalis* and *E. faecium* from very young calves, pigs and poultry

| Antimicrobial | Percent resistance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *E. faecalis* | | | | *E. faecium* | | | |
| | Very young calves n=185 | Pigs n=228 | Poultry n=140 | Total n=553 | Very young calves n=92 | Pigs n=57 | Poultry n=158 | Total n=307 |
| Ampicillin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Chloramphenicol | 3.8 | 8.3 | 0.0 | 4.7 | 0.0 | 1.8 | 0.6 | 0.7 |
| Ciprofloxacin | 1.6 | 0.9 | 0.7 | 1.1 | 79.4 | 33.3 | 45.6 | 53.4 |
| Erythromycin | 11.4 | 27.6 | 33.6 | 23.7 | 9.8 | 24.6 | 24.7 | 20.2 |
| High-level Gentamicin | 0.0 | 8.3 | 0.0 | 3.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nitrofurantoin | 1.1 | 0.4 | 1.4 | 0.9 | 9.8 | 21.1 | 29.8 | 22.2 |
| Quinupristin/ dalfopristin | - | - | - | - | 26.1 | 29.8 | 31.7 | 29.6 |
| High-level Streptomycin | 35.7 | 21.1 | 3.6 | 21.5 | 12.0 | 15.8 | 3.2 | 8.1 |
| Tetracycline | 54.6 | 43.0 | 77.9 | 55.7 | 62.0 | 38.6 | 35.4 | 44.0 |
| Vancomycin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

There was no resistance to ampicillin or vancomycin among *E. faecalis* or *E. faecium* from any of the animal groups. Two isolates, both from pigs, had intermediate-vancomycin resistance (MIC 8 mg/L), but did not have either the *vanA* or *vanB* gene.

Among the *E. faecalis* isolates, 53.1% of those from pigs and 42.2% from very young calves were susceptible to all the antimicrobials tested (excluding quinupristin/dalfopristin to which *E. faecalis* is intrinsically resistant) compared with 17.9% of isolates from poultry. Among the *E. faecium* isolates, 31.6% of those from pigs were fully susceptible compared with 20.3% of isolates from poultry and 5.4% from calves.

Compared with *E. faecalis* from other sources, isolates from very young calves were significantly more resistant to streptomycin, whereas isolates from pigs were more resistant to chloramphenicol and gentamicin, and isolates from poultry were more resistant to erythromycin and tetracycline. Compared with *E. faecium* from other sources, isolates from calves were significantly more resistant to ciprofloxacin and tetracycline, whereas isolates from pigs were more resistant to streptomycin, and isolates from poultry were more resistant to nitrofurantoin. While the bacitracin MICs were not interpreted, the MICs for poultry isolates were higher than those for calf or pig isolates, with 95.0% of *E. faecalis* and 98.7% of *E. faecium* isolates having bacitracin MICs ≥512 mg/L (Table 20 and Table 21 in the Appendix).

There were some significant differences in rates of resistance among *E. faecalis* and *E. faecium* from animals processed in the North Island compared with those processed in the South Island. *E. faecalis* from very young calves processed in the South Island were more resistant to streptomycin, and isolates from pigs processed in the North Island were more resistant to gentamicin and less resistant to tetracycline (Table 22 in the Appendix). *E. faecium* from calves processed in the North Island were more resistant to quinupristin/dalfopristin; isolates from pigs processed in the South Island were more resistant to ciprofloxacin, erythromycin and tetracycline; and isolates from poultry in the South Island were more resistant to tetracycline (Table 23 in the Appendix).

There were also some significant differences in rates of resistance among *E. faecalis*, but not *E. faecium*, from very young calves and poultry in the different quarters of the survey period (**Table 24** and **Table 25** in the Appendix)

# 4 Discussion

The principal aim of this survey was to estimate the prevalence of resistance to important and commonly used antimicrobials among representative collections of pathogenic bacteria (*Campylobacter* and *Salmonella*) and indicator, commensal bacteria (*E. coli, E. faecalis* and *E. faecium*) isolated from freshly dressed carcasses of very young calves, pigs and broiler poultry in New Zealand abattoirs and processing plants over a 12-month period. This aim was extended to include resistance among *Salmonella* and *E. coli* isolated during the 2008-2009 Fresh Produce Survey.[3]

This is the first such survey undertaken in New Zealand and should provide baseline information to monitor any changes in resistance among bacteria from food-producing animals as well as provide current information to guide policy decisions on the use of antimicrobials in animal husbandry in this country. The three animal groups included in the survey, very young calves, pigs and broiler poultry, were chosen as there is a greater use of antimicrobials in the rearing of these animals than other food animals.

*Resistance in relation to antibiotic use*

Data on the use of antimicrobials in animal rearing in this country is limited. The NZFSA monitors and reports on sales of antibiotics for use in animals, however, these reports to not provide information on the amounts of antibiotics sold specifically for use in the three animal species included in this survey.[15] However, some comments about known usage and the prevalence of resistance found in this survey can be made. Such comparisons are always complicated by cross resistance between antibiotics of the same or similar classes and also by linked resistance between antibiotics of different classes due, for example, to resistance determinants being carried on the same genetic element such as a plasmid.

Over the 2004-2009 period, zinc bacitracin accounted for 35-47%, by weight, of all antibiotic sales, and 71-80% of all antibiotics administered in feed and water. Almost all of this bacitracin is used in the broiler industry to control clostridial enteritis, and this use is reflected in the very high proportion (≥95%) of Enterococci from poultry in this survey that had high bacitracin MICs of ≥512 mg/L.

Penicillins, macrolides, sulphonamides/trimethoprim and tetracyclines account for the majority of the remaining antibiotic sales. Among food-producing animals the bulk of the penicillins are used in dairy cattle. Macrolides are used mainly in the pig industry, but erythromycin resistance was not more prevalent among isolates (Enterococci) from pigs than other animals. Sulphonamides are commonly used to treat scouring in calves, although the very young calves included in this survey are not usually treated. However, the highest rate of sulphonamide resistance was among *E. coli* isolated from very young calves, which may reflect the use of this antibiotic in other animals sharing the same environment. Tetracyclines are commonly used to control respiratory disease in pigs and tetracycline resistance in *E. coli* was most prevalent among isolates from pigs, but among Enterococci tetracycline resistance was most prevalent in *E. faecalis* from poultry.

*Comparison of resistance with that found among human bacterial isolates*

There is international concern, and now some evidence, that the use of antimicrobials in animal rearing and other agricultural uses is contributing to the problem of antibiotic resistance among human pathogens. However, the results of this survey indicate that bacteria from food-producing animals in New Zealand, or at least those that the general public are most likely to be exposed to via the food chain, are probably not a significant source of resistant human pathogens or a reservoir of resistance genes. Where there is comparable data, the prevalence of resistance among bacteria from the food animals and fresh produce included in this survey was usually less than that reported for human isolates of the same species isolated in New Zealand in 2009 (see Table 26, Figure 1 and Figure 2 in the Appendix).

Data on resistance among human *Campylobacter* isolates is limited, as it is not routinely tested in diagnostic laboratories. However, based on the data that is available for fluoroquinolone and erythromycin, resistance to each of these two antibiotics has varied between zero and 3% in recent years.[16] In this survey, similar levels of resistance to these two antibiotics were identified among the animal isolates of *C. jejuni*, with 2.3% ciprofloxacin resistance and no erythromycin resistance.

Due to the low numbers of *Salmonella* isolated from animal carcasses during the survey period and during the Fresh Produce Survey, it is difficult to make valid comparisons of the resistance found among this organism in this survey with other data. However, among human *Salmonella* isolates in New Zealand in 2009 some resistance was detected to most antibiotics tested (Table 26 in the Appendix) and ESBL- and AmpC β-lactamase- producing *Salmonella* were identified. Whereas only low levels of streptomycin, sulphonamide and trimethoprim resistance was detected among isolates included in this survey. Resistance among *Salmonella* from non-human sources, including animals, in New Zealand is routinely monitored by ESR and compared with resistance among human isolates. This monitoring has shown that almost invariably, where there is a difference in resistance, *Salmonella* from non-human sources are less resistant than those from human sources.[17]

The rates of resistance among the *E. coli* included in this survey were lower than those reported among *E. coli* from humans (see Figure 1 in the Appendix).[16] Rising rates of resistance to third-generation cephalosporins and fluoroquinolones among Gram-negative bacteria, such as *E. coli*, are a major concern in human medicine. Importantly no resistance was detected to either of these antimicrobials among the *E. coli* included in this survey. However, while no fluoroquinolone (ciprofloxacin) resistance was detected among *E. coli*, resistance to the earlier–generation quinolone, nalidixic acid, was detected, in particular among 5.6% of *E. coli* from poultry. This is of some concern as it is likely that these nalidixic acid-resistant isolates have the first of the two-step mutation that results in resistance to fluoroquinolones.[18]

The resistance data for *E. faecalis* and *E. faecium* available for human isolates and presented in Table 26 in the Appendix is combined for both species which makes it difficult to compare with the species-specific data collected in this survey.[16] There are usually significant differences in the antimicrobial susceptibility of *E. faecalis* and *E. faecium*. However, 90% of human enterococcal infections are usually due to *E. faecalis*, and therefore if the resistance among human isolates is compared with that among the animal *E. faecalis* included in this survey, once again it is notable that resistance was generally lower in the animal isolates (see Figure 2 in the Appendix). Importantly, no vancomycin resistance was detected among the animal Enterococci, but the rates of quinupristin/dalfopristin resistance detected in *E. faecium* were high, ranging from 26.1% to 31.7% across the animal groups.

The above comparisons of resistance among human isolates with that among the animal and fresh produce isolates included in this survey need to be interpreted with caution. The human isolate data is based on isolates recovered from diagnostic specimens. Rates of resistance among isolates from such specimens may be higher than those in the total bacterial population due to the recognised biases in such diagnostic specimens.[19,20] For example, a specimen may only be taken from a patient following the failure of initial empirical treatment which is more likely if the causative organism is resistant.

*Comparison of resistance with that found in earlier studies of animal bacterial isolates*

While this survey was considered a baseline survey, there have been some earlier and smaller studies of antimicrobial resistance among bacteria from animals and foods in New Zealand. These studies included Enterococci from poultry faecal samples;[21] *E. coli* and Enterococci from pig faecal samples;[22] *E. coli* and Enterococci from poultry carcass rinsates;[23,24] and *Campylobacter* from retail poultry.[23] While it is difficult to make direct comparisons of data from different studies due to different methodologies, comparison of the results from these studies with our results does not suggest a trend of increasing resistance among bacteria from animals in New Zealand.

Of these studies, the two most directly comparable with our results are those conducted by investigators at Massey University using *E. coli* and Enterococci obtained from NMD programme poultry rinsate samples in 2006.[23,24] Among *E. coli* from poultry we found higher rates of streptomycin (10.1 vs 1.7%), sulphonamide (30.7 vs 0.7%) and tetracycline (12.1 vs 4.4%) resistance, but otherwise similar or lower rates of resistance. Some of the differences in streptomycin, sulphonamide and tetracycline resistance in *E. coli* could be due to methodology as disc testing was used in the Massey studies and the end point can be difficult to determine for these antibiotics. Among Enterococci from poultry, we found higher tetracycline resistance in *E. faecalis* (77.9 vs 48.2%) and higher quinupristin/dalfopristin resistance (31.7 vs 13.8%) in *E. faecium*, but otherwise lower rates of resistance.

Of particular note, vancomycin resistance in enterococci appears to have diminished substantially. A 2001 study in the Dunedin area, just a year after the withdrawal of the use of avoparcin in the rearing of broiler poultry in this country, found a high prevalence (16.0%) of vanA-type vancomycin resistance among mainly *E. faecalis*, but also *E. faecium*, from poultry faecal samples.[21] In contrast, the Massey study in 2006 identified only one of 401 poultry carcass enterococcal isolates was vancomycin resistant.[23] In this survey no vancomycin-resistant enterococci were recovered from any of the animal groups.

*Comparison of resistance with that found among animal bacterial isolates in other countries*

The methodology used in the survey was modeled on the DANMAP system for the surveillance of antimicrobial resistance in bacteria from food animals.[11] Therefore, DANMAP resistance data is likely to provide the most valid data on which we can make an international comparison. However, the animal groups included in the DANMAP system do not specifically include the category of very young calves, but do include pigs and broiler poultry. Also, in the DANMAP system, the MICs are interpreted mainly according to the European EUCAST epidemiological cut-off values, whereas CLSI’s clinical breakpoints were mainly used to interpret the MICs obtained in this survey. Clinical breakpoints for MICs tend to be higher than epidemiological cut-off values, and therefore result in lower rates of resistance. While our use of clinical breakpoints allows the results from this survey to be more easily compared with resistance among human isolates in New Zealand, it makes it more difficult to compare the results with data on resistance among animal isolates in some other countries, especially those in Europe where epidemiological cut-off values are standardly used to interpret MICs.

After allowing for differences in interpretations of MICs and taking 95% confidence intervals into account, a comparison of 2009 DANMAP data with the results from this survey showed that, with the exception of higher resistance to sulphonamides in *E. coli* from poultry (30.7 vs 13.8%), resistance was either lower in New Zealand or not significantly different for the antibiotics that were commonly tested in this survey and reported in the 2009 DANMAP report.

Among isolates from poultry, *C. jejuni* isolated in New Zealand were less resistant than Danish isolates to ciprofloxacin (2.7 vs 13.3%), nalidixic acid (2.7 vs 13.3%) and tetracycline (0.3 vs 12.0%). *E. coli* from New Zealand poultry were less resistant to ampicillin (4.9 vs 18.4%), and there were no significant differences in resistance among Enterococci from New Zealand poultry compared with Danish poultry.

Among isolates from pigs, *E. coli* isolated in New Zealand were less resistant than Danish isolates to ampicillin (8.9 vs 26.0%) and trimethoprim (8.3 vs 18.7%). *E. faecalis* from New Zealand pigs were less resistant to chloramphenicol (8.3 vs 20.3%), erythromycin (27.6 vs 48.9%), high-level streptomycin (21.1 vs 36.8%) and tetracycline (43.0 vs 88.0%), and *E. faecium* from New Zealand pigs were less resistant to high-level streptomycin (15.8 vs 37.7%) and tetracycline (38.6 vs 66.2%).

The results from this survey were also compared with 2008 data from the NARMS surveillance of antimicrobial resistance among retail meats in the United States.[25] The methods used for the NARMS surveillance system are similar to those used for this survey, and the MICs are interpreted according to CLSI clinical breakpoints. However, the NARMS system monitors resistance among bacteria isolated from retail meats: chicken breast, ground turkey, ground beef and pork chop.

Compared with retail chicken breast meat in the United States in 2008, and taking 95% confidence intervals into account, *C. jejuni* from New Zealand poultry were less resistant to ciprofloxacin (2.7 vs 14.6%), nalidixic acid (2.7 vs 14.6%) and tetracycline (0.3 vs 49.9%). *E. coli* from New Zealand poultry were less resistant to ampicillin (4.9 vs 23.5%), cefotaxime/ceftriaxone (0.0 vs 11.1%), cefoxitin (0.3 vs 11.8%), ceftiofur (0.0 vs 10.8%), co-amoxiclav (0.0 vs 11.8%), gentamicin (0.0 vs 34.0%) and tetracycline (12.1 vs 43.8%). *E. faecalis* from New Zealand poultry were less resistant to high-level gentamicin (0.0 vs 17.7%), and *E. faecium* were less resistant to high-level gentamicin (0.0 vs 8.6%), nitrofurantoin (29.8 vs 46.3%), quinupristin/dalfopristin (31.7 vs 54.9%) and tetracycline (35.4 vs 64.3%).

Compared with retail pork chop meat in the United States in 2008, *E. coli* from New Zealand pigs were more resistant to sulphonamides (32.7 vs 16.4%). *E. faecalis* from New Zealand pigs were more resistant to chloramphenicol (8.3 vs 0.4%), erythromycin (27.6 vs 8.3%), high-level gentamicin (8.3 vs 0.4%) and high-level streptomycin (21.1 vs 7.6%), but less resistant to tetracycline (43.0 vs 76.9%). There were no significant differences in resistance among *E. faecium* from New Zealand pigs compared with American pork chop.

Overall these results suggest that resistance among *Campylobacter*, *E. coli* and Enterococci from New Zealand poultry tended to be lower than that among these bacteria isolated from American retail chicken breast. Whereas, resistance among *E. faecalis* from New Zealand pigs was higher than that among this bacterial species isolated from American retail pork chop meat. However, resistance among *E. coli* and *E. faecium* from New Zealand pigs and American pork chop meat was similar.

This survey has provided useful baseline data on antimicrobial resistance among certain bacteria isolated from selected food animals and fresh produce. It had one major limitation that should be addressed in any such future surveys: the 12-month length of the survey was insufficient to provide adequate numbers of *Salmonella* from any of the animal groups or

*Campylobacter* from very young calves or pigs to accurately assess antimicrobial resistance among these groupings. On the other hand, the low numbers of these two pathogens is obviously desirable from a food safety point of view.

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# Appendices

Table 5. Range of antimicrobials to be tested for each bacterial group, as recommended by the *NZFSA Working Group on Implementation of Antimicrobial Resistance Surveillance*

| | ***E. coli*** | ***Salmonella*** | ***Enterococcus***[1] | ***Campylobacter*** |
|---|---|---|---|---|
| ampicillin/amoxicillin | √ | √ | √ | |
| amoxicillin/clavulanate | √ | √ | | |
| bacitracin zinc | | | √ | |
| 3rd gen cephalosporins[2] | √ | √ | | |
| chloramphenicol | √ | √ | | |
| ciprofloxacin | √ | √ | √ | √ |
| erythomycin | | | | √ |
| gentamicin | √ | √ | √[3] | √ |
| nalidixic acid | √ | √ | | √ |
| nitrofurantoin | | | √ | |
| quinu/dalfopristin[4] | | | √ | |
| spectinomycin | √ | √ | | |
| streptomycin | √ | √ | √[3] | |
| sulphonamide | √ | √ | | |
| tetracycline | √ | √ | √ | √ |
| trimethoprim | √ | √ | | |
| tylosin | | | √ | |
| vancomycin | | | √ | |

Notes
[1] *E. faecalis* and *E. faecium* only
[2] To include screening for extended-spectrum β-lactamases (ESBLs) and confirmation of any screen-positive isolates
[3] High-level resistance only
[4] *E. faecium* only

## Table 6. Sensititre plate formats

Plate Code: **EUCAMP**[1]

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A** | GM 16 | SM 1 | SM 2 | SM 4 | SM 8 | SM 16 | GM 16 | SM 1 | SM 2 | SM 4 | SM 8 | SM 16 |
| **B** | GM 8 | CIP 4 | TE 16 | EM 32 | NX 64 | CM 32 | GM 8 | CIP 4 | TE 16 | EM 32 | NX 64 | CM 32 |
| **C** | GM 4 | CIP 2 | TE 8 | EM 16 | NX 32 | CM 16 | GM 4 | CIP 2 | TE 8 | EM 16 | NX 32 | CM 16 |
| **D** | GM 2 | CIP 1 | TE 4 | EM 8 | NX 16 | CM 8 | GM 2 | CIP 1 | TE 4 | EM 8 | NX 16 | CM 8 |
| **E** | GM 1 | CIP 0.5 | TE 2 | EM 4 | NX 8 | CM 4 | GM 1 | CIP 0.5 | TE 2 | EM 4 | NX 8 | CM 4 |
| **F** | GM 0.5 | CIP 0.25 | TE 1 | EM 2 | NX 4 | CM 2 | GM 0.5 | CIP 0.25 | TE 1 | EM 2 | NX 4 | CM 2 |
| **G** | GM 0.25 | CIP 0.12 | TE 0.5 | EM 1 | NX 2 | POS CON | GM 0.25 | CIP 0.12 | TE 0.5 | EM 1 | NX 2 | POS CON |
| **H** | GM 0.12 | CIP 0.06 | TE 0.25 | EM 0.5 | POS CON | POS CON | GM 0.12 | CIP 0.06 | TE 0.25 | EM 0.5 | POS CON | POS CON |

1 Note: plate accommodates two test isolates

| **Code** | **Antimicrobial** | **Concentration range (mg/L)** |
|---|---|---|
| GM | Gentamicin | 0.12-16 |
| SM | Streptomycin | 1-16 |
| CIP | Ciprofloxacin | 0.06-4 |
| TE | Tetracycline | 0.25-16 |
| EM | Erythromycin | 0.5-32 |
| NX | Nalidixic acid | 2-64 |
| CM | Chloramphenicol | 2-32 |
| POS CON | Positive control | |

Plate Code: **NZFSAN**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A** | CTAX 0.25 | CTAX 0.5 | CTAX 1 | CTAX 2 | CTAX 4 | CTAX 8 | CTAX 16 | CTAX 32 | CP 4 | CP 8 | CP 16 | CP 32 |
| **B** | CIP 0.03 | CIP 0.06 | CIP 0.12 | CIP 0.25 | CIP 0.5 | CIP 1 | CIP 2 | CIP 4 | APR 4 | APR 8 | APR 16 | APR 32 |
| **C** | CFOX 0.5 | CFOX 1 | CFOX 2 | CFOX 4 | CFOX 8 | CFOX 16 | CFOX 32 | CFUR 0.5 | CFUR 1 | CFUR 2 | CFUR 4 | CFUR 8 |
| **D** | GM 1 | GM 2 | GM 4 | GM 8 | GM 16 | GM 32 | NX 2 | NX 4 | NX 8 | NX 16 | NX 32 | NX 64 |
| **E** | AMP 1 | AMP 2 | AMP 4 | AMP 8 | AMP 16 | AMP 32 | SFM 64 | SFM 128 | SFM 256 | SFM 512 | SFM 1024 | CTAZ 1 |
| **F** | SP 16 | SP 32 | SP 64 | SP 128 | SP 256 | SM 4 | SM 8 | SM 16 | SM 32 | SM 64 | TM 4 | TM 32 |
| **G** | AMC 2 | AMC 4 | AMC 8 | AMC 16 | AMC 32 | TE 2 | TE 4 | TE 8 | TE 16 | TE 32 | TM 8 | POS CON |
| **H** | CM 4 | CM 8 | CM 16 | CM 32 | CM 64 | NE 2 | NE 4 | NE 8 | NE 16 | NE 32 | TM 16 | POS CON |

| **Code** | **Antimicrobial** | **Concentration range (mg/L)** |
|---|---|---|
| CTAX | Cefotaxime | 0.25-32 |
| CP | Cephalothin | 4-32 |
| CIP | Ciprofloxacin | 0.03-4 |
| APR | Apramycin | 2-32 |
| CFOX | Cefoxitin | 0.5-32 |
| CFUR | Ceftiofur | 0.5-8 |
| GM | Gentamicin | 1-32 |
| NX | Nalidixic acid | 2-64 |
| AMP | Ampicillin | 1-32 |
| SFM | Sulfamethoxazole | 64-1024 |
| CTAZ | Ceftazidime | 1 |
| SP | Spectinomycin | 16-256 |
| SM | Streptomycin | 4-64 |
| TM | Trimethoprim | 4-32 |
| AMC | Amoxicillin/clavulanic acid, 2:1 ratio (Co-amoxiclav) | 2-32[1] |
| TE | Tetracycline | 2-32 |
| CM | Chloramphenicol | 4-64 |
| NE | Neomycin | 2-32 |
| POS CON | Positive control | |

1 Refers to the amoxicillin concentration

Plate Code: **NZFSAP**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A** | GM 128 | BAC 2 | TYL 0.25 | EM 1 | TE 0.5 | CIP 0.5 | VM 0.5 | QD 0.5 | AMP 0.5 | CM 2 | NI 2 | SM 128 |
| **B** | GM 256 | BAC 4 | TYL 0.5 | EM 2 | TE 1 | CIP 1 | VM 1 | QD 1 | AMP 1 | CM 4 | NI 4 | SM 256 |
| **C** | GM 512 | BAC 8 | TYL 1 | EM 4 | TE 2 | CIP 2 | VM 2 | QD 2 | AMP 2 | CM 8 | NI 8 | SM 512 |
| **D** | GM 1024 | BAC 16 | TYL 2 | EM 8 | TE 4 | CIP 4 | VM 4 | QD 4 | AMP 4 | CM 16 | NI 16 | SM 1024 |
| **E** | GM 2048 | BAC 32 | TYL 4 | EM 16 | TE 8 | CIP 8 | VM 8 | QD 8 | AMP 8 | CM 32 | NI 32 | SM 2048 |
| **F** | | BAC 64 | TYL 8 | EM 32 | TE 16 | CIP 16 | VM 16 | QD 16 | AMP 16 | CM 64 | NI 64 | POS CON |
| **G** | | BAC 128 | TYL 16 | EM 64 | TE 32 | CIP 32 | VM 32 | QD 32 | AMP 32 | | | POS CON |
| **H** | | BAC 256 | TYL 32 | EM 128 | TE 64 | TE 128 | VM 64 | VM 128 | | | | POS CON |

| **Code** | **Antimicrobial** | **Concentration range (mg/L)** |
|---|---|---|
| GM | Gentamicin | 128-2048 |
| BAC | Bacitracin | 2-256 |
| TYL | Tylosin tartrate | 0.25-32 |
| EM | Erythromycin | 1-128 |
| TE | Tetracycline | 0.5-128 |
| CIP | Ciprofloxacin | 0.5-32 |
| VM | Vancomycin | 0.5-128 |
| QD | Quinupristin/dalfopristin | 0.5-32 |
| AMP | Ampicillin | 0.5-32 |
| CM | Chloramphenicol | 2-64 |
| NI | Nitrofurantoin | 2-64 |
| SM | Streptomycin | 128-2048 |
| POS CON | Positive control | |

## Table 7. Interpretation of minimum inhibitory concentrations

| | Minimum inhibitory concentration as mg/L (reference for interpretation)[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***Campylobacter*** | | | ***Salmonella* and *E. coli*** | | | **Enterococci** | | |
| | **S**[2] | **I**[2] | **R**[2] | **S** | **I** | **R** | **S** | **I** | **R** |
| Ampicillin | | | | ≤8 | 16 | ≥32 (8) | ≤8 | - | ≥16 (8) |
| Apramycin | | | | ≤16 | - | ≥32(11) | | | |
| Cefotaxime | | | | ≤1 | 2 | ≥4 (8) | | | |
| Cefoxitin | | | | ≤8 | 16 | ≥32 (8) | | | |
| Ceftazidime | | | | ≤4 | 8 | ≥16 (8) | | | |
| Ceftiofur | | | | ≤2 | 4 | ≥8 (10) | | | |
| Cephalothin | | | | ≤8 | 16 | ≥32 (8) | | | |
| Chloramphenicol | ≤16 | - | ≥32 (11) | ≤8 | 16 | ≥32 (8) | ≤8 | 16 | ≥32 (8) |
| Ciprofloxacin | ≤1 | 2 | ≥4 (9) | ≤1 | 2 | ≥4 (8) | ≤1 | 2 | ≥4 (8) |
| Co-amoxiclav[3] | | | | ≤8 | 16 | ≥32 (8) | | | |
| Erythromycin | ≤8 | 16 | ≥32 (9) | | | | ≤0.5 | 1-4 | ≥8 (8) |
| Gentamicin | ≤1/≤2 | - | ≥2/≥4[4](11) | ≤4 | 8 | ≥16 (8) | ≤512 | - | ≥1024[5](8) |
| Nalidixic acid | ≤16/≤32 | - | ≥32/≥64[6] (11) | ≤16 | - | ≥32 8) | | | |
| Neomycin | | | | ≤4/≤8 | - | ≥8/≥16[7] (11) | | | |
| Nitrofurantoin | | | | | | | ≤32 | 64 | ≥128 (8) |
| Quinupristin/dalfopristin | | | | | | | ≤1 | 2 | ≥4 (8) |
| Spectinomycin | | | | ≤32 | 64 | ≥128(10) | | | |
| Streptomycin | ≤2/≤4 | - | ≥4/≥8[8](11) | ≤16 | - | ≥32 (11) | ≤1024 | - | ≥2048[5](8) |
| Sulfamethoxazole | | | | ≤256 | - | ≥512 (8) | | | |
| Tetracycline | ≤4 | 8 | ≥16 (9) | ≤4 | 8 | ≥16 (8) | ≤4 | 8 | ≥16 (8) |
| Trimethoprim | | | | ≤8 | - | ≥16 (8) | | | |
| Vancomycin | | | | | | | ≤4 | 8-16 | ≥32 (8) |

1 The numbers given in parentheses refer to references cited in the Reference section of this document.
2 S, susceptible; I, intermediate resistance; R, resistant.
3 The concentrations given refer to the amoxicillin component.
4 DANMAP's gentamicin epidemiological cut-off values for *C. jejuni* and *C. coli* differ: ≤1 and ≥2 mg/L for *C. jejuni* and ≤2 and ≥4 mg/L for *C. coli*.
5 High-level resistance
6 DANMAP's nalidixic acid epidemiological cut-off values for *C. jejuni* and *C. coli* differ: ≤16 and ≥32 mg/L for *C. jejuni* and ≤32 and ≥64 mg/L for *C. coli*.
7 DANMAP's neomycin epidemiological cut-off values for *Salmonella* and *E. coli* differ: ≤4 and ≥8 mg/L for *Salmonella* and ≤8 and ≥16 mg/L for *E. coli*.
8 DANMAP's streptomycin epidemiological cut-off values for *C. jejuni* and *C. coli* differ: ≤2 and ≥4 mg/L for *C. jejuni* and ≤4 and ≥8 mg/L for *C. coli*.

Table 8. Isolation of *Campylobacter* from swabs of very young calf carcasses, pigs and poultry each quarter of the survey period

| **Plant** | **Target number of isolates for whole survey** | **Freq. of sampling**[1] | **Quarter 1** | | **Quarter 2** | | **Quarter 3** | | **Quarter 4** | | **Total** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Samples received/ isolates recovered** | **Isolates selected for AST** | **Samples received/ isolates recovered** | **Isolates selected for AST** | **Samples received/ isolates recovered** | **Isolates selected for AST** | **Samples received/ isolates recovered** | **Isolates selected for AST** | **Samples received/ isolates recovered** | **Isolates selected for AST** |
| **Very young calves** | | | | | | | | | | | | |
| **North Island plants** | | | | | | | | | | | | |
| 1 | 6 | W | [2] | | | | | | 55 / 0 | 0 | 55 / 0 | 0 |
| 2 | 40 | W | | | | | | | 60 / 1 | 1 | 60 / 1 | 1 |
| 3 | 12 | W | | | | | | | 50 / 0 | 0 | 50 / 0 | 0 |
| 4 | 30 | W | | | | | | | 35 / 0 | 0 | 35 / 0 | 0 |
| 5 | 15 | W | | | | | | | 55 / 0 | 0 | 55 / 0 | 0 |
| 6 | 10 | W | | | | | | | 60 / 0 | 0 | 60 / 0 | 0 |
| 7 | 30 | W | | | | | | | 55 / 3 | 3 | 55 / 3 | 3 |
| 8 | 30 | W | | | | | | | 60 / 0 | 0 | 60 / 0 | 0 |
| 9 | 16 | W | | | | | | | 40 / 1 | 1 | 40 / 1 | 1 |
| 10 | 16 | W | | | | | | | 60 / 6 | 6 | 60 / 6 | 6 |
| 11 | 8 | W | 20 / 0 | 0 | | | | | 50 / 3 | 3 | 70 / 3 | 3 |
| **South Island plants** | | | | | | | | | | | | |
| 12 | 5 | F | 20 / 1 | 1 | | | | | 40 / 5 | 5 | 60 / 6 | 6 |
| 13 | 4 | F | 10 / 1 | 1 | | | | | 40 / 1 | 1 | 50 / 2 | 2 |
| 14 | 8 | W | 15 / 2 | 2 | | | | | 25 / 1 | 1 | 40 / 3 | 3 |
| 15 | 4 | F | | | | | | | 10 / 0 | 0 | 10 / 0 | 0 |

| Plant | Target number of isolates for whole survey | Freq. of sampling[1] | Quarter 1 | | Quarter 2 | | Quarter 3 | | Quarter 4 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST |
| 16 | 12 | W | 20 / 5 | 5 | | | | | 35 / 1 | 1 | 55 / 6 | 6 |
| 17 | 1 | F | | | | | | | 5 / 0 | 0 | 5 / 0 | 0 |
| 18 | 8 | W | 25 / 2 | 2 | | | | | 45 / 3 | 3 | 70 / 5 | 5 |
| 19 | 1 | F | 5 / 0 | 0 | | | | | 50 / 2 | 2 | 55 / 2 | 2 |
| 20 | 4 | W | 25 / 3 | 3 | | | | | 30 / 1 | 1 | 55 / 4 | 4 |
| 21 | 8 | W | | | | | | | 45 / 5 | 5 | 45 / 5 | 5 |
| 22 | 15 | W | 15 / 0 | 0 | | | | | 35 / 0 | 0 | 50 / 0 | 0 |
| 23 | 1 | F | 4 / 2 | 2 | | | | | 0 / 0 | 0 | 4 / 2 | 2 |
| 24 | 6 | F | 25 / 4 | 4 | | | | | 35 / 3 | 3 | 60 / 7 | 7 |
| | | | | | | | | | | | | |
| **Pigs** | | | | | | | | | | | | |
| **North Island plants** | | | | | | | | | | | | |
| 25 | 58 | W | 50 / 0 | 0 | 65 / 1 | 1 | 60 / 0 | 0 | 65 / 0 | 0 | 240 / 1 | 1 |
| 26 | 6 | F | 7 / 0 | 0 | 4 / 0 | 0 | 5 / 0 | 0 | 4 / 0 | 0 | 20 / 0 | 0 |
| 27 | 28 | W | 50 / 4 | 4 | 60 / 1 | 1 | 70 / 0 | 0 | 65 / 1 | 1 | 245 / 6 | 6 |
| 28 | 34 | W | 55 / 0 | 0 | 65 / 0 | 0 | 60 / 0 | 0 | 60 / 0 | 0 | 240 / 0 | 0 |
| 29 | 18 | W | 40 / 0 | 0 | 50 / 3 | 3 | 50 / 0 | 0 | 60 / 0 | 0 | 200 / 3 | 3 |
| **South Island plants** | | | | | | | | | | | | |
| 30 | 6 | F | 7 / 0 | 0 | 5 / 0 | 0 | 4 / 0 | 0 | 5 / 0 | 0 | 21 / 0 | 0 |

| Plant | Target number of isolates for whole survey | Freq. of sampling[1] | Quarter 1 | | Quarter 2 | | Quarter 3 | | Quarter 4 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST |
| 31 | 46 | W | 40 / 0 | 0 | 65 / 0 | 0 | 65 / 0 | 0 | 60 / 0 | 0 | 230 / 0 | 0 |
| 32 | 46 | W | 50 / 0 | 0 | 65 / 0 | 0 | 65 / 0 | 0 | 60 / 1 | 1 | 240 / 1 | 1 |
| 33 | 58 | W | 55 / 0 | 0 | 50 / 0 | 0 | 55 / 0 | 0 | 65 / 0 | 0 | 225 / 0 | 0 |
| | | | | | | | | | | | | |
| **Poultry** | | | | | | | | | | | | |
| **North Island plants** | | | | | | | | | | | | |
| 34 | 35 | W | 19 / 19 | 10 | 21 / 19 | 9 | 22 / 22 | 11 | 19 / 19 | 8 | 81 / 79 | 38 |
| 35 | 53 | W | 15 / 15 | 15 | 18 / 15 | 14 | 20 / 20 | 14 | 17 / 16 | 13 | 70 / 66 | 56 |
| 36 | 88 | W | 13 / 13 | 13 | 23 / 23 | 23 | 20 / 20 | 19 | 21 / 19 | 19 | 77 / 75 | 74 |
| 37 | 55 | W | 12 / 12 | 12 | 19 / 19 | 15 | 28 / 28 | 15 | 21 / 20 | 14 | 80 / 79 | 56 |
| 38 | 1 | Q | 4 / 4 | 2 | 0 / 0 | 0 | 0 / 0 | 0 | 0 / 0 | 0 | 4 / 4 | 2 |
| 39 | 11 | F | 8 / 7 | 3 | 13 / 11 | 3 | 8 / 7 | 3 | 6 / 5 | 3 | 35 / 30 | 12 |
| **South Island plants** | | | | | | | | | | | | |
| 40 | 9 | F | 7 / 6 | 4 | 13 / 11 | 3 | 14 / 11 | 5 | 10 / 8 | 1 | 44 / 36 | 13 |
| 41 | 1 | Q | 3 / 3 | 2 | 0 / 0 | 0 | 0 / 0 | 0 | 0 / 0 | 0 | 3 / 3 | 2 |
| 42 | 44 | W | 13 / 12 | 12 | 19 / 18 | 14 | 6 / 6 | 6 | 13 / 12 | 12 | 51 / 48 | 44 |
| 43 | 1 | Q | 0 / 0 | 0 | 0 / 0 | 0 | 0 / 0 | 0 | 0 / 0 | 0 | 0 / 0 | 0 |

1 W, weekly; F fortnightly; Q, Quarterly.
2 Shaded cells represent the out-of-season quarters for processing very young calves.

Table 9. Isolation of *Escherichia coli* from swabs of very young calf carcasses, pigs and poultry each quarter of the survey period

| Plant | Target number of isolates for whole survey | Freq. of sampling[1] | Quarter 1 | | Quarter 2 | | Quarter 3 | | Quarter 4 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST |
| **Very young calves** | | | | | | | | | | | | |
| **North Island plants** | | | | | | | | | | | | |
| 1 | 6 | W | [2] | | | | | | 45 / 21 | 12 | 45 / 21 | 12 |
| 2 | 40 | W | | | | | | | 40 / 20 | 20 | 40 / 20 | 20 |
| 3 | 12 | W | | | | | | | 51 / 22 | 20 | 51 / 22 | 20 |
| 4 | 30 | W | | | | | | | 32 / 14 | 14 | 32 / 14 | 14 |
| 5 | 15 | W | | | | | | | 43 / 19 | 18 | 43 / 19 | 18 |
| 6 | 10 | W | | | | | | | 49 / 22 | 11 | 49 / 22 | 11 |
| 7 | 30 | W | | | | | | | 40 / 20 | 20 | 40 / 20 | 20 |
| 8 | 30 | W | | | | | | | 50 / 27 | 27 | 50 / 27 | 27 |
| 9 | 16 | W | | | | | | | 42 / 18 | 18 | 42 / 18 | 18 |
| 10 | 16 | W | | | | | | | 60 / 29 | 24 | 60 / 29 | 24 |
| 11 | 8 | W | 19 / 18 | 3 | | | | | 43 / 18 | 9 | 62 / 36 | 12 |
| **South Island plants** | | | | | | | | | | | | |
| 12 | 5 | F | 18 / 18 | 2 | | | | | 40 / 18 | 9 | 58 / 36 | 11 |
| 13 | 4 | F | 10 / 10 | 2 | | | | | 39 / 16 | 7 | 49 / 26 | 9 |
| 14 | 8 | W | 14 / 14 | 3 | | | | | 24 / 10 | 5 | 38 / 24 | 8 |
| 15 | 4 | F | | | | | | | 7 / 4 | 3 | 7 / 4 | 3 |

| **Plant** | **Target number of isolates for whole survey** | **Freq. of sampling**[1] | **Quarter 1** | | **Quarter 2** | | **Quarter 3** | | **Quarter 4** | | **Total** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Samples received/ isolates recovered** | **Isolates selected for AST** | **Samples received/ isolates recovered** | **Isolates selected for AST** | **Samples received/ isolates recovered** | **Isolates selected for AST** | **Samples received/ isolates recovered** | **Isolates selected for AST** | **Samples received/ isolates recovered** | **Isolates selected for AST** |
| 16 | 12 | W | 20 / 18 | 5 | | | | | 36 / 16 | 10 | 56 / 34 | 15 |
| 17 | 1 | F | | | | | | | 5 / 2 | 2 | 5 / 2 | 2 |
| 18 | 8 | W | 23 / 21 | 4 | | | | | 43 / 18 | 9 | 66 / 39 | 13 |
| 19 | 1 | F | 5 / 5 | 1 | | | | | 0 / 0 | 0 | 5 / 5 | 1 |
| 20 | 4 | W | 21 / 21 | 2 | | | | | 28 / 10 | 5 | 49 / 31 | 7 |
| 21 | 8 | W | | | | | | | 36 / 18 | 9 | 36 / 18 | 9 |
| 22 | 15 | W | 13 / 13 | 6 | | | | | 37 / 16 | 10 | 50 / 29 | 16 |
| 23 | 1 | F | 18 / 15 | 1 | | | | | 18 / 0 | 0 | 36 / 15 | 1 |
| 24 | 6 | F | 24 / 22 | 2 | | | | | 35 / 14 | 7 | 59 / 36 | 9 |
| | | | | | | | | | | | | |
| **Pigs** | | | | | | | | | | | | |
| **North Island plants** | | | | | | | | | | | | |
| 25 | 58 | W | 36 / 26 | 15 | 32 / 22 | 15 | 27 / 18 | 15 | 39 / 24 | 13 | 134 / 90 | 58 |
| 26 | 6 | F | 1 / 1 | 1 | 2 / 1 | 1 | 1 / 1 | 1 | 0 / 0 | 0 | 4 / 3 | 3 |
| 27 | 28 | W | 39 / 28 | 9 | 29 / 17 | 8 | 30 / 14 | 7 | 27 / 18 | 11 | 125 / 77 | 35 |
| 28 | 34 | W | 42 / 29 | 10 | 23 / 16 | 9 | 26 / 18 | 9 | 35 / 20 | 10 | 126 / 83 | 38 |
| 29 | 18 | W | 16 / 7 | 5 | 41 / 22 | 10 | 29 / 17 | 5 | 2 / 2 | 2 | 88 / 48 | 22 |
| **South Island plants** | | | | | | | | | | | | |
| 30 | 6 | F | 20 / 14 | 4 | 4 / 3 | 2 | 4 / 1 | 1 | 4 / 4 | 3 | 32 / 22 | 10 |

| Plant | Target number of isolates for whole survey | Freq. of sampling[1] | Quarter 1 | | Quarter 2 | | Quarter 3 | | Quarter 4 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST |
| 31 | 46 | W | 6 / 5 | 5 | 12 / 8 | 8 | 12 / 7 | 7 | 13 / 13 | 13 | 43 / 33 | 33 |
| 32 | 46 | W | 10 / 10 | 10 | 14 / 13 | 13 | 20 / 19 | 13 | 15 / 13 | 10 | 59 / 55 | 46 |
| 33 | 58 | W | 22 / 19 | 15 | 16 / 9 | 9 | 29 / 25 | 21 | 20 / 17 | 13 | 87 / 70 | 58 |
| | | | | | | | | | | | | |
| **Poultry** | | | | | | | | | | | | |
| **North Island plants** | | | | | | | | | | | | |
| 34 | 35 | W | 21 / 18 | 9 | 22 / 21 | 11 | 24 / 21 | 11 | 23 / 23 | 10 | 90 / 83 | 41 |
| 35 | 53 | W | 10 / 9 | 9 | 14 / 14 | 14 | 19 / 13 | 12 | 17 / 15 | 15 | 60 / 51 | 50 |
| 36 | 88 | W | 30 / 30 | 29 | 20 / 18 | 18 | 24 / 22 | 21 | 23 / 20 | 20 | 97 / 90 | 88 |
| 37 | 55 | W | 33 / 30 | 14 | 39 / 30 | 14 | 39 / 28 | 14 | 39 / 25 | 14 | 150 / 113 | 56 |
| 38 | 1 | Q | 3 / 3 | 1 | 0 / 0 | 0 | 0 / 0 | 0 | 0 / 0 | 0 | 3 / 3 | 1 |
| 39 | 11 | F | 23 / 22 | 3 | 24 / 21 | 4 | 21 / 14 | 4 | 24 / 16 | 3 | 92 / 73 | 14 |
| **South Island plants** | | | | | | | | | | | | |
| 40 | 9 | F | 11 / 7 | 3 | 11 / 10 | 4 | 4 / 2 | 2 | 4 / 2 | 2 | 30 / 21 | 11 |
| 41 | 1 | Q | 1 / 1 | 1 | 0 / 0 | 0 | 0 / 0 | 0 | 0 / 0 | 0 | 1 / 1 | 1 |
| 42 | 44 | W | 27 / 23 | 11 | 14 / 13 | 11 | 24 / 18 | 11 | 22 / 12 | 11 | 87 / 66 | 44 |
| 43 | 1 | Q | 0 / 0 | 0 | 0 / 0 | 0 | 0 / 0 | 0 | 0 / 0 | 0 | 0 / 0 | 0 |

1 W, weekly; F fortnightly; Q, Quarterly.

2 Shaded cells represent the out-of-season quarters for processing very young calves.

Table 10. Isolation of Enterococci from swabs of very young calf carcasses, pigs and poultry each quarter of the survey period

| Plant | Target number of isolates for whole survey | Freq. of sampling[1] | Quarter 1 | | Quarter 2 | | Quarter 3 | | Quarter 4 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST |
| **Very young calves** | | | | | | | | | | | | |
| **North Island plants** | | | | | | | | | | | | |
| 1 | 6 | W | [2] | | | | | | 55 / 20 | 12 | 55 / 20 | 12 |
| 2 | 40 | W | | | | | | | 55 / 20 | 14 | 55 / 20 | 14 |
| 3 | 12 | W | | | | | | | 50 / 33 | 16 | 50 / 33 | 16 |
| 4 | 30 | W | | | | | | | 35 / 20 | 15 | 35 / 20 | 15 |
| 5 | 15 | W | | | | | | | 55 / 25 | 14 | 55 / 25 | 14 |
| 6 | 10 | W | | | | | | | 60 / 46 | 16 | 60 / 46 | 16 |
| 7 | 30 | W | | | | | | | 55 / 21 | 16 | 55 / 21 | 16 |
| 8 | 30 | W | | | | | | | 55 / 23 | 18 | 55 / 23 | 18 |
| 9 | 16 | W | | | | | | | 40 / 22 | 11 | 40 / 22 | 11 |
| 10 | 16 | W | | | | | | | 60 / 31 | 25 | 60 / 31 | 25 |
| 11 | 8 | W | 20 / 9 | 4 | | | | | 50 / 34 | 21 | 70 / 43 | 25 |
| **South Island plants** | | | | | | | | | | | | |
| 12 | 5 | F | 20 / 10 | 3 | | | | | 40 / 30 | 6 | 60 / 40 | 9 |
| 13 | 4 | F | 10 / 4 | 2 | | | | | 40 / 17 | 4 | 50 / 21 | 6 |
| 14 | 8 | W | 15 / 9 | 4 | | | | | 25 / 14 | 6 | 40 / 23 | 10 |

| Plant | Target number of isolates for whole survey | Freq. of sampling[1] | Quarter 1 | | Quarter 2 | | Quarter 3 | | Quarter 4 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST |
| 15 | 4 | F | | | | | | | 10 / 1 | 1 | 10 / 1 | 1 |
| 16 | 12 | W | 20 / 5 | 4 | | | | | 35 / 14 | 11 | 55 / 19 | 15 |
| 17 | 1 | F | | | | | | | 5 / 3 | 2 | 5 / 3 | 2 |
| 18 | 8 | W | 25 / 8 | 4 | | | | | 40 / 18 | 6 | 65 / 26 | 10 |
| 19 | 1 | F | 5 / 1 | 1 | | | | | 45 / 24 | 1 | 50 / 25 | 2 |
| 20 | 4 | W | 25 / 15 | 4 | | | | | 35 / 24 | 3 | 60 / 39 | 7 |
| 21 | 8 | W | | | | | | | 40 / 21 | 8 | 40 / 21 | 8 |
| 22 | 15 | W | 15 / 1 | 1 | | | | | 40 / 23 | 10 | 55 / 24 | 11 |
| 23 | 1 | F | 3 / 3 | 3 | | | | | 0 / 0 | 0 | 3 / 3 | 3 |
| 24 | 6 | F | 25 / 8 | 2 | | | | | 35 / 19 | 9 | 60 / 27 | 11 |
| | | | | | | | | | | | | |
| **Pigs** | | | | | | | | | | | | |
| **North Island plants** | | | | | | | | | | | | |
| 25 | 58 | W | 50 / 15 | 14 | 60 / 22 | 18 | 60 / 12 | 8 | 65 / 17 | 16 | 235 / 66 | 56 |
| 26 | 6 | F | 5 / 2 | 2 | 3 / 1 | 0 | 5 / 1 | 1 | 2 / 1 | 0 | 15 / 5 | 3 |
| 27 | 28 | W | 50 / 21 | 14 | 60 / 23 | 17 | 70 / 17 | 13 | 65 / 14 | 14 | 245 / 75 | 58 |
| 28 | 34 | W | 55 / 24 | 17 | 60 / 11 | 6 | 60 / 17 | 15 | 60 / 4 | 3 | 235 / 56 | 41 |
| 29 | 18 | W | 40 / 23 | 18 | 50 / 17 | 15 | 50 / 17 | 11 | 50 / 0 | 0 | 190 / 57 | 44 |
| **South Island plants** | | | | | | | | | | | | |
| 30 | 6 | F | 7 / 6 | 4 | 5 / 2 | 2 | 4 / 1 | 1 | 5 / 1 | 0 | 21 / 10 | 7 |
| 31 | 46 | W | 40 / 3 | 2 | 65 / 3 | 2 | 65 / 12 | 9 | 60 / 10 | 7 | 230 / 28 | 20 |
| 32 | 46 | W | 50 / 10 | 7 | 65 / 8 | 6 | 65 / 8 | 5 | 60 / 10 | 7 | 240 / 36 | 25 |

| Plant | Target number of isolates for whole survey | Freq. of sampling[1] | Quarter 1 | | Quarter 2 | | Quarter 3 | | Quarter 4 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST | Samples received/ isolates recovered | Isolates selected for AST |
| 33 | 58 | W | 55 / 11 | 9 | 50 / 10 | 7 | 55 / 17 | 7 | 65 / 10 | 8 | 225 / 48 | 31 |
| | | | | | | | | | | | | |
| **Poultry** | | | | | | | | | | | | |
| **North Island plants** | | | | | | | | | | | | |
| 34 | 35 | W | 32 / 30 | 9 | 33 / 29 | 9 | 37 / 24 | 9 | 42 / 26 | 8 | 144 / 109 | 35 |
| 35 | 53 | W | 32 / 25 | 14 | 36 / 27 | 14 | 39 / 25 | 15 | 42 / 29 | 10 | 149 / 106 | 53 |
| 36 | 88 | W | 24 / 24 | 21 | 36 / 31 | 25 | 39 / 30 | 22 | 42 / 31 | 20 | 141 / 116 | 88 |
| 37 | 55 | W | 33 / 31 | 14 | 41 / 29 | 16 | 39 / 25 | 13 | 37 / 25 | 12 | 150 / 110 | 55 |
| 38 | 1 | Q | 9 / 9 | 1 | 0 / 0 | 0 | 0 / 0 | 0 | 0 / 0 | 0 | 9 / 9 | 1 |
| 39 | 11 | F | 20 / 18 | 3 | 24 / 15 | 3 | 21 / 10 | 3 | 24 / 11 | 2 | 89 / 54 | 11 |
| **South Island plants** | | | | | | | | | | | | |
| 40 | 9 | F | 15 / 8 | 1 | 24 / 17 | 4 | 18 / 8 | 3 | 18 / 9 | 1 | 75 / 42 | 9 |
| 41 | 1 | Q | 3 / 3 | 1 | 0 / 0 | 0 | 0 / 0 | 0 | 0 / 0 | 0 | 3 / 3 | 1 |
| 42 | 44 | W | 30 / 24 | 11 | 21 / 16 | 11 | 30 / 18 | 11 | 27 / 19 | 11 | 108 / 77 | 44 |
| 43 | 1 | Q | 3 / 1 | 1 | 0 / 0 | 0 | 0 / 0 | 0 | 0 / 0 | 0 | 3 / 1 | 1 |

1 W, weekly; F fortnightly; Q, Quarterly.

2 Shaded cells represent the out-of-season quarters for processing very young calves.

Table 11. Prevalence of resistance, intermediate resistance and susceptibility, and distribution of minimum inhibitory concentrations (MICs), among *Campylobacter jejuni* isolated from very young calves (n=49) and poultry (n=295)[1]

| Antimicrobial | Source | %S[2] | %I[2] | %R[2] (95% CIs) | Percent of isolates with an MIC of:[3] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0.03 | 0.06 | 0.12 | 0.25 | 0.5 | 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 | 256 | 512 | 1024 | 2048 |
| Chloramphenicol | calves | 100 | - | 0.0 (0.0-7.3) | | | | | | | 95.9 | 4.1 | | | | | | | | | |
| | poultry | 100 | - | 0.0 (0.0-1.3) | | | | | | | 99.3 | 0.7 | | | | | | | | | |
| Ciprofloxacin | calves | 100 | 0.0 | 0.0 (0.0-7.3) | | 42.9 | 51.0 | 6.1 | | | | | | | | | | | | | |
| | poultry | 97.3 | 0.0 | 2.7 (1.2-5.3) | | 64.4 | 31.2 | 0.3 | 1.4 | | | | 2.7 | | | | | | | | |
| Erythromycin | calves | 100 | 0.0 | 0.0 (0.0-7.3) | | | | | 85.7 | 12.2 | | 2.0 | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-1.3) | | | | | 95.6 | 2.0 | 2.0 | 0.3 | | | | | | | | | |
| Gentamicin | calves | 100 | - | 0.0 (0.0-7.3) | | | 10.2 | 42.9 | 46.9 | | | | | | | | | | | | |
| | poultry | 100 | - | 0.0 (0.0-1.3) | | | 8.1 | 52.9 | 36.6 | 2.4 | | | | | | | | | | | |
| Nalidixic acid | calves | 100 | - | 0.0 (0.0-7.3) | | | | | | | 6.1 | 71.4 | 18.4 | 4.1 | | | | | | | |
| | poultry | 97.3 | - | 2.7 (1.2-5.3) | | | | | | | 14.2 | 78.6 | 3.4 | 1.0 | | 2.4 | 0.3 | | | | |
| Streptomycin | calves | 91.8 | - | 8.2 (2.3-19.6) | | | | | | 71.4 | 20.4 | 2.0 | | | 6.1 | | | | | | |
| | poultry | 99.0 | - | 1.0 (0.2-3.0) | | | | | | 90.5 | 8.5 | 1.0 | | | | | | | | | |
| Tetracycline | calves | 100 | 0.0 | 0.0 (0.0-7.3) | | | | 98.0 | | 2.0 | | | | | | | | | | | |
| | poultry | 99.7 | 0.0 | 0.3 (0.0-1.9) | | | | 98.0 | 1.0 | 0.7 | | | | | 0.3 | | | | | | |

1 No *C. jejuni* isolated from pigs.

2 S, susceptible; I, intermediate resistance; R, resistant.

3 The white fields represent the range of dilutions tested. MIC values less than or equal to the lowest concentration tested are presented as this lowest concentration. MIC values greater than the highest concentration tested are presented as the next highest concentration after the highest concentration tested. The vertical bars indicate the breakpoints between the susceptibility categories. For antibiotics where there are two vertical lines, the first line represents the breakpoint between susceptible and intermediate, and the second line represents the breakpoint between intermediate and resistant. For antibiotics where there is one vertical line, the line represents the breakpoint between susceptible and resistant.

**Table 12. Prevalence of resistance, intermediate resistance and susceptibility, and distribution of minimum inhibitory concentrations (MICs), among *Campylobacter coli* isolated from very young calves (n=7), pigs (n=10) and poultry (n=2)**

| Antimicrobial | Source | %S[1] | %I[1] | %R[1] (95% CIs) | Percent of isolates with an MIC of:[2] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0.03 | 0.06 | 0.12 | 0.25 | 0.5 | 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 | 256 | 512 | 1024 | 2048 |
| Chloramphenicol | calves | 100 | - | 0.0 (0.0-41.0) | | | | | | | 100 | | | | | | | | | | |
| | pigs | 100 | - | 0.0 (0.0-30.8) | | | | | | | 80.0 | 20.0 | | | | | | | | | |
| | poultry | 100 | - | 0.0 (0.0-84.2) | | | | | | | 100 | | | | | | | | | | |
| Ciprofloxacin | calves | 100 | 0.0 | 0.0 (0.0-41.0) | | 85.7 | 14.3 | | | | | | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-30.8) | | 30.0 | 60.0 | 10.0 | | | | | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-84.2) | | 100 | | | | | | | | | | | | | | | |
| Erythromycin | calves | 100 | 0.0 | 0.0 (0.0-41.0) | | | | | 85.7 | | 14.3 | | | | | | | | | | |
| | pigs | 80.0 | 0.0 | 20.0 (2.5-55.6) | | | | | 20.0 | 50.0 | | | 10.0 | | | 20.0 | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-84.2) | | | | | 100 | | | | | | | | | | | | |
| Gentamicin | calves | 100 | - | 0.0 (0.0-41.0) | | | | | 28.6 | 71.4 | | | | | | | | | | | |
| | pigs | 100 | - | 0.0 (0.0-30.8) | | | | | 60.0 | 40.0 | | | | | | | | | | | |
| | poultry | 100 | - | 0.0 (0.0-84.2) | | | | | 100 | | | | | | | | | | | | |
| Nalidixic acid | calves | 100 | - | 0.0 (0.0-41.0) | | | | | | | | 85.7 | 14.3 | | | | | | | | |
| | pigs | 100 | - | 0.0 (0.0-30.8) | | | | | | | | 60.0 | 40.0 | | | | | | | | |
| | poultry | 100 | - | 0.0 (0.0-84.2) | | | | | | | | 100 | | | | | | | | | |
| Streptomycin | calves | 100 | - | 0.0 (0.0-41.0) | | | | | | | 14.3 | 85.7 | | | | | | | | | |
| | pigs | 80 | - | 20.0 (2.5-55.6) | | | | | | | 50.0 | 30.0 | | | 20.0 | | | | | | |
| | poultry | 100 | - | 0.0 (0.0-84.2) | | | | | | 50.0 | 50.0 | | | | | | | | | | |
| Tetracycline | calves | 100 | 0.0 | 0.0 (0.0-41.0) | | | | 100 | | | | | | | | | | | | | |
| | pigs | 70 | 0.0 | 30.0 (6.7-65.2) | | | | 70.0 | | | | | | | 30.0 | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-84.2) | | | | 100 | | | | | | | | | | | | | |

1 S, susceptible; I, intermediate resistance; R, resistant.

2 The white fields represent the range of dilutions tested. MIC values less than or equal to the lowest concentration tested are presented as this lowest concentration. MIC values greater than the highest concentration tested are presented as the next highest concentration after the highest concentration tested. The vertical bars indicate the breakpoints between the susceptibility categories. For antibiotics where there are two vertical lines, the first line represents the breakpoint between susceptible and intermediate, and the second line represents the breakpoint between intermediate and resistant. For antibiotics where there is one vertical line, the line represents the breakpoint between susceptible and resistant.

**Table 13. Resistance among *Campylobacter jejuni* from very young calves and poultry recovered from processing plants in the North Island versus the South Island[1]**

| | Percent resistance and P value for any significant, P ≤0.05, differences between resistance in the North Island and that in the South Island within the animal group or total | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Very young calves n=49 | | | Poultry n=295 | | | All animal groups n=344 | | |
| | North Island n=13 | South Island n=36 | P value | North Island n=236 | South Island n=59 | P value | North Island n=249 | South Island n=95 | P value |
| Chloramphenicol | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| Ciprofloxacin | 0.0 | 0.0 | | 0.4 | 11.9 | <0.0001 | 0.4 | 7.4 | 0.0001 |
| Erythromycin | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| Gentamicin | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| Nalidixic acid | 0.0 | 0.0 | | 0.4 | 11.9 | <0.0001 | 0.4 | 7.4 | 0.0001 |
| Streptomycin | 7.7 | 8.3 | | 0.9 | 1.7 | | 1.2 | 4.2 | |
| Tetracycline | 0.0 | 0.0 | | 0.4 | 0.0 | | 0.4 | 0.0 | |

1 No *C. jejuni* isolated from pigs.

## Table 14. Resistance among *Campylobacter jejuni* from very young calves and poultry during each quarter of the survey period[1,2,3]

| | Percent resistance | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Very young calves n=49 | | Poultry n=295 | | | | All animal groups n=344 | | | |
| | Q1 n=18 | Q4 n=31 | Q1 n=73 | Q2 n=81 | Q3 n=72 | Q4 n=69 | Q1 n=91 | Q2 n=81 | Q3 n=72 | Q4 n=100 |
| Chloramphenicol | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Ciprofloxacin | 0.0 | 0.0 | 0.0 | 0.0 | 2.8 | 8.7 | 0.0 | 0.0 | 2.8 | 6.0 |
| Erythromycin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Gentamicin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nalidixic acid | 0.0 | 0.0 | 0.0 | 0.0 | 2.8 | 8.7 | 0.0 | 0.0 | 2.8 | 6.0 |
| Streptomycin | 11.1 | 6.5 | 2.7 | 0.0 | 1.4 | 0.0 | 4.4 | 0.0 | 1.4 | 2.0 |
| Tetracycline | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 | 0.0 | 0.0 | 0.0 | 1.0 |

1 No *C. jejuni* isolated from pigs.

2 Q1, 5 October-31 December 2009; Q2, 1 January-31 March 2010; Q3, 1 April-30 June 2010; Q4, 1 July-3 October 2010.

3 Shaded cells indicate where there was a significant (P ≤0.05) difference in resistance between the quarters.

Table 15. Serotypes among *Salmonella* isolated from very young calves, pigs, poultry and fresh produce

| | Number (%) of isolates | | | | |
|---|---|---|---|---|---|
| **Serotype** | **Very young calves (n=19)** | **Pigs (n=6)** | **Poultry (n=3)** | **Fresh produce (n=2[1])** | **Total (n=30)** |
| *S*. Brandenburg | 9 (47.4) | 3 (50.0) | | | 12 (40.0) |
| *S*. Derby | | 1 (16.7) | 2 (66.7) | | 3 (10.0) |
| *S*. Infantis | | | 1 (33.3) | | 1 (3.3) |
| *S*. London | | 1 (16.7) | | | 1 (3.3) |
| *S*. Ruiru | 1 (5.3) | | | | 1 (3.3) |
| *S*. Senftenberg | 1 (5.3) | | | | 1 (3.3) |
| *S*. Typimurium | | | | | |
| phage type 1 | 1 (5.3) | | | | 1 (3.3) |
| phage type 9 | 3 (15.8) | | | | 3 (10.0) |
| phage type 12a | 1 (5.3) | | | | 1 (3.3) |
| phage type 101 | 2 (10.5) | 1 (16.7) | | | 3 (10.0) |
| phage type 156 | 1 (5.3) | | | | 1 (3.3) |
| RDNC-May06 | | | | 2 (100) | 2 (6.7) |

Both from organic lettuce.

Table 16. Prevalence of resistance, intermediate resistance and susceptibility, and distribution of minimum inhibitory concentrations (MICs), among *Salmonella* isolated from very young calves (n=19), pigs (n=6), poultry (n=3) and fresh produce (n=2)

| Antimicrobial | Source | %S[1] | %I[1] | %R[1] (95% CIs) | Percent of isolates with an MIC of:[2] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0.03 | 0.06 | 0.12 | 0.25 | 0.5 | 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 | 256 | 512 | 1024 | 2048 |
| Ampicillin | calves | 100 | 0.0 | 0.0 (0.0-17.6) | | | | | | 89.5 | 10.5 | | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-45.9) | | | | | | 100 | | | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-70.8) | | | | | | 66.7 | 33.3 | | | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-84.2) | | | | | | | 100 | | | | | | | | | | |
| Apramycin | calves | 100 | - | 0.0 (0.0-17.6) | | | | | | | | 94.7 | 5.3 | | | | | | | | |
| | pigs | 100 | - | 0.0 (0.0-45.9) | | | | | | | | 100 | | | | | | | | | |
| | poultry | 100 | - | 0.0 (0.0-70.8) | | | | | | | | 100 | | | | | | | | | |
| | produce | 100 | - | 0.0 (0.0-84.2) | | | | | | | | 100 | | | | | | | | | |
| Cefotaxime | calves | 100 | 0.0 | 0.0 (0.0-17.6) | | | | 100 | | | | | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-45.9) | | | | 100 | | | | | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-70.8) | | | | 100 | | | | | | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-84.2) | | | | 100 | | | | | | | | | | | | | |
| Cefoxitin | calves | 100 | 0.0 | 0.0 (0.0-17.6) | | | | | | | 89.5 | 10.5 | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-45.9) | | | | | | | 83.3 | 16.7 | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-70.8) | | | | | | | | 100 | | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-84.2) | | | | | | | 50.0 | 50.0 | | | | | | | | | |
| Ceftazidime | calves | 100 | 0.0 | 0.0 (0.0-17.6) | | | | | | 100 | | | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-45.9) | | | | | | 100 | | | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-70.8) | | | | | | 100 | | | | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-84.2) | | | | | | 100 | | | | | | | | | | | |
| Ceftiofur | calves | 100 | 0.0 | 0.0 (0.0-17.6) | | | | | 26.3 | 73.7 | | | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-45.9) | | | | | 16.7 | 83.3 | | | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-70.8) | | | | | 33.3 | 66.7 | | | | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-84.2) | | | | | | 100 | | | | | | | | | | | |
| Cephalothin | calves | 100 | 0.0 | 0.0 (0.0-17.6) | | | | | | | | 100 | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-45.9) | | | | | | | | 100 | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-70.8) | | | | | | | | 100 | | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-84.2) | | | | | | | | 100 | | | | | | | | | |

| Antimicrobial | Source | %S[1] | %I[1] | %R[1] (95% CIs) | Percent of isolates with an MIC of:[2] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0.03 | 0.06 | 0.12 | 0.25 | 0.5 | 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 | 256 | 512 | 1024 | 2048 |
| Chloramphenicol | calves | 100 | 0.0 | 0.0 (0.0-17.6) | | | | | | | | | 100 | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-45.9) | | | | | | | | | 100 | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-70.8) | | | | | | | | | 100 | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-84.2) | | | | | | | | | 100 | | | | | | | | |
| Ciprofloxacin | calves | 100 | 0.0 | 0.0 (0.0-17.6) | 100 | | | | | | | | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-45.9) | 100 | | | | | | | | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-70.8) | 100 | | | | | | | | | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-84.2) | 100 | | | | | | | | | | | | | | | | |
| Co-amoxiclav | calves | 100 | 0.0 | 0.0 (0.0-17.6) | | | | | | | 100 | | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-45.9) | | | | | | | 100 | | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-70.8) | | | | | | | 100 | | | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-84.2) | | | | | | | 100 | | | | | | | | | | |
| Gentamicin | calves | 100 | 0.0 | 0.0 (0.0-17.6) | | | | | | 94.7 | 5.3 | | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-45.8) | | | | | | 100 | | | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-70.8) | | | | | | 100 | | | | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-84.2) | | | | | | 100 | | | | | | | | | | | |
| Nalidixic acid | calves | 100 | - | 0.0 (0.0-17.6) | | | | | | | 5.3 | 84.2 | 10.5 | | | | | | | | |
| | pigs | 100 | - | 0.0 (0.0-45.9) | | | | | | | | 100 | | | | | | | | | |
| | poultry | 100 | - | 0.0 (0.0-70.8) | | | | | | | | 100 | | | | | | | | | |
| | produce | 100 | - | 0.0 (0.0-84.2) | | | | | | | | 100 | | | | | | | | | |
| Neomycin | calves | 100 | - | 0.0 (0.0-17.6) | | | | | | | 100 | | | | | | | | | | |
| | pigs | 100 | - | 0.0 (0.0-45.9) | | | | | | | 100 | | | | | | | | | | |
| | poultry | 100 | - | 0.0 (0.0-70.8) | | | | | | | 100 | | | | | | | | | | |
| | produce | 100 | - | 0.0 (0.0-84.2) | | | | | | | 100 | | | | | | | | | | |
| Spectinomycin | calves | 63.2 | 36.8 | 0.0 (0.0-17.6) | | | | | | | | | | | 63.2 | 36.8 | | | | | |
| | pigs | 66.7 | 33.3 | 0.0 (0.0-45.9) | | | | | | | | | | | 66.7 | 33.3 | | | | | |
| | poultry | 66.7 | 33.3 | 0.0 (0.0-70.8) | | | | | | | | | | | 66.7 | 33.3 | | | | | |
| | produce | 50.0 | 50.0 | 0.0 (0.0-84.2) | | | | | | | | | | | 50.0 | 50.0 | | | | | |
| Streptomycin | calves | 89.5 | - | 10.5 (1.3-33.1) | | | | | | | | | 42.1 | 47.4 | 10.5 | | | | | | |
| | pigs | 100 | - | 0.0 (0.0-45.9) | | | | | | | | 33.3 | 50.0 | 16.7 | | | | | | | |
| | poultry | 100 | - | 0.0 (0.0-70.8) | | | | | | | | | 100 | | | | | | | | |
| | produce | 100 | - | 0.0 (0.0-84.2) | | | | | | | | | | 100 | | | | | | | |

| Antimicrobial | Source | %S[1] | %I[1] | %R[1] (95% CIs) | Percent of isolates with an MIC of:[2] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0.03 | 0.06 | 0.12 | 0.25 | 0.5 | 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 | 256 | 512 | 1024 | 2048 |
| Sulfamethoxazole | calves | 100 | - | 0.0 (0.0-17.6) | | | | | | | | | | | | 36.8 | 63.2 | | | | |
| | pigs | 66.7 | - | 33.3 (4.3-77.7) | | | | | | | | | | | | 50.0 | 16.7 | | | | 33.3 |
| | poultry | 100 | - | 0.0 (0.0-70.8) | | | | | | | | | | | | 33.3 | | 66.7 | | | |
| | produce | 100 | - | 0.0 (0.0-84.2) | | | | | | | | | | | | | 50.0 | 50.0 | | | |
| Tetracycline | calves | 100 | 0.0 | 0.0 (0.0-17.6) | | | | | | | 100 | | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-45.9) | | | | | | | 100 | | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-70.8) | | | | | | | 100 | | | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-84.2) | | | | | | | 100 | | | | | | | | | | |
| Trimethoprim | calves | 100 | - | 0.0 (0.0-17.6) | | | | | | | | 100 | | | | | | | | | |
| | pigs | 83.3 | - | 16.7 (0.4-64.1) | | | | | | | | 83.3 | | | | 16.7 | | | | | |
| | poultry | 100 | - | 0.0 (0.0-70.8) | | | | | | | | 100 | | | | | | | | | |
| | produce | 100 | - | 0.0 (0.0-84.2) | | | | | | | | 100 | | | | | | | | | |

1 S, susceptible; I, intermediate resistance; R, resistant.

2 The white fields represent the range of dilutions tested. MIC values less than or equal to the lowest concentration tested are presented as this lowest concentration. MIC values greater than the highest concentration tested are presented as the next highest concentration after the highest concentration tested. The vertical bars indicate the breakpoints between the susceptibility categories. For antibiotics where there are two vertical lines, the first line represents the breakpoint between susceptible and intermediate, and the second line represents the breakpoint between intermediate and resistant. For antibiotics where there is one vertical line, the line represents the breakpoint between susceptible and resistant

Table 17. Prevalence of resistance, intermediate resistance and susceptibility, and distribution of minimum inhibitory concentrations (MICs), among *Escherichia coli* isolated from very young calves (n=300), pigs (n=303), poultry (n=306) and fresh produce (n=90)

| Antimicrobial | Source | %S[1] | %I[1] | %R[1] (95% CIs) | Percent of isolates with an MIC of:[2] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **0.03** | **0.06** | **0.12** | **0.25** | **0.5** | **1** | **2** | **4** | **8** | **16** | **32** | **64** | **128** | **256** | **512** | **1024** | **2048** |
| Ampicillin | calves | 76.0 | 0.3 | 23.7 (19.0-28.9) | | | | | | 2.0 | 38.3 | 34.7 | 1.0 | 0.3 | | 23.7 | | | | | |
| | pigs | 89.8 | 1.3 | 8.9 (6.0-12.7) | | | | | | 8.3 | 46.9 | 33.0 | 1.7 | 1.3 | | 8.9 | | | | | |
| | poultry | 95.1 | 0.0 | 4.9 (2.8-8.0) | | | | | | 12.4 | 55.6 | 25.2 | 2.0 | | 0.3 | 4.6 | | | | | |
| | produce | 95.6 | 2.2 | 2.2 (0.3-7.8) | | | | | | 5.6 | 38.9 | 50.0 | 1.1 | 2.2 | 1.1 | 1.1 | | | | | |
| Apramycin | calves | 100 | - | 0.0 (0.0-1.2) | | | | | | | | 93.7 | 6.0 | 0.3 | | | | | | | |
| | pigs | 99.7 | - | 0.3 (0.0-1.8) | | | | | | | | 92.4 | 6.6 | 0.7 | 0.3 | | | | | | |
| | poultry | 99.7 | - | 0.3 (0.0-1.8) | | | | | | | | 91.8 | 7.5 | 0.3 | | 0.3 | | | | | |
| | produce | 100 | - | 0.0 (0.0-4.0) | | | | | | | | 94.4 | 4.4 | 1.1 | | | | | | | |
| Cefotaxime | calves | 99.3 | 0.7 | 0.0 (0.0-1.2) | | | | 97.7 | 1.0 | 0.7 | 0.7 | | | | | | | | | | |
| | pigs | 99.7 | 0.3 | 0.0 (0.0-1.2) | | | | 99.7 | | | 0.3 | | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-1.2) | | | | 100 | | | | | | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-4.0) | | | | 100 | | | | | | | | | | | | | |
| Cefoxitin | calves | 98.3 | 0.7 | 1.0 (0.2-2.9) | | | | | | 0.3 | 28.3 | 62.3 | 7.3 | 0.7 | 1.0 | | | | | | |
| | pigs | 98.0 | 0.7 | 1.3 (0.4-3.3) | | | | | | 1.0 | 32.7 | 55.5 | 8.9 | 0.7 | 0.7 | 0.7 | | | | | |
| | poultry | 99.7 | 0.0 | 0.3 (0.0-1.8) | | | | | 0.3 | 5.6 | 35.0 | 45.8 | 13.1 | | 0.3 | | | | | | |
| | produce | 97.8 | 0.0 | 2.2 (0.3-7.8) | | | | | | | 16.7 | 65.6 | 15.6 | | | 2.2 | | | | | |
| Ceftazidime | calves | NI[3] | NI | NI | | | | | | 98.3 | 1.7 | | | | | | | | | | |
| | pigs | NI | NI | NI | | | | | | 99.7 | 0.3 | | | | | | | | | | |
| | poultry | NI | NI | NI | | | | | | 99.7 | 0.3 | | | | | | | | | | |
| | produce | NI | NI | NI | | | | | | 98.9 | 1.1 | | | | | | | | | | |
| Ceftiofur | calves | 100 | 0.0 | 0.0 (0.0-1.2) | | | | | 98.0 | 2.0 | | | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-1.2) | | | | | 98.4 | 1.3 | 0.3 | | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-1.2) | | | | | 99.7 | 0.3 | | | | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-4.0) | | | | | 98.9 | 1.1 | | | | | | | | | | | |
| Cephalothin | calves | 74.7 | 21.3 | 4.0 (2.1-6.9) | | | | | | | | 24.7 | 50.0 | 21.3 | 2.3 | 1.7 | | | | | |
| | pigs | 80.5 | 17.5 | 2.0 (0.7-4.3) | | | | | | | | 42.6 | 38.0 | 17.5 | 1.3 | 0.7 | | | | | |
| | poultry | 86.3 | 11.8 | 2.0 (0.7-4.2) | | | | | | | | 50.7 | 35.6 | 11.8 | 2.0 | | | | | | |
| | produce | 87.8 | 10.0 | 2.2 (0.3-7.8) | | | | | | | | 36.7 | 51.1 | 10.0 | | 2.2 | | | | | |

| Antimicrobial | Source | %S[1] | %I[1] | %R[1] (95% CIs) | Percent of isolates with an MIC of:[2] 0.03 | 0.06 | 0.12 | 0.25 | 0.5 | 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 | 256 | 512 | 1024 | 2048 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chloramphenicol | calves | 95.0 | 1.7 | 3.3 (1.6-6.0) | | | | | | | | 26.3 | 68.7 | 1.7 | 0.7 | | 2.7 | | | | |
| | pigs | 84.2 | 5.6 | 10.2 (7.1-14.2) | | | | | | | | 13.5 | 70.6 | 5.6 | 5.3 | 5.0 | | | | | |
| | poultry | 97.7 | 1.6 | 0.7 (0.8-2.3) | | | | | | | | 25.5 | 72.2 | 1.6 | 0.7 | | | | | | |
| | produce | 91.1 | 7.8 | 1.1 (0.0-6.0) | | | | | | | | 6.7 | 84.4 | 7.8 | 1.1 | | | | | | |
| Ciprofloxacin | calves | 100 | 0.0 | 0.0 (0.0-1.2) | 98.3 | 0.7 | 1.0 | | | | | | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-1.2) | 98.7 | 0.7 | 0.7 | | | | | | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-1.2) | 93.8 | 0.7 | 1.3 | 3.9 | 0.3 | | | | | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-4.0) | 100 | | | | | | | | | | | | | | | | |
| Co-amoxiclav | calves | 97.7 | 1.3 | 1.0 (0.2-2.9) | | | | | | | 34.0 | 40.7 | 23.0 | 1.3 | 0.7 | 0.3 | | | | | |
| | pigs | 99.3 | 0.0 | 0.7 (0.1-2.4) | | | | | | | 36.6 | 50.5 | 12.2 | | 0.7 | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-1.2) | | | | | | | 49.0 | 46.4 | 4.6 | | | | | | | | |
| | produce | 96.7 | 0.0 | 3.3 (0.7-9.4) | | | | | | | 28.9 | 66.7 | 1.1 | | 1.1 | 2.2 | | | | | |
| Gentamicin | calves | 100 | 0.0 | 0.0 (0.0-1.2) | | | | | | 98.3 | 1.7 | | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-1.2) | | | | | | 96.4 | 3.0 | 0.7 | | | | | | | | | |
| | poultry | 99.7 | 0.3 | 0.0 (0.0-1.2) | | | | | | 96.4 | 2.3 | 1.0 | 0.3 | | | | | | | | |
| | produce | 100 | 0.0 | 0.0 (0.0-4.0) | | | | | | 98.9 | 1.1 | | | | | | | | | | |
| Nalidixic acid | calves | 99.7 | - | 0.3 (0.0-1.8) | | | | | | | 78.0 | 21.0 | | 0.7 | 0.3 | | | | | | |
| | pigs | 99.3 | - | 0.7 (0.1-2.4) | | | | | | | 68.0 | 30.4 | 1.0 | | | | 0.7 | | | | |
| | poultry | 94.4 | - | 5.6 (3.3-8.7) | | | | | | | 81.4 | 12.1 | 1.0 | | | 2.0 | 3.6 | | | | |
| | produce | 100 | - | 0.0 (0.0-4.0) | | | | | | | 55.6 | 43.3 | 1.1 | | | | | | | | |
| Neomycin | calves | 71.7 | - | 28.3 (23.3-33.8) | | | | | | | 70.3 | 1.0 | 0.3 | 2.3 | 12.0 | 14.0 | | | | | |
| | pigs | 97.4 | - | 2.6 (1.1-5.1) | | | | | | | 95.1 | 2.3 | | 0.7 | 0.3 | 1.7 | | | | | |
| | poultry | 97.1 | - | 2.9 (1.4-5.5) | | | | | | | 95.1 | 1.3 | 0.7 | 0.3 | 2.0 | 0.7 | | | | | |
| | produce | 100 | - | 0.0 (0.0-4.0) | | | | | | | 98.9 | 1.1 | | | | | | | | | |
| Spectinomycin | calves | 90.3 | 1.0 | 8.7 (5.7-12.4) | | | | | | | | | | 78.3 | 12.0 | 1.0 | 4.0 | 1.7 | 3.0 | | |
| | pigs | 71.3 | 4.3 | 24.4 (19.7-29.7) | | | | | | | | | | 48.5 | 22.8 | 4.3 | 10.2 | 7.3 | 6.9 | | |
| | poultry | 93.5 | 0.7 | 5.9 (3.5-9.1) | | | | | | | | | | 76.8 | 16.7 | 0.7 | 5.6 | 0.3 | | | |
| | produce | 96.7 | 3.3 | 0.0 (0.0-4.0) | | | | | | | | | | 40.0 | 56.7 | 3.3 | | | | | |
| Streptomycin | calves | 55.7 | - | 44.3 (38.6-50.2) | | | | | | | | 49.0 | 5.3 | 1.3 | 7.3 | 11.0 | 26.0 | | | | |
| | pigs | 67.7 | - | 32.3 (27.1-37.9) | | | | | | | | 48.2 | 13.5 | 5.9 | 12.9 | 6.9 | 12.5 | | | | |
| | poultry | 89.9 | - | 10.1 (7.0-14.1) | | | | | | | | 74.5 | 11.4 | 3.9 | 3.9 | 3.6 | 2.6 | | | | |
| | produce | 98.9 | - | 1.1 (0.0-6.0) | | | | | | | | 71.1 | 26.7 | 1.1 | 1.1 | | | | | | |

| Antimicrobial | Source | %S[1] | %I[1] | %R[1] (95% Cis) | Percent of isolates with an MIC of:[2] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **0.03** | **0.06** | **0.12** | **0.25** | **0.5** | **1** | **2** | **4** | **8** | **16** | **32** | **64** | **128** | **256** | **512** | **1024** | **2048** |
| Sulfamethoxazole | calves | 55.0 | - | 45.0 (39.3-50.8) | | | | | | | | | | | | 54.3 | | 0.7 | 0.3 | 0.3 | 44.3 |
| | pigs | 67.3 | - | 32.7 (27.4-38.3) | | | | | | | | | | | | 65.0 | 0.7 | 1.7 | 1.0 | 0.3 | 31.4 |
| | poultry | 69.3 | - | 30.7 (25.6-36.2) | | | | | | | | | | | | 68.6 | 0.7 | | 0.3 | 0.3 | 30.1 |
| | produce | 98.9 | - | 1.1 (0.0-6.0) | | | | | | | | | | | | 98.9 | | | | | 1.1 |
| Tetracycline | calves | 58.7 | 0.7 | 40.7 (35.1-46.5) | | | | | | | 57.0 | 1.7 | 0.7 | | 1.0 | 39.7 | | | | | |
| | pigs | 49.8 | 1.7 | 48.5 (42.8-54.3) | | | | | | | 48.2 | 1.7 | 1.7 | 0.3 | 3.0 | 45.2 | | | | | |
| | poultry | 87.6 | 0.3 | 12.1(8.7-16.3) | | | | | | | 85.0 | 2.6 | 0.3 | 1.3 | 2.3 | 8.5 | | | | | |
| | produce | 93.3 | 0.0 | 6.7 (2.5-13.9) | | | | | | | 92.2 | 1.1 | | 1.1 | | 5.6 | | | | | |
| Trimethoprim | calves | 87.3 | - | 12.7 (9.1-17.0) | | | | | | | | 86.7 | 0.7 | 0.3 | | 12.3 | | | | | |
| | pigs | 91.8 | - | 8.3 (5.4-11.9) | | | | | | | | 91.4 | 0.3 | 0.7 | | 7.6 | | | | | |
| | poultry | 93.1 | - | 6.9 (4.3-10.3) | | | | | | | | 93.1 | | | | 6.9 | | | | | |
| | produce | 98.9 | - | 1.1 (0.0-6.0) | | | | | | | | 98.9 | | | | 1.1 | | | | | |

1 S, susceptible; I, intermediate resistance; R, resistant.

2 The white fields represent the range of dilutions tested. MIC values less than or equal to the lowest concentration tested are presented as this lowest concentration. MIC values greater than the highest concentration tested are presented as the next highest concentration after the highest concentration tested. The vertical bars indicate the breakpoints between the susceptibility categories. For antibiotics where there are two vertical lines, the first line represents the breakpoint between susceptible and intermediate, and the second line represents the breakpoint between intermediate and resistant. For antibiotics where there is one vertical line, the line represents the breakpoint between susceptible and resistant.

3 NI, not interpretable as ceftazidime only tested at the ESBL screening concentration of 1 mg/L which is below the breakpoint between susceptible and intermediate, therefore the susceptibility categories cannot be calculated.

Table 18. Resistance among *Escherichia coli* from very young calves, pigs and poultry recovered from processing plants in the North Island versus the South Island

| | Percent resistance and P value for any significant, P ≤0.05, differences between resistance in the North Island and that in the South Island within the animal group or total | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Very young calves n=300** | | | **Pigs n=303** | | | **Poultry n=306** | | | **All animal groups n=909** | | |
| | **North Island n=196** | **South Island n=104** | **P value** | **North Island n=156** | **South Island n=147** | **P value** | **North Island n=250** | **South Island n=56** | **P value** | **North Island n=602** | **South Island n=307** | **P value** |
| Ampicillin | 20.9 | 28.9 | | 11.5 | 6.1 | | 4.8 | 5.4 | | 11.8 | 13.7 | |
| Apramycin | 0.0 | 0.0 | | 0.6 | 0.0 | | 0.4 | 0.0 | | 0.3 | 0.0 | |
| Cefotaxime | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| Cefoxitin | 1.0 | 1.0 | | 0.6 | 2.0 | | 0.0 | 1.8 | 0.0343 | 0.5 | 1.6 | |
| Ceftiofur | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| Cephalothin | 4.1 | 3.9 | | 1.9 | 2.0 | | 2.0 | 1.8 | | 2.7 | 2.6 | |
| Chloramphenicol | 4.1 | 1.9 | | 14.7 | 5.4 | 0.0076 | 0.4 | 1.8 | | 5.3 | 3.6 | |
| Ciprofloxacin | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| Co-amoxiclav | 1.0 | 1.0 | | 0.6 | 0.7 | | 0.0 | 0.0 | | 0.5 | 0.7 | |
| Gentamicin | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| Nalidixic acid | 0.5 | 0.0 | | 0.6 | 0.7 | | 5.6 | 5.4 | | 2.7 | 1.3 | |
| Neomycin | 28.6 | 27.9 | | 3.9 | 1.4 | | 2.8 | 3.6 | | 11.5 | 10.8 | |
| Spectinomycin | 8.2 | 9.6 | | 30.1 | 18.4 | 0.0172 | 3.6 | 16.1 | 0.0003 | 12.0 | 15.0 | |
| Streptomycin | 45.4 | 42.3 | | 39.7 | 24.5 | 0.0046 | 8.0 | 19.6 | 0.0091 | 28.4 | 29.6 | |
| Sulfamethoxazole | 45.4 | 44.2 | | 39.1 | 25.9 | 0.0140 | 31.6 | 26.8 | | 38.0 | 32.3 | |
| Tetracycline | 39.8 | 42.3 | | 41.7 | 55.8 | 0.0140 | 12.4 | 10.7 | | 28.9 | 43.0 | <0.0001 |
| Trimethoprim | 12.8 | 12.5 | | 9.0 | 7.5 | | 4.0 | 19.6 | <0.0001 | 8.1 | 11.4 | |

Table 19. Resistance among *Escherichia coli* from very young calves, pigs and poultry during each quarter of the survey period[1,2]

| | Percent resistance | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Very young calves n=300 | | Pigs n=303 | | | | Poultry n=306 | | | | All animal groups n=909 | | | |
| | Q1 n=31 | Q4 n=269 | Q1 n=74 | Q2 n=75 | Q3 n=79 | Q4 n=75 | Q1 n=80 | Q2 n=76 | Q3 n=75 | Q4 n=75 | Q1 n=185 | Q2 n=151 | Q3 n=154 | Q4 n=419 |
| Ampicillin | 38.7 | 21.9 | 4.1 | 13.3 | 11.4 | 6.7 | 6.3 | 4.0 | 4.0 | 5.3 | 10.8 | 8.6 | 7.8 | 16.2 |
| Apramycin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 0.5 |
| Cefotaxime | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Cefoxitin | 0.0 | 1.1 | 2.7 | 0.0 | 1.3 | 1.3 | 0.0 | 0.0 | 1.3 | 0.0 | 1.1 | 0.0 | 1.3 | 1.0 |
| Ceftiofur | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Cephalothin | 6.5 | 3.7 | 2.7 | 1.3 | 1.3 | 2.7 | 1.3 | 1.3 | 1.3 | 4.0 | 2.7 | 1.3 | 1.3 | 3.6 |
| Chloramphenicol | 0.0 | 3.7 | 13.5 | 6.7 | 8.9 | 12.0 | 0.0 | 0.0 | 1.3 | 1.3 | 5.4 | 3.3 | 5.2 | 4.8 |
| Ciprofloxacin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Co-amoxiclav | 0.0 | 1.1 | 0.0 | 0.0 | 1.3 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 1.0 |
| Gentamicin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nalidixic acid | 0.0 | 0.4 | 1.4 | 1.3 | 0.0 | 0.0 | 3.8 | 5.3 | 4.0 | 9.3 | 2.2 | 3.3 | 2.0 | 1.9 |
| Neomycin | 45.2 | 26.4 | 1.4 | 2.7 | 0.0 | 6.7 | 3.8 | 2.6 | 1.3 | 4.0 | 9.7 | 2.7 | 0.7 | 18.9 |
| Spectinomycin | 3.2 | 9.3 | 23.0 | 21.3 | 22.8 | 30.7 | 6.3 | 5.3 | 9.3 | 2.7 | 12.4 | 13.3 | 16.2 | 11.9 |
| Streptomycin | 58.1 | 42.8 | 27.0 | 34.7 | 31.7 | 36.0 | 10.0 | 9.2 | 12.0 | 9.3 | 24.9 | 21.9 | 22.1 | 35.6 |
| Sulfamethoxazole | 58.1 | 43.5 | 28.4 | 29.3 | 29.1 | 44.0 | 33.8 | 27.6 | 34.7 | 26.7 | 35.7 | 28.5 | 31.8 | 40.6 |
| Tetracycline | 58.1 | 38.7 | 33.8 | 50.7 | 54.4 | 54.7 | 11.3 | 11.8 | 10.7 | 14.7 | 28.1 | 31.1 | 33.1 | 37.2 |
| Trimethoprim | 19.4 | 11.9 | 10.8 | 6.7 | 8.9 | 6.7 | 10.0 | 5.3 | 6.7 | 5.3 | 11.9 | 6.0 | 7.8 | 9.8 |

1 Q1, 5 October-31 December 2009; Q2, 1 January-31 March 2010; Q3, 1 April-30 June 2010; Q4, 1 July-3 October 2010.

2 Shaded cells indicate where there was a significant (P ≤0.05) difference in resistance between the quarters.

Table 20. Prevalence of resistance, intermediate resistance and susceptibility, and distribution of minimum inhibitory concentrations (MICs), among *Enterococcus faecalis* isolated from very young calves (n=185), pigs (n=228) and poultry (n=140)

| Antimicrobial | Source | %S[1] | %I[1] | %R[1] (95% CIs) | Percent of isolates with an MIC of:[2] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0.03 | 0.06 | 0.12 | 0.25 | 0.5 | 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 | 256 | 512 | 1024 | 2048 |
| Ampicillin | calves | 100 | 0.0 | 0.0 (0.0-2.0) | | | | | 30.3 | 63.8 | 4.9 | 1.1 | | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-1.6) | | | | | 29.0 | 66.2 | 4.0 | 0.9 | | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-2.6) | | | | | 30.7 | 65.0 | 3.6 | 0.7 | | | | | | | | | |
| Bacitracin[3] | calves | - | - | - | | | | | | | | | 1.1 | 3.2 | 8.1 | 33.5 | 47.6 | 1.6 | 4.9 | | |
| | pigs | - | - | - | | | | | | | 0.4 | | | 0.4 | 10.1 | 31.6 | 45.6 | 5.7 | 6.1 | | |
| | poultry | - | - | - | | | | | | | | | | | 0.7 | 2.1 | 1.4 | 0.7 | 95.0 | | |
| Chloramphenicol | calves | 86.5 | 9.7 | 3.8 (1.5-7.6) | | | | | | | | 2.7 | 83.8 | 9.7 | | 3.2 | 0.5 | | | | |
| | pigs | 85.5 | 6.1 | 8.3 (5.1-12.7) | | | | | | | 0.4 | 8.3 | 76.8 | 6.1 | 0.4 | 5.3 | 2.6 | | | | |
| | poultry | 95.0 | 5.0 | 0.0 (0.0-2.6) | | | | | | | | 10.0 | 85.0 | 5.0 | | | | | | | |
| Ciprofloxacin | calves | 77.3 | 21.1 | 1.6 (0.3-4.7) | | | | | 8.1 | 69.2 | 21.1 | 1.6 | | | | | | | | | |
| | pigs | 83.8 | 15.4 | 0.9 (0.1-3.1) | | | | | 22.8 | 61.0 | 15.4 | 0.4 | 0.4 | | | | | | | | |
| | poultry | 81.4 | 17.9 | 0.7 (0.0-3.9) | | | | | 15.7 | 65.7 | 17.9 | 0.7 | | | | | | | | | |
| Erythromycin[4] | calves | - | - | 11.4 (7.2-16.8) | | | | | | 80.5 | 6.5 | 1.6 | 1.1 | | | | | 10.3 | | | |
| | pigs | - | - | 27.6 (21.9-33.9) | | | | | | 61.0 | 11.0 | 0.4 | 0.9 | 0.9 | 0.4 | | 0.4 | 25.0 | | | |
| | poultry | - | - | 33.6 (25.8-42.0) | | | | | | 55.0 | 10.0 | 1.4 | 10.7 | 2.9 | 0.7 | 0.7 | | 18.6 | | | |
| High-level Gentamicin | calves | 100 | - | 0.0 (0.0-2.0) | | | | | | | | | | | | | 100 | | | | |
| | pigs | 91.7 | - | 8.3 (5.1-12.7) | | | | | | | | | | | | | 89.5 | 2.2 | | | 8.3 |
| | poultry | 100 | - | 0.0 (0.0-2.6) | | | | | | | | | | | | | 100 | | | | |
| Nitrofurantoin | calves | 80.0 | 18.9 | 1.1 (0.1-3.9) | | | | | | | | | 6.0 | 52.4 | 21.6 | 18.9 | 1.1 | | | | |
| | pigs | 92.5 | 7.0 | 0.4 (0.0-2.4) | | | | | | | 0.4 | | 12.3 | 74.6 | 5.3 | 7.0 | 0.4 | | | | |
| | poultry | 93.6 | 5.0 | 1.4 (0.2-5.1) | | | | | | | | | 11.4 | 72.1 | 10.0 | 5.0 | 1.4 | | | | |
| High-level Streptomycin | calves | 64.3 | - | 35.7 (28.8-43.0) | | | | | | | | | | | | | 61.1 | 1.1 | | 2.2 | 35.7 |
| | pigs | 79.0 | - | 21.1 (15.9-26.9) | | | | | | | | | | | | | 76.8 | 0.9 | 0.4 | 0.9 | 21.1 |
| | poultry | 96.4 | - | 3.6 (1.2-8.1) | | | | | | | | | | | | | 91.4 | 4.3 | 0.7 | | 3.6 |
| Tetracycline | calves | 43.8 | 1.6 | 54.6 (47.1-61.9) | | | | | 13.5 | 28.1 | 1.1 | 1.1 | 1.6 | 2.7 | 24.9 | 22.2 | 4.9 | | | | |
| | pigs | 56.6 | 0.4 | 43.0 (36.5-49.7) | | | | | 39.9 | 14.9 | 1.3 | 0.4 | 0.4 | 1.8 | 4.4 | 18.9 | 18.0 | | | | |
| | poultry | 22.1 | 0.0 | 77.9 (70.1-84.4) | | | | | 15.0 | 7.1 | | | | | 10.0 | 22.9 | 45.0 | | | | |

| Antimicrobial | Source | %S[1] | %I[1] | %R[1] (95% CIs) | Percent of isolates with an MIC of:[2] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0.03 | 0.06 | 0.12 | 0.25 | 0.5 | 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 | 256 | 512 | 1024 | 2048 |
| Tylosin[3] | calves | - | - | - | | | | | | 6.0 | 79.5 | 2.2 | 0.5 | 0.5 | | 11.4 | | | | | |
| | pigs | - | - | - | | | | | | 10.5 | 58.8 | 1.8 | 0.9 | | 0.4 | 27.6 | | | | | |
| | poultry | - | - | - | | | | | | 3.6 | 61.4 | 0.7 | | | 0.7 | 33.6 | | | | | |
| Vancomycin | calves | 100 | 0.0 | 0.0 (0.0-2.0) | | | | | 15.1 | 55.7 | 28.7 | 0.5 | | | | | | | | | |
| | pigs | 99.6 | 0.4 | 0.0 (0.0-1.6) | | | | | 4.0 | 71.9 | 23.7 | | 0.4 | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-2.6) | | | | | | 36.4 | 62.1 | 1.4 | | | | | | | | | |

1 S, susceptible; I, intermediate resistance; R, resistant.

2 The white fields represent the range of dilutions tested. MIC values less than or equal to the lowest concentration tested are presented as this lowest concentration. MIC values greater than the highest concentration tested are presented as the next highest concentration after the highest concentration tested. The vertical bars indicate the breakpoints between the susceptibility categories. For antibiotics where there are two vertical lines, the first line represents the breakpoint between susceptible and intermediate, and the second line represents the breakpoint between intermediate and resistant. For antibiotics where there is one vertical line, the line represents the breakpoint between susceptible and resistant.

3 There are no bacitracin or tylosin interpretive standards for Enterococci.

4 Erythromycin susceptible and intermediate isolates cannot be distinguished with the range of concentrations used.

Table 21. Prevalence of resistance, intermediate resistance and susceptibility, and distribution of minimum inhibitory concentrations (MICs), among *Enterococcus faecium* isolated from very young calves (n=92), pigs (n=57) and poultry (n=158)

| Antimicrobial | Source | %S[1] | %I[1] | %R[1] (95% CIs) | Percent of isolates with an MIC of:[2] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0.03 | 0.06 | 0.12 | 0.25 | 0.5 | 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 | 256 | 512 | 1024 | 2048 |
| Ampicillin | calves | 100 | 0.0 | 0.0 (0.0-3.9) | | | | | 65.2 | 18.5 | 8.7 | 5.4 | 2.2 | | | | | | | | |
| | pigs | 100 | 0.0 | 0.0 (0.0-6.3) | | | | | 38.6 | 17.5 | 15.8 | 21.1 | 7.0 | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-2.3) | | | | | 36.1 | 19.6 | 21.5 | 17.7 | 5.1 | | | | | | | | |
| Bacitracin[3] | calves | - | - | - | | | | | | | | | 2.2 | 2.2 | 9.8 | 56.5 | 14.1 | 8.7 | 6.5 | | |
| | pigs | - | - | - | | | | | | | | | 1.8 | 3.5 | 5.3 | 5.3 | 35.1 | 19.3 | 29.8 | | |
| | poultry | - | - | - | | | | | | | | | | | 0.6 | | 0.6 | | 98.7 | | |
| Chloramphenicol | calves | 98.9 | 1.1 | 0.0 (0.0-3.9) | | | | | | | | 12.0 | 87.0 | 1.1 | | | | | | | |
| | pigs | 93.0 | 5.3 | 1.8 (0.0-9.4) | | | | | | | | 40.4 | 52.6 | 5.3 | | 1.8 | | | | | |
| | poultry | 89.2 | 10.1 | 0.6 (0.0-3.5) | | | | | | | | 22.8 | 66.5 | 10.1 | 0.6 | | | | | | |
| Ciprofloxacin | calves | 9.8 | 10.9 | 79.4 (69.6-87.1) | | | | | 2.2 | 7.6 | 10.9 | 79.4 | | | | | | | | | |
| | pigs | 42.1 | 24.6 | 33.3 (21.4-47.1) | | | | | 14.1 | 28.1 | 24.6 | 26.3 | 7.0 | | | | | | | | |
| | poultry | 26.6 | 27.9 | 45.6 (37.6-53.7) | | | | | 4.4 | 22.2 | 27.9 | 41.8 | 3.8 | | | | | | | | |
| Erythromycin[4] | calves | - | - | 9.8 (4.6-17.8) | | | | | | 79.4 | 7.6 | 3.3 | 1.1 | | | | 1.1 | 7.6 | | | |
| | pigs | - | - | 24.6 (14.1-37.8) | | | | | | 57.9 | 14.0 | 3.5 | 7.0 | 3.5 | | | | 14.0 | | | |
| | poultry | - | - | 24.7 (18.2-32.2) | | | | | | 69.6 | 3.2 | 2.5 | 0.6 | 0.6 | 1.9 | | 1.3 | 20.3 | | | |
| High-level Gentamicin | calves | 100 | - | 0.0 (0.0-3.9) | | | | | | | | | | | | | 100 | | | | |
| | pigs | 100 | - | 0.0 (0.0-6.3) | | | | | | | | | | | | | 100 | | | | |
| | poultry | 100 | - | 0.0 (0.0-2.3) | | | | | | | | | | | | | 100 | | | | |
| Nitrofurantoin | calves | 18.5 | 71.7 | 9.8 (4.6-17.8) | | | | | | | | | | 7.6 | 10.9 | 71.7 | 9.8 | | | | |
| | pigs | 10.5 | 68.4 | 21.1 (11.4-33.9) | | | | | | | | | | 1.8 | 8.8 | 68.4 | 21.1 | | | | |
| | poultry | 33.5 | 36.7 | 29.8 (22.7-37.5) | | | | | | | | | 0.6 | 3.8 | 29.1 | 36.7 | 29.8 | | | | |
| Quinupristin/ dalfopristin | calves | 66.3 | 7.6 | 26.1 (17.5-36.3) | | | | | 65.2 | 1.1 | 7.6 | 18.5 | 7.6 | | | | | | | | |
| | pigs | 50.9 | 19.3 | 29.8 (18.4-43.4) | | | | | 38.6 | 12.3 | 19.3 | 22.8 | 7.0 | | | | | | | | |
| | poultry | 22.2 | 46.2 | 31.7 (24.5-39.5) | | | | | 8.9 | 13.3 | 46.2 | 22.2 | 9.5 | | | | | | | | |
| High-level Streptomycin | calves | 88.0 | - | 12.0 (6.1-20.4) | | | | | | | | | | | | | 84.8 | 2.2 | | 1.1 | 12.0 |
| | pigs | 84.2 | - | 15.8 (7.4-27.9) | | | | | | | | | | | | | 82.5 | 1.8 | | | 15.8 |
| | poultry | 96.8 | - | 3.2 (1.0-7.2) | | | | | | | | | | | | | 96.2 | 0.6 | | | 3.2 |
| Tetracycline | calves | 37.0 | 1.1 | 62.0 (51.2-71.9) | | | | | 33.7 | 3.3 | | | 1.1 | 1.1 | 12.0 | 38.0 | 10.9 | | | | |
| | pigs | 61.4 | 0.0 | 38.6 (26.0-52.4) | | | | | 54.4 | 1.8 | 1.8 | 3.5 | | 1.8 | 1.8 | 17.5 | 17.5 | | | | |
| | poultry | 60.1 | 4.4 | 35.4 (28.0-43.4) | | | | | 53.2 | 3.2 | 1.3 | 2.5 | 4.4 | 1.9 | 3.8 | 23.4 | 6.3 | | | | |
| Antimicrobial | Source | %S[1] | %I[1] | %R[1] | Percent of isolates with an MIC of:[2] | | | | | | | | | | | | | | | | |

| | | | | (95% CIs) | 0.03 | 0.06 | 0.12 | 0.25 | 0.5 | 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 | 256 | 512 | 1024 | 2048 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tylosin[3] | calves | - | - | - | | | | | | 43.5 | 31.5 | 8.7 | 7.6 | | | 8.7 | | | | | |
| | pigs | - | - | - | | | | | | 3.5 | 54.4 | 24.6 | 3.5 | | | 14.0 | | | | | |
| | poultry | - | - | - | | | | | | 1.3 | 27.2 | 45.6 | 2.5 | | | 23.4 | | | | | |
| Vancomycin | calves | 100 | 0.0 | 0.0 (0.0-3.9) | | | | | 76.1 | 12.0 | 12.0 | | | | | | | | | | |
| | pigs | 98.3 | 1.8 | 0.0 (0.0-6.3) | | | | | 66.7 | 12.3 | 17.5 | 1.8 | 1.8 | | | | | | | | |
| | poultry | 100 | 0.0 | 0.0 (0.0-2.3) | | | | | 63.9 | 26.0 | 10.1 | | | | | | | | | | |

1 S, susceptible; I, intermediate resistance; R, resistant.

2 The white fields represent the range of dilutions tested. MIC values less than or equal to the lowest concentration tested are presented as this lowest concentration. MIC values greater than the highest concentration tested are presented as the next highest concentration after the highest concentration tested. The vertical bars indicate the breakpoints between the susceptibility categories. For antibiotics where there are two vertical lines, the first line represents the breakpoint between susceptible and intermediate, and the second line represents the breakpoint between intermediate and resistant. For antibiotics where there is one vertical line, the line represents the breakpoint between susceptible and resistant.

3 There are no bacitracin or tylosin interpretive standards for Enterococci.

4 Erythromycin susceptible and intermediate isolates cannot be distinguished with the range of concentrations used.

Table 22. Resistance among *Enterococcus faecalis* from very young calves, pigs and poultry recovered from processing plants in the North Island versus the South Island

| | Percent resistance and P value for any significant, P ≤0.05, differences between resistance in the North Island and that in the South Island within the animal group or total | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Very young calves n=185 | | | Pigs n=228 | | | Poultry n=140 | | | All animal groups n=553 | | |
| | North Island n=126 | South Island n=59 | P value | North Island n=164 | South Island n=64 | P value | North Island n=112 | South Island n=28 | P value | North Island n=401 | South Island n=151 | P value |
| Ampicillin | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| Chloramphenicol | 3.2 | 5.1 | | 9.8 | 4.7 | | 0.0 | 0.0 | | 5.0 | 4.0 | |
| Ciprofloxacin | 1.6 | 1.7 | | 0.0 | 3.1 | | 0.9 | 0.0 | | 0.8 | 2.0 | |
| Erythromycin | 11.1 | 11.9 | | 30.5 | 20.3 | | 33.9 | 32.1 | | 25.4 | 19.2 | |
| High-level Gentamicin | 0.0 | 0.0 | | 11.0 | 1.6 | 0.0173 | 0.0 | 0.0 | | 4.5 | 0.7 | 0.0282 |
| Nitrofurantoin | 1.6 | 0.0 | | 0.6 | 0.0 | | 1.8 | 0.0 | | 1.2 | 0.0 | |
| High-level Streptomycin | 27.8 | 52.5 | 0.0010 | 23.2 | 15.6 | | 4.5 | 0.0 | | 19.4 | 27.2 | 0.0482 |
| Tetracycline | 52.4 | 59.3 | | 34.2 | 65.6 | <0.0001 | 76.8 | 82.1 | | 51.7 | 66.2 | 0.0023 |
| Vancomycin | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | |

Table 23. Resistance among *Enterococcus faecium* from very young calves, pigs and poultry recovered from processing plants in the North Island versus the South Island

| | Percent resistance and P value for any significant, P ≤0.05, differences between resistance in the North Island and that in the South Island within the animal group or total | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Very young calves n=92** | | | **Pigs n=57** | | | **Poultry n=158** | | | **All animal groups n=307** | | |
| | **North Island n=56** | **South Island n=36** | **P value** | **North Island n=38** | **South Island n=19** | **P value** | **North Island n=131** | **South Island n=27** | **P value** | **North Island n=225** | **South Island n=82** | **P value** |
| Ampicillin | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| Chloramphenicol | 0.0 | 0.0 | | 0.0 | 5.3 | | 0.8 | 0.0 | | 0.4 | 1.2 | |
| Ciprofloxacin | 80.4 | 77.8 | | 18.4 | 63.2 | 0.0007 | 44.3 | 51.9 | | 48.9 | 65.9 | 0.0084 |
| Erythromycin | 12.5 | 5.6 | | 15.8 | 42.1 | 0.0487 | 24.4 | 25.9 | | 20.0 | 20.7 | |
| High-level Gentamicin | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| Nitrofurantoin | 14.3 | 2.8 | | 18.4 | 26.3 | | 31.3 | 22.2 | | 24.9 | 14.6 | |
| Quinupristin/ dalfopristin | 33.9 | 13.9 | 0.0327 | 23.7 | 42.1 | | 31.3 | 33.3 | | 30.7 | 26.8 | |
| High-level Streptomycin | 12.5 | 11.1 | | 10.5 | 26.3 | | 3.8 | 0.0 | | 7.1 | 11.0 | |
| Tetracycline | 67.9 | 52.8 | | 29.0 | 57.9 | 0.0343 | 31.3 | 55.6 | 0.0164 | 40.0 | 54.9 | 0.0201 |
| Vancomycin | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | |

Table 24. Resistance among *Enterococcus faecalis* from very young calves, pigs and poultry during each quarter of the survey period[1,2]

| | Percent resistance | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Very young calves n=185** | | **Pigs n=228** | | | | **Poultry n=140** | | | | **All animal groups n=553** | | | |
| | **Q1 n=19** | **Q4 n=166** | **Q1 n=75** | **Q2 n=54** | **Q3 n=57** | **Q4 n=42** | **Q1 n=41** | **Q2 n=32** | **Q3 n=38** | **Q4 n=29** | **Q1 n=135** | **Q2 n=86** | **Q3 n=95** | **Q4 n=237** |
| Ampicillin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Chloramphenicol | 0.0 | 4.2 | 5.3 | 11.1 | 5.3 | 14.3 | 0.0 | 0.0 | 0.0 | 0.0 | 3.0 | 7.0 | 3.2 | 5.5 |
| Ciprofloxacin | 0.0 | 1.8 | 0.0 | 1.9 | 0.0 | 2.4 | 0.0 | 0.0 | 2.6 | 0.0 | 0.0 | 1.2 | 1.1 | 1.7 |
| Erythromycin | 21.1 | 10.2 | 22.7 | 24.1 | 35.1 | 31.0 | 26.8 | 21.9 | 39.5 | 48.3 | 23.7 | 23.3 | 36.8 | 18.6 |
| High-level Gentamicin | 0.0 | 0.0 | 6.7 | 7.4 | 12.3 | 7.1 | 0.0 | 0.0 | 0.0 | 0.0 | 3.7 | 4.7 | 7.4 | 1.3 |
| Nitrofurantoin | 0.0 | 1.2 | 0.0 | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 | 2.6 | 3.5 | 0.0 | 1.2 | 1.1 | 1.3 |
| High-level Streptomycin | 57.9 | 33.1 | 20.0 | 22.2 | 26.3 | 14.3 | 0.0 | 0.0 | 7.9 | 6.9 | 19.3 | 14.0 | 19.0 | 26.6 |
| Tetracycline | 57.9 | 54.2 | 37.3 | 37.0 | 52.6 | 47.6 | 87.8 | 62.5 | 73.7 | 86.2 | 55.6 | 46.5 | 61.1 | 57.0 |
| Vancomycin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

1 Q1, 5 October-31 December 2009; Q2, 1 January-31 March 2010; Q3, 1 April-30 June 2010; Q4, 1 July-3 October 2010.
2 Shaded cells indicate where there was a significant (P ≤0.05) difference in resistance between the quarters.

Table 25. Resistance among *Enterococcus faecium* from very young calves, pigs and poultry during each quarter of the survey period[1,2]

| | Percent resistance | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Very young calves n=92 | | Pigs n=57 | | | | Poultry n=158 | | | | All animal groups n=307 | | | |
| | Q1 n=13 | Q4 n=79 | Q1 n=12 | Q2 n=19 | Q3 n=12 | Q4 n=14 | Q1 n=35 | Q2 n=50 | Q3 n=38 | Q4 n=35 | Q1 n=60 | Q2 n=69 | Q3 n=50 | Q4 n=128 |
| Ampicillin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Chloramphenicol | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.1 | 0.0 | 0.0 | 2.6 | 0.0 | 0.0 | 0.0 | 2.0 | 0.8 |
| Ciprofloxacin | 84.6 | 78.5 | 25.0 | 36.8 | 25.0 | 42.9 | 51.4 | 46.0 | 42.1 | 42.9 | 53.3 | 43.5 | 38.0 | 64.8 |
| Erythromycin | 7.7 | 10.1 | 16.7 | 47.4 | 16.7 | 7.1 | 37.1 | 20.0 | 18.4 | 25.7 | 26.7 | 27.5 | 18.0 | 14.1 |
| High-level Gentamicin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nitrofurantoin | 0.0 | 11.4 | 16.7 | 36.8 | 25.0 | 0.0 | 17.1 | 34.0 | 23.7 | 42.9 | 13.3 | 34.8 | 24.0 | 18.8 |
| Quinupristin/ dalfopristin | 15.4 | 27.9 | 16.7 | 52.6 | 25.0 | 14.3 | 37.1 | 34.0 | 29.0 | 25.7 | 28.3 | 39.1 | 28.0 | 25.8 |
| High-level Streptomycin | 15.4 | 11.4 | 0.0 | 31.6 | 8.3 | 14.3 | 5.7 | 4.0 | 2.6 | 0.0 | 6.7 | 11.6 | 4.0 | 8.6 |
| Tetracycline | 46.2 | 64.6 | 33.3 | 47.4 | 33.3 | 35.7 | 31.4 | 44.0 | 34.2 | 28.6 | 35.0 | 44.9 | 34.0 | 51.6 |
| Vancomycin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

1 Q1, 5 October-31 December 2009; Q2, 1 January-31 March 2010; Q3, 1 April-30 June 2010; Q4, 1 July-3 October 2010.

2 Shaded cells indicate where there was a significant (P ≤0.05) difference in resistance between the quarters.

Table 26. Resistance among human isolates of *Campylobacter, Salmonella*, *Escherichia coli, Enterococcus faecalis* and *E. faecium*, 2009[1]

| **Antimicrobial** | **Percent resistance** | | | |
|---|---|---|---|---|
| | ***Campylobacter*** | ***Salmonella*** | ***E. coli***[2] | ***E. faecalis/ E. faecium*** |
| Ampicillin | | 5.5 | 51.4 | 3.6 |
| Cefotaxime | | | 3.0 | |
| Cephalothin | | 1.7[3] | 22.2 | |
| Chloramphenicol | | 3.0 | | |
| Ciprofloxacin | 1.6 | 0.9 | 7.7 | |
| Co-amoxiclav | | 1.7 | 10.7 | |
| Erythromycin | 0.0 | | | |
| Gentamicin | | 1.7 | 3.7 | 25.5[4] |
| Nalidixic acid | | 3.8 | | |
| Nitrofurantoin | | | | 0.8 |
| Streptomycin | | 5.1 | | |
| Sulphonamides | | 6.0 | | |
| Tetracycline | | 4.7 | | 68.9 |
| Trimethoprim | | 2.1 | 24.1 | |
| Vancomycin | | | | 0.4 |

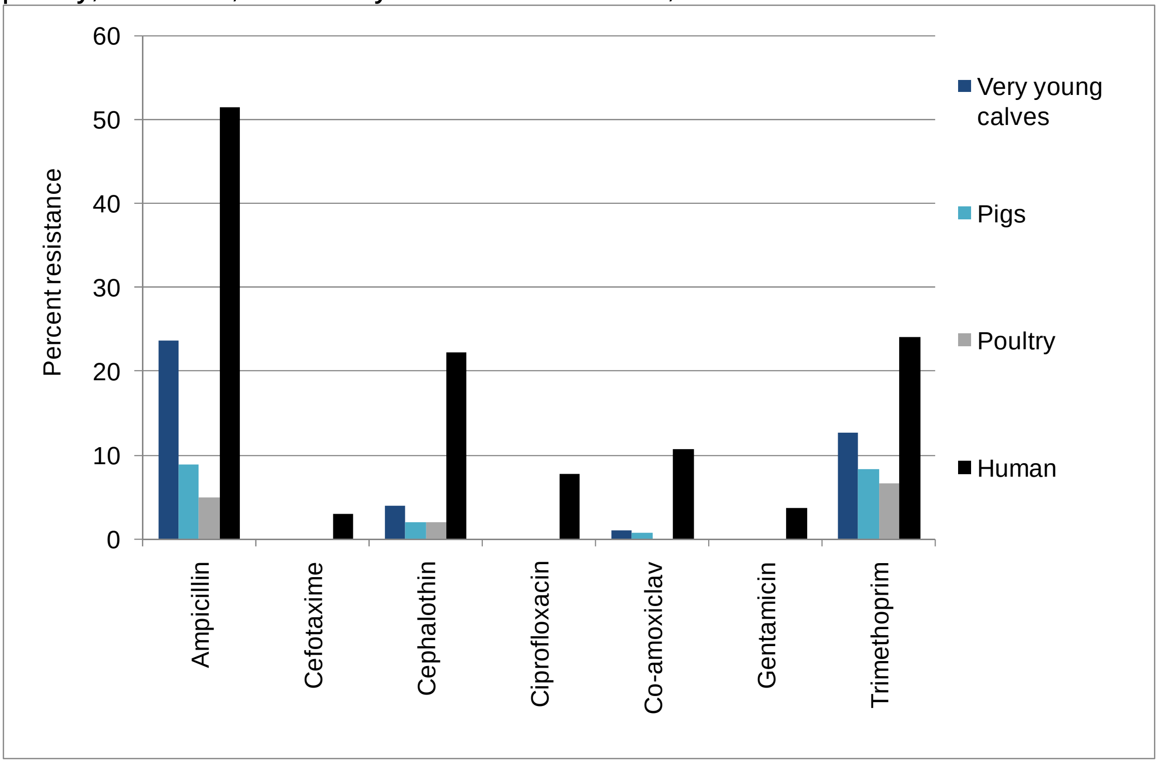
1 The *Campylobacter*, *E. coli* and Enterococci data is based on resistance data collected from diagnostic laboratories throughout New Zealand and is available at http://www.surv.esr.cri.nz/antimicrobial/general_antimicrobial_susceptibility.php. The *Salmonella* data is based on isolates referred to ESR for serotyping, a random sample of which is susceptibility tested, and the results are available at http://www.surv.esr.cri.nz/antimicrobial/salmonella.php.

2 Data for urinary *E. coli*.

3 There were four cephalothin-resistant isolates and three produced extended-spectrum-β-lactamase and one produced AmpC β-lactamase.

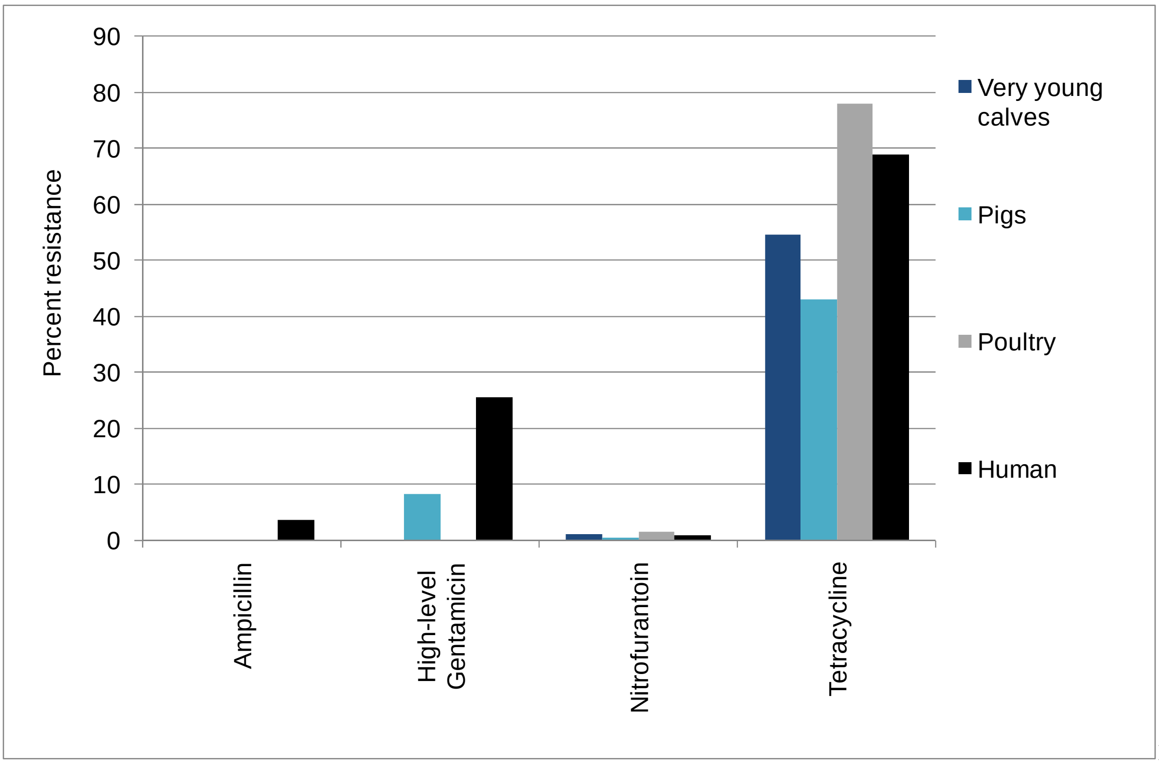
4 High-level gentamicin resistance.

Figure 1. Comparison of resistance among *Escherichia coli* from very young calves, pigs, poultry, 2009-2010, and urinary isolates from humans, 2009[1]




1 The human *E. coli* data is based on resistance data collected from diagnostic laboratories throughout New Zealand and is available at http://www.surv.esr.cri.nz/antimicrobial/general_antimicrobial_susceptibility.php.

Figure 2. Comparison of resistance among *E. faecalis* from very young calves, pigs, poultry, 2009-2010, with *E. faecalis* and *E. faecium* isolates from humans, 2009[1]




1 The human *E. faecalis and E faecium* data is based on resistance data collected from diagnostic laboratories throughout New Zealand and is available at http://www.surv.esr.cri.nz/antimicrobial/general_antimicrobial_susceptibility.php. Separate data for only *E. faecalis* is not available, but 90% of human enterococcal infections are usually due to *E. faecalis*.