



NCTC

National Collection
of Type Cultures

NCTC[®]

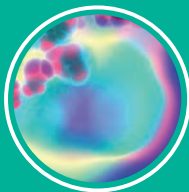
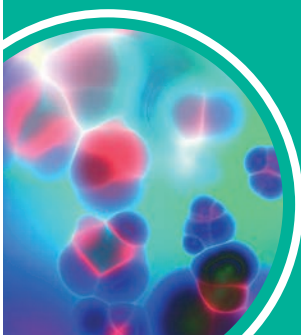
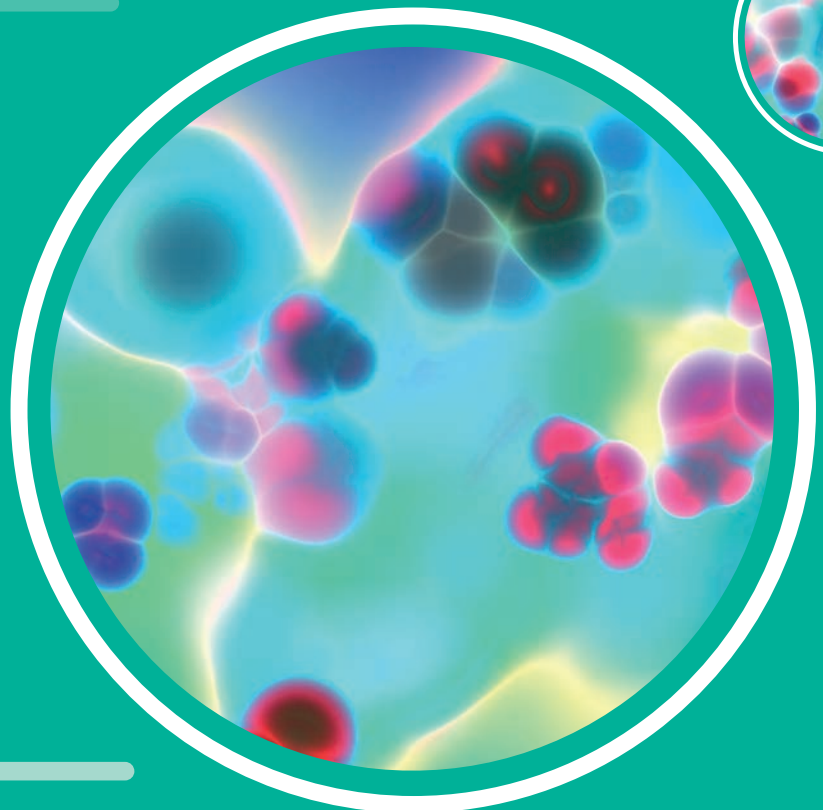
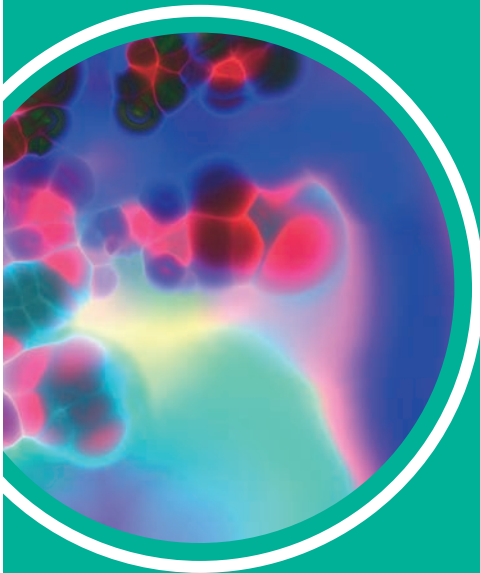
The National Collection of Type Cultures

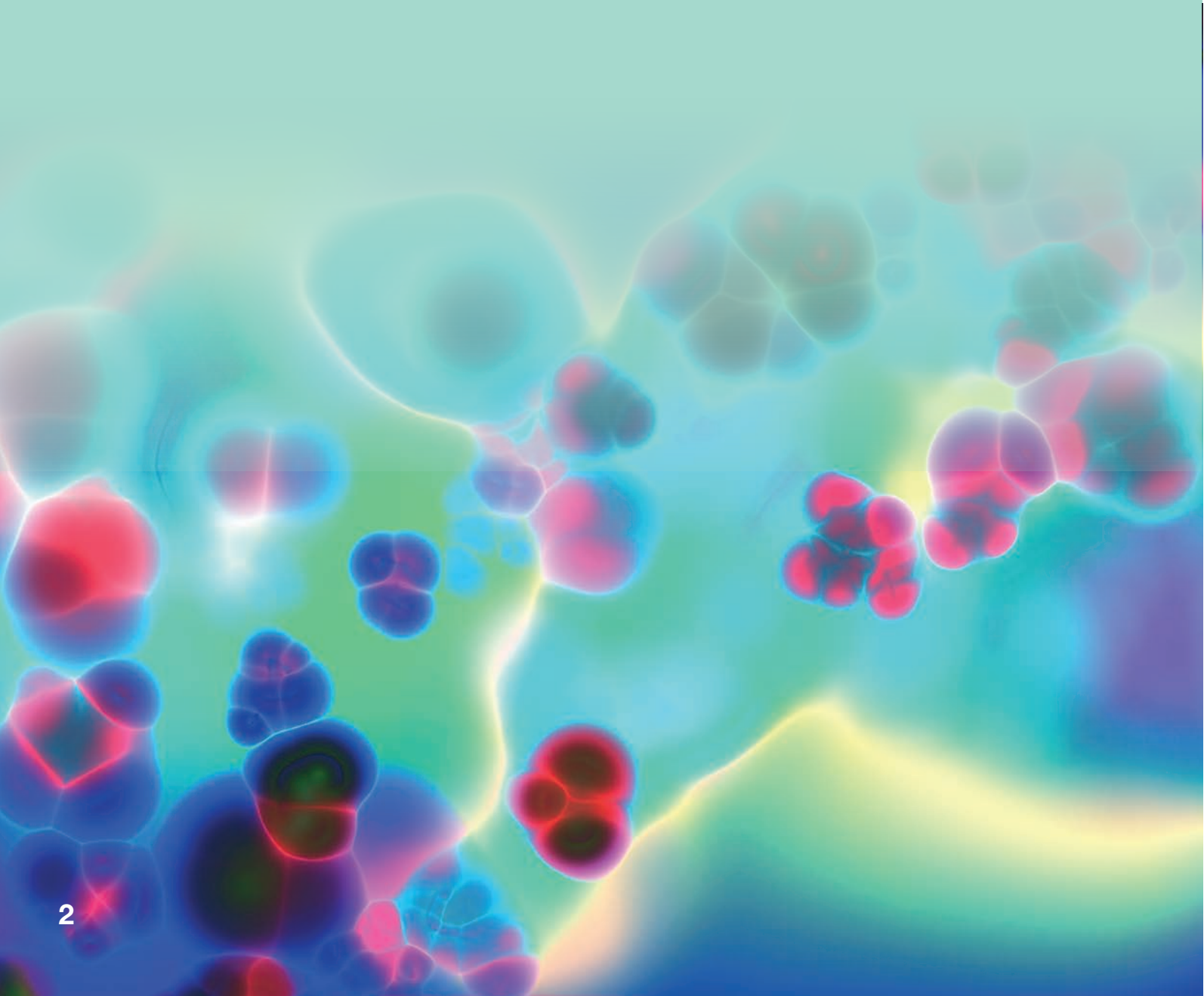
Antimicrobial

Resistant Strains:

Resistance Reference Strains

Susceptibility Testing Control Strains





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Antimicrobial Susceptibility Testing Control Strains

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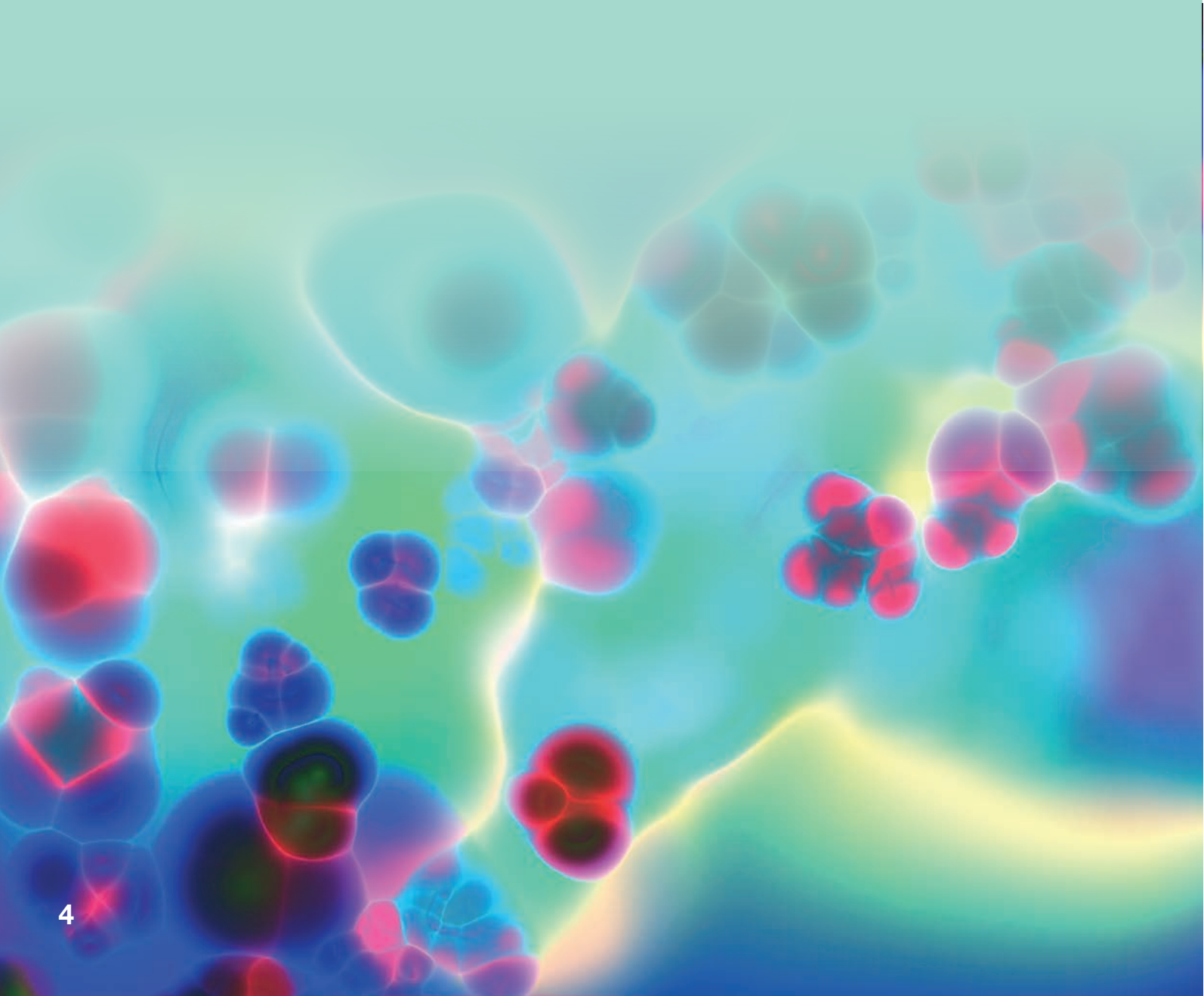
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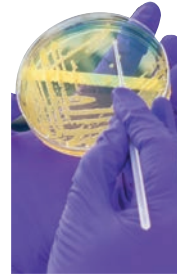
The significant increase in the incidence of antibiotic resistance in bacteria observed in recent years represents a major challenge to public health microbiology worldwide. Not least among these challenges are extended-spectrum β -lactamases (ESBLs) and carbapenemases among Enterobacterales and other Gram-negative microorganisms and vancomycin resistance among enterococci.

The UK Health Security Agency's Antimicrobial Resistance and Healthcare Associated Infections (AMRHA) Reference Unit is the national reference laboratory responsible for the detection and investigation of antibiotic resistance, especially in healthcare-associated and sexually-transmitted bacterial pathogens, and offers molecular detection of the genetic determinants of certain key resistances.



Section 1

Antimicrobial Resistance Reference Strains



The UK Health Security Agency's National Collection of Type Cultures (NCTC), working in partnership with The UK Health Security Agency's Antimicrobial Resistance and Healthcare Associated Infections (AMRHAI) Reference Unit, offers a range of reference strains with characterised resistance mechanisms. These include:

- a range of extended-spectrum β -lactamases (ESBLs), including examples of all major CTX-M groups
- a range of carbapenemases, including examples of all of the five major groups which dominate internationally, namely KPC and OXA-48 non-metallo-enzymes and IMP, NDM and VIM metallo-carbapenemases and control strains for use in conjunction with UKHSA guidance
- historic and contemporary vancomycin-resistant enterococci isolates, including strains with both acquired and intrinsic resistance determinants
- *Staphylococcus aureus* strains with a variety of resistance determinants and phenotypes including penicillin resistance and *mecA* and *mecC* mediated methicillin resistance
- a 15 strain WHO recommended panel of *Neisseria gonorrhoeae*, including a strain with combined ceftriaxone and high-level azithromycin resistance
- *Escherichia coli* and *Salmonella enterica* strains that carry the *mcr-1* gene conferring colistin resistance

With the exception of laboratory-derived strains containing fully sequenced plasmids, most of these strains are partially-characterised and, as such, are likely to have other resistance mechanisms in addition to those specified.

Strains are manufactured in accordance with the requirements of ISO 9001:2015 and undergo extensive ISO 17025:2017 accredited quality control by NCTC and testing by AMRHAI to re-authenticate the characteristics of the strain as new batches are prepared.

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www.culturecollections.org.uk/products/bacteria/search.jsp

1. Penicillinase without Extended-Spectrum β -Lactamase (ESBL) activity

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|------------------------------|----------------------------|--|-------------------------|
| <i>Escherichia coli</i> | NCTC 11560 | TEM-1 β -lactamase producer ¹ | |
| | NCTC 11954 | β -lactamase producing strain ² | ATCC 35218 |
| <i>Staphylococcus aureus</i> | NCTC 11561 | β -lactamase producing strain | |

2. Extended-Spectrum β -Lactamases (ESBLs)

2.1 TEM β -lactamases

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|-------------------------|----------------------------|--|-------------------------|
| <i>Escherichia coli</i> | NCTC 13351 | TEM-3 ESBL – Transconjugant (control strain isolated in Clermont-Ferrand in 1985) ¹⁷ | |
| | NCTC 13352 | TEM-10 ESBL – Transconjugant (control strain TEM-10 producer isolated in Chicago in 1988) ² | |

2.2 SHV β -lactamases

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|------------------------------|----------------------------|-----------------------|--|
| <i>Klebsiella pneumoniae</i> | NCTC 13368 | SHV-18 control strain | ATCC 700603; CCUG 45421; LMG 20218 |

2.3 CTX-M β -lactamases

| Organism | NCTC [®] Strain Reference | Characteristics | Other Collection Number |
|-------------------------|------------------------------------|---|-------------------------|
| <i>Escherichia coli</i> | NCTC 13353 | Strain EO 487. CTX-M-15 ESBL producer. Control strain for group 1 <i>bla</i> _{CTX-M} multiplex PCR assays ³ | |
| | NCTC 13400 | Strain Tr499 = DH5- β derivative. Source of pEK499 (fully sequenced plasmid GenBank Accession No EU935739) encoding CTX-M-15 enzyme. Fusion of type FII and FIA replicons, and harbours ten antibiotic resistance genes ⁴ | |
| | NCTC 13441 | Strain EO 499. CTX-M-15 ESBL producer – Uropathogenic strain O25:H4 sequence type (ST) 131. Clinical isolate harbouring sequenced plasmid pEK499 (see NCTC 13400); Strain for group 1 <i>bla</i> _{CTX-M} multiplex PCR assays ³ | |
| | NCTC 13450 | Strain Tr516 = DH5- β derivative. Source of pEK516 (fully sequenced plasmid GenBank Accession No EU935738), which encodes CTX-M-15 enzyme. Harbours seven antibiotic resistance genes ⁴ | |
| | NCTC 13451 | Strain J499 = J53 derivative. Source of pEK499 (fully sequenced plasmid GenBank Accession No EU935739) encoding CTX-M-15 enzyme. Fusion of type FII and FIA replicons, and harbours ten antibiotic resistance genes ⁴ | |
| | NCTC 13452 | Strain J204 = J53 derivative. Source of pEK204 (fully sequenced plasmid GenBank Accession No EU935740), encoding CTX-M-3 enzyme. Plasmid pEK204 (93,732-bp) belongs to incompatibility group IncI1, and harbours two antibiotic resistance genes ⁴ | |
| | | | |

2.3 CTX-M β-lactamases continued

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|------------------------------|----------------------------|---|-------------------------|
| <i>Enterobacter cloacae</i> | NCTC 13464 | Strain carries <i>bla</i> _{CTX-M} group 9 gene ⁵ | |
| <i>Escherichia coli</i> | NCTC 13461 | Strain carries <i>bla</i> _{CTX-M} group 1 gene ⁵ | |
| | NCTC 13462 | Strain carries <i>bla</i> _{CTX-M} group 2 gene ⁵ | |
| | NCTC 13463 | Strain carries <i>bla</i> _{CTX-M} group 8 gene ⁵ | |
| | NCTC 14477 | Strain carries bla-ctx-M-1 gene | CCUG 62975 |
| <i>Klebsiella pneumoniae</i> | NCTC 13465 | Strain carries <i>bla</i> _{CTX-M} group 25 gene ⁵ | |

2.4 VEB & PER β-lactamases

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|-------------------------------|----------------------------|---|-------------------------|
| <i>Pseudomonas aeruginosa</i> | NCTC 13437 | VIM-10 metallo-carbapenemase; VEB-1 ESBL ⁶ | |
| | NCTC 14383 | PER β-lactamase | |

3. AmpC β-lactamases

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|-----------------------------|----------------------------|---|-------------------------|
| <i>Enterobacter cloacae</i> | NCTC 13405 | Strain 684. Inducible AmpC β-lactamase, wild type. Strain for AmpC detection tests | |
| | NCTC 13406 | Strain 684-con. AmpC β-lactamase de-repressed (i.e. constitutive hyper-producing) mutant of NCTC 13405. Strain for AmpC detection tests | |
| <i>Escherichia coli</i> | NCTC 14476 | Plasmid-mediated AmpC betalactamase, subgroup CIT (ESBL-M), also resistant to quinolones, trimethoprim | CCUG 58543 |

4. Carbapenemases

4.1 Class A Carbapenemases

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|-------------------------------------|----------------------------|--|-------------------------|
| <i>Enterobacter asburiae</i> | NCTC 14055 | FRI-2 non-metallo-carbapenemase ⁸ | |
| <i>Enterobacter cloacae</i> | NCTC 14322 | KPC-4 non-metallo-carbapenemase ⁹ | |
| <i>Enterobacter cloacae</i> complex | NCTC 13922 | NMC-A non-metallo-carbapenemase | |
| | NCTC 13925 | IMI-2 non-metallo-carbapenemase | |
| | NCTC 14336 | KPC-2 non-metallo-carbapenemase ⁹ | |
| <i>Escherichia coli</i> | NCTC 13919 | GES-5 non-metallo-carbapenemase | |
| | NCTC 14320 | KPC non-metallo-carbapenemase IMP metallo-carbapenemase OXA-48-like non-metallo-carbapenemase ⁹ | |
| | NCTC 14321 | KPC non-metallo-carbapenemase OXA-48-like non-metallo-carbapenemase ⁹ | |
| <i>Klebsiella pneumoniae</i> | NCTC 13438 | KPC-3 non-metallo-carbapenemase Member of the international ST258 clone ⁷ | |
| | NCTC 14327 | KPC-3 non-metallo-carbapenemase ⁹ | |
| | NCTC 14384 | KPC-33 non-metallo-carbapenemase Produces KPC-33 variant with D179Y substitution that confers resistance to ceftazidime/avibactam | |
| <i>Serratia marcescens</i> | NCTC 13920 | SME-4 non-metallo-carbapenemase | |

4.2 Class B Carbapenemases (Metallo-β-lactamases)

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|----------------------------------|----------------------------|--|-------------------------|
| <i>Citrobacter freundii</i> | NCTC 14089 | GIM-1 metallo-carbapenemase | |
| <i>Enterobacter cloacae</i> | NCTC 14326 | VIM-1 metallo-carbapenemase ⁹ | |
| | NCTC 14328 | VIM-4 metallo-carbapenemase ⁹ | |
| <i>Escherichia coli</i> | NCTC 13476 | IMP-type metallo-carbapenemase | CCUG 68729 |
| | NCTC 14320 | IMP metallo-carbapenemase KPC non-metallo-carbapenemase OXA-48-like non-metallo-carbapenemase ⁹ | |
| | NCTC 14325 | NDM-7 metallo-carbapenemase ⁹ | |
| | NCTC 14333 | NDM-4 metallo-carbapenemase ⁹ | |
| | NCTC 14339 | NDM-5 metallo-carbapenemase ⁹ | |
| <i>Klebsiella pneumoniae</i> | NCTC 13439 | VIM-1 metallo-carbapenemase; QnrS1 (outbreak strain) ¹⁰ | |
| | NCTC 13440 | VIM-1 metallo-carbapenemase; QnrS1 (sporadic) ¹⁰ | |
| | NCTC 13443 | NDM-1 metallo-carbapenemase | CCUG 68728 |
| | NCTC 14323 | NDM-1 metallo-carbapenemase OXA-48 non-metallo-carbapenemase ⁹ | |
| | NCTC 14331 | NDM-1 metallo-carbapenemase ⁹ | |
| | NCTC 14332 | NDM-1 metallo-carbapenemase OXA-232 non-metallo-carbapenemase ⁹ | |
| | NCTC 14334 | IMP-4 metallo-carbapenemase ⁹ | |
| | NCTC 14337 | IMP-1 metallo-carbapenemase ⁹ | |
| <i>Pseudomonas aeruginosa</i> | NCTC 13437 | VIM-10 metallo-carbapenemase; VEB-1 ESBL ⁷ | |
| | NCTC 13921 | SPM-1 metallo-carbapenemase ¹¹ | |
| | NCTC 14361 | SIM metallo-carbapenemase | |
| <i>Pseudomonas guariconensis</i> | NCTC 14056 | DIM-1 metallo-carbapenemase | |
| <i>Salmonella Seftenberg</i> | NCTC 13953 | NDM-1 metallo-carbapenemase ¹² | |

4.3 Class D Carbapenemases (OXA carbapenemases)

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|--------------------------------|----------------------------|--|-------------------------|
| <i>Acinetobacter baumannii</i> | NCTC 13301 | OXA-23 (and OXA-51-like) non-metallo-carbapenemases ¹³ | |
| | NCTC 13302 | OXA-25 (OXA-24/40-like) (and OXA-51-like) non-metallo-carbapenemases ¹³ | |
| | NCTC 13303 | OXA-26 (and OXA-51-like) non-metallo-carbapenemases ¹³ | |
| | NCTC 13304 | OXA-27 (and OXA-51-like) non-metallo-carbapenemases ¹³ | |
| | NCTC 13305 | OXA-58 (and OXA-51-like) non-metallo-carbapenemases ¹⁴ | |
| | NCTC 13420 | OXA-51-like non-metallo-carbapenemase (SE clone genotype) ¹⁵ | |
| | NCTC 13421 | OXA-23 and OXA-51-like non-metallo-carbapenemases (Clone 2 genotype) ¹⁵ | |
| | NCTC 13422 | OXA-51-like non-metallo-carbapenemase (NW clone genotype) | |
| | NCTC 13423 | OXA-51-like non-metallo-carbapenemase (T strain, UK3) ¹⁶ | |
| | NCTC 13424 | OXA-23 and OXA-51-like non-metallo-carbapenemases (Clone 1 genotype) ¹⁵ | |
| <i>Escherichia coli</i> | NCTC 14320 | OXA-48-like non-metallo-carbapenemase IMP metallo-carbapenemase KPC non-metallo-carbapenemase ⁹ | |
| | NCTC 14321 | OXA-48-like non-metallo-carbapenemase KPC non-metallo-carbapenemase ⁹ | |
| | NCTC 14324 | OXA-484 non-metallo-carbapenemase ⁹ | |
| | NCTC 14329 | OXA-244 non-metallo-carbapenemase ⁹ | |
| | NCTC 14338 | OXA-48 non-metallo-carbapenemase ⁹ | |
| <i>Klebsiella pneumoniae</i> | NCTC 13442 | OXA-48 non-metallo-carbapenemase (Sequence type 353) ¹⁷ | CCUG 68727 |
| | NCTC 14323 | OXA-48 non-metallo-carbapenemase NDM-1 metallo-carbapenemase ⁹ | |
| | NCTC 14330 | OXA-181 non-metallo-carbapenemase ⁹ | |
| | NCTC 14332 | OXA-232 non-metallo-carbapenemase ⁹ NDM-1 metallo-carbapenemase ⁹ | |
| | NCTC 14335 | OXA-232 non-metallo-carbapenemase ⁹ | |
| <i>Salmonella Typhimurium</i> | NCTC 13954 | OXA-48 non-metallo-carbapenemase pOXA-48a-like plasmid positive ¹² | |

5. Plasmid-mediated Fluoroquinolone Resistance

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|------------------------------|----------------------------|--|-------------------------|
| <i>Escherichia coli</i> | NCTC 13400 | aac(6')-Ib-cr aminoglycoside acetyltransferase ⁴ | |
| | NCTC 13441 | aac(6')-Ib-cr aminoglycoside acetyltransferase ^{3, 4} | |
| | NCTC 13450 | aac(6')-Ib-cr aminoglycoside acetyltransferase ⁴ | |
| | NCTC 13451 | aac(6')-Ib-cr aminoglycoside acetyltransferase ⁴ | |
| <i>Klebsiella pneumoniae</i> | NCTC 13439 | VIM-1 metallo-carbapenemase; QnrS1 (outbreak strain) ¹⁰ | |
| | NCTC 13440 | VIM-1 metallo-carbapenemase; QnrS1 (sporadic) ¹⁰ | |

6. Vancomycin Resistant Enterococci

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|-----------------------------------|----------------------------|---|---|
| <i>Enterococcus casseliflavus</i> | NCTC 12361 | VanC-type glycopeptide resistance (low-level, intrinsic to species) | ATCC 25788, CCM 2478, CCUG 18657, CIP 103018, DSM 20680 |
| <i>Enterococcus faecalis</i> | NCTC 12201 | First VRE reported in the UK, VanA-type glycopeptide resistance ¹⁸ | |
| | NCTC 12203 | First VRE reported in the UK, VanA-type glycopeptide resistance ¹⁸ | |
| | NCTC 13379 | VanB-type glycopeptide resistance | ATCC 51299; CIP104676; WDCM 00085; WDCM 00152 |
| | NCTC 13779 | VanA-type glycopeptide resistance. Contemporary hospital-adapted VRE lineage. Clinical isolate from bacteraemia, 2007 ¹⁹ | |
| | NCTC 13780 | VanA-type glycopeptide resistance. Contemporary hospital-adapted VRE lineage. Clinical isolate from bacteraemia, 2006 ¹⁹ | |
| <i>Enterococcus faecium</i> | NCTC 12202 | First VRE reported in the UK, VanA-type glycopeptide resistance ¹⁸ | |
| | NCTC 12204 | First VRE reported in the UK, VanA-type glycopeptide resistance ¹⁸ | |

7. Multidrug Resistance Plasmids

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|-------------------------|----------------------------|---|-------------------------|
| <i>Escherichia coli</i> | NCTC 13400 | Strain Tr499 = DH5-β derivative. Source of pEK499 (fully sequenced plasmid GenBank Accession No EU935739). Fusion of type FII and FIA replicons, and harbours ten antibiotic resistance genes ⁴ | |
| | NCTC 13451 | Strain J499 = J53 derivative. Source of pEK499 (fully sequenced plasmid GenBank Accession No EU935739). Fusion of type FII and FIA replicons, and harbours ten antibiotic resistance genes ⁴ | |
| | NCTC 13450 | Strain Tr516 = DH5-β derivative. Source of pEK516 (fully sequenced plasmid GenBank Accession No EU935738). Harbours seven antibiotic resistance genes ⁴ | |
| | NCTC 13452 | Strain J204 = J53 derivative. Source of pEK204 (fully sequenced plasmid GenBank Accession No EU935740), encoding CTX-M-3 enzyme. Plasmid pEK204 (93,732-bp) belongs to incompatibility group IncI1, and harbours two antibiotic resistance genes ⁴ | |

8. Methicillin-Resistant *Staphylococcus aureus*

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|------------------------------|----------------------------|---|-------------------------|
| <i>Staphylococcus aureus</i> | NCTC 13142 | EMRSA-15 strain. Epidemic MRSA from UK, <i>mecA</i> positive ²⁰ | |
| | NCTC 13435 | PVL-positive community acquired MRSA strain belonging to clonal complex 80, commonly known as the so-called European clone of community acquired MRSA ²³ | |
| | NCTC 13552 | Strain LGA251. Positive for the <i>mecA</i> homologue, <i>mecC</i> ²¹ | |
| | NCTC 13656 | PVL-negative community acquired MRSA strain belonging to clonal complex 59, a clone that originated in East Asia. Positive for the <i>mupA</i> gene conferring high-level resistance to mupirocin ²² | |
| | NCTC 14245 | PVL-positive community acquired MRSA. A USA300 strain, a lineage of community acquired MRSA dominant in the USA | |

8. Methicillin-Resistant *Staphylococcus aureus* continued

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|------------------------------|----------------------------|--|-------------------------|
| <i>Staphylococcus aureus</i> | NCTC 14457 | <i>mecC</i> positive MRSA strains from human clinical background ²⁴ | |
| | NCTC 14458 | | |
| | NCTC 14459 | | |
| | NCTC 14460 | | |
| | NCTC 14461 | | |
| | NCTC 14462 | | |
| | NCTC 14464 | | |
| | NCTC 14465 | | |
| | NCTC 14579 | | |

9. Colistin resistance

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|---|----------------------------|---|-------------------------|
| <i>Acinetobacter colistiniresistens</i> | NCTC 14468 | Intrinsically phenotypically colistin resistant | CNCTC 7573 |
| <i>Escherichia coli</i> | NCTC 13846 | Colistin resistant, <i>mcr-1</i> positive ²⁵ | DSM 105182 |
| <i>Salmonella</i> Typhimurium | NCTC 13952 | Colistin resistant, <i>mcr-1</i> positive | |

10. Linezolid resistance

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|-----------------------------------|----------------------------|---|-------------------------|
| <i>Enterococcus faecalis</i> | NCTC 14360 | Positive control for the detection of <i>poxtA</i> , which confers resistance to linezolid | |
| <i>Enterococcus faecium</i> | NCTC 13923 | Positive control for the detection of <i>optrA</i> conferring resistance to linezolid | |
| | NCTC 14638 | Positive control strain for the detection of linezolid resistance associated with homozygous G2576T mutations in all copies of 23S rRNA genes | |
| <i>Staphylococcus epidermidis</i> | NCTC 13924 | Positive control for the detection of <i>cfp</i> or G2576T mutation both of which confer resistance to linezolid ²⁶ | |

11. Additional strains

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|-----------------------------------|----------------------------|--|-------------------------|
| <i>Clostridiodes difficile</i> | NCTC 14385 | Plasmid-mediated metronidazole resistance. To be used for research and non-commercial uses only | |
| <i>Staphylococcus aureus</i> | NCTC 14617 | Resistant to penicillin. Susceptible to teicoplanin, vancomycin, linezolid, daptomycin | |
| <i>Staphylococcus epidermidis</i> | NCTC 14218 | Methicillin-resistant <i>Staphylococcus epidermidis</i> (MRSE) strains with rifampicin resistant phenotype. Each strain is one of three globally distributed lineages. See reference for details ²⁷ | |
| | NCTC 14219 | | |
| | NCTC 14220 | | |
| <i>Streptococcus pneumoniae</i> | NCTC 14143 | Resistant to clindamycin, erythromycin and tetracycline. Susceptible to increased exposure to penicillin and ampicillin | |

Section 2

Antimicrobial Susceptibility Testing Control Strains



NCTC offers a wide range of strains that can be used as controls in antimicrobial susceptibility testing to:

- monitor test performance and quality of the materials used
- confirm that the in-use method will detect resistance

NCTC strains are verified by The UK Health Security Agency's Antimicrobial Resistance and Healthcare Associated Infections (AMRHA) Reference Unit, Gastrointestinal Bacteria Reference Unit (GBRU) and Anaerobic Reference Unit (ARU), and are used in diagnostic testing laboratories worldwide.

The strains (including equivalents) listed are specifically recommended by one or more of the following:

- the European Committee on Antimicrobial Susceptibility Testing (EUCAST)
- Clinical and Laboratory Standards Institute (CLSI)
- United Kingdom Standards for Microbiology Investigations (formerly National Standard Methods)

For more information or to order online visit: www.culturecollections.org.uk

1. The European Committee on Antimicrobial Susceptibility Testing (EUCAST)

1.1 Routine and extended internal quality control for MIC determination and/or disk diffusion as recommended by EUCAST. Version 10.0, 2020

| Organism | NCTC® Strain Reference | Routine or extended internal QC | Characteristics | Other Collection Number |
|---------------------------------|----------------------------|---------------------------------|---|--|
| <i>Campylobacter jejuni</i> | NCTC 11351 | Routine | | ATCC 33560; CCUG 11284; CIP 702; DSM 4688 |
| <i>Enterococcus faecalis</i> | NCTC 12697 | Routine | | ATCC 29212; WDCM 00087 |
| | NCTC 13379 | Extended | High-level gentamicin resistant (HLGR), <i>vanB</i> -positive | ATCC 51299; CIP 10467; WDCM 00085; WDCM 00152 |
| <i>Escherichia coli</i> | NCTC 11954 | Routine | TEM-1 β -lactamase (Non- ESBL) producer | ATCC 35218 |
| | NCTC 12241 | Routine | | ATCC 25922; DSM 1103; NCIMB 12210; WDCM 00013 |
| | NCTC 13846 | Routine | <i>mcr-1</i> positive | DSM 105182 |
| <i>Haemophilus influenzae</i> | NCTC 12699 | Extended | | ATCC 49247 |
| | NCTC 12975 | Routine | | ATCC 49766; CIP 103570 |
| <i>Klebsiella pneumoniae</i> | NCTC 13368 | Routine and Extended | SHV-18 ESBL-producing | ATCC 700603; CCUG 45421; LMG 20218 |
| <i>Mannheimia haemolytica</i> | NCTC 9380 | Routine | | ATCC 33396; DSM 10531; CCUG 12392 |
| <i>Pseudomonas aeruginosa</i> | NCTC 12903 | Routine | | ATCC 27853; WDCM 00025 |
| <i>Staphylococcus aureus</i> | NCTC 12493 | Extended | Methicillin-resistant (MRSA), <i>mecA</i> -positive | WDCM 00212 |
| | NCTC 12973 | Routine | Weak β -lactamase positive, <i>mecA</i> -negative | ATCC 29213; CIP 103429; DSM 2569; JCM 2874; WDCM 00131 |
| <i>Streptococcus pneumoniae</i> | NCTC 12977 | Routine | Susceptible to increased exposure to penicillin. (altered penicillin-binding protein) | ATCC 49619; CIP 104340 |

2. Clinical and Laboratory Standards Institute (CLSI)

2.1 Strains and equivalent strains recommended for CLSI M100-ED30:2020 Performance Standards for Antimicrobial Susceptibility Testing, 30th Edition Appendix C.

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|-------------------------------------|----------------------------|---|---|
| <i>Acinetobacter baumannii</i> | NCTC 13304 | OXA-27, OXA-23-like, OXA-51-like carbapenemases | |
| <i>Bacteroides fragilis</i> | NCTC 9343 | β-lactamase positive | ATCC 25285; DSM 2151 |
| <i>Bacteroides thetaiotaomicron</i> | NCTC 13706 | β-lactamase positive | |
| <i>Enterococcus faecalis</i> | NCTC 12697 | | ATCC 29212; WDCM 00087 |
| | NCTC 13379 | Resistant to vancomycin (VanB) and high- level aminoglycosides | ATCC 51299; CIP 10467; WDCM 00085; WDCM 00152 |
| | NCTC 13763 | | ATCC 33186; WDCM 00210 |
| <i>Escherichia coli</i> | NCTC 11954 | Contains plasmid-encoded TEM-1 β- lactamase (Non-ESBL) producer | ATCC 35218 |
| | NCTC 12241 | β-lactamase negative | ATCC 25922; DSM 1103; NCIMB 12210; WDCM 00013 |
| | NCTC 13353 | CTX-M-15 ESBL-producing strain | |
| <i>Haemophilus influenzae</i> | NCTC 12699 | BLNAR (β-lactamase negative, ampicillin resistant) | ATCC 49247 |
| | NCTC 12975 | Ampicillin susceptible | ATCC 49766; CIP 103570 |
| | NCTC 13377 | | ATCC 10211; CIP 103708 |
| <i>Klebsiella pneumoniae</i> | NCTC 13368 | SHV-18 ESBL-producing strain | ATCC 700603; CCUG 45421; LMG 20218 |

2. Clinical and Laboratory Standards Institute (CLSI) continued

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|---------------------------------|----------------------------|--|--|
| <i>Klebsiella pneumoniae</i> | NCTC 13809 | KPC-producing strain | ATCC BAA- 1705 |
| | NCTC 13810 | Resistant to carbapenems by mechanisms other than carbapenemase activity | ATCC BAA- 1706 |
| <i>Neisseria gonorrhoeae</i> | NCTC 12700 | CMRNG (Chromosome-mediated resistant <i>Neisseria gonorrhoeae</i>) | ATCC 49226 |
| <i>Pseudomonas aeruginosa</i> | NCTC 12903 | Contains inducible AmpC β-lactamase | ATCC 27853; WDCM 00025 |
| <i>Staphylococcus aureus</i> | NCTC 12973 | Weak β-lactamase positive, <i>mecA</i> -negative | ATCC 29213; CIP 103429; DSM 2569; JCM 2874; WDCM 00131 |
| | NCTC 12981 | β-lactamase negative, <i>mecA</i> negative | ATCC 25923; CIP 76.25; DSM 1104; JCM 2413; WDCM 00034 |
| | NCTC 13373 | Oxacillin resistant, <i>mecA</i> positive | ATCC 43300; WDCM 00211 |
| | NCTC 13811 | Contains inducible <i>erm(A)</i> -mediated resistance | ATCC BAA- 977 |
| | NCTC 13812 | Contains <i>msr(A)</i> -mediated macrolide-only resistance | ATCC BAA- 976 |
| | NCTC 13813 | High-level mupirocin resistance mediated by the <i>mupA</i> gene | ATCC BAA- 1708 |
| <i>Streptococcus pneumoniae</i> | NCTC 12977 | Penicillin intermediate (altered penicillin-binding protein) | ATCC 49619; CIP 104340 |

3. UK Standards for Microbiology Investigations (UKSMI)

3.1 Recommended in B59: Enterobacterales producing extended-spectrum β -lactamases

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|------------------------------|----------------------------|--|--|
| <i>Escherichia coli</i> | NCTC 13351 | TEM-3 (broad spectrum ESBL) | |
| | NCTC 13352 | TEM-10 (ceftazidimase, less active against cefotaxime) | |
| | NCTC 13353 | CTX-M-15 (cefotaximase, less active against ceftazidime) | |
| <i>Klebsiella pneumoniae</i> | NCTC 13368 | SHV-18 ESBL-producing | ATCC 700603; CCUG 45421; LMG 20218 |

Note: Either *E. coli* NCTC 10418 or ATCC 25922 (NCTC equivalent = NCTC 12241) should be used as a negative control in ESBL confirmation tests.

3.2 Recommended in B60: Detection of bacteria with carbapenem-hydrolysing β -lactamases (carbapenemases)

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|---|----------------------------|---|-------------------------|
| Class A Carbapenemase | | | |
| <i>Klebsiella pneumoniae</i> | NCTC 13438 | Member of the international ST258 clone producing KPC-3 carbapenemase | |
| Class B Carbapenemases (Metallo-β-lactamases) | | | |
| <i>Escherichia coli</i> | NCTC 13476 | IMP-type metallo-carbapenemase (unsequenced) | CCUG 68729 |
| <i>Klebsiella pneumoniae</i> | NCTC 13439 | VIM-1 metallo-carbapenemase; QnrS1 (outbreak strain) | |
| | NCTC 13440 | VIM-1 metallo-carbapenemase; QnrS1 (sporadic) | |
| | NCTC 13443 | New Delhi Metallo- β -lactamase (NDM-1) | CCUG 68728 |
| <i>Pseudomonas aeruginosa</i> | NCTC 13437 | VIM-10 metallo-carbapenemase; VEB-1 ESBL | |

3.3 Recommended in B60: Detection of bacteria with carbapenem-hydrolysing β -lactamases (carbapenemases) continued

| Organism | NCTC® Strain Reference | Characteristics | Other Collection Number |
|--|----------------------------|--|-------------------------|
| Class D Carbapenemases (OXA carbapenemases) | | | |
| <i>Acinetobacter baumannii</i> | NCTC 13301 | OXA-23 (also with OXA-51-like) | |
| | NCTC 13302 | OXA-25 (OXA-24/40-like) (also with OXA- 51-like) | |
| | NCTC 13303 | OXA-26 (also with OXA-51-like) | |
| | NCTC 13304 | OXA-27 (also with OXA-51-like) | |
| | NCTC 13305 | (A 15) OXA-58 (also with OXA-51-like) | |
| | NCTC 13420 | SE Clone OXA-51-like | |
| | NCTC 13421 | OXA-23 Clone 2 (also with OXA-51-like) | |
| | NCTC 13422 | NW Clone OXA-51-like | |
| | NCTC 13423 | T strain (UK3) OXA-51-like | |
| | NCTC 13424 | OXA-23 Clone 1 (also with OXA-51-like) | |
| <i>Klebsiella pneumoniae</i> | NCTC 13442 | Sequence type 353 with OXA-48 | CCUG 68727 |

Note: Either *E. coli* NCTC 10418 or ATCC 25922 (NCTC equivalent = NCTC 12241) should be used as a negative control in confirmation tests.

4. World Health Organisation (WHO) - *Neisseria gonorrhoeae* panel

As listed in Unemo *et al* 'The novel 2016 WHO *Neisseria gonorrhoeae* reference strains for global quality assurance of laboratory investigations: phenotypic, genetic and reference genome characterization.' J Antimicrob Chemother. 2016 Nov;71(11):3096-3108²⁸, except for NCTC 14208²⁹.

| Organism | NCTC® Strain Reference | WHO Designation | Characteristics | Other Collection Number |
|------------------------------|----------------------------|-----------------|---|-------------------------|
| <i>Neisseria gonorrhoeae</i> | NCTC 13477 | WHO F | Fully susceptible isolate | CCUG 57595 |
| | NCTC 13478 | WHO G | Resistant to ciprofloxacin (low-level), penicillin (intermediate) tetracycline (TRNG) | CCUG 57596 |
| | NCTC 13479 | WHO K | Resistant to cefixime (low-level), ciprofloxacin (high-level), penicillin G, tetracycline | CCUG 57597 |
| | NCTC 13480 | WHO L | Resistant to azithromycin (intermediate), penicillin G, ceftriaxone (low-level), ciprofloxacin (high-level), tetracycline | CCUG 57598 |
| | NCTC 13480 | WHO M | Resistant to ciprofloxacin, penicillin G (penicillinase-producing), tetracycline | CCUG 57599 |
| | NCTC 13482 | WHO N | Resistant to penicillin G (penicillinase-producing), ciprofloxacin, tetracycline | CCUG 57600 |
| | NCTC 13483 | WHO O | Resistant to penicillin G (penicillinase-producing), spectinomycin, tetracycline | CCUG 57601 |
| | NCTC 13484 | WHO P | Resistant to azithromycin, penicillin G (intermediate), tetracycline (intermediate) | CCUG 57602 |
| | NCTC 14208 | WHO Q | Resistant to ceftriaxone (high-level), penicillin, azithromycin (high-level), ciprofloxacin, tetracycline | |
| | NCTC 13817 | WHO U | Resistant to azithromycin, ciprofloxacin (high-level), penicillin G (intermediate), tetracycline (intermediate) | |
| | NCTC 13818 | WHO V | Resistant to azithromycin (high-level), ciprofloxacin (high-level), penicillin G (penicillinase-producing), tetracycline | |

4. World Health Organisation (WHO) - *Neisseria gonorrhoeae* panel continued

| Organism | NCTC® Strain Reference | WHO Designation | Characteristics | Other Collection Number |
|------------------------------|----------------------------|-----------------|---|-------------------------|
| <i>Neisseria gonorrhoeae</i> | NCTC 13819 | WHO W | Resistant to cefixime (low-level), ciprofloxacin (high-level), penicillin G, tetracycline | |
| | NCTC 13820 | WHO X | Resistant to azithromycin (intermediate). Cefixime (high-level), ceftriaxone (high-level), ciprofloxacin (high-level), penicillin G | |
| | NCTC 13821 | WHO Y | Resistant to azithromycin, cefixime (high-level), ceftriaxone (high-level) and ciprofloxacin (high-level), penicillin G, tetracycline | |
| | NCTC 13822 | WHO Z | Resistant to azithromycin, ceftriaxone (low-level), cefixime (high-level) and ciprofloxacin (high-level), penicillin G, tetracycline | |

Antimicrobial Resistance (AMR) in *N. gonorrhoeae* is of significant international concern. Several high profile bodies have issued plans aiming to ensure that gonorrhoea remains a treatable infection. A consistent theme within all the recommendations is emphasis on AMR surveillance of *N. gonorrhoeae* isolates to monitor regional trends and detect new and emerging resistance. However the lack of a gold standard phenotypic AMR method for *N. gonorrhoeae* can be challenging for laboratories, making data comparisons between laboratories difficult.

To address this, a set of 14 well-characterised WHO *N. gonorrhoeae* reference strains have been described

and deposited within NCTC by Dr. Magnus Unemo from the WHO Collaborating Centre in Orebro, Sweden. This panel contains strains which display examples of all sensitive and resistant phenotypes to antimicrobials (current and historic) used to treat gonorrhoea. All the strains have full reference genomes available and have been extensively characterised (MLST, NG-MAST type, plasmid status etc.). It is envisaged that they will be invaluable quality control strains for any laboratory undertaking either molecular diagnostics and/or AMR testing on *N. gonorrhoeae* isolates for surveillance or individual patient management purposes.

5. Positive Control Strains for the Validation of Commercial Assays for the Detection of Acquired Carbapenemases

The UK Health Security Agency's Guidance Document (GW-427) "Commercial Assays for the Detection of Acquired Carbapenemases" provides evidence-based guidance for the selection and validation of one or more commercially available methods for the detection of carbapenemase-producing Gram-negative bacteria. The below strains cover the common and epidemiologically significant KPC, OXA-48-like, NDM, VIM and IMP carbapenemase gene variants known to be circulating in the UK and elsewhere.

| Organism | NCTC® Strain Reference | Characteristics |
|-------------------------------------|-----------------------------|---|
| <i>Escherichia coli</i> | NCTC 14320 | KPC non-metallo-carbapenemase IMP metallo-carbapenemase OXA-48-like non-metallo-carbapenemase |
| | NCTC 14321 | KPC non-metallo-carbapenemase OXA-48-like non-metallo-carbapenemase |
| | NCTC 14324 | OXA-484 non-metallo-carbapenemase |
| | NCTC 14325 | NDM-7 metallo-carbapenemase |
| | NCTC 14329 | OXA-244 non-metallo-carbapenemase |
| | NCTC 14333 | NDM-4 metallo-carbapenemase |
| | NCTC 14338 | OXA-48 non-metallo-carbapenemase |
| | NCTC 14339 | NDM-5 metallo-carbapenemase |
| <i>Enterobacter cloacae</i> complex | NCTC 14322 | KPC-4 non-metallo-carbapenemase |
| | NCTC 14326 | VIM-1 metallo-carbapenemase |
| | NCTC 14328 | VIM-4 metallo-carbapenemase |
| | NCTC 14336 | KPC-2 non-metallo-carbapenemase |
| <i>Klebsiella pneumoniae</i> | NCTC 14323 | NDM-1 metallo-carbapenemase OXA-48 non-metallo-carbapenemase |
| | NCTC 14327 | KPC-3 non-metallo-carbapenemase |
| | NCTC 14330 | OXA-181 non-metallo-carbapenemase |
| | NCTC 14331 | NDM-1 metallo-carbapenemase |
| | NCTC 14332 | NDM-1 metallo-carbapenemase OXA-232 non-metallo-carbapenemase |
| | NCTC 14334 | IMP-4 metallo-carbapenemase |
| | NCTC 14335 | OXA-232 non-metallo-carbapenemase |
| NCTC 14337 | IMP-1 metallo-carbapenemase | |

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Useful Websites

www.gov.uk

UKHSA Antimicrobial Resistance and Healthcare Associated Infections (AMRHA) Reference Unit

www.eucast.org

The European Committee on Antimicrobial Susceptibility Testing (EUCAST)

www.clsi.org

Clinical and Laboratory Standards Institute (CLSI)

www.gov.uk

UK Standards for Microbiological Investigations

www.bsac.org.uk

British Society for Antimicrobial Chemotherapy (BSAC)

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