9.5 Antimicrobial Resistance

Key Points

- There were 2,771 reports of invasive *E. coli* infection, an increase of 9.5% from 2,530 in 2013:
  - The proportions of invasive *E. coli* resistant to 3rd generation cephalosporins (3GCs) (12.9%), ciprofloxacin (26.2%) and aminoglycosides (14.5%) and those that exhibited multi-drug resistance (15.0%) were at their highest levels since surveillance began
- There were 1,118 reports of *S. aureus* bloodstream infection (BSI), an increase of 2.2% from 1,094 in 2013:
  - Of those, 218 (19.5%) were meticillin-resistant *S. aureus* (MRSA), which is the lowest annual proportion reported to date
  - For acute hospitals, the rate of MRSA BSI was 0.055 cases per 1,000 bed days used (BDU), a slight decrease from 0.056 in 2013. Conversely, the rate of meticillin-susceptible *S. aureus* (MSSA) BSI increased from 0.218 in 2013 to 0.227 in 2014
- There were 404 reports of *E. faecium* BSI, a slight decrease of 1.2% from 409 in 2013:
  - Vancomycin-resistant *E. faecium* (VREfm) accounted for 46.0%, which is the highest annual proportion reported to date
- There were 358 reports of invasive *K. pneumoniae* infection, an increase of 9.8% from 326 in 2013:
  - The proportions of invasive *K. pneumoniae* resistant to 3GCs (12.8%) and those that were ESBL-positive (11.0%) decreased from 2013 (21.2% and 18.4%, respectively) when they were at their highest levels reported to date
  - Two predominant clones have been identified among *K. pneumoniae* that are both ESBL-positive and non-susceptible to ciprofloxacin and gentamicin. Some also produce carbapenemases. Together, these are termed multi-drug resistant *K. pneumoniae* (MDRKP). An outbreak control team was established in October 2013 to investigate this emerging threat. The proportion of invasive *K. pneumoniae* that were MDRKP decreased between 2013 (12.3%, or 40 of 325 isolates) and 2014 (8.1%, or 29 of 358 isolates)
  - Two invasive *K. pneumoniae* isolates were carbapenemase-producers, also known as carbapenem-resistant *Enterobacteriaceae* (CRE)
- There were 331 reports of invasive *S. pneumoniae* infection, an increase of 6.4% from 311 in 2013:
  - Of those, 56 (17.1%) were penicillin non-susceptible *S. pneumoniae* (PNSP), a decrease from 20.7% in 2013
  - The national rate of invasive infection was 7.2 per 100,000 population, an increase compared to 6.8 in 2013
  - Serotype data were available for 298 (or 90%) of 331 invasive *S. pneumoniae* isolates. Results indicate good coverage (68%) for the 23-valent pneumococcal polysaccharide vaccine (PPV23) in its target population (adults ≥65 years)
- There were 182 reports of invasive *P. aeruginosa* infection, a decrease of 12% from 207 in 2013 and resistance to all indicator antimicrobials, except for piperacillin-tazobactam, decreased
- Enhanced surveillance data were provided on 2,202 records (cases or isolates under the EARS-Net definition) from 21 laboratories, representing 40% of all reported cases in 2014
- See http://www.hpsc.ie for further details of EARS-Net, antimicrobial resistance and enhanced BSI surveillance in Ireland
- European data are available at http://ecdc.europa.eu/en/activities/surveillance/EARS-Net/Pages/Database.aspx

Introduction
The European Antimicrobial Resistance Surveillance Network (EARS-Net), previously the European Antimicrobial Resistance Surveillance System (EARSS), collects routinely-generated antimicrobial susceptibility testing data on seven important bacterial pathogens using the EARS-Net case definition. Participating laboratories in Ireland submit data on the "primary" or first isolate from blood or cerebrospinal fluid (CSF) per patient per quarter. EARS-Net does not distinguish clinically significant isolates from contaminants, nor does it distinguish between hospital-acquired, healthcare-associated and community-acquired infections. EARS-Net primarily serves as a surveillance system to measure national levels of antimicrobial resistance (AMR). In 2014, all 39 microbiology laboratories participated in EARS-Net resulting in complete coverage of the Irish population.

Escherichia coli
There were 2,771 reports of invasive *E. coli* infection (2,765 from blood and six from CSF) from 2,705 patients, an increase of 9.5% from 2,530 reports in 2013. **Table 1** displays the annual trends since 2005 in the proportion of *E. coli* isolates resistant to the five "indicator" antimicrobials/antimicrobial classes [ampicillin, third-generation cephalosporins (3GCs); cefotaxime, ceftriaxone, ceftazidime or cefpodoxime, fluoroquinolones (ciprofloxacin or ofloxacin), aminoglycosides (gentamicin, amikacin or tobramycin) and carbapenems (meropenem or ertapenem)]:

- Of 2,769 isolates, 357 (12.9%) were resistant to 3GCs and of those, 268 were extended-spectrum beta-lactamase (ESBL)-positive and 87 ESBL-negative
- Of 2,769 isolates, 725 (26.2%) were resistant to ciprofloxacin
- Of 2,771 isolates, 310 (11.2%) were resistant to gentamicin [403 (14.5%) of 2,771 were aminoglycoside-resistant (i.e. resistant to gentamicin, tobramycin or amikacin)]
- Two (0.1%) of 2,270 isolates were resistant to carbapenems, one of which was confirmed to be a carbapenemase-producer (an NDM)

In 2014, resistance to 3GCs, ciprofloxacin and aminoglycosides were at their highest levels since surveillance began (**Figure 1**). The trend in 3GC resistance was upwards between 2004 and 2014, which is highly significant (P<0.001), although there appeared to be a levelling off in 2014.

In 2014, Ireland had moderately high levels (10 to <25%) of resistance to 3GCs (**Figure 2**) and aminoglycosides (ranking 13th and 11th, respectively, out of 30 countries reporting to EARS-Net) and a higher level (25 to <50%) of resistance to ciprofloxacin (ranking 13th). The median proportions for resistance among EARS-Net countries was 11.3% for 3GCs, 22.5% for ciprofloxacin and 12.3% for aminoglycosides.

ESBLs are enzymes that confer resistance to most penicillins and cephalosporins (including 3GCs). ESBL-positive bacteria (including *E. coli* and *K. pneumoniae*) are also often resistant to other classes of antimicrobials and have emerged as important causes of healthcare-associated infection (HCAI). ESBLs were detected in 280 (10.2%) of 2,757 isolates tested. In 2014, ESBL production amongst invasive *E. coli* isolates was at its second highest level (after 2013) since surveillance began. The trend in ESBL production was upwards between 2004 and 2013, which was highly significant (P<0.001). In 2014, ESBL production appeared to level off.

Of 2,766 isolates tested against all five "indicator" antimicrobials, 416 (15.0%) reported from 50 hospitals/institutions were identified as multi-drug resistant (MDR) *E. coli*, defined as resistance to three or more of the indicator antimicrobials OR any isolate with resistance to carbapenems), a slight increase from 14.8% in 2013:

- 153 resistant to ampicillin, 3GCs, ciprofloxacin and aminoglycosides (of which 137 ESBL-positive and 15 ESBL-negative)
- 119 resistant to ampicillin, 3GCs and ciprofloxacin (of which 108 ESBL-positive and 11 ESBL-negative)
- 134 resistant to ampicillin, ciprofloxacin and aminoglycosides (of which 4 ESBL-positive and 129 ESBL-negative)
- Eight resistant to ampicillin, 3GCs and aminoglycosides (of which 5 ESBL-positive and 3 ESBL-negative)
- One resistant to ampicillin, 3GCs and carbapenems (ESBL not reported)
- One resistant to ampicillin and carbapenems (ESBL-negative)

In 2014, MDR *E. coli* was at its highest level since surveillance began. Since 2009, the trend in MDR *E. coli* has been upwards, which is highly significant (P<0.001).

Females were slightly more likely (1.1-times) to have an invasive *E. coli* infection than males (highly significant, P<0.001). The frequency of invasive *E. coli* infection increased with age, with the majority (n=2,134; 77%) occurring in adults aged over 60. The median age was 74 years (95%CI, 73-74).

Staphylococcus aureus
There were 1,118 reports of *S. aureus* BSI from 1,072 patients, an increase of 2.2% from 2013 (n=1,094). Of those, 218 (19.5%) were MRSA, which represents the lowest annual proportion since surveillance began in 1999 (**Table 1** shows data from 2005). In 2010, the proportion was 24.4%, the first year that MRSA accounted for <25% of *S. aureus* BSI in Ireland, thus changing from red to orange on the EARS-Net map and 2014 was the eighth successive year in which a decrease was observed. The overall downward trend over this time period is highly significant (P<0.001) (**Figure 3**). Overall, there was a 1.8% reduction in the

Table 1. Summary of EARS-Net data by pathogen and year, 2005-2014

Pathogen	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number laboratories by year-end	41	42	44	42	43	40†	41†	41	41	39†
E. coli										
Number of isolates	1445	1656	1785	1926	2064	2170	2210	2450	2530	2771
%Ampicillin-R*	67.6	70.7	68.3	70.4	68.7	68.4	71.9	69.6	70.9	69.9
%3GC-R*	4.1	4.2	6.7	7.4	7.5	8.3	9.5	10.8	12.8	12.9
%ESBL-producers*	2.4	2.5	4.1	5.0	5.8	6.1	7.5	8.8	10.5	10.2
%Ciprofloxacin-R*	17.3	21.5	22.1	23.3	22.3	23.6	23.8	25.2	25.3	26.2
%Gentamicin-R*	8.5	7.7	9.9	10.2	7.7	9.4	8.7	9.7	9.8	11.2
%Gentamicin/Amikacin/Tobramycin-R*	8.6	8.6	10.6	11.0	9.3	11.8	12.2	12.6	12.8	14.5
%Carbapenem1-R*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
%MDR*	7.7	9.0	11.3	12.1	10.4	11.7	13.0	13.4	14.8	15.0
Number laboratories by year-end	42	42	44	43	43	40†	41†	41	41	39†
S. aureus										
Number of isolates	1424	1412	1393	1303	1309	1251	1095	1060	1094	1118
Number Meticillin-R (or MRSA)	592	592	536	439	355	305	263	242	222	218
%Meticillin-R (or MRSA)	41.6	41.9	38.5	33.7	27.1	24.4	24.0	22.8	20.3	19.5
Number laboratories by year-end	41	42	44	42	43	40†	41†	41	41	39†
E. faecium										
Number of isolates	224	265	330	406	397	392	364	392	409	404
%Ampicillin-R*	92.3	93.9	93.1	95.1	92.9	95.6	95.9	92.9	93.2	95.3
%Vancomycin-R (VREfm)	31.7	37.1	33.4	35.7	38.3	39.3	37.4	45.4	43.1	46.0
%HLG-R*	51.4	44.3	35.2	28.1	39.1	39.6	36.8	39.3	41.4	44.1
%MDR*	25.6	25.6	22.7	16.2	26.7	24.9	21.1	20.3	19.6	22.2
Number laboratories by year-end		36	39	41	42	40†	41†	41	41	39†
K. pneumoniae										
Number of isolates	No data	217	244	310	323	326	312	345	326	358
%Ampicillin-R*		97.7	99.2	99.7	99.7	99.1	100.0	98.5	99.1	100.0
%3GC-R*		10.2	9.9	11.4	11.2	10.5	8.0	11.9	21.2	12.8
%ESBL-producers*		8.6	3.7	7.7	8.2	5.0	5.6	8.8	18.4	11.0
%Ciprofloxacin-R*		15.3	18.1	12.8	13.0	10.5	13.2	11.9	20.9	17.3
%Gentamicin-R*		7.8	9.9	10.7	11.1	6.8	7.4	9.9	16.9	12.6
%Gentamicin/Amikacin/Tobramycin-R*		9.2	11.1	10.7	11.1	7.1	8.3	9.6	17.5	13.2
%Carbapenem[1]-R*		0.0	0.6	0.0	0.0	0.0	1.6	0.3	1.2	1.1
%MDRKP[2]*		1.7	2.9	3.9	4.3	2.2	4.6	5.3	12.3	8.1
%MDR*		11.2	11.9	10.6	11.9	8.0	8.4	9.9	19.7	13.7
Number laboratories by year-end	42	42	44	42	43	40†	41†	41	41	39†
S. pneumoniae										
Number of isolates	401	407	438	447	356	314	327	321	311	331
%Penicillin-NS*	11.7	15.7	17.4	23.1	20.2	18.2	19.6	19.6	20.8	17.1
of which: %HLR	3.0	2.9	5.7	6.0	5.6	4.8	6.1	4.7	2.3	2.4
%Int	8.7	12.5	11.0	16.8	13.8	12.7	13.5	15.0	18.3	14.5
%Erythromycin-R*	12.1	16.1	16.4	16.7	17.3	15.7	18.9	16.9	17.9	13.8
%Penicillin-NS/Erythromycin-R	3.2	7.4	7.9	10.2	11.9	12.6	13.8	12.1	13.3	10.4
Number laboratories by year-end	41	42	44	42	43	40†	41†	41	41	39†
E. faecalis										
Number of isolates	290	294	280	301	289	298	265	298	336	316
%Ampicillin-R*	3.5	4.5	2.2	0.7	2.1	0.7	0.8	4.0	2.7	1.9
%Vancomycin-R (VREfa)	2.5	3.7	2.9	3.7	0.7	0.3	4.9	3.0	2.1	2.8
%HLG-R*	44.4	42.4	36.9	30.5	36.7	29.7	29.1	32.9	33.6	33.0
Number laboratories by year-end		36	39	41	42	40†	41†	41	41	39†
P. aeruginosa										
Number of isolates	No data	128	177	199	248	222	184	219	207	182
%Piperacillin/tazobactam-R*		9.4	12.6	9.7	8.9	10.0	2.8	17.4	15.2	16.5
%Ceftazidime-R*		10.6	11.8	8.7	11.8	9.2	8.2	15.2	10.7	8.9
%Imipenem/meropenem-R*		11.8	12.2	9.3	10.2	8.3	12.0	19.6	12.1	11.6
%Ciprofloxacin-R*		18.0	22.9	21.8	12.1	13.2	12.6	20.6	15.0	13.7
%Gentamicin-R*		10.2	13.3	9.0	7.7	8.7	6.5	11.9	11.6	4.9
%Gentamicin/Amikacin/Tobramycin-R*		10.2	13.3	9.0	7.7	8.7	6.5	11.9	11.6	5.5
%MDR*		9.5	12.4	11.1	6.4	6.5	4.0	13.0	9.4	6.7
Number laboratories by year-end									41	39†
Acinetobacter spp.										
Number of isolates	No data	No data	No data	No data	No data	No data	No data	No data	91	93
%Ciprofloxacin-R*									3	8
%Gentamicin-R*									0	3
%Gentamicin/Amikacin/Tobramycin-R*									1	3
%Carbapenem1-R*									4	4
%MDR*									0	2

R, Resistant; NS, Non-Susceptible [includes isolates with intermediate (Int) and high-level resistance (HLR)]
MRSA, Meticillin-Resistant S. aureus; VREfm, Vancomycin-Resistant E. faecium; VREfa, Vancomycin-Resistant E. faecalis
HLG, High-Level Gentamicin; 3GC, 3rd-Generation Cephalosporin (includes cefotaxime, ceftriaxone, ceftazidime and cefpodoxime); ESBL, Extended-Spectrum Beta-Lactamase; MDR, Multi-Drug Resistant
* Not all isolates tested
† The number of laboratories processing blood cultures has changed a number of times between 2006 and 2014; however, coverage of acute hospitals has remained at 100%
[1] Carbapenems include imipenem, meropenem and ertapenem
[2] MDRKP, MDR K. pneumoniae phenotype (ESBL-producer plus non-susceptibility to Ciprofloxacin and Gentamicin) OR carbapenemase-producer (e.g. KPC, OXA-48)

number of reported MRSA BSI compared with 2013 (218 versus 222). In contrast, the total number of MSSA BSI increased by 3.2% compared with 2013 (900 versus 872).

Despite the decrease in numbers and proportion of MRSA BSI in 2014, Ireland still had one of the higher proportions of MRSA in Europe (see http://ecdc.europa.eu/en/activities/surveillance/EARS-Net/Pages/Database.aspx for more detailed European data, including EARS-Net tables, charts and maps) (**Figure 4**). Ireland ranked 12th out of 30 countries reporting to EARS-Net (compared to 11th of 30 countries in 2013), with the median proportion of MRSA BSI at 13.1%. All countries with MRSA proportions higher than Ireland are located in Southern and Central/Eastern Europe.
The MRSA rate for all acute hospitals in 2014 was 0.055 cases per 1,000 BDU, a slight decrease from 0.056 in 2013, whilst the MSSA rate increased from 0.219 to 0.227 [rates are calculated from denominator data (bed days used) obtained from the HSE Business Intelligence Unit (BIU) for all acute public hospitals; and directly from private hospitals where available, where both numerator (*S. aureus* numbers) and denominator data have been provided].

Males were approximately 1.8-times more likely to have invasive *S. aureus*, MRSA or MSSA infection than females (highly significant; P<0.001). The frequency of invasive *S. aureus* infection increased with age, with the majority of infections (n=678; 61%) occurring in adults aged over 60. The median age for MRSA infection was 73 years (95%CI, 71-76) and for MSSA infection was 64 years (95%CI, 62-65). This was considered to be a

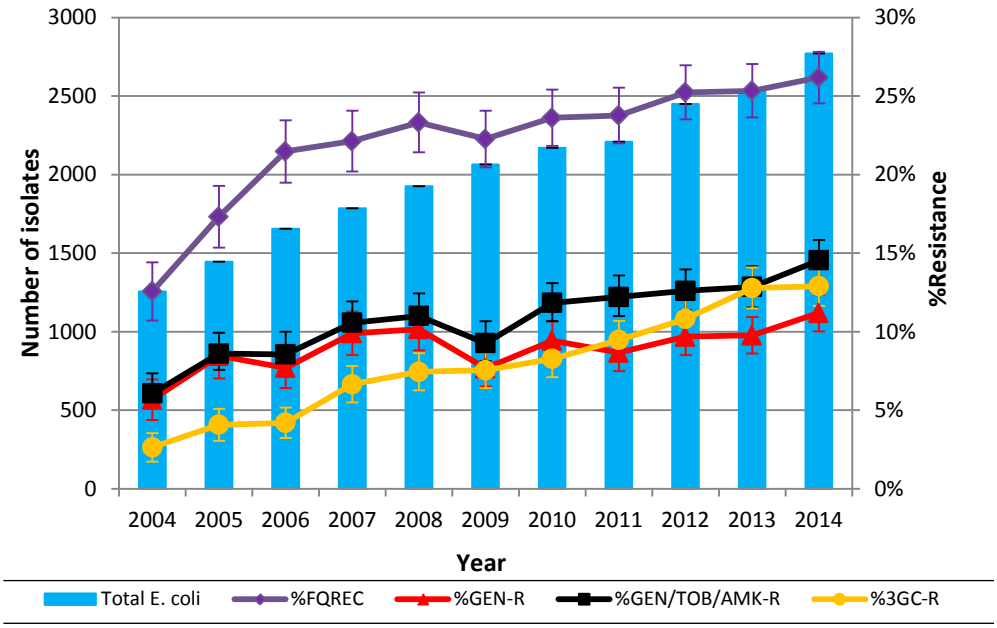


Figure 1. Trends for E. coli – total numbers of E. coli and percentage resistance to 3rd generation cephalosporins (3GCs), ciprofloxacin/ofloxacin (CIP/OFX), gentamicin (GEN) and gentamicin/amikacin/tobramycin (GEN/AMK/TOB) with 95% confidence intervals

Table 2. Age and gender breakdown of patients by organism with major resistance profiles (data from laboratories participating in enhanced surveillance for 2014). The proportion of isolates detected <48 hours and >5 days post-admission is also shown

		Total for 2014	Percent female	Mean age in years	Detected <48 hours after admission	Detected >5 days after admission
Staphylococcus aureus	Meticillin-resistant (MRSA)	**92**	42%	71.5	57%	32%
	Meticillin-susceptible	**378**	35%	56.5	62%	25%
Streptococcus pneumoniae	Penicillin-non-susceptible	**21**	52%	53.9	90%	5%
	Penicillin-susceptible	**111**	51%	61.2	95%	2%
Enterococci	Vancomycin-resistant	**77**	40%	65.5	9%	81%
	Vancomycin-sensitive	**221**	46%	67.3	40%	48%
Escherichia coli	Fluoroquinolone-resistant	**273**	45%	76.2	73%	22%
	Fluoroquinolone-susceptible	**819**	56%	68.5	74%	19%
Klebsiella pneumoniae		**139**	45%	66.7	51%	35%
Pseudomonas aeruginosa		**71**	44%	69.0	68%	23%

significant difference, as the confidence intervals did not overlap.

Enterococcus faecium
There were 404 reports of *E. faecium* BSI from 390 patients, a decrease of 1.2% from 2013 (n=409). **Table 1** displays the annual trends since 2005 in the proportion of *E. faecium* isolates resistant to the three "indicator" antimicrobials (ampicillin, vancomycin and high-level gentamicin):

- Of 404 isolates, 186 (46.0%) were resistant to vancomycin, with an increase in the proportion of vancomycin-resistant *E. faecium* (VREfm) from 43.1% (2013) **(Figure 5)**
- Of 392 isolates, 173 (44.1%) were resistant to high-level gentamicin (**Figure 5**)
- Of 392 isolates tested against the three "indicator" antimicrobials, 87 (22.2%) reported from 20 hospitals [with the majority (71; or 82%) coming from the nine tertiary hospitals] were resistant to all three and termed MDR *E. faecium*, which represents an increase from 19.6% in 2013

Since 2008, Ireland has had the highest proportion of VREfm in Europe. In 2014, countries with the next highest proportions of VREfm were: Cyprus (40%), Greece (27.3%) and Romania (25%) (**Figure 6**), whilst the median proportion of VREfm in EARS-Net countries was just 4.5%.

Males were approximately 1.4-times more likely to have invasive *E. faecium* infection than females (approaching borderline significance; P=0.06). The frequency of invasive *E. faecium* infection increased with age, with the majority of infections (n=299; 74%) occurring in adults aged over 60. The median age was 69 years (95%CI, 67-71).

Klebsiella pneumoniae
There were 358 reports of invasive *K. pneumoniae* infection (354 from blood and four from CSF) from 356 patients, an increase of 9.8% from 2013 (n=326). **Table 1** displays annual trends since 2006 in the proportion of *K. pneumoniae* isolates resistant to the five "indicator" antimicrobials (as for *E. coli* above):

- Of 358 isolates, 46 (12.8%) were resistant to 3GCs, of which 37 were ESBL-positive and nine were ESBL-negative
- Of 358 isolates, 62 (17.3%) were resistant to ciprofloxacin
- Of 357 isolates, 45 (12.6%) were resistant to gentamicin [47 (13.2%) of 357 were aminoglycoside-resistant (i.e. resistant to gentamicin, tobramycin or amikacin)]
- Of 354 isolates, four (1.1%) were resistant to carbapenems, with two confirmed to be carbapenemase-producers (from different hospitals; one OXA-48 and one KPC-type CRE) and two confirmed not to be carbapenemase-producers. The two invasive carbapenemase-producing *K. pneumoniae* isolates in 2014 followed two isolates in 2013 (both OXA-48) and four isolates in 2011 (3 OXA-48 and one KPC)

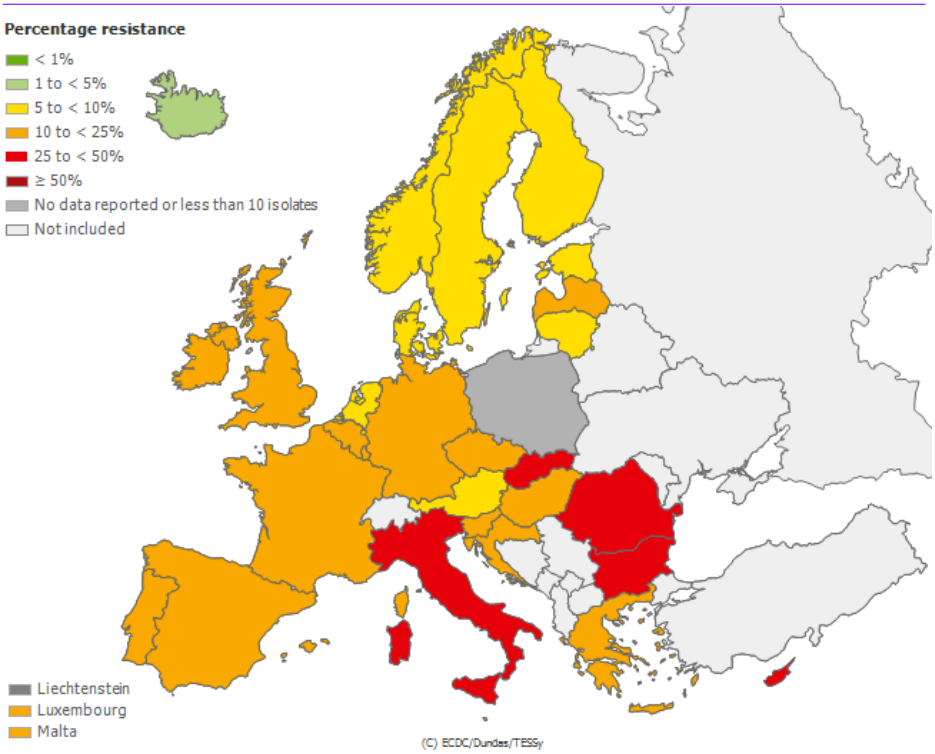


Figure 2. Distribution of 3rd-generation cephalosporin resistant E. coli in EARS-Net countries in 2014
Map downloaded from ECDC's TESSy database on 21/10/2015:
http://ecdc.europa.eu/en/activities/surveillance/EARS-Net/Pages/Database.aspx

Resistance to 3GCs, ciprofloxacin and gentamicin/ aminoglycosides all decreased in 2014 compared with 2013 when they were at their highest levels since surveillance began (**Figure 7**).

No invasive *K. pneumoniae* isolates were reported as susceptible to ampicillin, which is as expected as *K. pneumoniae* are inherently resistant to ampicillin.

ESBLs were detected in 39 (11.0%) of 354 isolates tested. In 2014, ESBL production amongst invasive *K. pneumoniae* isolates was at its second highest level (after 2013) since surveillance began.

Of 357 isolates, 49 (13.7%) reported by 22 hospitals that were tested against all five "indicator" antimicrobials were identified as MDR *Klebsiella pneumoniae*, a decrease from 19.7% in 2013:

- Three resistant to ampicillin, 3GCs, ciprofloxacin, aminoglycosides and carbapenems (of which one ESBL-positive and two ESBL-negative)
- 30 resistant to ampicillin, 3GCs, ciprofloxacin and aminoglycosides (of which 28 ESBL-positive and two ESBL-negative)
- One resistant to ampicillin, 3GCs, aminoglycosides and carbapenems (ESBL-positive)
- Three resistant to ampicillin, 3GCs and ciprofloxacin (of which two ESBL-positive and one ESBL-negative)
- Two resistant to ampicillin, 3GCs and aminoglycosides (both ESBL-positive)
- 10 resistant to ampicillin, ciprofloxacin and aminoglycosides (of which nine ESBL-negative)

In 2013, the Antimicrobial Resistance and Microbial Ecology (ARME) group at NUI Galway alerted HPSC to the presence of two predominant *K. pneumoniae* clones implicated in both patient infection and colonisation in a number of Irish hospitals. Both clones were simultaneously ESBL-positive and non-susceptible to ciprofloxacin and gentamicin. Some were also found to produce carbapenemases. Together, these are termed multi-drug resistant *K. pneumoniae* (MDRKP). The proportion of invasive *K. pneumoniae* that were MDRKP increased from 5.3% (18 of 342 isolates) in 2012 to 12.3% (40 of 325 isolates) in 2013 as displayed in **Figure 8**. An outbreak control team was established in October 2013 to evaluate this emerging threat. In 2014, the proportion decreased to 8.1% (29 of 358 isolates).

Antimicrobial resistance in invasive *K. pneumoniae* isolates in Ireland have been among the lowest in Europe, but this appeared to be changing as of 2013 (**Figure 7**). However, resistance to 3GCs, fluoroquinolones and aminoglycosides all decreased in 2014 (perhaps in response to implementation of measures recommended by the MDRKP outbreak control team) with Ireland ranking 21st, 20th and 19th, respectively, among 29 countries reporting to EARS-Net indicating that resistance levels in Ireland are still relatively low. The median proportions among EARS-Net countries were 30.7% for 3GCs, 33.3% for fluoroquinolones and 22.3% for aminoglycosides. With only two reports of carbapenemase-producing *K. pneumoniae*, Ireland ranked 23rd of 28 countries in 2014, with the median proportion among EARS-Net countries being 1.3% (**Figure 9**).

Males were approximately 1.5-times more likely to have an invasive *K. pneumoniae* infection than females (highly significant, P=0.001). The frequency of invasive *K. pneumoniae* infection increased with age with the majority of infections (n=252; 70%) occurring in adults aged over 60. The median age was 69 years (95%CI, 67-71).

Streptococcus pneumoniae

There were 331 reports of invasive *S. pneumoniae* infection (322 from blood and nine from CSF) from 310 patients, an increase of 6.4% from 2013 (n=311). **Table**

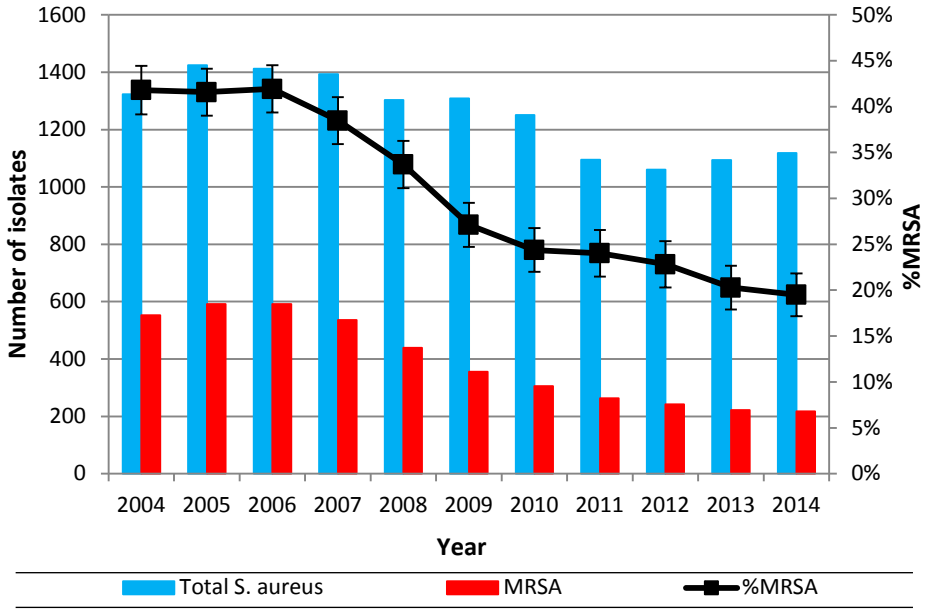


Figure 3. Trends for S. aureus – total numbers of S. aureus/MRSA and percentage MRSA with 95% confidence intervals

1 displays annual trends since 2005 in the proportions of *S. pneumoniae* isolates non-susceptible/resistant to penicillin and erythromycin.

Penicillin non-susceptible *S. pneumoniae* (PNSP) accounted for 17.1% (n=56) of all isolates tested against penicillin (n=328) in 2014. Of the PNSP isolates, 48 were intermediately-resistant (Int; MIC=0.1-1 mg/L for laboratories following the Clinical Laboratory Standards Institute (CLSI) guidelines (for non-meningitis syndrome via oral administration) and MIC=0.1-2mg/L for those following European Committee on Antimicrobial Susceptibility Testing (EUCAST) non-meningitis guidelines) and eight were high-level resistant (HLR; MIC >1.0mg/L for CLSI and >2mg/L for EUCAST) to penicillin. Penicillin susceptibility was not determined for three isolates. Forty-four (13.8%) of 319 isolates were resistant to erythromycin.

There was a decrease in the proportion of PNSP isolates from 20.8% in 2013 to 17.1% in 2014 as displayed in **Figure 10**. The proportion that displayed penicillin HLR remained stable at 2.5%. In 2014, Ireland remained among European countries with the highest proportions of PNSP ranking 8th of 28 countries overall; and 4th of 20 countries reporting ≥50 isolates. In 2014, the median proportion amongst EARS-Net countries was 8.9%. However, it is important to consider that comparison

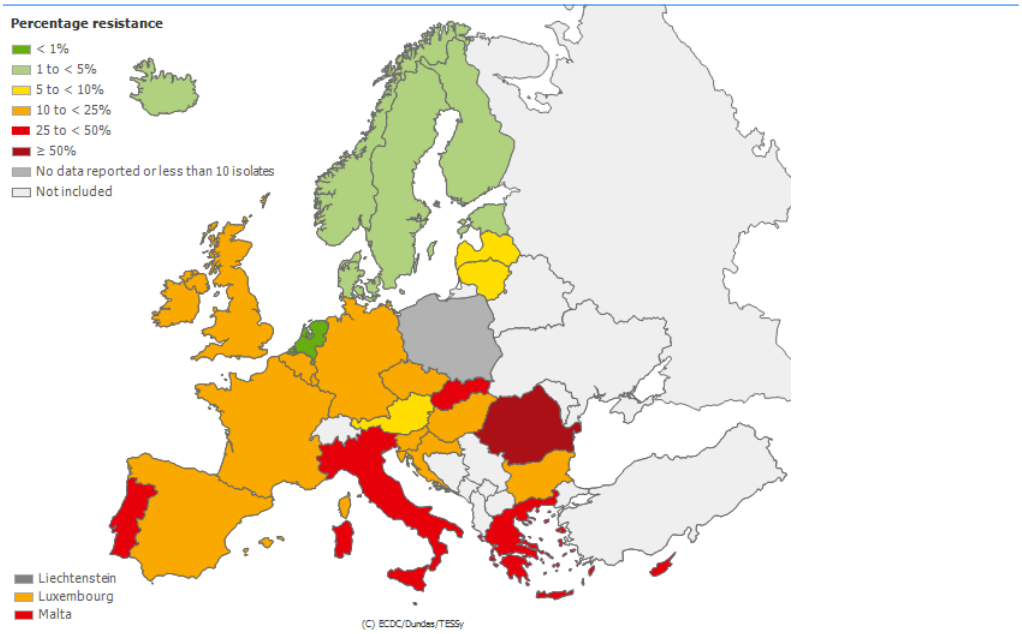


Figure 4. Distribution of MRSA in EARS-Net countries in 2014
Map obtained from ECDC on 21/10/2015:
http://ecdc.europa.eu/en/activities/surveillance/EARS-Net/Pages/Database.aspx

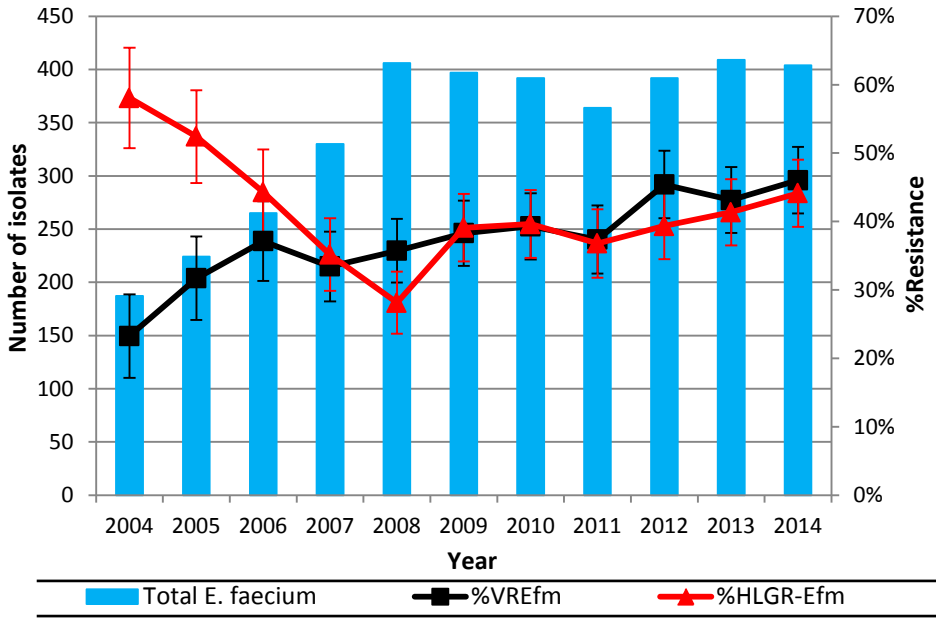


Figure 5. Trends for E. faecium – total numbers of E. faecium and percentage resistance to vancomycin (VREfm) and high-level gentamicin (HLG) with 95% confidence intervals

with other EARS-Net countries can be problematic due to the possibility of different interpretive criteria being applied to the data from different countries (and indeed from different laboratories within a country):

- CLSI provides three sets of breakpoints for interpreting penicillin susceptibility of *S. pneumoniae* isolates: meningitis, non-meningitis and oral
- EUCAST provides two sets of breakpoints: meningitis and infections other than meningitis

Many Irish microbiology laboratories have already switched, or are currently in the process of switching, from CLSI to EUCAST guidelines: 33 laboratories had switched by the end of 2014, an increase from 27 by the end of 2013. In Ireland, EARS-Net data are reported using the EUCAST breakpoints for infections other than meningitis or the CLSI breakpoints for "oral administration" (which correspond to the original CLSI breakpoints), as these are broadly similar for epidemiological purposes and thus facilitate a more meaningful analysis of the data. This also permits a relatively consistent approach for comparing historical data.

Moderately high levels of erythromycin resistance were seen, with Ireland ranking 16th of 28 countries overall and 14th of 21 countries reporting 50 or more isolates. This is similar to the situation observed in much of Southern and Central/Eastern Europe. In 2014, the median proportion amongst EARS-Net countries was 14.3%.

Of 317 isolates tested against both penicillin and erythromycin in 2014, 33 (10.4%) were simultaneously PNSP (28 Int, 5 HLR) and erythromycin-resistant, which is the lowest proportion in the last six years.

In early 2007, a national pilot project was established as a collaborative initiative between RCSI/Beaumont Hospital, Children's University Hospital, Temple St and HPSC, with the aim of providing baseline serotyping data on invasive *S. pneumoniae* isolates. This project pre-dates the introduction of the 7-valent pneumococcal conjugate vaccine (PCV7) into the childhood immunisation schedule in September 2008. PCV13 replaced PCV7 from September 2010.

In 2014, serotype data were available for 298 pneumococcal isolates reported by 32 of the 34 laboratories reporting pneumococcal isolates to EARS-Net, representing 90% of all pneumococcal isolates reported:

- Of 154 isolates from patients aged ≥65 years, 105 (68%) belonged to serotypes included in the PPV23 vaccine
- Only 13 isolates were referred for typing from patients aged <2 years (the target population for the PCV13 vaccine) and all 13 were non-vaccine serotypes

The most common serotypes identified were: 7F (n=31), 15A and 22F (n=25 each), 3 (n=24), 8 (n=22), 19A (n=19), 10A (n=14) and 6C and 33F (n=12 each) representing 62% of all isolates typed.

Of the 56 PNSP isolates, 51 (91%) were serotyped:

- Of 32 isolates from patients age ≥65 years, 16 (50%) belonged to serotypes included in the pneumococcal polysaccharide vaccine (PPV23) vaccine
- Of two isolates from children <2 years, one belonged to a serotype included in the PCV13 vaccine

Ongoing surveillance of the predominant serotypes is required, as strains with non-vaccine serotypes have

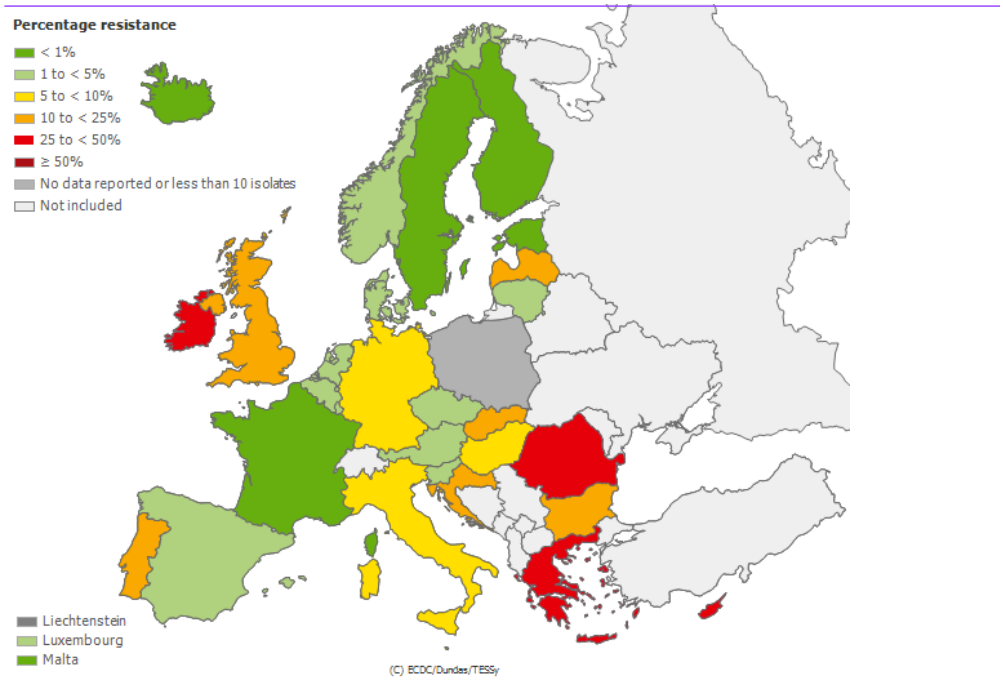


Figure 6. Distribution of vancomycin-resistant E. faecium (VREfm) in EARS-Net countries in 2014
Map downloaded from ECDC's TESSy database on 21/10/2015:
http://ecdc.europa.eu/en/activities/surveillance/EARS-Net/Pages/Database.aspx

been reported to increase in prevalence following the introduction of conjugate vaccines in other countries, hence the need for a fully-resourced Irish pneumococcal reference laboratory. The separate chapter on invasive pneumococcal disease (IPD) in Ireland in 2014 contains additional information on pneumococcal serotyping.

In 2014, the rate of IPD in Ireland was estimated at 7.2 cases per 100,000 population, an increase compared with 6.8 in 2013 (note that both rates were calculated using 2011 census data). The highest rates of IPD were observed in the older age groups [adults aged 65-74 (23.9 per 100,000), 75-79 (36.3 per 100,000) and ≥80 (47.5 per 100,000)] with a smaller peak in young children [aged <1 year (12.4 per 100,000) and 1 year (9.0 per 100,000)] as displayed in **Figure 11**. The IPD rates in all age groups were broadly similar to 2013.

Males were approximately 1.1-times more likely to have an invasive *S. pneumoniae* infection than females, but this was not statistically significant (P=0.41). The frequency of invasive *S. pneumoniae* infection increased with age, with the majority (n=200; 60%) occurring in adults aged over 60. The median age was 66 years (95%CI, 62-68).

Enterococcus faecalis
There were 316 reports of *E. faecalis* BSI from 308 patients, a decrease of 6.0% from 2013 (n=336). Table 1 displays annual trends since 2005 in the proportions of *E. faecalis* isolates resistant to the three "indicator" antimicrobials (as for *E. faecium*):

- Of 316 isolates, nine (2.8%) were resistant to vancomycin (VREfa), with Ireland ranking 5th amongst European countries for resistance. The median proportion in Europe was 0.2%, although the proportion of VREfa in Ireland has decreased from the highest reported proportion of 4.9% in 2011
- Of 300 isolates, 99 (33.0%) were resistant to high-level gentamicin

Six isolates were reported resistant to ampicillin, which is suggestive of misidentification of species or misclassification, as resistance to ampicillin is rare in *E. faecalis*.

Males were approximately 1.5-times more likely to have invasive *E. faecalis* infection than females (highly significant; P<0.001). The frequency of invasive *E. faecalis* infection increased with age, with the majority of infections (n=211; 67%) occurring in adults aged over 60. The median age was 68 years (95%CI, 67-71).

Pseudomonas aeruginosa
There were 182 reports of invasive *P. aeruginosa* infection (179 from blood and three from CSF) from 176 patients, a decrease of 12.0% from 2013 (n=207). **Table 1** displays annual trends since 2006 in the proportion of *P. aeruginosa* isolates resistant to the five "indicator" antimicrobials/antimicrobial classes [piperacillin-tazobactam, ceftazidime, carbapenems (meropenem or imipenem), fluoroquinolones (ciprofloxacin or ofloxacin) and aminoglycosides (gentamicin, amikacin or tobramycin)]:

- Of 182 isolates, 30 (16.5%) were resistant to piperacillin-tazobactam
- Of 179 isolates, 16 (8.9%) were resistant to ceftazidime

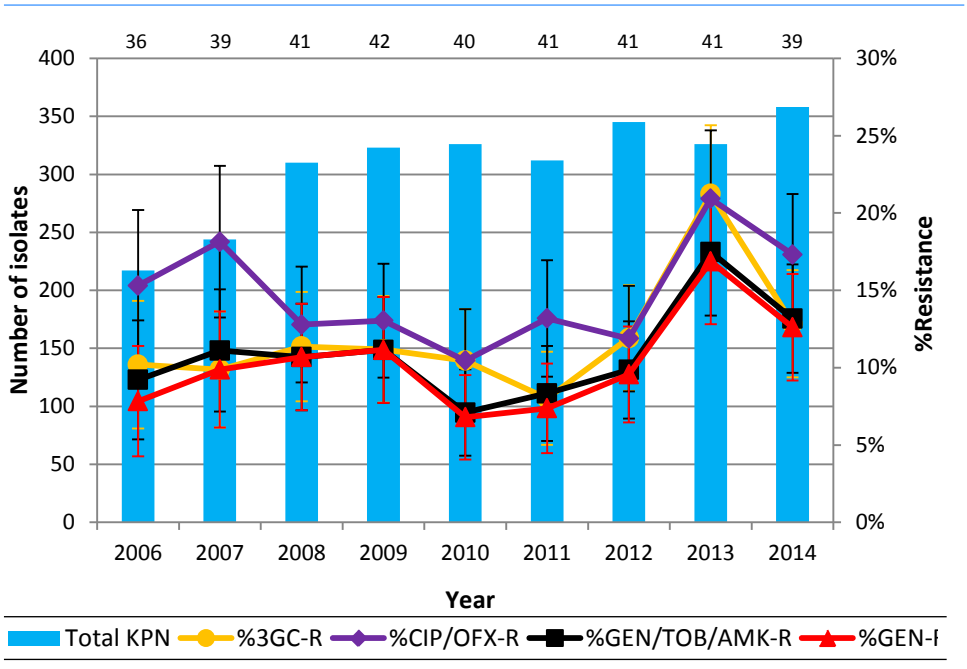


Figure 7. Trends for K. pneumoniae – total numbers of K. pneumoniae and percentage resistance to 3rd generation cephalosporins (3GCs), ciprofloxacin/ofloxacin (CIP/OFX), gentamicin (GEN) and gentamicin/amikacin/tobramycin (GEN/AMK/TOB) with 95% confidence intervals
Number of participating laboratories indicated above the bars

- Of 181 isolates, 21 (11.6%) were resistant to imipenem or meropenem
- Of 182 isolates, 25 (13.7%) were resistant to ciprofloxacin
- Of 182 isolates, 9 (4.9%) were resistant to gentamicin [10 (5.5%) of 182 were aminoglycoside-resistant (i.e. resistant to gentamicin, tobramycin or amikacin)]

In 2014, resistance to all but one of the indicator antimicrobials (piperacillin-tazobactam) decreased compared with 2013.

Twelve (6.7%) of 179 isolates reported from 10 hospitals that were tested against all five "indicator" antimicrobials were identified as MDR *Pseudomonas aeruginosa*, defined as resistance to three or more of the indicator antimicrobials:

- Three resistant to all five antimicrobial classes
- Two resistant to four of five antimicrobial classes
- Seven resistant to three of five antimicrobial classes

Antimicrobial resistance levels amongst *P. aeruginosa* isolates in Ireland are at moderately low levels in comparison with other European countries, with Ireland ranking between 16th and 24th of 29 countries for all five indicator antimicrobials.

Males were approximately 1.5-times more likely to have invasive *P. aeruginosa* infection than females (significant; P=0.01). The frequency of invasive *P. aeruginosa* infection increased with age, with the majority of infections (n=130; 71%) occurring in adults aged over 60. The median age was 68 years (95%CI, 66-72).

Acinetobacter spp.

There were 93 reports of invasive infection caused by *Acinetobacter spp.* (90 from blood and one from CSF) from 91 patients, a slight increase from 2013 (n=91). **Table 1** displays annual trends since 2013 in the proportion of *Acinetobacter spp.* isolates resistant to the three "indicator" antimicrobials/antimicrobial classes [carbapenems (meropenem or imipenem), fluoroquinolones (ciprofloxacin or ofloxacin) and gentamicin]:

- Of 83 isolates, three were resistant to imipenem or meropenem
- Of 88 isolates, seven were resistant to ciprofloxacin
- Of 91 isolates, three were resistant to gentamicin [no additional isolates were resistant to the other aminoglycosides (amikacin or tobramycin)]

Two of 83 isolates reported from two hospitals were identified as MDR *Acinetobacter spp.*, i.e. resistant to all three "indicator" antimicrobials.

Enhanced Surveillance

The voluntary EARS-Net enhanced surveillance programme was established in 2004. Laboratories that participate in EARS-Net are invited to provide additional demographic and clinical data on invasive pathogens causing BSI.

In 2014, enhanced surveillance data on 2,202 individual records (cases or isolates under the EARS-Net definition) were submitted from 21 participating laboratories, representing 40% of all reports to EARS-Net. **Table 2** displays demographic and other basic data for the major resistance profiles of pathogens reported to EARS-Net enhanced surveillance.

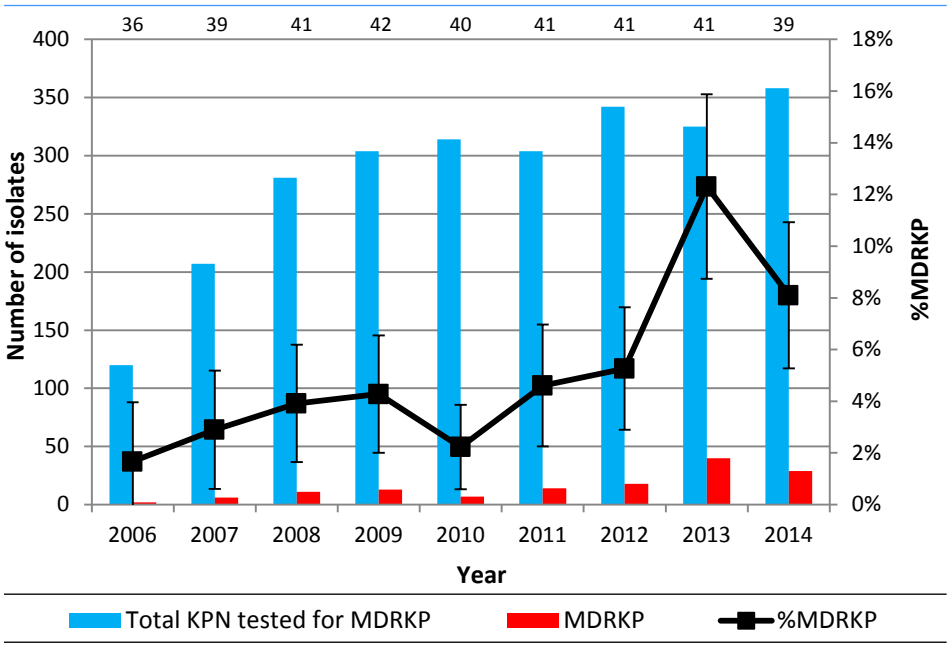


Figure 8. Trends for K. pneumoniae isolates with the MDRKP phenotype (simultaneously ESBL-producers and non-susceptible to both ciprofloxacin and gentamicin and/or a carbapenemase-producer) — numbers and percentage with MDRKP phenotype with 95% confidence intervals
Number of participating laboratories indicated above the bars

1. *S. aureus* BSI

- 51% of MRSA BSIs and 51% of MSSA BSIs were reported as healthcare-associated infection
- 18% of MRSA BSIs were reported as device-associated with
    - 10% CVC/CVC-PICC-associated and 3% PVC-associated BSIs specifically reported
- 26% of MSSA BSIs were reported as device-associated with
    - 11% CVC/CVC-PICC-associated, 7% PVC-associated and 5% dialysis catheter-associated BSIs specifically reported
- 27% of patients with MRSA and 21% of patients with MSSA BSIs were noted as having recent exposure to antibiotics

2. Enterococcal BSI

- All of the vancomycin-resistant enterococcal BSIs (VRE) and 67% of the vancomycin-susceptible enterococcal (VSE) BSIs were reported as healthcare-associated infection
- 31% of VRE BSIs were reported as device-associated with
    - 24% specifically reported as CVC/CVC-PICC-associated BSIs
- 17% of VSE BSIs were reported as device-associated with
    - 11% specifically reported as CVC/CVC-PICC-associated BSIs
- 29% of patients with VRE BSIs and 19% of patients with VSE BSIs were noted as having recent exposure to antibiotics

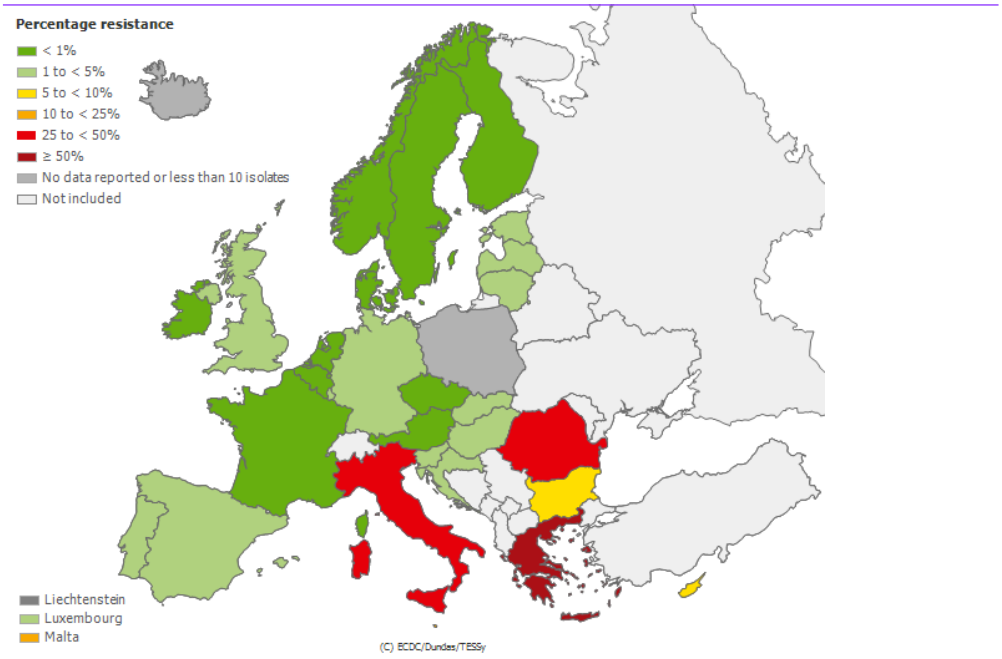


Figure 9. Distribution of carbapenem-resistant K. pneumonie in EARS-Net countries in 2014
Map downloaded from ECDC's TESSy database on 21/10/2015:
http://ecdc.europa.eu/en/activities/surveillance/EARS-Net/Pages/Database.aspx

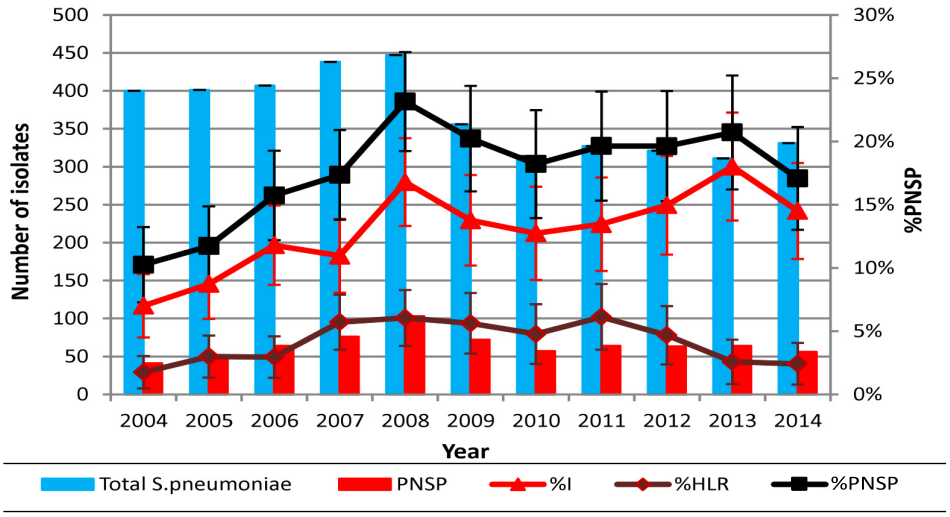


Figure 10. Trends for S. pneumoniae – total numbers of S. pneumoniae/PNSP and percentage PNSP with 95% confidence intervals
HLR, High-level resistant; I, Intermediately resistant

3. *S. pneumoniae* BSI
- The majority of both PNSP and PSSP BSIs were community-acquired
- Respiratory tract infection remained the most common source of pneumococcal BSI

4. *E. coli* BSI
- The majority (52%) of fluoroquinolone-resistant *E. coli* (FQREC) BSIs were reported as healthcare-associated infection, which contrasts with 36% for fluoroquinolone-susceptible *E. coli*
    - o The most common source of *E. coli* bloodstream infection was urinary tract infection, with 11% FQREC BSI reported in association with the presence of a urinary catheter
    - o Recent antibiotic exposure was noted in 23% of cases of *E. coli* BSI

Conclusion

For the eighth consecutive year, the proportion of *S. aureus* BSI attributable to MRSA further declined to 19.5%, the lowest reported level since Ireland joined EARS-Net in 1999. Unfortunately, antimicrobial resistance in other important BSI causative pathogens increased further and remains a cause for concern.

For the eighth consecutive year, Ireland remained the European country with the highest proportion of VREfm BSI (46.0%), with Cyprus, Greece and Romania now also reporting proportions over 25% and therefore appearing red on the map.

Following the establishment of the national multidrug resistant *K. pneumoniae* (MDRKP) outbreak control team (OCT) in 2013 to look at the emerging problem of MDRKP, initial recommendations were made to try to control the spread of MDRKP strains in healthcare settings. Due to the wide-reaching nature of this outbreak and the growing threat posed by antimicrobial resistance, the OCT proposed that a national task force should be established with greater powers to influence and implement changes in policy and infrastructure needed. Between 2012 and 2013, EARS-Net data revealed a large increase in invasive *K. pneumoniae* that were MDRKP (from 5.3% to 12.3% of isolates), supporting the hypothesis of emergence and dissemination of MDRKP in Ireland. A reduction in MDRKP was seen in 2014 (to 8.1% of isolates) and this may be in part due to some of the control measures put in place during 2014. However, many of the recommendations have still not been fully implemented due to resource issues: screening for carriage of MDRKP (and other resistant organisms) is still not widely carried out and there is an overall lack of isolation facilities.

In 2014, there were two reported cases of invasive carbapenemase-producing *K. pneumoniae* (CRE) infection in Ireland. Greece (63%) and Italy (36%) remained the European countries with the largest proportions of invasive CRE infections (amongst *K. pneumoniae*). For the first time, all 29 EARS-Net participant countries that provided data reported one or more cases of invasive CRE with 16 of these reporting five or more cases. This clearly illustrates the successful dissemination of these highly resistant microorganisms in Europe. Suboptimal infection prevention and control practices and lack of antimicrobial stewardship programmes in both acute and non-acute healthcare settings may have contributed to this dissemination. To address the threat of MDR-*Enterobacteriaceae*, such as MDRKP, ESBLs and CRE to Ireland, it is vital that control measures are strengthened in both acute and non-acute healthcare settings, with implementation of the recommendations contained in the "Guidelines for the prevention and control of multi-drug resistant organisms, other than

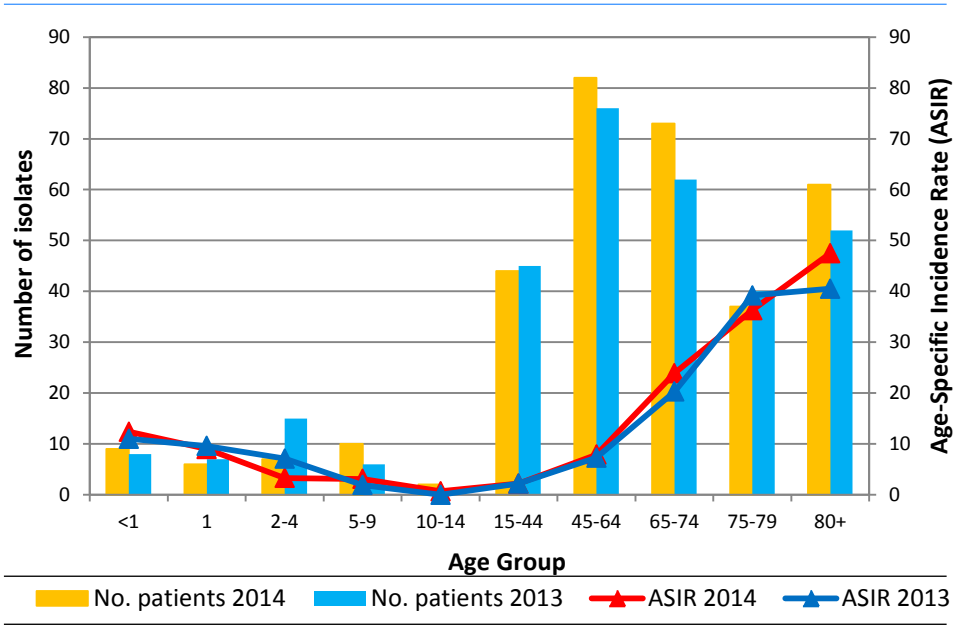


Figure 11. Numbers and age-specific incidence rates of patients with invasive S. pneumoniae infection in 2014 compared with 2013
ASIR, age-specific incidence rate

MRSA", published in 2013 (available at http://www.hpsc.ie/A-Z/MicrobiologyAntimicrobialResistance/InfectionControlandHAI/Guidelines/) and the "Guidelines for antimicrobial stewardship in hospitals", published in 2009 (available at http://www.hpsc.ie/A-Z/MicrobiologyAntimicrobialResistance/StrategyforthecontrolofAntimicrobialResistanceinIrelandSARI/AntibioticStewardship/Publications/).

The decline in the burden of MRSA BSI in recent years may be partly attributable to improvements in infection prevention and control interventions, such as increased emphasis on and improved healthcare worker awareness of the importance of compliance with standard and contact precautions, screening of patients for MRSA carriage and the availability of decolonisation regimens to eradicate MRSA carriage. The development of and strengthening of hospital antimicrobial stewardship programmes and restricted prescribing of certain broad spectrum antimicrobials, particularly in response to other healthcare associated infections, such as *Clostridium difficile* infection, may also have positively contributed to the decreasing proportion of MRSA BSI.

Since 2008, pneumococcal conjugate vaccines have been a component of the childhood immunisation programme, an intervention which has already resulted in a reduction in the burden of paediatric invasive pneumococcal disease (IPD) in Ireland. However, pneumococcal antimicrobial resistance remains a major problem in Ireland. Clearly, IPD manifesting as BSI or meningitis reflects the most severe form of pneumococcal infection and data on other more common manifestations of infection (e.g., pneumonia, sinusitis and otitis media) are not captured by EARS-Net. While data from invasive infections is extremely valuable in comparing national levels of AMR, the true burden of infection caused by antimicrobial-resistant pneumococci may be underestimated.

The enhanced EARS-Net surveillance data are particularly useful in informing infection prevention and control programmes, both nationally and in those hospitals that participate in the surveillance scheme. Participation in enhanced surveillance can also help to identify risk factors and potentially preventable healthcare-associated infections that can be targeted as part of preventative programmes (e.g. invasive medical device-related infections).

Infections caused by antimicrobial-resistant bacteria result in excess patient mortality, morbidity and costs to the healthcare system. Rising levels of AMR threaten many aspects of healthcare that we currently take for granted. It is critical that comprehensive infection prevention and control and antimicrobial stewardship programmes continue to be developed and maintained at all levels and settings within the Irish health service. To this end, it is vital that recommendations and guidelines produced by the HSE RCPI Clinical Advisory Group on HCAI and AMR are implemented.

HPSC thanks all the microbiology laboratories for their continued participation and enthusiasm for the EARS-Net project.

The data presented in this report were taken from the EARS-Net database on **1st October 2015**.

Enhanced surveillance of Carbapenem Resistant *Enterobacteriaceae* (CRE)

Summary:

- In 2014, enhanced surveillance data was received on 43 cases of CRE colonisation/infection. This represented an increase compared with 2013 and 2012, when enhanced surveillance data was received on 24 and 32 CRE cases, respectively. In contrast, the National Carbapenemase Producing *Enterobacteriaceae* (CPE) Reference Laboratory Service (CPEaRLS) at Galway University Hospital confirmed carbapenemase production in 82 *Enterobacteriaceae* isolates in 2014
- Five patients (12%) had a history of hospitalisation abroad (Ghana, India, Libya/Tunisia, Vietnam: OXA-48-type CRE isolated; Iraq: NDM-type CRE isolated)
- The clinical significance of the CRE isolate was reported for all patients, representing colonisation in the majority (n=32; 74%). CRE infection was reported for the remaining 11 patients

Introduction

Carbapenem-resistant *Enterobacteriaceae* (CRE) are multi-drug resistant Gram-negative bacteria and includes carbapenemase enzyme producers and those bacteria that are resistant to carbapenems (e.g. imipenem, meropenem) as a result of a combination of resistance mechanisms (such as broad-spectrum β-lactamases and bacterial cell porin loss). These bacteria can be easily spread between patients in healthcare settings and have the ability to cause infections for which effective antimicrobial therapy may be lacking. Carbapenemase production has spread worldwide in the past 15 years and is now a prominent resistance mechanism reported in many countries.

Detection of confirmed carbapenemase-producing CRE, hereafter known as CRE, became notifiable in Ireland in March 2011 under the category of "unusual cluster or changing pattern of illness". Upon amendment to the Infectious Diseases Regulations in September 2011, invasive CRE infection (blood, CSF or normally sterile site) became notifiable in its own category. The CRE enhanced surveillance scheme was established in June 2011 and reporting of CRE isolates from any site, whether colonisation or infection is encouraged.

Enhanced surveillance data

CRE cases reported to enhanced surveillance

In 2014, enhanced surveillance data was received from 9 laboratories on 43 confirmed cases of carbapenemase-producing CRE and one tertiary hospital reported a CRE outbreak. **Figure 1** displays annual trends in CRE cases and types reported to enhanced surveillance since 2011. Of the 43 patients, 23 were female (53%). The median age was 71 years (range: 1 – 94 years).

Patient location
At the time of CRE detection, 40 patients (93%) were hospitalised, two (4%) were in long-term care facilities and one (2%) was in the community. Of the 40 hospitalised patients, 10 (25%) had been admitted from home, seven (16%) were transfers from another acute hospital, three had been admitted from long-term care/ nursing homes (7%) and the source of admission was not provided for the remaining 20 patients (45%). Of the seven patients who had been transferred from another acute hospital, two were repatriated from hospitals abroad (in Libya/Tunisia and Vietnam).

Time to CRE colonisation/infection (days from patient's admission to the time they became positive for CRE) could be calculated for 36 of 40 admitted patients. The median time to CRE colonisation/infection was 7.5 days (range: 0 – 42).

Presence of other multi-drug resistant organisms (MDROs)
At the time of CRE detection, 13 patients (30%) were already known to be colonised or infected with one or more other multi-drug resistant organisms (MDROs), including eight with MRSA, four with ESBL-producing *Enterobacteriaceae*, three with VRE and one with Pseudomonas (note: two patients were colonised with two and three other MDROs, respectively), and 11 of those were inpatients.

Travel history
Seven patients (16%) reported foreign travel (Ghana, India, Iraq, Libya/Tunisia, Norway, Philippines and Vietnam) in the last 12 months and 21 (48%) reported none. The travel history was unknown for the remaining 16 (36%).

Risk factors
Two patients had no identifiable risk factors for CRE colonisation or infection and risk factor data was unknown or not provided for four patients. Of the remaining 37 patients, 26 (70%) had more than one risk factor. Reported risk factors included: hospitalisation in the past 12 months (35; 95%); history of surgery in the past six months (12; 32%); and history of admission to intensive care in the last 12 months (8; 21%). Reported underlying co-morbidities included: diabetes mellitus (6 patients); chronic lung disease (6 patients); immunocompromise (5 patients); renal disease (5 patients); urological abnormality (4 patients); and liver disease (1 patient).

Prior antimicrobial exposure
Antimicrobial exposure history prior to isolation of CRE was provided for 29 patients (67%), 27 of whom were hospitalised and eight of whom received more than one antimicrobial class:

- β-lactam – β-lactamase inhibitor combination agents - 25 (86%)
- Carbapenems - 4 (14%)
- Aminoglycosides - 4 (14%)
- Fluoroquinolones - 3 (10%)
- Cephalosporins - 2 (7%)
- Colistin - 1 (3%)
- Co-trimoxazole - 1 (3%)

Clinical significance and source of infection
The clinical significance of the CRE isolate was reported for all patients, representing colonisation in the majority (n=32). CRE infection was reported for the remaining 11 patients, with three cases of respiratory tract infection, two cases each of bacteraemia, intra-abdominal infection and urinary tract infection, and one case each of skin/soft tissue infection and infection of prosthetic material.

Specimen type
The majority of CRE (n=33; 77%) were isolated from screening swabs (rectal or stoma) or faeces. Three isolates were detected from blood (7%), five from urine (11%), and one each from peritoneal fluid and a peritoneal swab.

Outcome
Outcome was reported for 36 of the 40 hospitalised patients (90%):

- Five died (14%)

  For four of the five deaths, the patient was reported to have had CRE infection. The potential contribution of CRE infection to patient death was not collected. Date of death was provided for all five patients allowing the interval between CRE-positive specimen date and death to be calculated for all patients. These intervals were one, two, eight, 45 and 90 days, respectively
- 27 (75%) were discharged home
- Four (11%) remained inpatients at the time the surveillance form was returned, one of whom had already had CRE infection; however, it is not known if the remaining three CRE colonised patients subsequently went on to develop CRE infection later in the hospital admission

Outcome was also reported for the three non-hospitalised patients, all of whom survived.

Enterobacteriaceae species
Klebsiella pneumoniae accounted for the majority (n=27; 63%) of CRE isolates. In addition, there were eight cases of *Escherichia coli* CRE, 6 cases of *K. oxytoca* CRE and one case each of *Citrobacter freundii* CRE and *Enterobacter cloacae* CRE reported.

Carbapenemase types reported
The carbapenemase enzyme types reported to enhanced surveillance were: 20 KPC (47%), 12 NDM (28%), nine OXA48 (21%), one IMP and one VIM. This contrasts with 82 CRE confirmed by the CPEaRLS in 2014, subdivided as follows: 44 KPC (54%), 17 OXA48 (21%), 17 NDM-1 (21%), 2 IMP and 2 VIM. Therefore, a significant proportion of confirmed CPE cases (48%) in 2014 were not reported to the enhanced surveillance scheme.

Susceptibility of isolates
Susceptibility testing data was provided on all 43 isolates:

- Carbapenems
    - Meropenem: reported on all 43 isolates, with 39 resistant (91%); minimum inhibitory concentrations ranged from 0.064 to >256 mg/L
    - Ertapenem: reported on all 43 isolates, with all isolates resistant; minimum inhibitory concentrations ranged from 2 to >256 mg/L

- Aminoglycosides: reported on 40 isolates, with 29 (73%) resistant to one or more of the aminoglycosides listed below
    - Gentamicin: reported on 38 isolates, with 14 resistant (37%)
    - Tobramycin: reported on 38 isolates, with 13 resistant (34%)
    - Amikacin: reported on 37 isolates, with 19 resistant (51%)

- Fluoroquinolones: reported on 31 isolates, with 23 resistant (74%)

- Tigecycline: reported on 34 isolates, with 10 resistant (29%)

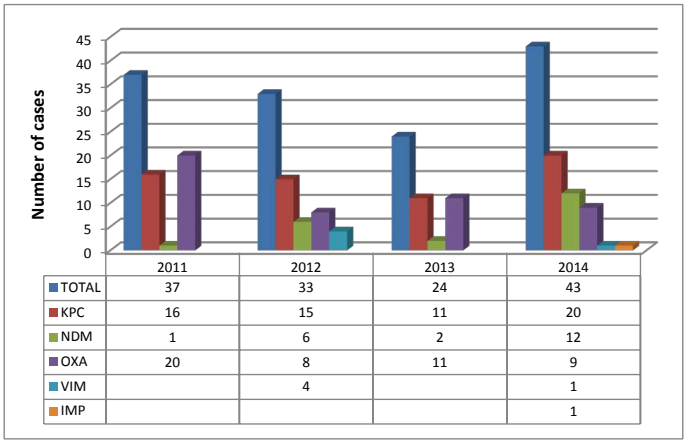
- Colistin: reported on 33 isolates, with three resistant (9%)

Conclusion
In 2014, 43 cases of CRE colonisation/ infection were reported to the enhanced CRE surveillance system representing an increase of 80% from 24 cases in 2013; however, data from the CPEaRLS indicate that there were twice as many confirmed cases.

In response to the emergence of CRE, Irish "Guidelines for the prevention and control of multi-drug resistant organisms, excluding MRSA, in the healthcare setting" were developed under the auspices of the Royal College of Physicians of Ireland (RCPI) Clinical Advisory Group on Healthcare-Associated Infections and Antimicrobial Resistance and were first published in early 2013 (available at http://www.hpsc.ie/A-Z/MicrobiologyAntimicrobialResistance/InfectionControlandHAI/Guidelines/). In response to the changing epidemiology of CRE and other types of multi-drug resistance in *Enterobacteriaceae* in Ireland, the guidelines on screening for carriage of resistant *Enterobacteriaceae* were further updated in July 2014. The latest versions of the guidelines are available at http://www.hpsc.ie/A-Z/MicrobiologyAntimicrobialResistance/StrategyforthecontrolofAntimicrobialResistanceinIrelandSARI/CarbapenemResistantEnterobacteriaceaeCRE/ScreeningforCREinIreland/

Acknowledgements:
Sincere thanks to colleagues working in microbiology laboratories and infection prevention and control teams across Ireland for submitting enhanced surveillance data on patients with CRE.

Sincere thanks also to colleagues in the CPEaRLS, Galway University Hospital for data on confirmed carbapenemase-producing *Enterobacteriaceae* in 2014 (Source: CPEaRLS annual report 2014).



	2011	2012	2013	2014
TOTAL	37	33	24	43
KPC	16	15	11	20
NDM	1	6	2	12
OXA	20	8	11	9
VIM		4		1
IMP				1

Figure 1. Annual trends in CRE cases and types reported to HPSC since enhanced surveillance of CRE commenced in 2011
Please note that the reduction in reported cases between 2012 and 2013 reflects under-reporting rather than a true decline in CRE. Approximately twice as many isolates were confirmed by the CPEaRLS, Galway University Hospital in 2013 (n=48) and 2014 (n=82) than were reported to the voluntary CRE enhanced surveillance scheme