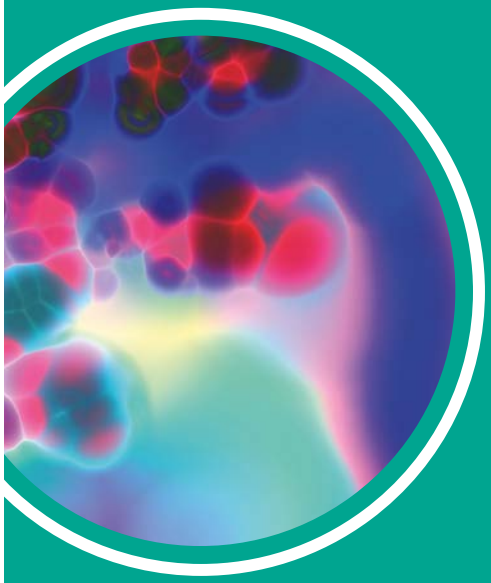
National Collection of Type Cultures 100TH Anniversary NCTC Operated by Public Health England

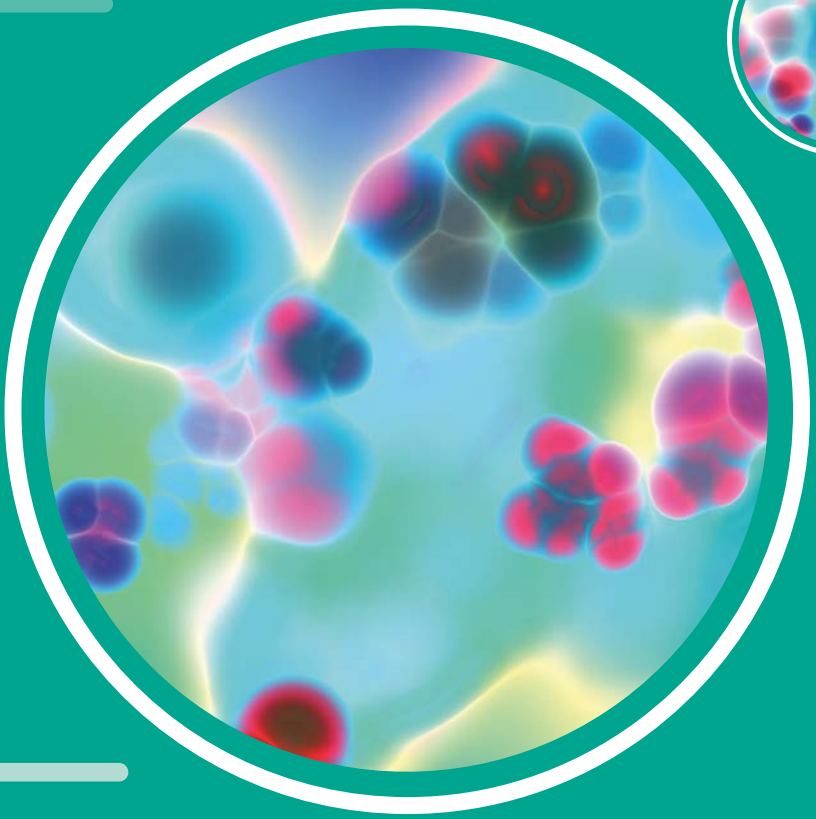
NCTC®

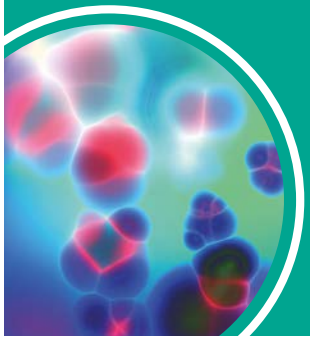
The National Collection of Type Cultures

Antimicrobial Resistant Strains:

Resistance Reference Strains
Susceptibility Testing Control Strains







Contents

NCTC®

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.

Public Health England's Antimicrobial Resistance and Healthcare Associated Infections (AMRHAI) 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

Public Health England's National Collection of Type Cultures (NCTC), working in partnership with Public Health England'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 PHE guidance

- historic and contemporary vancomycin-resistant enterococci isolates, including strains with both acquired and intrinsic resistance determinants

- the first methicillin-resistant *Staphylococcus aureus* to carry the *mecA* gene homologue *mecC*

- A 15 strain WHO recommended panel of *Neisseria gonorrhoeae*, including a strain with combined ceftriaxone and high-level azithromycin resistance

- *Escherichia coli* strain with the *mcr-1* gene conferring transferable 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, although plasmids and genes are not re-sequenced.

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To browse the NCTC online catalogue in full visit:
www.phe-culturecollections.org.uk/products/bacteria/search.jsp

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

Organism	NCTC® Strain Reference	Characteristics	Other Collection Number
Escherichia coli	NCTC 11560	TEM-1 β-lactamase producer[1]	
	NCTC 11954	β-lactamase producing strain[2]	ATCC 35218
Staphylococcus aureus	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
Escherichia coli	NCTC 13351	TEM-3 ESBL – Transconjugant (control strain isolated in Clermont-Ferrand in 1985)[1]	
	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
Klebsiella pneumoniae	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
Escherichia coli	NCTC 13353	Strain EO 487. CTX-M-15 ESBL producer. Control strain for group 1 *bla*$_{CTX-M}$ multiplex PCR assays[3]	
	NCTC 13451	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 *bla*$_{CTX-M}$ 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 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 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 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
Escherichia coli	NCTC 13461	Strain harbours *bla*$_{CTX-M}$ group 1 gene[5]	
	NCTC 13462	Strain harbours *bla*$_{CTX-M}$ group 2 gene[5]	
	NCTC 13463	Strain harbours *bla*$_{CTX-M}$ group 8 gene[5]	
Enterobacter cloacae	NCTC 13464	Strain harbours *bla*$_{CTX-M}$ group 9 gene[5]	
Klebsiella pneumoniae	NCTC 13465	Strain harbours *bla*$_{CTX-M}$ group 25 gene[5]	

2.4 VEB & PER β-lactamases

Organism	NCTC® Strain Reference	Characteristics	Other Collection Number
Pseudomonas aeruginosa	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
Enterobacter cloacae	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	

4. Carbapenemases

4.1 Class A Carbapenemases

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

4.2 Class B Carbapenemases (Metallo-β-lactamases)

Organism	NCTC® Strain Reference	Characteristics	Other Collection Number
Pseudomonas aeruginosa	NCTC 13437	VIM-10 metallo-carbapenemase; VEB-1 ESBL[7]	
Klebsiella pneumoniae	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
Escherichia coli	NCTC 13476	IMP-type metallo-carbapenemase	CCUG 68729
Pseudomonas aeruginosa	NCTC 13921	SPM-1 metallo-carbapenemase[11]	
***Salmonella* Seftenberg**	NCTC 13953	NDM-1 metallo-carbapenemase[12]	
Pseudomonas guariconensis	NCTC 14056	DIM-1 metallo-carbapenemase	
Citrobacter freundii	NCTC 14089	GIM-1 metallo-carbapenemase	
Escherichia coli	NCTC 14320	IMP metallo-carbapenemase KPC non-metallo-carbapenemase OXA-48-like non-metallo-carbapenemase[9]	
Klebsiella pneumoniae	NCTC 14323	NDM-1 metallo-carbapenemase OXA-48 non-metallo-carbapenemase[9]	
Escherichia coli	NCTC 14325	NDM-7 metallo-carbapenemase[9]	
Enterobacter cloacae	NCTC 14326	VIM-1 metallo-carbapenemase[9]	
	NCTC 14328	VIM-4 metallo-carbapenemase[9]	
Klebsiella pneumoniae	NCTC 14331	NDM-1 metallo-carbapenemase[9]	
	NCTC 14332	NDM-1 metallo-carbapenemase OXA-232 non-metallo-carbapenemase[9]	
Escherichia coli	NCTC 14333	NDM-4 metallo-carbapenemase[9]	
Klebsiella pneumoniae	NCTC 14334	IMP-4 metallo-carbapenemase[9]	
	NCTC 14337	IMP-1 metallo-carbapenemase[9]	
Escherichia coli	NCTC 14339	NDM-5 metallo-carbapenemase[9]	
Pseudomonas aeruginosa	NCTC 14361	SIM metallo-carbapenemase	

4.3 Class D Carbapenemases (OXA carbapenemases)

Organism	NCTC® Strain Reference	Characteristics	Other Collection Number
Acinetobacter baumannii	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 13421	OXA-23 and OXA-51-like non-metallo-carbapenemases (Clone 2 genotype)[15]	
	NCTC 13424	OXA-23 and OXA-51-like non-metallo-carbapenemases (Clone 1 genotype)[15]	
	NCTC 13420	OXA-51-like non-metallo-carbapenemase (SE clone 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]	
Klebsiella pneumoniae	NCTC 13442	OXA-48 non-metallo-carbapenemase (Sequence type 353)[17]	CCUG 68727
***Salmonella* Typhimurium**	NCTC 13954	OXA-48 non-metallo-carbapenemase pOXA-48a-like plasmid positive[12]	
Escherichia coli	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]	
Klebsiella pneumoniae	NCTC 14323	OXA-48 non-metallo-carbapenemase NDM-1 metallo-carbapenemase[9]	
Escherichia coli	NCTC 14324	OXA-484 non-metallo-carbapenemase[9]	
	NCTC 14329	OXA-244 non-metallo-carbapenemase[9]	
Klebsiella pneumoniae	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]	
Escherichia coli	NCTC 14338	OXA-48 non-metallo-carbapenemase[9]	

5. Plasmid-mediated Fluoroquinolone Resistance

Organism	NCTC® Strain Reference	Characteristics	Other Collection Number
Klebsiella pneumoniae	NCTC 13439	VIM-1 metallo-carbapenemase; QnrS1 (outbreak strain)[10]	
	NCTC 13440	VIM-1 metallo-carbapenemase; QnrS1 (sporadic)[10]	
Escherichia coli	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]	

6. Vancomycin Resistant Enterococci

Organism	NCTC® Strain Reference	Characteristics	Other Collection Number
Enterococcus faecium	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]	
Enterococcus faecalis	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
Enterococcus casseliflavus	NCTC 12361	VanC-type glycopeptide resistance (low-level, intrinsic to species)	ATCC 25788, CCM 2478, CCUG 18657, CIP 103018, DSM 20680
Enterococcus faecalis	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]	

7. Multidrug Resistance Plasmids

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

9. Colistin resistance

Organism	NCTC® Strain Reference	Characteristics	Other Collection Number
Escherichia coli	NCTC 13846	Colistin resistant, *mcr-1* positive[24]	DSMZ 105182
Salmonella* Typhimurium *(monophasic)	NCTC 13952	Colistin resistant, *mcr-1* positive	

10. Linezolid resistance

Organism	NCTC® Strain Reference	Characteristics	Other Collection Number
Enterococcus faecium	NCTC 13923	Positive control for the detection of *optrA* conferring resistance to linezolid	
Staphylococcus epidermidis	NCTC 13924	Positive control for the detection of *cfr* or G2576T mutation both of which confer resistance to linezolid[25]	
Enterococcus faecalis	NCTC 14360	Positive control for the detection of *poxtA*, which confers resistance to linezolid	

11. Additional strains

Organism	NCTC® Strain Reference	Characteristics	Other Collection Number
Streptococcus pneumoniae	NCTC 14143	Resistant to clindamycin, erythromycin and tetracycline. Susceptible to increased exposure to penicillin and ampicillin	
Staphylococcus epidermidis	NCTC 14218 NCTC 14219 NCTC 14220	Methicillin-resistant *Staphylococcus epidermidis* (MRSE) strains with rifampicin resistant phenotype. Each strain is one of three globally distributed lineages. See reference for details[26]	
Clostridiodes difficile	NCTC 14385	Plasmid-mediated metronidazole resistance. To be used for research and non-commercial uses only	

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 Public Health England's Antimicrobial Resistance and Healthcare Associated Infections (AMRHAI) 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)

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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
Campylobacter jejuni	NCTC 11351	Routine		ATCC 33560; CCUG 11284; CIP 702; DSM 4688
Enterococcus faecalis	NCTC 12697	Routine		ATCC 29212; WDCM 00087
	NCTC 13379	Extended	High-level gentamicin resistant (HLGR), *vanB*-positive	ATCC 51299; CIP 10467; WDCM 00085; WDCM 00152
Escherichia coli	NCTC 12241	Routine		ATCC 25922; DSM 1103; NCIMB 12210; WDCM 00013
	NCTC 11954	Routine	TEM-1 β-lactamase (Non- ESBL) producer	ATCC 35218
	NCTC 13846	Routine	*mcr-1* positive	DSMZ 105182
Haemophilus influenzae	NCTC 12975	Routine		ATCC 49766; CIP 103570
	NCTC 12699	Extended		ATCC 49247
Klebsiella pneumoniae	NCTC 13368	Routine and Extended	SHV-18 ESBL-producing	ATCC 700603; CCUG 45421; LMG 20218
Pseudomonas aeruginosa	NCTC 12903	Routine		ATCC 27853; WDCM 00025
Staphylococcus aureus	NCTC 12493	Extended	Methicillin-resistant (MRSA), *mecA*-positive	WDCM 00212
	NCTC 12973	Routine	Weak β-lactamase positive, *mecA*-negative	ATCC 29213; CIP 103429; DSM 2569; JCM 2874; WDCM 00131
Streptococcus pneumoniae	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
Acinetobacter baumannii	NCTC 13304	OXA-27, OXA-23-like, OXA-51-like carbapenemases	
Bacteroides fragilis	NCTC 9343	β-lactamase positive	ATCC 25285; DSM 2151
Bacteroides thetaiotaomicron	NCTC 13706	β-lactamase positive	
Enterococcus faecalis	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 12697		ATCC 29212, WDCM 00087
	NCTC 13763		ATCC 33186; WDCM 00210
Escherichia coli	NCTC 12241	β-lactamase negative	ATCC 25922; DSM 1103; NCIMB 12210; WDCM 00013
	NCTC 11954	Contains plasmid-encoded TEM-1 β- lactamase (Non-ESBL) producer	ATCC 35218
	NCTC 13353	CTX-M-15 ESBL-producing strain	
Haemophilus influenzae	NCTC 12699	BLNAR (β-lactamase negative, ampicillin resistant)	ATCC 49247
	NCTC 12975	Ampicillin susceptible	ATCC 49766; CIP 103570
	NCTC 13377		ATCC 10211; CIP 103708
Klebsiella pneumoniae	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
Klebsiella pneumoniae	NCTC 13809	KPC-producing strain	ATCC BAA- 1705
	NCTC 13810	Resistant to carbapenems by mechanisms other than carbapenemase activity	ATCC BAA- 1706
Neisseria gonorrhoeae	NCTC 12700	CMRNG (Chromosome-mediated resistant *Neisseria gonorrhoeae*)	ATCC 49226
Pseudomonas aeruginosa	NCTC 12903	Contains inducible AmpC β-lactamase	ATCC 27853; WDCM 00025
Staphylococcus aureus	NCTC 12981	β-lactamase negative, *mecA* negative	ATCC 25923; CIP 76.25; DSM 1104; JCM 2413; WDCM 00034
	NCTC 12973	Weak β-lactamase positive, *mecA*-negative	ATCC 29213; CIP 103429; DSM 2569; JCM 2874; WDCM 00131
	NCTC 13373	Oxacillin resistant, *mecA*-positive	ATCC 43300; WDCM 00211
	NCTC 13811	Contains inducible *erm*(A)-mediated resistance	ATCC BAA- 977
	NCTC 13812	Contains *msr*(A)-mediated macrolide-only resistance	ATCC BAA- 976
	NCTC 13813	High-level mupirocin resistance mediated by the *mupA* gene	ATCC BAA- 1708
Streptococcus pneumoniae	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
Escherichia coli	NCTC 13353	CTX-M-15 (cefotaximase, less active against ceftazidime)	
	NCTC 13351	TEM-3 (broad spectrum ESBL)	
	NCTC 13352	TEM-10 (ceftazidimase, less active against cefotaxime)	
Klebsiella pneumoniae	NCTC 13368	SHV-18 ESBL-producing	ATCC 700603; CCUG 45421; LMG 20218

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

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

Organism	NCTC® Strain Reference	Characteristics	Other Collection Number
Class A Carbapenemase			
Klebsiella pneumoniae	NCTC 13438	Member of the international ST258 clone producing KPC-3 carbapenemase	
Class B Carbapenemases (Metallo-β-lactamases)			
Escherichia coli	NCTC 13476	IMP-type metallo-carbapenemase (unsequenced)	CCUG 68729
Klebsiella pneumoniae	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
Pseudomonas aeruginosa	NCTC 13437	VIM-10 metallo-carbapenemase; VEB-1 ESBL	

3.1 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)			
Acinetobacter baumannii	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 13421	OXA-23 Clone 2 (also with OXA-51-like)	
	NCTC 13424	OXA-23 Clone 1 (also with OXA-51-like)	
	NCTC 13420	SE Clone OXA-51-like	
	NCTC 13422	NW Clone OXA-51-like	
	NCTC 13423	T strain (UK3) OXA-51-like	
Klebsiella pneumoniae	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):3096-3108[27], except for NCTC 14208[28].

Organism	NCTC® Strain Reference	WHO Designation	Characteristics	Other Collection Number
Neisseria gonorrhoeae	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), cipro loxacin (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
Neisseria gonorrhoeae	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

Public Health England 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
Escherichia coli	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
***Enterobacter cloacae* 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
Klebsiella pneumoniae	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
PHE Antimicrobial Resistance and Healthcare Associated Infections (AMRHAI) 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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