NCPERLS ANNUAL REPORT 2017

National Carbapenemase Producing Enterobacterales (CPE) Reference Laboratory Service

Summary

This is the fifth annual report since the establishment of the CPE reference laboratory in late 2012. The most important point in this report is that in 2017 433 people in Ireland were identified as colonised or infected with CPE. This is likely to be substantially less than the total number of patients who acquired CPE because of limited screening for CPE in many hospitals in 2017. The total number of CPE isolates received is considerably higher at 547 because a number of patients are colonised with more than one kind of CPE.

In 2017 the number of carbapenemase producing Enterobacterales isolates increased by 34.7**%** compared to 2016. KPC, OXA-48 and NDM remain the most common carbapenemase genes detected in Ireland. CPE was associated mainly with the *Klebsiella species* and OXA-48 was the most common CPE enzyme detected in 2017. There was a dramatic increase in the number of OXA-48 producing Enterobacterales. The increasing number of Carbapenemase producing organisms represents a significant threat in particular to the most vulnerable of hospitalised patients although patient to patient spread in other settings also contributes to spread.

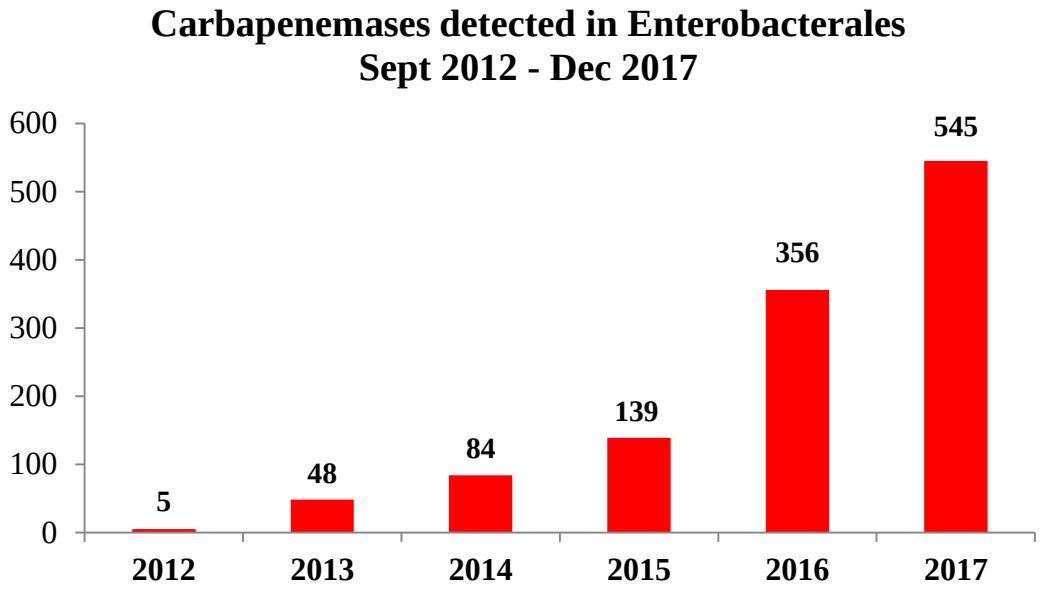


Figure 1: Carbapenemases detected in clinical isolates of Enterobacterales in Ireland Sept 2012 to Dec 2017.

1. Establishment and Funding of the Service

The National Carbapenemase Producing Enterobacterales (CPE) Reference Laboratory Service (NCPERLS) was established in October 2012 by the Health Service Executive. The service is funded by a central allocation to Galway University Hospital to provide a salary for 1 Senior Medical scientist and consumable costs. The service was further supported by funding from MSD to purchase a second AB7500 Real-Time PCR System (2013) and an automated DNA extraction system (2014). In 2017 GUH supported access to an instrument for whole genome sequencing. This technology is transforming the way the work of the CPE reference laboratory is performed. This represents the fourth annual report of the NCPERL service. This report provides some background on the problem of CPE and briefly summarises the output of the service in 2017. Many of the methods used in delivery of the NCPERL service are included on the scope of accreditation of the Department of Medical Microbiology at GUH although whole genome sequencing and bioinformatics analysis is not yet accredited.

2. Carbapenemase Producing Enterobacterales (CPE)

The websites of the HSE-Health Protection Surveillance Centre (HPSC) and the National Healthcare Associated Infection and Antimicrobial Resistance Team summarises CPE in Ireland and contains a useful fact-sheets for patients and members of the public, policy and guidance documents related to CPE are available: www.hpsc.ie and www.hse.ie/hcai

The carbapenem antibiotics include: doripenem, ertapenem, imipenem and meropenem. Meropenem is the carbapenem most widely used for treatment of infection in Ireland at present. The carbapenems now play a very important part in the treatment of infection. They are especially important for treatment of infection with the very broad group of bacteria known as Gram-Negative bacilli. Within that broad group there is a family known as the Enterobacterales which includes well know bacteria such as *E. coli*, *Klebsiella pneumoniae* and *Enterobacter* spp. The Enterobacterales are so called because they are associated with the gastrointestinal

tract of humans and animals. Everyone has vast numbers of Enterobacterales in their colon. Some Enterobacterales cause gastrointestinal infection (e.g. *Salmonella, Shigella*, Shiga-Toxigenic/Vero-toxigenic *E. coli*) but most Enterobacterales (e.g. *E. coli*, *Klebsiella pneumoniae* and *Enterobacter* spp.) are harmless when confined to the gut and do not cause disease in most people most of the time. However *E. coli* is the most common cause of cystitis and other urinary tract infections even in otherwise healthy people and all the Enterobacterales are important causes of blood stream infection, pneumonia and other serious infections in vulnerable groups of patients.

Antibiotics play a vital role in prevention and treatment of infection with Enterobacterales. In recent decades many Enterobacterales have become increasingly resistant to antibiotics. *E. coli* is a useful example on which to base a very general overview of a complex process. Fifty years ago most *E. coli* were very sensitive to ampicillin. Now half or more than half of all *E. coli* causing infection in people in Ireland are resistant to ampicillin. As ampicillin resistance became more common alternative newer agents were needed to treat infection. These included penicillin based combinations (for example amoxicillin-clavulanic acid, piperacillin-tazobactam) and cephalosporins (for example cefotaxime, ceftriaxone). In the last 20 years resistance to these agents have also become increasingly common. An important example of this increasing resistance is the Extended Spectrum Beta-Lactamase producers a.k.a. ESBL's which are generally resistant to cephalosporins such as cefotaxime and ceftriaxone. ESBL's are now very widely disseminated in Ireland, as elsewhere, in hospitals, in nursing homes and in the community and have also been found in food and water.

Recent data from the EARS-net surveillance scheme collated by HPSC indicates that the percentage of those patients with *E. coli* bloodstream infection in which the organism was an ESBL *E. coli* remains steady at 11.1% (2016) to 11.3% (2017) and the percentage that were caused by multidrug resistant (MDR) *E. coli* (displaying resistance to three or more antimicrobial classes) remained the same 14.3% (2016) to 14.2% in 2017. The figure for Carbapenemase Producing *E. coli* was stable at 0.3% (0.2% in 2016). All CPE *E.coli* BSI isolates (n=4) were OXA-48. The percentage of those patients with *Klebsiella pneumoniae* bloodstream infections in which the organism was MDR was up from 14.7% in 2016 to 16.5% in 2017. There were 4 carbapenem resistant MDRKP BSI were reported compared to 5 in 2016.

This 2017 data on blood stream infection suggest some steadying in numbers of cases of infection with some categories of antimicrobial resistant organism however it is not possible to determine with confidence at this point if this is a meaningful trend. It is important to note that in 2006 only 2.5% of *E. coli* BSI were ESBL producers. It is also important to note that blood stream isolates for Enterobacterales are the tip of an iceberg in terms of assessing dissemination of antimicrobial resistant Enterobacterales. For every case of blood stream infection detected there are many cases of individuals that have less serious infections or that are colonised but not infected.

http://www.hpsc.ie/a-z/microbiologyantimicrobialresistance/europeanantimicrobialresistancesurveillancesystemearss/ears-netdataandreports/

As recently as a few years ago the carbapenem antibiotics such as meropenem, represented antibiotics "to depend on" for treatment of life-threatening infection with *E. coli* or indeed a *Klebsiella pneumoniae.* One could expect meropenem to work even when the bacteria were resistant to almost everything else. That situation has changed and carbapenem-resistant Enterobacterales are increasingly common. Carbapenem resistant bacteria (CRE) can be considered in two groups. The group that causes most concern from a public health perspective are the Carbapenemase producers (CPE's) however the "other" CRE also represent a problem for treating patients with infection.
[Note the terms CPE and CRE are frequently used as interchangeable though this is not precise]

The Carbapenemase Producers (CPE's)

Carbapenemase producers (a.k.a. CPE's) produce enzymes that can inactivate the carbapenems antibiotics. These bacteria are also generally resistant to many penicillins and cephalosporins. The genes for these enzymes are usually on mobile genetic elements that can transfer easily from one bacteria to another. It is in the nature of Enterobacterales that they spread easily from person to person by the faecal-oral route directly (hand to hand) and indirectly (in water and food). In addition to resistance to penicillins, cephalosporins and carbapenems, CPE's are very often

resistant to many other families of antibiotics. In some cases there are very few antibiotics available.

The Non-Carbapenemase Producing but Carbapenem Resistant Enterobacterales

In some cases Enterobacterales are resistant to carbapenems although they do not produce one of the known carbapenemase enzymes. In most cases these bacteria are resistant because of a number of smaller changes that added together make them resistant. Usually there is one or a number of changes that prevent the carbapenem from getting into the bacteria very efficiently together with one or more enzymes that are not very efficient against carbapenem but are sufficient to break down the small amount getting into the cell.

Treating Infection with Carbapenem-Resistant Enterobacterales

Whether due to true CPE or a mixture of other changes the range of antibiotics available for treating infections with Enterobacterales that are resistant to carbapenems is limited. The situation is made worse because few new families of antibiotics have become available for clinical use in the last 30 years. All Enterobacterales that are resistant to carbapenems, therefore represent a threat to the most vulnerable patients within the health care system but the threat is generally greatest with CPE because of their propensity for spread.

A recent positive development with respect to treatment of CPE infection is the availability in Ireland of the combination ceftazidime-avibactam. This combination is active against OXA-48 like and KPC variants of CPE though not against metallo-carbapenemases such as NDM. While this combination is a very valuable addition to the options available to treat patients infected with some types of CPE it is worth noting that resistance to this combination has already been reported.
https://ecdc.europa.eu/en/publications-data/rapid-risk-assessment-emergence-resistance-ceftazidime-avibactam-carbapenem

When CPE cause serious infection they are an immediate risk to the life of the patient concerned. Even if the CPE are just resident in the gut it is a long-term risk to that patient, because it may subsequently cause infection. Colonisation with CPE is also a risk to all other patients because the bacteria may spread to other, even more vulnerable patients particularly in the hospital, clinic or nursing home. It is important to stress that once a patient has acquired a CPE in their gut there is no accepted process that is likely to be successful at eradication. One must expect that the person who picks up CPE will remain at risk of CPE infection themselves and be a potential source of spread to others indefinitely.

Carbapenem-Resistance in Other Families of Bacteria

The situation is made more complicated because some members of certain environmental Gram-negative bacteria are naturally resistant to carbapenems. Examples include *Acinetobacter species* and *Stenotrophomonas maltophilia*. Other environmental bacteria are naturally susceptible to carbapenems but very readily become resistant e.g. *Pseudomonas aeruginosa*. In some cases multi-drug resistant bacteria of these species (especially *Acinetobacter species*) may spread rapidly in healthcare environments. It is a concern that a number of *Acinetobacters spp* with transferrable high level carbapenem resistance have been detected in Ireland recently. This organism could represent a significant threat if it is established in a hospital and disseminates widely.

The Emergence of Transferable Colistin Resistance

For some years now one of the key treatment options for patients infected with CRE has been colistin. This is an old antibiotic that was not widely used until very recently because of concerns regarding dosing and toxicity. It has become a critically important therapeutic agent recently because of the progressive loss of other options due to increasing resistance. In 2015 a group of researchers based in China reported widespread dissemination of Enterobacterales that are resistant to colistin by virtue of a transferrable gene *mcr*-1. This report was rapidly followed by reports of detection of this gene in many other countries including other EU member states. The first cases of the *mcr*-1 gene have been detected in three human clinical isolates from two patients in Ireland during 2017 by the NCPERL (2 patients one with OXA-

48 in *Klebsiella oxytoca* and *E.coli* with *mcr*-1 gene detected in both isolates and one patient with OXA-48 and IMP co-produced in *Klebsiella pneumonia*). In one case there was a history of recent hospitalisation outside of Ireland.

Changing Technology

Methods for classification and sub classification (typing) of bacteria are undergoing a very rapid transformation. In particular determining and comparing the entire DNA sequence of bacteria (whole genome sequencing, WGS) for the purpose of tracking routes of spread of infection is increasingly important. Following the acquisition of na instrument for whole genome sequencing in late 2017 the reference laboratory service in 2018 is increasingly based on whole genome sequencing and bio-informatic analysis.

The roles of the National CPE Reference Laboratory Service are

1. To support clinical laboratories by differentiating between CPE's and carbapenem resistance due to other reasons
2. To provide extended antibiotic susceptibility testing on CPE's when requested
3. To help trace pathways of spread of CPE's by assessing the degree of similarity between CPE's from different patients and from different hospitals
4. To provide support in investigation of suspected outbreaks of CPE infection
5. To provide national data to inform public health policy on the scope of the problem and the effectiveness of responses

This annual report contributes to achieve the objective of informing clinicians and policy makers. For information on submission of isolates please see users guide (Appendix 3).

Summary of Data for 2017

3.1 Methodology

For all isolates submitted, species identification was confirmed using MALDI-TOF mass spectrometry. Colistin MIC was determined on all Carbapenemase producing isolates using the TREK Sensititre (semi-automated microbroth dilution). Routine phenotypic detection and characterisation of Carbapenem resistant Enterobacterales

was determined using a commercial kit – ROSCO KPC/MBL and OXA-48 Carbapenemase Confirm Kit. To date all suspect CPE isolates submitted were analysed by molecular methods for all the more common genes associated with CPE (OXA-48, KPC, NDM-1, VIM and IMP) and a number of uncommon genes when required (IMI, GES, OXA-23, OXA-24/40, OXA-51 and OXA-58).

In addition to examination for CPE genes, as appropriate, isolates are examined by molecular methods for certain non-CPE genes that may contribute to make the bacteria resistant to carbapenems. The detection of these genes can help to provide an explanation for non-carbapenemase mediated carbapenem resistance (Table 5).

All submitted isolates are stored frozen at -80°C for a minimum of 3 years to permit re-evaluation and to enable additional studies in the event that new concerns arise, to support new method validation and to allow potential for additional analysis should new methods become available. Reports from the NCPERLS provide the referring laboratory with a detailed report of all analyses performed for their records and with an interpretive comment where appropriate. Preliminary reports are generally provided within 7 days of receipt of isolates. Where the laboratory is alerted to particular urgency in a specific case an effort is made to expedite the preliminary report.

Printed reports are issued by mail to the named responsible person in referring laboratory. The NCPERLs does not notify the isolate as the referring laboratory undertakes notification. When there is evidence of cross transmission of bacteria within a hospital or between hospitals the relevant contact people in the hospital(s) are informed.

3.2 CPE in Ireland in 2017

From January to December 2017 1155 isolates were submitted to the NCPERLS by clinical laboratories throughout Ireland. This represents an increase of 52% on the number submitted in 2016. Managing this increase was possible because of the commitment of the medical scientists involved,the support of other staff in the Department of Medical Microbiology at GUH and the continuing support of the Saolta Group. Where multiple copies of an isolate were received from a given patient only the first isolate is included in the data. To manage the workload it became necessary at the end of the first quarter of 2017 to limit extended susceptibility testing to those isolates where it was specifically requested by the sending laboratory.

A total of 580 (50.2%) isolates were confirmed by molecular methods as carbapenemase producers - Table 1. Of the 580 carbapenemase producers 558 were Enterobacterales isolates, 20 *Acinetobacter species* and 2 non-culturable samples. Of the 580 Enterobacterales isolates, 545 were isolates from patients. A number of patients were colonised with more than one kind of CPE or duplicates of isolates were received by the NCPERL i.e. 545 isolates were from 433 newly identified patients. The number of isolates with a CPE-like phenotype (n=578) exceeds the number of Enterobacterales isolates with confirmed CPE by molecular methods (n=558). In most cases this is most likely accounted for by the known limited specificity of the phenotypic methods. It is important that laboratories use methods of testing that allow them to detect those isolates with reduced susceptibility (increased minimum inhibitory concentration) even though they may not cross the threshold for clinical resistance. http://www.eucast.org/fileadmin/src/media/PDFs/EUCAST_files/Resistance_mechanisms/EUCAST_detection_of_resistance_mechanisms_170711.pdf

Carbapenemase producing Enterobacterales were isolated from blood (*n* = 7), rectal swab/faeces (*n* = 443), urines (*n* = 51), respiratory samples (*n* = 18), other sites (*n* = 33), not stated (12) environmental samples (*n* = 16) - Table 2. Most isolates (56%) were from males and the age range was <1 – 97 years.

In 2017, Carbapenemase genes were associated mainly with *Klebsiella species*, with OXA-48 dominating as the most common enzyme detected followed by KPC, NDM and IMP (Table 3). The dramatic increase in OXA-48 seen in 2016 (n=270) has followed the same pattern in 2017 (n=417). In 2016 KPC (n=48) numbers saw a drop from the initial peak in 2015 (n=65), these numbers have risen back to similar levels in 2017 (n=64) (Figure 2). The increase in OXA-48 Enterobacterales was largely due to an ongoing outbreak in Dublin Midlands but OXA-48 was also detected in Ireland East, RCSI, Saolta, South South West as well as Dublin Midlands - as illustrated in Table 4. KPC remains predominately associated with the University of Limerick Hospital Group.

Co-carriage of CPE has been seen in a number of isolates:

- One environmental sample, *Citrobacter species* with KPC and IMP
- One rectal swab, *Citrobacter species* with NDM and OXA-48
- One rectal swab, *Klebsiella pneumoniae* with OXA-48 and IMP
- One rectal swab, *Klebsiella pneumoniae* with NDM and OXA-48
- One rectal swab, *Escherichia coli* with NDM and IMP

In addition to multiple CPE genes in Enterobacterales a similar phenomenon was observed in on isolate of *Acinteobacter baumannii* complex with NDM and OXA-58.

Patients have had multiple isolates detected with the same type of CPE:

- 74 patients with 2-4 different isolates with OXA-48 detected
- 6 patients with 2-3 different isolates with KPC detected
- 2 patients with 2 different isolates with IMP detected
- 1 patient with 2 different isolates with NDM detected

This reflects the high mobility of the genetic elements that code for many CPE genes.

Patients have had multiple CPE detected in different species:

- 1 OXA-48 *Enterobacter cloacae complex* and VIM in another strain of *Enterobacter cloacae complex*
- 1 NDM *Klebsiella pneumoniae* and OXA-23 *Acinetobacter species*
- 1 Co-producer NDM and OXA-48 *Citrobacter species* and OXA-48 *Citrobacter species*
- 1 OXA-48 *Escherichia coli* and OXA-181/232 variant in *Escherichia coli* and *Enterobacter cloacae complex*
- 1 Co-producer NDM and OXA-48 in *K.pneumoniae* and OXA-48 in *Escherichia coli*

Referral of CPE isolates from the same patient from different healthcare institutions occurred in 9 cases.

Where appropriate, isolates were examined by molecular methods for non-CPE genes, including CTX-M and plasmid-mediated *ampC* genes. Findings are displayed in Table 5. Of the 354 isolates detected additional resistance genes, mainly *bla*CTX-M group 1 (n=236), followed by *bla*CTX-M group 9 (n=59).

During 2017, colistin MIC determined by Microbroth Dilution using the TREK Sensititre was carried out on all carbapenemase producing isolates. Isolates with a colistin MIC of ≥ 2ug /ml were further investigated by molecular methods for the

presence of *mcr*-1 gene. The first *mcr*-1 gene detected in Ireland by the NCPERLS occurred in June 2017 in *Escherichia coli* OXA-48 with the colistin M.I.C. of 4ug /ml. This patient also had a *Klebsiella oxytoca* OXA-48 with the colistin M.I.C. of </=1ug /ml but was tested for the resistance gene and was found to have *mcr*-1 detected. This finding prompted the NCPERL to test every isolate received for *mcr*-1 gene from June 2017 onwards. The second patient with *mcr*-1 gene detected occurred in November 2017 in *Klebsiella pneumoniae* co-producing OXA-48 and IMP with a colistin M.I.C. of 0.25ug /ml. This indicates that phenotypic testing for resistance to colistin has serious limitations for monitoring dissemination of the *mcr* gene. The adoption of whole genome sequencing in 2018 will mean that all isolates referred to the reference laboratory are assessed for *mcr* genes.

Table 1: Number of each species of bacteria submitted with Phenotypic and Molecular findings

Species	No. Submitted	No. with CPE Phenotype (ROSCO)	No. Confirmed CPE
E.coli	297	169	154
Klebsiella spp.	327	191	192
Enterobacter spp.	326	120	123
Citrobacter spp	84	74	75
Other Enterobacterales	44	24	14
Total	**1078**	**578**	**558**

Note: *Acinetobacter spp* (submitted 42 isolates, 20 with carbapenemase detected), *Pseudomonas spp* (submitted 25 isolates, none with carbapenemase detected), Other Gram negative bacteria (Submitted 4 isolates, none with carbapenemase detected) and non-culturable samples (submitted 6, 2 with carbapenemase detected)

Table 2: CPE Isolates and their sample source

CPE Enzyme	Screening sample	Urine	Respiratory	Blood	Other site	Not stated	Environmental
OXA-48	332	37	8	7	27	8	6
KPC	51	4	4	0	2	3	4
NDM	24	4	1	0	0	0	0
IMP	14	3	1	0	1	0	3
VIM	8	1	2	0	2	1	0
IMI	4	0	0	0	0	0	0
OXA-23	7	1	2	0	1	0	1
OXA-24	1	0	0	0	0	0	0
OXA-58	2	1	0	0	2	0	0
Total (n=580)	**443**	**51**	**18**	**7**	**35**	**12**	**14**

Table 3: Type of Carbapenemase by Species

Species	KPC	OXA-48	NDM	VIM	IMP	IMI	OXA-23	OXA-24	OXA-58
E.coli	8	133	12	0	1	0	0	0	0
Klebsiella spp	26	146	11	3	6	0	0	0	0
Enterobacter spp	11	84	1	11	13	3	0	0	0
Citrobacter spp	22	49	2	0	2	0	0	0	0
Other Enterobacterales	1	11	1	0	0	1	0	0	0
Pseudomonas spp	0	0	0	0	0	0	0	0	0
Acinetobacter spp	0	0	2	0	0	0	12	1	5
Unknown	0	2	0	0	0	0	0	0	0
Total (n=580)	**68**	**425**	**29**	**14**	**22**	**4**	**12**	**1**	**5**

Table 4: Total number of newly detected patients with Enterobacterales CPE in Ireland by Hospital Group 2017

Hospital Group	KPC	OXA-48	NDM	VIM	IMP	IMI
Dublin-Midlands	2	141	9	0	1	0
Ireland East	2	53	2	1	0	1
RCSI		33	1	1	0	0
University Limerick	37	1	1	0	0	0
South/South West	3	35	1	0	0	0
Saolta	1	37	4	10	1	0
The Children's	0	0	2	0	1	0
Other*	7	24	5	1	12	1
Total (n=433)	52	324	25	13	15	4

Other*: Non-HSE Hospitals, Nursing Homes/LTCF or GP samples.

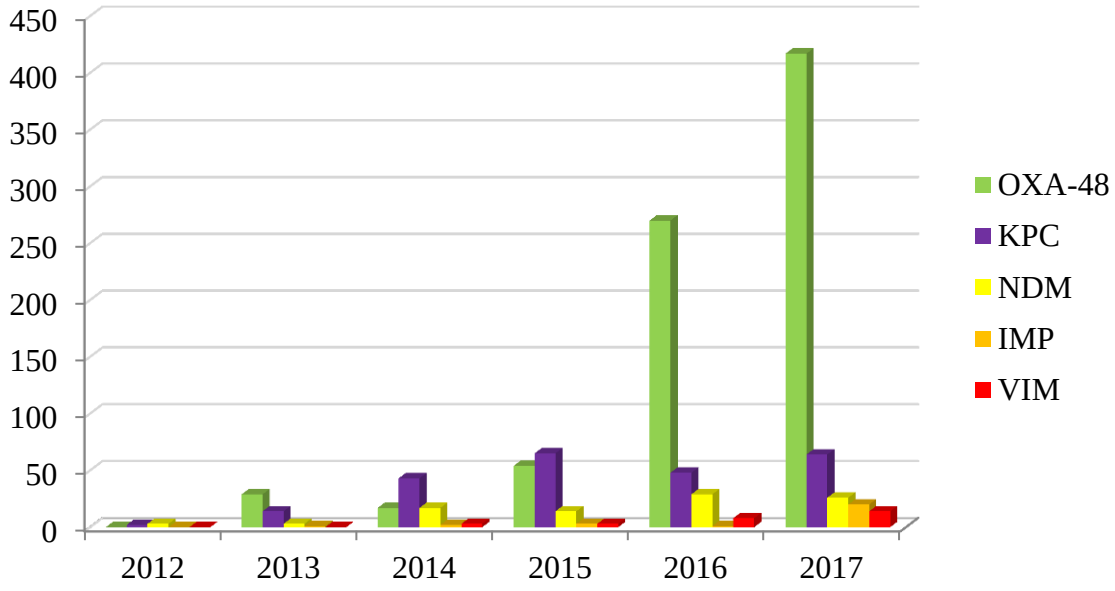
Note: This data is based on bacterial cultures submitted to the National CPE reference laboratory service based at Galway University Hospital. Patients are counted once only in the hospital/hospital group from which their first CPE isolate was submitted to the reference laboratory. It should not be assumed that the location of the patient at the time of first detection represents the hospital/hospital group in which colonisation/infection was acquired. All Non-Enterobacterales and environmental isolates are excluded from this data. Hospital groups differ substantially in the terms of bed numbers and scope of services provided. Furthermore differences in number of isolates are likely to be related in a substantial measure to difference in screening practices. Comparisons between hospital groups based on these data are not valid.

Table 5: Additional Resistance Genes Findings

Species	CTX-M Grp 1	CTX-M Grp 2	CTX-M Grp 9	Pm-ampC	CTX-M + Pm-ampC
E.coli **(*n* = 119)**	75	0	19	17	8
***Klebsiella* spp (*n* = 120)**	81	1	6	30	2
***Enterobacter spp* (*n* = 108)**	78*	0	31*	NT	NT
Other (n=8)	3	1	4	NT	NT
Total (n=354)	**236**	**2**	**59**	**47**	**10**

Note: One *Enterobacter species* had both CTX-M group 1 and CTX-M group 9 genes detected (occurs in both columns but counted once overall i.e. n=108)

Figure 2: Common Carbapenemases detected in Enterobacterales 2013 – 2017



Progress in 2018

For 2018 the reference laboratory service aims to continue to provide a quality service to its users and to develop capacity in relation to Whole Genome Sequencing.

Acknowledgements

We would like to acknowledge the support of the HSE, in particular Dr Philip Crowley, National Director, Quality & Patient Safety Division for their support in establishing this service. We thank Galway University Hospitals and the Saolta Group for ongoing support for the service. Thank you to the clinical laboratories who submit isolates. We would also like to acknowledge the National Reference Laboratory service of Public Health England, in particular Professor Neil Woodford, Public Health England, Antimicrobial Resistance and Healthcare Associated Infections Reference Unit (AMRHAI) for advice and support in setting up the service and for their continuing support with rare or atypical isolates. We acknowledge colleagues in the Staten Serum Institute Copenhagen, Denmark for providing material for use as positive control in establishing the *mcr*-1 assay.

Martin Cormican Director of the NCPERLs

For more information please contact martin.cormican@hse.ie

Appendix 1

Total number of newly detected patients with Enterobacterales CPE per Hospital in Ireland 2017

	KPC	OXA-48	NDM	VIM	IMP	IMI
University Limerick Hospital Group						
University Hospital Limerick	35	1	1			
Ennis Hospital	1					
St. John's Hospital	1					
The Children's Hospital Group						
Our Lady's Children's Hospital, Crumlin			1		1	
Temple Street Children's University Hospital			1			
South/South West Hospital Group						
Cork University Hospital	2	2				
University Hospital Waterford	1	24				
University Hospital Kerry			1			
South Tipperary General Hospital		8				
Mercy University Hospital Cork		1				
Saolta Hospital Group						
University Hospital Galway/ Merlin Park	1	32	4	6	1	2
Letterkenny University Hospital		1				
Mayo General Hospital				2		
Silgo Regional Hospital		4		1		
Roscommon County Hospital				1		
Royal College of Surgeons Ireland Hospital Group						
Beaumont Hospital Dublin		29				
Connolly Hospital Dublin		1		1		
Our Lady of Lourdes Hospital Drogheda		1	1			
Rotunda Hospital Dublin		2				
Ireland East Hospital Group						
The Mater Misericordiae University Hospital Dublin	2	13	1			
St Vincent's University Hospital Dublin		12	1	1		1
Wexford General Hospital		7				
St Luke's General Hospital, Kilkenny		16				
Our Lady's Hospital, Navan		3				
National Maternity Hospital, Holles St, Dublin		1				
Midlands Regional Hospital, Mullingar		1				
Dublin Midlands Hospital Group						
St James' Hospital Dublin		27	2			
Tallaght Hospital, Dublin	2	96	7		1	
Naas General Hospital		16				
St Luke's Radiation Oncology Network		2				
Other Healthcare facilities (Non-HSE Hospitals, Nursing Homes/LTCF or GP samples)	7	24	5	1	12	1
Total (n=433)	**52**	**324**	**25**	**13**	**15**	**4**

Appendix 2

Staff of the NCPERLS

Although the NCPERLS was established with a single appointment a number of other staff in the Department of Medical Microbiology contribute to the work also to ensure continuity of service.

Elaine McGrath (Senior Scientist for NCPERLS)

Alma Tuohy

Sana Tansey

Joanne King

Niall Delappe

Mark Maguire

Maeve Hetherington

Wendy Brennan (Acting Senior Scientist for NCPERLS)

Tom Whyte (Chief Medical Scientist)

Frances Higgins/Anne Coleman (Quality Manager)

Belinda Hanahoe (Surveillance Scientist)

Teck Wee Boo

Deirbhile Keady

Eithne McCarthy

Laura Ryan

Una Ni Riain

Dimitar Nashev

Dearbhaile Morris (NUIGalway)

Appendix 3

Users Guide

A copy of the recent Reference Laboratory User Guide and Request form are available through the following link:

http://www.saolta.ie/publications

Appendix 4 Associated Presentations and Publications

TW Boo, N O'Connell, J King, McGrath E, R Hill. First report of IMI carbapenemase-producing colistin-resistant *Enterobacter* clinical isolate in Ireland. Euro Surveill. 2013; 18 (31)

Prof. Hajo Grundmann *et al*. Occurrence of carbapenemase-producing *Klebsiella pneumoniae* and *Escherichia coli* in the European survey of carbapenemase-producing Enterobacterales (EuSCAPE): a prospective, multinational study. The Lancet: Infectious Diseases. 2017; 17 (2): 153 – 163

O'Connor, Ciara; Cormican, Martin; Wee Boo, Teck; McGrath, Elaine; Slevin, Barbara; O'Gorman, Alan; Commane, Marion; Mahony, Stephane; O'Donovan, Eimear; Powell, James; Monahan, Regina; Finnegan, Cathriona; Kiernan, Miranda G; Coffey, Calvin J; Power, Lorraine; O'Connell, Nuala H; Dunne, Colum. An Irish outbreak of New Delhi metallo-β-lactamase (NDM)-1 carbapenemase-producing Enterobacterales: increasing but unrecognised prevalence. 2016; 94 (4): 351 - 357