BSAC Methods for Antimicrobial Susceptibility Testing

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Abstract

Summary of changes in version 11

Table 5: Incubation conditions for antimicrobial susceptibility tests on various organisms

Change to the incubation temperature and duration of incubation for *Campylobacter* spp.

8.2 Detection of methicillin/oxacillin/cefoxitin resistance in staphylococci by use of cefoxitin as the test agent

- Amendment stating that testing is for all staphylococci not just *Staphylococcus aureus*.
- Reading cefoxitin zones of inhibition is for all staphylococci (Figure 3)

8.2.7 Interpretation:

- For *S. saprophyticus*

- For coagulase staphylococci other than *S. saprophyticus*

Table 6. MIC and zone diameter breakpoints for Enterobacteriaceae (including *Salmonella* and *Shigella* spp.)

Change in MIC or zone diameter breakpoints

- Co-amoxiclav (UTI)
- Azithromycin (*S. typhi* only)

Change to comments

- Cefixime
- Cefotaxime
- Ceftazidime
- Ceftriaxone

Table 8. MIC and zone diameter breakpoints for *Pseudomonas* spp.

Change in MIC or zone diameter breakpoints

- Amikacin

Table 10. MIC and zone diameter breakpoints for staphylococci

Removal of recommendations which can now be found in the “Legacy” section

- Mupirocin (5μg disc)

Change in MIC or zone diameter breakpoints

- Cefoxitin (*S. saprophyticus*)
- Vancomycin (coagulase negative staphylococci)

Change to comments

- Cefoxitin (*S. saprophyticus*)
- Vancomycin (coagulase negative staphylococci)

- Clindamycin
- Erythromycin

Table 11. MIC and zone diameter breakpoints for *Streptococcus pneumoniae*

Change in MIC or zone diameter breakpoints

- Meropenem (meningitis)
- Linezolid

Change to comments

- Linezolid

Table 13. MIC and zone diameter breakpoints for α-haemolytic streptococci

Change to comments

- Clindamycin
- Erythromycin

Table 14. MIC and zone diameter breakpoints for β-haemolytic streptococci

Change in MIC or zone diameter breakpoints

- Trimethoprim (Group B streptococci)

Change to comments

- Clindamycin

Table 15. MIC and zone diameter breakpoints for *Moraxella catarrhalis*

Change in MIC or zone diameter breakpoints

- Cefaclor
- Cefuroxime
- Cefuroxime axetil
- Nalidixic acid
- Chloramphenicol

Change to comments

- Cefaclor
- Chloramphenicol

Table 16. MIC and zone diameter breakpoints for *Neisseria gonorrhoeae*

Change to comments

- Tetracycline

Table 18. MIC and zone diameter breakpoints for *Haemophilus influenzae*

Change in MIC or zone diameter breakpoints

- Amoxicillin
- Co-amoxiclav
- Meropenem (meningitis)
- Chloramphenicol

Change to comments

- Amoxicillin
- Chloramphenicol

Table 20. MIC and zone diameter breakpoints for *Campylobacter* spp.

Change in MIC or zone diameter breakpoints

- Ciprofloxacin
- Nalidixic acid
- Erythromycin

Change to comments

- Erythromycin

Table 24. MIC and zone diameter breakpoints for Clostridium difficile

Change in MIC or zone diameter breakpoints

- Daptomycin
- Fusidic acid
- Metronidazole
- Moxifloxacin
- Tigecycline
- Rifampicin
- Vancomycin

Change to comments

- Daptomycin
- Fusidic acid
- Metronidazole
- Moxifloxacin
- Tigecycline
- Rifampicin
- Vancomycin

Additional information

Table 1: MIC breakpoints for *Helicobacter pylori* based on epidemiological "cut-off" values (ECOFFs), which distinguish "wild-type" isolates from those with reduced susceptibility

Change in MIC or zone diameter breakpoints

- Amoxicillin

- Clarithromycin
- Levofloxacin
- Tetracycline
- Metronidazole
- Rifampicin

4. Susceptibility testing *Listeria* spp.

Table 3: MIC ranges for "wild type" *Listeria* spp.

Change in MIC or zone diameter breakpoints

- Ampicillin
- Penicillin
- Meropenem
- Cotrimoxazole

Change to comments

- Cotrimoxazole

Control of susceptibility testing

Table 3: Acceptable zone diameter (mm) ranges for control strains on Iso-Sensitest agar supplemented with 5% defibrinated horse blood, with or without the addition of NAD, plates incubated at 35-37^{0}C in air for 18-20 h.

Change in acceptable range

- Erythromycin v *Staphylococcus aureus* NCTC 6571

Table 6: Acceptable zone diameter (mm) ranges for control strains on Iso-Sensitest agar supplemented with 5% defibrinated horse blood with or without the addition of NAD, plates incubated at 35-37^{0}C in 4-6% CO_2 for 18-20 h.

Change in acceptable range

- Co-amoxiclav v *Staphylococcus aureus* NCTC 6571

9. Control of MIC determination

Tables 7-10 provide target MIC (mg/L) values for recommended control strains by BSAC methodology.[1,2] MICs should be within one two-fold dilution of the target values **i.e. target MIC 1 mg/L acceptable range 0.5 – 2 mg/L**.

Table 7: Target MICs (mg/L) for *Haemophilus influenzae*, *Enterococcus faecalis*, *Streptococcus pneumoniae*, *Bacteroides fragilis* and *Neisseria gonorrhoeae* control strains by BSAC methods

Change in MIC

- Linezolid

Table 8: Target MICs (mg/L) for *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* control strains by BSAC methods

Change in MIC

- Cefoxitin
- Colistin
- Daptomycin
- Doripenem
- Piperacillin/tazobactam
- Sulphamethoxazole
- Tetracycline

NB.

All changes to the tables are shown in bold text.

Preface

Since the *Journal of Antimicrobial Chemotherapy* Supplement containing the BSAC standardized disc susceptibility testing method was published in 2001, there have been various changes to the recommendations and these have been posted on the BSAC website (http://www.bsac.org.uk). One major organizational change has been the harmonisation of MIC breakpoints in Europe.

In 2002 the BSAC agreed to participate with several other European national susceptibility testing committees, namely CA-SFM (Comité de l'Antibiogramme de la Société Française de Microbiologie, France), the CRG (Commissie Richtlijnen Gevoeligheidsbepalingen (The Netherlands), DIN (Deutsches Institut für Normung, Germany), NWGA (Norwegian Working Group on Antimicrobials, Norway) and the SRGA (Swedish Reference Group of Antibiotics, Sweden), in a project to harmonize antimicrobial breakpoints, including previously established values that varied among countries. This work is being undertaken by the European Committee on Antimicrobial Susceptibility Testing (EUCAST) with the support and collaboration of the national committees, and is funded by the European Union, the European Society for Clinical Microbiology and Infectious Diseases (ESCMID) and the national committees, including the BSAC. The review process includes application of more recent techniques, such as pharmacodynamic analysis, and current data, where available, on susceptibility distributions, resistance mechanisms and clinical outcomes as related to *in vitro* tests. There is extensive discussion between EUCAST and the national committees, including the BSAC Working Party on antimicrobial susceptibility testing, and wide consultation on proposals. In the interest of international standardization of susceptibility testing, and the need to update older breakpoints, these developments are welcomed by the BSAC.

The implication of such harmonization is that over time some MIC breakpoints will change slightly and these changes will be reflected, where necessary, in corresponding changes to zone diameter breakpoints in the BSAC disc diffusion method. It is appreciated that changes in the method require additional work for laboratories in changing templates and laboratory information systems, and that the wider use of `intermediate' categories will add complexity. Nevertheless the benefits of international standardization are considerable, and review of some older breakpoints is undoubtedly warranted.

In line with the European consensus EUCAST MIC breakpoints are defined as follows:

- Clinically resistant: level of antimicrobial susceptibility which results in a high likelihood of therapeutic failure
- Clinically susceptible: level of antimicrobial susceptibility associated with a high likelihood of therapeutic success
- Clinically intermediate: a level of antimicrobial susceptibility associated with uncertain therapeutic effect. It implies that an infection due to the isolate may be appropriately treated in body sites where the drugs are physically concentrated or when a high dosage of drug can be

used; it also indicates a buffer zone that should prevent small, uncontrolled, technical factors from causing major discrepancies in interpretation.

The presentation of MIC breakpoints (mg/L) has also been amended to avoid the theoretical 'gap' inherent in the previous system as follows:

MIC ≤ (as previously) MIC breakpoint concentration = organism is susceptible

MIC > (previously≥) MIC breakpoint concentration = organism is resistant

In practice, this does result in changes to breakpoint systems based on two-fold dilutions. However, the appearance of the tables will change, e.g. R ≥16, S ≤8 will change to R>8, S ≤8.

Disc Diffusion Method for Antimicrobial Susceptibility Testing

1. Preparation of plates

1.1 Prepare Iso-Sensitest agar (ISA) (see list of suppliers) or media shown to have the same performance as ISA, according to the manufacturer's instructions. Supplement media for fastidious organisms with 5% defibrinated horse blood or 5% defibrinated horse blood and 20 mg/L β-nicotinamide adenine dinucleotide (NAD) as indicated in Table 1. Use Columbia agar with 2% NaCl for methicillin/oxacillin susceptibility testing of staphylococci.

Table 1: Media and supplementation for antimicrobial susceptibility testing of different groups of organisms

Organisms	Medium
Enterobacteriaceae	ISA
Pseudomonas spp.	ISA
Stenotrophomonas maltophilia	ISA
Staphylococci (tests other than methicillin/oxacillin)	ISA
Staphylococcus aureus (tests using cefoxitin to detect methicillin/oxacillin/cefoxitin resistance)	ISA
Staphylococci (tests using methicillin or oxacillin for the detection of methicillin/oxacillin/cefoxitin resistance)	Columbia agar (*see suppliers*) with 2% NaCl[1]
Enterococci	ISA
Streptococcus pneumoniae	ISA + 5% defibrinated horse blood[2]
α-Haemolytic streptococci	ISA + 5% defibrinated horse blood + 20 mg/L NAD
β-Haemolytic streptococci	ISA + 5% defibrinated horse blood[2]
Moraxella catarrhalis	ISA + 5% defibrinated horse blood[2]
Haemophilus spp.	ISA + 5% defibrinated horse blood + 20 mg/L NAD
Neisseria gonorrhoeae	ISA + 5% defibrinated horse blood[2]
Neisseria meningitidis	ISA + 5% defibrinated horse blood[2]
Pasteurella multocida	ISA + 5% defibrinated horse blood + 20 mg/L NAD
Bacteroides fragilis, Bacteroides thetaiotaomicron, Clostridium perfringens	ISA + 5% defibrinated horse blood + 20 mg/L NAD
Campylobacter spp.	ISA + 5% defibrinated horse blood[2]
Coryneform organisms	ISA + 5% defibrinated horse blood + 20 mg/L NAD

[1] See Section 8.
[2] ISA supplemented with 5% defibrinated horse blood + 20mg/L NAD may be used.

1.2 Pour sufficient molten agar into sterile Petri dishes to give a depth of 4 mm ± 0.5 mm (25 mL in 90 mm diameter Petri dishes).

1.3 Dry the surface of the agar to remove excess moisture before use. The length of time needed to dry the surface of the agar depends on the drying conditions, e.g. whether a fan-assisted drying cabinet or 'still air' incubator is used, whether plates are dried before storage and storage conditions. **It is important that plates are not over dried.**

1.4 Store the plates in vented plastic boxes at 8-10°C prior to use. Alternatively the plates may be stored at 4-8°C in sealed plastic bags. Plate drying, method of storage and storage time should be determined by individual laboratories as part of their quality assurance programme. In particular, quality control tests should confirm that excess surface moisture is not produced and that plates are not over-dried.

2. Selection of control organisms

2.1 The performance of the tests should be monitored by the use of appropriate control strains (see section on control of antimicrobial susceptibility testing). The control strains listed (Tables 2a, 2b) include susceptible strains that have been chosen to monitor test performance and resistant strains that can be used to confirm that the method will detect a mechanism of resistance.

2.2 Store control strains at –70°C on beads in glycerol broth. Non-fastidious organisms may be stored at –20°C. Two vials of each control strain should be stored, one for an 'in-use' supply, the other for archiving.

2.3 Every week subculture a bead from the 'in-use' vial on to appropriate non-selective media and check for purity. From this pure culture, prepare one subculture on each of the following 5 days. For fastidious organisms that will not survive on plates for 5/6 days, subculture the strain daily for no more than 6 days.

Table 2a: Susceptible control strains or control strains with low-level resistance that have been chosen to monitor test performance of antimicrobial susceptibility testing

Organism	Strain		Characteristics
	Either	Or	
Escherichia coli	NCTC 12241 (ATCC 25922)	NCTC 10418	Susceptible
Staphylococcus aureus	NCTC 12981 (ATCC 25923)	NCTC 6571	Susceptible
Pseudomonas aeruginosa	NCTC 12934 (ATCC 27853)	NCTC 10662	Susceptible
Enterococcus faecalis	NCTC 12697 (ATCC 29212)		Susceptible
Haemophilus influenzae	NCTC 11931		Susceptible
Streptococcus pneumoniae	NCTC 12977 (ATCC 49619)		Low-level resistant to penicillin
Neisseria gonorrhoeae	NCTC 12700 (ATCC 49226)		Low-level resistant to penicillin
Pasteurella multocida	NCTC 8489		Susceptible
Bacteroides fragilis	NCTC 9343 (ATCC 25285)		Susceptible
Bacteroides thetaiotaomicron	ATCC 29741		Susceptible
Clostridium perfringens	NCTC 8359 (ATCC 12915)		Susceptible

Table 2b: Control strains with a resistance mechanism that can be used to confirm that the method will detect resistance.

Organism	Strain	Characteristics
Escherichia coli	NCTC 11560	TEM-1 ß-lactamase-producer
Staphylococcus aureus	NCTC 12493	*MecA* positive, methicillin resistant
Haemophilus influenzae	NCTC 12699 (ATCC 49247)	Resistant to ß-lactams (ß-lactamase-negative)

3. Preparation of inoculum

The inoculum should give semi-confluent growth of colonies after overnight incubation. Use of an inoculum that yields semi-confluent growth has the advantage that an incorrect inoculum can easily be observed. A denser inoculum will result in reduced zones of inhibition and a lighter inoculum will have the opposite effect. The following methods reliably give semi-confluent growth with most isolates.

NB. Other methods of obtaining semi-confluent growth may be used if they are shown to be equivalent to the following.

3.1 Comparison with a 0.5 McFarland standard

3.1.1 *Preparation of the 0.5 McFarland standard*
Add 0.5 mL of 0.048 M $BaCl_2$ (1.17% w/v $BaCl_2$. $2H_2O$) to 99.5 mL of 0.18 M H_2SO_4 (1% w/v) with constant stirring. Thoroughly mix the suspension to ensure that it is even. Using matched cuvettes with a 1 cm light path and water as a blank standard, measure the absorbance in a spectrophotometer at a wavelength of 625 nm. The acceptable absorbance range for the standard is 0.08-0.13. Distribute the standard into screw-cap tubes of the same size and volume as those used in growing the broth cultures. Seal the tubes tightly to prevent loss by evaporation. Store protected from light at room temperature. Vigorously agitate the turbidity standard on a vortex mixer before use. Standards may be stored for up to six months, after which time they should be discarded. Prepared standards can be purchased (See list of suppliers), but commercial standards should be checked to ensure that absorbance is within the acceptable range as indicated above.

3.1.2 *Inoculum preparation by the growth method* (for non-fastidious organisms, e.g. Enterobacteriaceae, *Pseudomonas* spp. and staphylococci)
Touch at least four morphologically similar colonies (when possible) with a sterile loop. Transfer the growth into Iso-Sensitest broth or an equivalent that has been shown not to interfere with the test. Incubate the broth, with shaking at 35-37°C, until the visible turbidity is equal to or greater than that of a 0.5 McFarland standard.

3.1.3 *Inoculum preparation by the direct colony suspension method* (the method of choice for fastidious organisms, i.e. *Haemophilus* spp., *Neisseria gonorrhoeae*, *Neisseria meningitidis*, *Moraxella catarrhalis, Streptococcus pneumoniae*, α and β-haemolytic streptococci, *Clostridium perfringens, Bacteroides fragilis*, *Bacteroides thetaiotaomicron*, *Campylobacter* spp., *Pasteurella multocida* and Coryneform organisms).
Colonies are taken directly from the plate into Iso-Sensitest broth (or equivalent) or sterile distilled water. The density of the suspension should match or exceed that of a 0.5 McFarland standard.

NB. With some organisms production of an even suspension of the required turbidity is difficult and growth in broth, if possible, is a more satisfactory option.

3.1.4 *Adjustment of the organism suspension to the density of a 0.5 McFarland standard*
Adjust the density of the organism suspension to equal that of a 0.5 McFarland standard by adding sterile distilled water. To aid comparison, compare the test and standard suspensions against a white background with a contrasting black line.

NB. Suspension should be used within 15 min.

3.1.5 *Dilution of suspension in distilled water before inoculation*

Dilute the suspension (density adjusted to that of a 0.5 McFarland standard) in distilled water as indicated in Table 3.

Table 3: Dilution of the suspension (density adjusted to that of a 0.5 McFarland standard) in distilled water

Dilute 1:100	Dilute 1:10	No dilution
β-Haemolytic streptococci	Staphylococci	*Neisseria gonorrhoeae*
Enterococci	*Serratia* spp.	*Campylobacter* spp.
Enterobacteriaceae	*Streptococcus pneumoniae*	
Pseudomonas spp.	*Neisseria meningitidis*	
Stenotrophomonas maltophilia	*Moraxella catarrhalis*	
Acinetobacter spp.	α-haemolytic streptococci	
Haemophilus spp.	*Clostridium perfringens*	
Pasteurella multocida	Coryneform organisms	
Bacteroides fragilis		
Bacteroides thetaiotaomicron		

NB. These suspensions should be used within 15 min of preparation.

3.2 Photometric standardization of turbidity of suspensions

A photometric method of preparing inocula was described by Moosdeen *et al* (1988)[1] and from this the following simplified procedure has been developed. The spectrophotometer must have a cell holder for 100 x 12 mm test tubes. A much simpler photometer would also probably be acceptable. The 100 x 12 mm test tubes could also be replaced with another tube/cuvette system if required, but the dilutions would need to be recalibrated.

3.2.1 Suspend colonies (touch 4-5 when possible) in 3 mL distilled water or broth in a 100 x 12 mm glass tube (note that tubes are not reused) to give just visible turbidity. It is essential to get an even suspension.

NB. These suspensions should be used within 15 min of preparation.

3.2.2 Zero the spectrophotometer with a sterile water or broth blank (as appropriate) at a wavelength of 500 nm and measure the absorbance of the bacterial suspension.

3.2.3 From table 4 select the volume to transfer (with the appropriate fixed volume micropipette) to 5 mL sterile distilled water.

3.2.4 Mix the diluted suspension to ensure that it is even

NB. Suspension should be used within 15 min. of preparation

Table 4: Dilution of suspensions of test organisms according to absorbance reading

Organisms	Absorbance reading at 500 nm	Volume (μL) to transfer to 5 mL sterile distilled water
Enterobacteriaceae Enterococci *Pseudomonas* spp. Staphylococci	0.01 - 0.05	250
	>0.05 - 0.1	125
	>0.1 - 0.3	40
	>0.3 - 0.6	20
	>0.6 - 1.0	10
Haemophilus spp. Streptococci Miscellaneous fastidious Organisms	0.01 - 0.05	500
	>0.05 - 0.1	250
	>0.1 - 0.3	125
	>0.3 - 0.6	80
	>0.6 - 1.0	40

NB. As spectrophotometers may differ, it may be necessary to adjust the dilutions slightly to achieve semi-confluent growth with any individual set of laboratory conditions.

3.3 Direct antimicrobial susceptibility testing of urine specimens and blood cultures

Direct susceptibility testing is not advocated as the control of inoculum is very difficult. Direct testing is, however, undertaken in many laboratories in order to provide more rapid test results. The following methods have been recommended by laboratories that use the BSAC method and. will achieve the correct inoculum size for a reasonable proportion of infected urines and blood cultures If the inoculum is not correct (i.e. growth is not semi-confluent) or the culture is mixed, the test must be repeated.

3.3.1 Urine specimens

3.3.1.1 Method 1

Thoroughly mix the urine specimen, then place a 10 μL loop of urine in the centre of the susceptibility plate and spread evenly with a dry swab.

3.3.1.2 Method 2

Thoroughly mix the urine specimen, then dip a sterile cotton-wool swab in the urine and remove excess by turning the swab against the inside of the container. Use the swab to make a cross in the centre of the susceptibility plate and spread evenly with another sterile dry swab. If only small numbers of organisms are seen in microscopy, the initial cotton-wool swab may be used to inoculate and spread the susceptibility plate.

3.3.2 Positive blood cultures

The method depends on the Gram reaction of the infecting organism.

3.3.2.1 Gram-negative bacilli.

Using a venting needle, place one drop of the blood culture in 5 mL of sterile water, then dip a sterile cotton-wool swab in the suspension and remove excess by turning the swab against the inside of the container. Use the swab to spread the inoculum evenly over the surface of the susceptibility plate.

3.3.2.2 Gram-positive organisms.

It is not always possible accurately to predict the genera of Gram-positive organisms from the Gram's stain. However, careful observation of the morphology, coupled with clinical information, should make an "educated guess" correct most of the time.

Staphylococci and enterococci.
Using a venting needle, place three drops of the blood culture in 5 mL of sterile water, then dip a sterile cotton-wool swab in the suspension and remove excess by turning the swab against the inside of the container. Use the swab to spread the inoculum evenly over the surface of the susceptibility plate.

Pneumococci, “viridans” streptococci and diptheroids.
Using a venting needle, place one drop of the blood culture in the centre of a susceptibility plate, and spread the inoculum evenly over the surface of the plate.

4. Inoculation of agar plate

Use the adjusted suspension within 15 min to inoculate plates by dipping a sterile cotton-wool swab into the suspension and remove the excess liquid by turning the swab against the side of the container. Spread the inoculum evenly over the entire surface of the plate by swabbing in three directions. Allow the plate to dry before applying discs.

NB. If inoculated plates are left at room temperature for extended times before the discs are applied, the organism may begin to grow, resulting in reduced zones of inhibition. Discs should therefore be applied to the surface of the agar within 15 min of inoculation.

5. Antimicrobial discs

Refer to interpretation tables 6-23 for the appropriate disc contents for the organisms tested.

5.1 Storage and handling of discs.

Loss of potency of agents in discs will result in reduced zones of inhibition. To avoid loss of potency due to inadequate handling of discs the following are recommended:

5.1.1 Store discs in sealed containers with a desiccant and protected from light (this is particularly important for some light-susceptible agents such as metronidazole, chloramphenicol and the quinolones).

5.1.2 Store stocks at -20°C except for drugs known to be unstable at this temperature. If this is not possible, store discs at <8°C.

5.1.3 Store working supplies of discs at <8°C.

5.1.4 To prevent condensation, allow discs to warm to room temperature before opening containers.

5.1.5 Store disc dispensers in sealed containers with an indicating desiccant.

5.1.6 Discard discs on the expiry date shown on the side of the container.

5.2 Application of discs

Discs should be firmly applied to the dry surface of the inoculated susceptibility plate. The contact with the agar should be even. A 90 mm plate will accommodate six discs without unacceptable overlapping of zones.

6. Incubation

If the plates are left for extended times at room temperature after discs are applied, larger zones of inhibition may be obtained compared with zones produced when plates are incubated immediately. Plates should therefore be incubated within 15 min of disc application.

6.1 Conditions of incubation
Incubate plates under conditions listed in table 5.

Table 5: Incubation conditions for antimicrobial susceptibility tests on various organisms

Organisms	Incubation conditions
Enterobacteriaceae	35-37°C in air for 18-20 h
Acinetobacter spp.	35-37°C in air for 18-20 h
Pseudomonas spp.	35-37°C in air for 18-20 h
Stenotrophomonas maltophilia	30°C in air for 18-20 h
Staphylococci (other than methicillin/oxacillin/cefoxitin)	35-37°C in air for 18-20 h
Staphylococcus aureus using cefoxitin for the detection of methicillin/oxacillin/cefoxitin resistance	35°C in air for 18-20 h
Staphylococci using methicillin or oxacillin to detect resistance	30°C in air for 24 h
Moraxella catarrhalis	35-37°C in air for 18-20 h
α-Haemolytic streptococci	35-37°C in 4-6% CO_2 in air for 18-20 h
β-Haemolytic streptococci	35-37°C in air for 18-20 h
Enterococci	35-37°C in air for 24 h[1]
Neisseria meningitidis	35-37°C in 4-6 % CO_2 in air for 18-20 h
Streptococcus pneumoniae	35-37°C in 4-6 % CO_2 in air for 18-20 h
Haemophilus spp.	35-37°C in 4-6 % CO_2 in air for 18-20 h
Neisseria gonorrhoeae	35-37°C in 4-6 % CO_2 in air for 18-20 h
Pasteurella multocida	35-37°C in 4- 6% CO_2 in air for 18-20 h
Coryneform organisms	35-37°C in 4-6% CO_2 in air for 18-20 h
Campylobacter spp.	**42°C** in microaerophilic conditions for **24 h**
Bacteroides fragilis, Bacteroides thetaiotaomicron, Clostridium perfringens	35-37°C in 10% CO_2/10% H_2/80% N_2 for 18-20 h (anaerobic cabinet or jar)

[1]It is essential that plates are incubated for at least 24 h before reporting a strain as susceptible to vancomycin or teicoplanin.

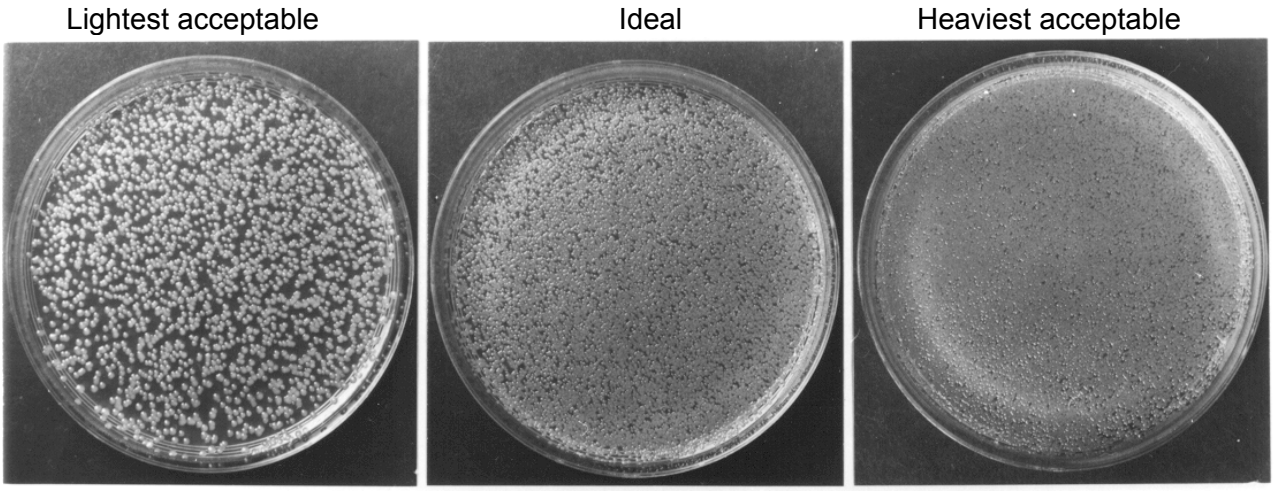
NB. Stacking plates too high in the incubator may affect results owing to uneven heating of plates. The efficiency of heating of plates depends on the incubator and the racking system used. Control of incubation, including height of plate stacking, should therefore be part of the laboratory's Quality Assurance programme.

7. Measuring zones and interpretation of susceptibility

7.1 Acceptable inoculum density

The inoculum should give semi-confluent growth of colonies on the susceptibility plate, within the range illustrated in Figure 1.

Figure 1: Acceptable inoculum density range for a Gram-negative rod



7.2 Measuring zones

7.2.1 Measure the diameters of zones of inhibition to the nearest millimetre (zone edge should be taken as the point of inhibition as judged by the naked eye) with a ruler, callipers or an automated zone reader.

7.2.2 Tiny colonies at the edge of the zone, films of growth as a result of the swarming of *Proteus* spp. and slight growth within sulphonamide or trimethoprim zones should be ignored.

7.2.3 Colonies growing within the zone of inhibition should be subcultured and identified and the test repeated if necessary.

7.2.4 When using cefoxitin for the detection of methicillin/oxacillin/cefoxitin resistance in *S. aureus,* measure the obvious zone, taking care to examine zones carefully in good light to detect minute colonies that may be present within the zone of inhibition (see Figure 3)

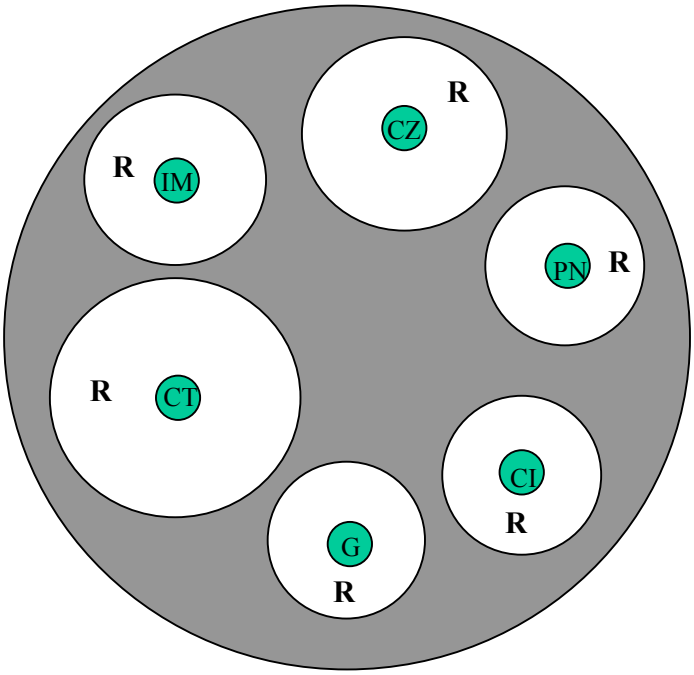
7.2.5 Confirm that the zone of inhibition for the control strain falls within the acceptable ranges in Tables 20-23 before interpreting the test (see section on control of the disc diffusion method).

7.3 Use of templates for interpreting zone diameters

A template may be used for interpreting zone diameters (see Figure 2). A program for preparing templates is available from the BSAC (http://www.bsac.org.uk).

The test plate is placed over the template and the zones of inhibition are examined in relationship to the template zones. If the zone of inhibition of the test strain is within the area marked with an ‘R’, the organism is resistant. If the zone of inhibition is equal to or larger than the marked area, the organism is susceptible.

Figure 2: Template for interpreting zone diameters



8. Oxacillin/cefoxitin testing of staphylococci

Methicillin susceptibility testing is difficult with some strains. Expression of resistance is affected by test conditions and resistance is often heterogeneous, with only a proportion of cells showing resistance. Adding NaCl or lowering incubation temperatures increases the proportion of cells showing resistance. Methicillin susceptibility testing of coagulase-negative staphylococci is further complicated as some strains do not grow well on media containing NaCl and are often slower-growing than *Staphylococcus aureus*. Detection of methicillin resistance in coagulase-negative staphylococci may require incubation for 48 h.

8.1 Method for detection of oxacillin resistance in *S. aureus* and coagulase-negative staphylococci

8.1.1 Medium

Prepare Columbia (See list of suppliers) or Mueller-Hinton agar (See list of suppliers) following the manufacturer's instructions and add 2% NaCl. After autoclaving, mix well to distribute the sodium chloride. Pour plates to give a depth of 4 mm (± 0.5 mm) in a 90 mm sterile Petri dish (25 ml). Dry and store plates as previously described (section 1).

8.1.2 Inoculum

Prepare inoculum as previously described (section 3).

8.1.3 Control

Susceptible control strains (*Staphylococcus aureus* ATCC 25923 or NCTC 6571) test the reliability of disc content.
Staphylococcus aureus NCTC 12493 is a methicillin resistant strain and is used to check that the test will detect resistant organisms (although no strain can be representative of all the MRSA types in terms of their response to changes in test conditions).

8.1.4 Discs

Place a oxacillin 1 μg disc on to the surface of inoculated agar.
Discs should be stored and handled as previously described (section 5).

8.1.5 Incubation

Incubate plates for 24 h at 30°C.

8.1.6 Zone measurement

Measure zone diameters (mm) as previously described (section 7).
Examine zones carefully in good light to detect colonies, which may be minute, in zones. If there is suspicion that the colonies growing within zones are contaminants they should be identified and the isolate re-tested for resistance to methicillin/oxacillin if necessary.

8.1.7 Interpretation

For oxacillin interpretation is as follows:
Susceptible = ≥ 15 mm diameter, resistant = ≤ 14 mm diameter.

NB. Hyper-production of β-lactamase does not confer clinical resistance to penicillinase-resistant penicillins and such isolates should be reported susceptible to oxacillin. Some hyper-producers of β-lactamase give zones within the range of 7-14 mm and, if possible, such isolates should be checked by a PCR method for *mec*A or by a latex agglutination test for PBP2a. Increase in oxacillin zone size in the presence of clavulanic acid is not a reliable test for hyper-producers of β-lactamase as zones of inhibition with some MRSA also increase in the presence of clavulanic acid. Rarely, hyper-producers of β-lactamase give no zone in this test and would therefore not be distinguished from MRSA.

8.2 Detection of methicillin/oxacillin/cefoxitin resistance in **staphylococci** by use of cefoxitin as the test agent

8.2.1 Medium

Prepare Iso-Sensitest agar as previously described (section 1).

8.2.2 Inoculum

Prepare inoculum as previously described (section 3).

8.2.3 Control

Use control strains as previously described (section 8.1.3).

8.2.4 Discs

Place a 10 μg cefoxitin disc on the surface of inoculated agar.
Discs should be stored and handled as previously described (section 5).

8.2.5 Incubation

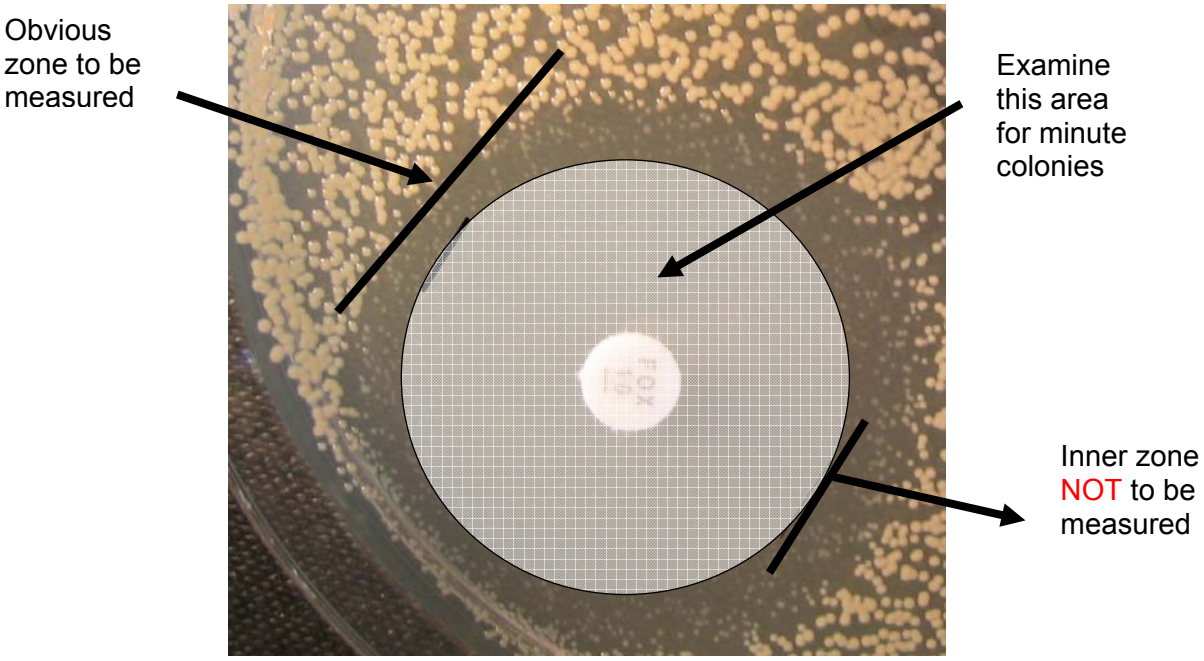
Incubate plates at 35°C for 18-20 h.

NB. It is important that the temperature does not exceed 36°C, as tests incubated at higher temperatures are less reliable.

8.2.6 Zone measurement

Measure zone diameters as previously described (section 7), reading the obvious zone edge (see Figure 3).
Examine zones carefully in good light to detect colonies, which may be minute, in zones. If there is suspicion that the colonies growing within zones are contaminants they should be identified and the isolate re-tested for resistance to cefoxitin if necessary.

Figure 3: Reading cefoxitin zones of inhibition with **staphylococci**



8.2.7 Interpretation:

For *S. aureus*
Susceptible = ≥22 mm diameter, resistant = ≤21 mm diameter

For *S. saprophyticus*
Susceptible = ≥20 mm diameter, resistant = ≤19 mm diameter

For coagulase staphylococci other than *S. saprophyticus*
Susceptible = ≥27 mm diameter, intermediate = 22-26 mm, resistant = ≤21 mm diameter

NB. Hyper -production of β-lactamase does not confer clinical resistance to penicillinase-resistant penicillins and such isolates should be reported susceptible to cefoxitin. Hyper-producers of β-lactamase give zones within the ranges of the susceptible population.

Table 6. MIC and zone diameter breakpoints for Enterobacteriaceae (including *Salmonella* and *Shigella* spp.)

The identification of Enterobacteriaceae to species level is essential before applying Expert Rules for the interpretation of susceptibility.

Comments 1-5 relate to urinary tract infections (UTIs) only.

[1]UTI recommendations are for organisms associated with uncomplicated urinary infections only. For complicated UTI systemic recommendations should be used.

[2]If an organism is isolated from multiple sites, for example from blood and urine, interpretation of susceptibility should be made with regard to the systemic site (e.g., if the blood isolate is resistant and the urine isolate susceptible, both should be reported resistant irrespective of the results obtained using interpretative criteria for urine isolates).

[3]For agents not listed, criteria given for systemic isolates may be used for urinary tract isolates. Intermediate susceptibility infers that the infection may respond as the agent is concentrated at the site of infection.

[4]Direct susceptibility tests on urine samples may be interpreted only if the inoculum gives semi-confluent growth.

[5] In the absence of definitive organism identification, use the recommendations most appropriate for the presumptive identification, accepting that on some occasions the interpretation may be incorrect. A more cautious approach is to use the systemic recommendations.

Table 6. MIC and zone diameter breakpoints for Enterobacteriaceae (including *Salmonella* and *Shigella* spp.)

	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Aminoglycosides								
Amikacin	16	16	8	30	15	16-18	19	*Salmonella* spp. should be reported resistant to these agents, irrespective of susceptibility testing result, as they are inactive against *Salmonella* spp. *in vivo*. Individual aminoglycoside agents must be tested; susceptibility to other aminoglycosides cannot be inferred from the gentamicin result and *vice versa*.
Gentamicin	4	4	2	10	16	17-19	20	
Tobramycin	4	4	2	10	17	18-20	21	
Penicillins								
Amoxicillin	8	-	8	10	14	-	15	Species that have chromosomal penicillinases (*Klebsiella* spp.) or those that typically have inducible AmpC enzymes (e.g. *Enterobacter* spp., *Citrobacter* spp. and *Serratia* spp.) are intrinsically resistant to ampicillin/amoxicillin.
Ampicillin	8	-	8	10	14	-	15	
Co-amoxiclav **Systemic**	8	-	8	20/10	20	-	21	Species that typically have inducible AmpC enzymes (e.g. *Enterobacter* spp., *Citrobacter* spp. and *Serratia* spp.) are intrinsically resistant to co-amoxiclav. Zone diameter based on a 2:1 ratio of amoxicillin: clavulanate are currently under review to establish correlation with an MIC breakpoint with a fixed concentration of clavulanate.
Co-amoxiclav UTI[1-5]	**32**	-	**32**	20/10	**12**	-	**13**	

Table 6. MIC and zone diameter breakpoints for Enterobacteriaceae (including *Salmonella* and *Shigella* spp.)								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Penicillins cont.								
Mecillinam UTI[1-5]	8	-	8	10	13	-	14	These interpretative criteria are for *E. coli*, *Klebsiella* spp. and *P. mirabilis* only. Isolates of *Escherichia coli* and *Klebsiella* spp. that produce ESBLs often appear susceptible to mecillinam *in vitro* but clinical efficacy against these organisms is unproven.
Piperacillin	16	16	8	75	20	21-22	23	
Piperacillin-tazobactam	16	16	8	75/10	20	21-22	23	
Temocillin	8	-	8	30	19	-	20	The distribution of zone diameters for ESBL and AmpC producers straddles the breakpoint. Organisms that appear resistant by disc diffusion should have resistance confirmed by MIC determination. No EUCAST BP at present based on BSAC data.
Temocillin UTI[1-5]	32	-	32	30	11	-	12	No EUCAST BP at present based on BSAC data.
Ticarcillin-clavulanate	16	16	8	75/10	22	-	23	The zone diameter breakpoint relates to an MIC of 8 mg/L as no data for the intermediate category are currently available.
Cephalosporins								
Cefalexin UTI[1-5]	16	-	16	30	15	-	16	These interpretative criteria are for *E. coli* and *Klebsiella* spp. only. Cefalexin results may be used to report susceptibility to cefadroxil and cefradine.
Cefalexin UTI[1-5]	16	-	16	30	17	-	18	These interpretative criteria are for *P. mirabilis* only. Cefalexin results may be used to report susceptibility to cefadroxil and cefradine.
Cefepime	4	2-4	1	30	26	27-31	32	
Cefixime	1	-	1	5	19	-	20	**MIC breakpoint for UTI only.**
Cefotaxime	2	2	1	30	23	24-29	30	***Enterobacter* spp., *Citrobacter freundii*, *Serratia* spp. and *Morganella morganii.* If susceptible *in- vitro*, the use of monotherapy of cefotaxime should be discouraged, owing to the risk of selection of resistance, or suppress the susceptibility testing result for this agent.** **http://www.eucast.org/expert_rules/**
Cefoxitin (AmpC screen)				30			**23**	This is an epidemiological "cut off" for AmpC detection which has high sensitivity, but poor specificity as susceptibility is also affected by permeability.

Table 6. MIC and zone diameter breakpoints for Enterobacteriaceae (including *Salmonella* and *Shigella* spp.)								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Cephalosporins cont.								
Cefpodoxime (ESBL screen)	1	-	1	10	19	-	20	If screening for ESBLs is required for infection control or epidemiological purposes, Enterobacteriaceae isolates should be screened with cefpodoxime or both cefotaxime (or ceftriaxone) and ceftazidime. The presence of ESBLs should be confirmed with a specific test.
Ceftazidime	4	2-4	1	30	22	23-26	27	***Enterobacter* spp., *Citrobacter freundii*, *Serratia* spp. and *Morganella morganii*. If susceptible to ceftazidime or ceftriaxone *in- vitro*, the use of monotherapy of ceftazidime or ceftriaxone should be discouraged, owing to the risk of selection of resistance, or suppress the susceptibility testing result for this agent.** http://www.eucast.org/expert_rules/
Ceftriaxone	2	2	1	30	23	24-27	28	
Cefuroxime (axetil) UTI[1-5] only	8	-	8	30	19	-	20	*Salmonella* spp. should be reported resistant to these agents, irrespective of susceptibility testing result, as they are inactive *in-vivo*. For parenteral cefuroxime the breakpoint relates to a dosage of 1.5 g three times a day and to *E. coli*, *Klebsiella* spp. and *P. mirabilis* only.
Cefuroxime (parenteral)	8	-	8	30	19	-	20	
Carbapenems								
Doripenem	4	2-4	1	10	18	19-23	24	Detection of carbapenem resistance is difficult. Guidance on detection is given at http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1294740725984 *Proteus* spp. and *Morganella morganii* are considered poor targets for imipenem.
Ertapenem	1	1	0.5	10	15	16-27	28	
Imipenem	8	4-8	2	10	16	17-20	21	
Meropenem	8	4-8	2	10	19	20-26	27	
Other β-Lactams								
Aztreonam	4	2-4	1	30	22	23-27	28	
Quinolones								
Ciprofloxacin	1	1	0.5	1	16	17-19	20	For ciprofloxacin, there is clinical evidence to indicate a poor response in systemic infections caused by *Salmonella* spp. with reduced susceptibility to fluoroquinolones. Isolates with MICs greater than 0.06 mg/L should be reported as resistant. It is recommended that the ciprofloxacin MIC should be determined for all invasive salmonellae infections.

Table 6. MIC and zone diameter breakpoints for Enterobacteriaceae (including *Salmonella* and *Shigella* spp.)								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Quinolones cont.								
Levofloxacin	2	2	1	1	13	14-16	17	
Moxifloxacin	1	1	0.5	1	16	17-19	20	
Nalidixic acid UTI[1-5]	16	-	16	30	17	-	18	
Norfloxacin (Systemic)	1	1	0.5	2	18	19-25	26	
Norfloxacin UTI[1-5]	4	-	4	2	15	-	16	No EUCAST breakpoint. BSAC data used.
Ofloxacin	1	1	0.5	5	25	26-28	29	
Macrolides, lincosamides and streptogramins								
Azithromycin ***S. typhi* only**	**-**	**-**	**-**	**15**	**18**	**-**	**19**	Azithromycin has been used in the treatment of infections with *S. typhi* (MIC ≤16 mg/L for wild type isolates) and some enteric infections.
Tetracyclines								
Tigecycline	2	2	1	15	19	20-23	24	Disc diffusion for Enterobacteriaceae other than *E.coli* may not give reliable results and for these organisms an MIC method should be used if tigecycline therapy is considered. Susceptibility of *E. coli* isolates appearing intermediate or resistant should be confirmed with an MIC method. *Morganella morganii*, *Providencia* spp. and *Proteus* spp. are considered inherently non-susceptible to tigecycline.
Miscellaneous antibiotics								
Chloramphenicol	8	-	8	30	20	-	21	
Colistin	2	-	2					The disc diffusion test is inappropriate because it does not reliably detect low level resistance. Colistin susceptibility should be determined with an MIC method.
Co-trimoxazole	4	4	2	1.25/ 23.75	15	-	16	The MIC breakpoint is based on the trimethoprim concentration in a 1:19 combination with Sulfamethoxazole. For advice on testing susceptibility to co-trimoxazole, see Appendix 1. The zone diameter breakpoint relates to an MIC of 2 mg/L as no data for the intermediate category are currently available.
Trimethoprim UTI[1-5]	4	4	2	2.5	13	14-16	17	

Table 6. MIC and zone diameter breakpoints for Enterobacteriaceae (including *Salmonella* and *Shigella* spp.)								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Miscellaneous antibiotics cont.								
Fosfomycin UTI[1-5]	32	-	32	200/ 50	24	-	25	These interpretative criteria are for *E. coli* only. Disc content indicates 200 μg fosfomycin/ 50 μg glucose-6-phosphate.
Fosfomycin UTI[1-5]	32	-	32	200/ 50	36	-	37	These interpretative criteria are for *P. mirabilis* only. Disc content indicates 200 μg fosfomycin/ 50 μg glucose-6-phosphate. The susceptibility of *Proteus* spp. that swarms up to the disc can be difficult to interpret.
Nitrofurantoin UTI[1-5]	64	-	64	200	16	-	17	These interpretative criteria are for *E. coli* only.

Table 7. MIC and zone diameter breakpoints for *Acinetobacter* spp.

	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Aminoglycosides								
Amikacin	16	16	8	30	18	19-20	21	
Gentamicin	4	-	4	10	19	-	20	
Penicillins								
Piperacillin-tazobactam	16	16	8	75/10	19	20-21	22	No EUCAST MIC BP as there is insufficient clinical evidence. BSAC data used.
Carbapenems								
Doripenem	4	2-4	1	10	14	15-21	22	
Imipenem	8	4-8	2	10	13	14-24	25	
Meropenem	8	4-8	2	10	12	13-19	20	
Quinolones								
Ciprofloxacin	1	-	1	1	20	-	21	
Tetracyclines								
Tigecycline								No EUCAST MIC BP as there is insufficient clinical evidence. For determining susceptibility an MIC method should be used and the EUCAST Non-Species specific MIC BP of S = 0.25 mg/L, R = > 0.5 mg/L applied to interpret susceptibility.
Miscellaneous antibiotics								
Colistin	2	-	2	-	-	-	-	Disc diffusion susceptibility testing is unreliable. An MIC method is therefore recommended.

Table 8. MIC and zone diameter breakpoints for *Pseudomonas* spp.

Table 8. MIC and zone diameter breakpoints for *Pseudomonas* spp.								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Aminoglycosides								
Amikacin	16	16	8	30	15	**16-21**	**22**	
Gentamicin	4	-	4	10	17	-	18	
Netilmicin	4	-	4	10	13	-	14	
Tobramycin	4	-	4	10	19	-	20	
Penicillins								
Piperacillin	16	-	16	75	24	-	25	
Piperacillin-tazobactam	16	-	16	75/10	24	-	25	
Ticarcillin	16	-	16	75	19	-	20	
Ticarcillin-clavulanate	16	-	16	75/10	19	-	20	
Cephalosporins								
Ceftazidime	8	-	8	30	23	-	24	
Carbapenems								
Doripenem	4	2-4	1	10	24	25-31	32	The detection of resistance mediated by carbapenemases is difficult, particularly if resistance is not fully expressed. For epidemiological or cross infection purposes consideration should be given to testing isolates resistant to ceftazidime and a carbapenem for the presence of carbapenemases (http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1294740725984)
Imipenem	8	8	4	10	16	17-22	23	
Meropenem	8	4-8	2	10	15	16-19	20	
Other β-Lactams								
Aztreonam	16	2-16	1	30	19	20-35	36	Relates only to isolates from patients with cystic fibrosis given high dosage therapy to treat P. *aeruginosa*.

Table 8. MIC and zone diameter breakpoints for *Pseudomonas* spp.								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Quinolones								
Ciprofloxacin	1	1	0.5	1	12	13-22	23	
Ciprofloxacin	1	1	0.5	5	19	20-29	30	
Levofloxacin	2	2	1	5	16	17-21	22	No EUCAST MIC BP as there is insufficient clinical evidence. EUCAST non-species specific MIC breakpoint and BSAC data used.
Miscellaneous antibiotics								
Colistin	4	-	4					The disc diffusion test is unreliable. Colistin susceptibility should be determined with an MIC method.

Table 9. MIC and zone diameter breakpoints for *Stenotrophomonas maltophilia*

	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Co-trimoxazole	4	-	4	1.25/23.75	19	-	20	For *Stenotrophomonas maltophilia*, susceptibility testing is not recommended except for co-trimoxazole (see www.bsac.org.uk BSA Standardized Susceptibility Testing Method, Additional Methodology, *Stenotrophomonas maltophilia*) The MIC breakpoint is based on the trimethoprim concentration in a 1:19 combination with sulfamethoxazole.

Table 10. MIC and zone diameter breakpoints for staphylococci

Comments 1-3 relate to urinary tract infections (UTI) only.
[1] These recommendations are for organisms associated with uncomplicated urinary tract infections only. For complicated infections and infections caused by *Staphylococcus aureus* and *Staphylococcus epidermidis*, which are associated with more serious infections, systemic recommendations should be used.
[2] If an organism is isolated from multiple sites, for example from blood and urine, interpretation of susceptibility should be made with regard to the systemic site (e.g., if the blood isolate is resistant and the urine isolate susceptible, both should be reported resistant irrespective of the results obtained using interpretative criteria for urine isolates).
[3] Direct susceptibility tests on urine samples may be interpreted only if the inoculum gives semi-confluent growth.

Table 10. MIC and zone diameter breakpoints for staphylococci								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Aminoglycosides								
Amikacin for *Staphylococcus aureus*	16	16	8	30	15	16-18	19	
Amikacin for coagulase-negative staphylococci	16	16	8	30	21	22-24	25	
Gentamicin	1	-	1	10	19	-	20	
Tobramycin for *Staphylococcus aureus*	1	-	1	10	20	-	21	
Tobramycin for coagulase-negative staphylococci	1	-	1	10	29	-	30	
Neomycin	-	-	-	10	16	-	17	For topical use only. The zone diameter breakpoint distinguishes the “wild type” susceptible population from isolates with reduced susceptibility.

Table 10. MIC and zone diameter breakpoints for staphylococci

β-Lactams

Most staphylococci are penicillinase-producers. The benzylpenicillin will mostly, but not unequivocally, separate β-lactamase producers.
Isolates positive for β-lactamase are resistant to benzylpenicillin, phenoxymethylpenicillin, amino-,carboxy-and ureidopenicillins. Isolates negative for β-lactamase and susceptible to cefoxitin (cefoxitin is used to screen for "methicillin resistance") can be reported susceptible to these drugs.
Isolates positive for β-lactamase and susceptible to cefoxitin are susceptible to penicillin- β-lactamase inhibitor combinations and penicillinase-resistant penicillins (oxacillin, cloxacillin, dicloxacillin and flucloxacin).
Isolates resistant to cefoxitin are methicillin resistant and resistant to β-lactam agents, including β-lactamase inhibitor combinations, except for cephalosporins with approved anti-MRSA activity and clinical breakpoints.

	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Ampicillin UTI[1-3] *Staphylococcus saprophyticus*	-	-	-	25	25	-	26	Staphylococci exhibiting resistance to oxacillin/cefoxitin should be regarded as resistant to other penicillins, cephalosporins, carbapenems and combinations of β-lactam and β-lactamase inhibitors**.** For coagulase negative staphylococci with cefoxitin zone diameters of 22-26 mm, PCR for *mec*A is required to determine susceptibility for treatment of deep seated infection with any β-lactam. For oxacillin tests on Mueller–Hinton or Columbia agars with 2% NaCl: Some hyper-producers of β-lactamase give zones within the range of 7-14 mm and if possible, should be checked by a PCR method for *mecA* or a latex agglutination test for PBP2a. Increase in oxacillin zone size in the presence of clavulanic acid is not a reliable test for hyper-producers of β-lactamase as zones of inhibition with some MRSA also increase in the presence of clavulanic acid. Rarely, hyper-producers of β-lactamase give no zone in this test and would therefore not be distinguished from MRSA. **For *S. saprophyticus* there is very little data for resistant *mecA* strains.** With penicillin check for a heaped zone edge which indicates β-lactamase mediated resistance.
Cefoxitin *Staphylococcus aureus* (Screen)	4	-	-	10	21	-	22	
Cefoxitin *S. saprophyticus* (Screen)	-	-	-	10	**19**	**-**	**20**	
Cefoxitin coagulase-negative staphylococci (Screen)	4			10	21	22-26	27	
Oxacillin (Screen)	2			1	14	-	15	
Penicillin	0.12	-	0.12	1 unit	24	-	25	

Table 10. MIC and zone diameter breakpoints for staphylococci								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Quinolones								
Ciprofloxacin	1	-	1	1	13	-	14	MIC breakpoints relate to high-dose therapy (750 mg BD).
Ciprofloxacin UTI[1-3] *Staphylococcus saprophyticus*	1	-	1	1	17	-	18	
Moxifloxacin	1	1	0.5	1	15	16-19	20	
Ofloxacin	1	-	1	5	27	-	28	
Glycopeptides								
Teicoplanin *Staphylococcus aureus*	2	-	2	-	-	-	-	Disc diffusion for staphylococci does not give reliable results. An MIC method should be used to determine susceptibility, positive results requiring confirmation. Population analysis is the most reliable method for confirming resistance and for distinguishing susceptible, hetero-GISA and GISA isolates. If, on clinical grounds, resistance to vancomycin is suspected, it is recommended that the organism be sent to a specialist laboratory, such as Southmead Hospital in Bristol[1] or the Antibiotic Research Laboratory in Cardiff[2]. (http://www.bsac.org.uk/Resources/BSAC/Use%20of%20gradient%20tests.pdf)
Teicoplanin Coagulase negative staphylococci	4	-	4	-	-	-	-	
Vancomycin *Staphylococcus aureus*	2	-	2	-	-	-	-	
Vancomycin Coagulase negative staphylococci	**4**	-	**4**	-	-	-	-	
Macrolides, lincosamides and streptogramins								
Azithromycin	2	2	1	15	19	-	20	The zone diameter breakpoint relates to an MIC of 1 mg/l as no data for the intermediate category are currently available.
Clarithromycin	2	2	1	2	14	15-17	18	

Table 10. MIC and zone diameter breakpoints for staphylococci								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Macrolides, lincosamides and streptogramins cont.								
Clindamycin	0.5	0.5	0.25	2	22	23-25	26	Erythromycin can be used to determine the susceptibility to azithromycin, clarithromycin and roxithromycin. Organisms that appear resistant to erythromycin, but susceptible to clindamycin should be checked for the presence of inducible resistance (see http://www.bsac.org.uk/Resources/BSAC/Testing_for_dissociated_resistance_in_staphylococc12.pdf. Inducible clindamycin resistance can be detected only in the presence of a macrolide antibiotic. **If positive, report as resistant to clindamycin or report as susceptible with a warning that clinical failure during treatment with clindamycin may occur by selection of constitutively resistant mutants and the use of clindamycin best avoided in severe infection.**
Erythromycin	2	2	1	5	16	17-19	20	
Quinupristin-dalfopristin	2	2	1	15	18	19-21	22	The presence of blood has a marked effect on the activity of Quinupristin-dalfopristin. On the rare occasions when blood needs to be added to enhance the growth of staphylococci, susceptible ≥15 mm, resistant ≤14 mm.

Table 10. MIC and zone diameter breakpoints for staphylococci								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Tetracyclines								
Doxycycline	2	2	1	30	30	-	31	The zone diameter breakpoint relates to an MIC of 1 mg/l as no data for the intermediate category are currently available.
Minocycline	1	1	0.5	30	27	-	28	The zone diameter breakpoint relates to an MIC of 0.5 mg/l as no data for the intermediate category are currently available.
Tetracycline	2	2	1	10	19	-	20	The zone diameter breakpoint relates to an MIC of 1 mg/l as no data for the intermediate category are currently available. Staphylococci susceptible to tetracycline are also susceptible to doxycycline and minocycline. Some staphylococci resistant to tetracycline may be susceptible to minocycline and doxycycline.
Tigecycline	0.5	-	0.5	15	25	-	26	Strains with MIC values above the susceptible breakpoint are very rare or not yet reported. The identification and antimicrobial susceptibility tests on any such isolate must be repeated and if the result is confirmed the isolate must be sent to a reference laboratory. Until there is further evidence regarding clinical response for confirmed isolates with MIC above the current resistant breakpoint they should be reported as resistant.

Table 10. MIC and zone diameter breakpoints for staphylococci								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Miscellaneous antibiotics								
Daptomycin	1	-	1	-	-	-	-	Strains with MIC values above the susceptible breakpoint are very rare or not yet reported. The identification and antimicrobial susceptibility tests on any such isolate must be repeated and if the result is confirmed the isolate sent to a reference laboratory. Until there is evidence regarding the clinical response for confirmed isolates with MIC above the current resistant breakpoint they should be reported resistant. Susceptibility testing by disc diffusion is not reliable. Susceptibility should be determined using a broth dilution method with Mueller Hinton broth or by an MIC method on Mueller Hinton agar.
Chloramphenicol	8	-	8	10	14	-	15	
Co-trimoxazole	4	4	2	1.25/23.75	13	14-16	17	For advice on testing susceptibility to co-trimoxazole see Appendix 1. The MIC breakpoint is based on the trimethoprim concentration in a 1:19 combination with sulfamethoxazole.
Trimethoprim	1	-	1	5	19	-	20	Breakpoints are epidemiological “cut-offs” based on distributions for the “wild type” population. However, there is no clear evidence correlating these breakpoints with clinical efficacy.
Trimethoprim UTI[1-3] *Staphylococcus saprophyticus*	4	4	2	2.5	12	13-14	15	
Fosfomycin (IV)	32	-	32	200/50	33	-	34	Disc content indicates 200 μg fosfomycin/50 μg glucose-6-phosphate
Fusidic acid	1	-	1	10	29	-	30	
Linezolid	4	-	4	10	19	-	20	

Table 10. MIC and zone diameter breakpoints for staphylococci								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Miscellaneous antibiotics cont.								
Mupirocin	256	2-256	1	20	6	7-26	27	
Nitrofurantoin UTI[1-3] *Staphylococcus saprophyticus*	64	-	64	200	19	-	20	
Rifampicin	0.5	0.12-0.5	0.06	2	23	24-29	30	

[1] = Department of Microbiology, Lime Walk Building, Southmead Hospital Westbury–on-Trym, Bristol, BS10 5NB.

[2] = Public Health Wales, Microbiology Cardiff, University Hospital of Wales, Heath Park, Cardiff, CF14 4XW.

Table 11. MIC and zone diameter breakpoints for *Streptococcus pneumoniae*

Table 11. MIC and zone diameter breakpoints for *Streptococcus pneumoniae*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Most MIC values for penicillin, ampicillin, amoxicillin and piperacillin (with or without a β-lactamase inhibitor) differ by no more than one dilution step and isolates fully susceptible to benzlpenicillin (MIC ≤0.06 mg/L; susceptible by oxacillin disc screen) can be reported susceptible to β-lactam agents that have been given breakpoints.								
Penicillins								Reduced susceptibility to penicillin in *Streptococcus pneumoniae* is most reliably detected with an oxacillin 1 μg disc; confirm resistance with a penicillin MIC determination. Infections with organisms with a penicillin MIC ≤ 2mg/L may be effectively treated if adequate doses are used except in infections of the central nervous system. In addition, cefotaxime or ceftriaxone MIC determination is advised for isolates from meningitis or other invasive infections. Isolates categorised as susceptible with the oxacillin 1 μg disc can be reported susceptible to cefepime, cefotaxime, cefpodoxime, ceftriaxone, cefuroxime ± axetil and cefaclor. Isolates with MIC values above the S/I breakpoint for cefotaxime or ceftriaxone are very rare. The identification and antimicrobial susceptibility tests on any such isolate must be repeated and if the result is confirmed the isolate sent to a reference laboratory. Until there is evidence regarding clinical response for confirmed isolates with MIC above the current resistant breakpoint they should be reported resistant.
Penicillin	2	0.12-2	0.06	Oxacillin1	10	11-19	20	
Cephalosporins								
Cefaclor	0.5	0.06-0.5	0.03	-	-	-	-	
Cefotaxime	2	1-2	0.5	-	-	-	-	
Cefpodoxime	0.5	0.5	0.25	-	-	-	-	
Ceftriaxone	2	1-2	0.5	-	-	-	-	
Cefuroxime	1	1	0.5	-	-	-	-	

Table 11. MIC and zone diameter breakpoints for *Streptococcus pneumoniae*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Carbapenems								
Ertapenem	0.5	-	0.5	-	-	-	-	Screen for β-lactam resistance with the oxacillin 1 μg disc. Isolates categorised as susceptible can be reported susceptible for ertapenem, imipenem and meropenem. Meropenem is the only carbapenem used for meningitis. For use in meningitis determine the meropenem MIC value. Isolates with MIC values above the S/I breakpoint are very rare or not yet reported. The identification and antimicrobial susceptibility tests on any such isolate must be repeated and if the result is confirmed the isolate sent to a reference laboratory. Until there is evidence regarding clinical response for confirmed isolates with MIC above the current resistant breakpoint they should be reported resistant.
Imipenem	2	-	2	-	-	-	-	
Meropenem (Infections other than meningitis)	2	-	2	-	-	-	-	
Meropenem (for meningitis)	**1**	**0.5-1**	**0.25**	-	-	-	-	
Quinolones								
Ciprofloxacin	2	0.25-2	0.12	1	9	10-24	25	"Wild type" isolates (ciprofloxacin MICs 0.25-2 mg/L; ofloxacin MICs 0.25-4 mg/L) are considered intermediate in susceptibility.
Ofloxacin	4	0.25-4	0.12	5	15	16-27	28	
Levofloxacin	2	-	2	1	9	-	10	
Moxifloxacin	0.5	-	0.5	1	17	-	18	
Glycopeptides								
Vancomycin	2	-	2	5	12	-	13	

Table 11. MIC and zone diameter breakpoints for *Streptococcus pneumoniae*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Tetracyclines								
Tetracycline	2	2	1	10	19	-	20	The zone diameter breakpoint relates to an MIC of 1 mg/l as no data for the intermediate category are currently available. Isolates susceptible to tetracycline are also susceptible to doxycycline and minocycline. Some isolates resistant to tetracycline may be susceptible to minocycline and /or doxycycline.
Macrolides, lincosamides and streptogramins								
Azithromycin	0.5	0.5	0.25	15	19	20-21	22	
Clarithromycin	0.5	0.5	0.25	2	19	20-21	22	
Erythromycin	0.5	0.5	0.25	5	19	20-21	22	Erythromycin can be used to determine susceptibility to azithromycin, clarithromycin and roxithromycin.
Telithromycin	0.5	0.5	0.25	15	28	-	29	No EUCAST breakpoint, BSAC data used. Insufficient data are available to distinguish the intermediate category.
Miscellaneous antibiotics								
Chloramphenicol	8	-	8	10	17	-	18	
Co-trimoxazole	2	2	1	1.25/23.75	16	-	17	For advice on testing susceptibility to co-trimoxazole see Appendix 1. The MIC breakpoint is based on the trimethoprim concentration in a 1:19 combination with sulfamethoxazole.
Linezolid	4	**4**	**2**	10	19	-	20	**Zone diameter breakpoint relates to an MIC of 2 mg/L as no data for the intermediate category are currently available.**
Rifampicin	0.5	0.12-0.5	0.06	5	20	21-22	23	

Table 12. MIC and zone diameter breakpoints for enterococci

Comments 1-3 relate to urinary tract infections (UTIs) only.
[1] UTI recommendations are for organisms associated with uncomplicated urinary tract infections only. For complicated urinary tract infections, systemic recommendations should be used.
[2] If an organism is isolated from multiple sites, for example from blood and urine, interpretation of susceptibility should be made with regard to the systemic site (e.g., if the blood isolate is resistant and the urine isolate susceptible, both should be reported resistant irrespective of the results obtained using interpretative criteria for urine isolates).
[3] Direct susceptibility tests on urine samples may be interpreted only if the inoculum gives semi-confluent growth.
NB. For isolates from endocarditis the MIC should be determined and interpreted according to national endocarditis guidelines (Elliott TS et al. Guidelines for the antibiotic treatment of endocarditis in adults: report of the Working Party of the British Society for Antimicrobial Chemotherapy. J Antimicrob Chemother. 2004; **54**: 971-81).

Table 12. MIC and zone diameter breakpoints for enterococci

	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Aminoglycosides								
Gentamicin	128	-	128	200	14	-	15	High-level gentamicin-resistant enterococci usually give no zone or only a trace of inhibition around gentamicin 200 μg discs. Occasionally, however, the plasmid carrying the resistance gene may be unstable and the resistance is seen as a zone of inhibition with a few small colonies within the zone. Retesting of resistant colonies results in growth to the disc or increased numbers of colonies within the zone. Zones should be carefully examined to avoid missing such resistant organisms. If in doubt, isolates may be sent to a reference laboratory for confirmation.
Streptomycin	128	-	128	300	23	-	24	The EUCAST breakpoint is 512 mg/L tested on Mueller- Hinton agar which correlates with the MIC breakpoint of 128 mg/L on Iso-Sensitest agar and the zone criteria given.
Penicillins								
Ampicillin	8	8	4	10	19	-	20	The MIC breakpoint has changed but a review of the data indicates that no adjustment of the zone diameter breakpoints is necessary. Co-amoxiclav susceptibility can be inferred from the ampicillin result.
Carbapenems								
Imipenem	8	8	4	10	16	17-18	19	Recommendations for *E. faecalis* only.

Table 12. MIC and zone diameter breakpoints for enterococci								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Glycopeptides								
Teicoplanin	2	-	2	30	19	-	20	To ensure that microcolonies indicating reduced susceptibility to the glycopeptides are detected, it is essential that plates are incubated for at least 24 h before reporting a strain as susceptible to vancomycin or teicoplanin.
Vancomycin	4	-	4	5	12	-	13	
Macrolides, lincosamides and streptogramins								
Quinupristin-dalfopristin	4	2-4	1	15	11	12-19	20	Generally, *E. faecalis* are intermediate or resistant and *E. faecium* are susceptible. The presence of blood has a marked effect on the activity of quinupristin-dalfopristin. On the rare occasions when blood needs to be added to enhance the growth of enterococci, breakpoints are ≥15 mm, ≤14 mm.
Tetracyclines								
Tigecycline	0.5	0.5	0.25	15	20	-	21	Isolates with MIC values above the susceptible breakpoint are very rare or not yet reported, so there is no intermediate category for disc diffusion. The identification and antimicrobial susceptibility tests on any such isolate must be repeated and if the result is confirmed the isolate must be sent to a reference laboratory. Until there is evidence regarding clinical response for confirmed isolates with MIC above the current resistant breakpoint they should be reported resistant.
Miscellaneous antibiotics								
Linezolid	4	-	4	10	19	-	20	
Nitrofurantoin UTI[1-3]	64	-	64	200	19	-	20	
Trimethoprim UTI[1-3]	1	0.06-1	0.03	2.5	21	22-50	>50	There is some doubt about the clinical relevance of testing the susceptibility of enterococci to trimethoprim. The breakpoints have been set to interpret all enterococci as intermediate.

Table 13. MIC and zone diameter breakpoints for α-haemolytic streptococci

N.B. For isolates from endocarditis the MIC should be determined and interpreted according to national endocarditis guidelines (Elliott TS et al. Guidelines for the antibiotic treatment of endocarditis in adults: report of the Working Party of the British Society for Antimicrobial Chemotherapy. J Antimicrob Chemother. 2004; **54**: 971-81).

Table 13. MIC and zone diameter breakpoints for α-haemolytic streptococci

	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Penicillins								
Amoxicillin	2	1-2	0.5	2	14	15-23	24	
Penicillin	2	0.5-2	0.25	1 unit	10	11-16	17	
Cephalosporins								
Cefotaxime	0.5	-	0.5	5	22	-	23	
Glycopeptides								
Teicoplanin	2	-	2	30	15	-	16	
Vancomycin	2	-	2	5	13	-	14	
Macrolides, lincosamides and streptogramins								
Clindamycin	0.5	-	0.5	2	19	-	20	Organisms that appear resistant to erythromycin, but susceptible to clindamycin should be checked for the presence of inducible MLS_B resistance (see http://www.bsac.org.uk/Resources/BSAC/Testing_for_dissociated_resistance_in_staphylococc12.pdf). Inducible clindamycin resistance can be detected only in the presence of a macrolide antibiotic. **If positive, report as susceptible to clindamycin with a warning that resistance may develop during treatment.** No EUCAST MIC breakpoint for erythromycin as there is insufficient clinical evidence. BSAC data used.
Erythromycin	2	-	2	5	19	-	20	
Miscellaneous antibiotics								
Linezolid	2	-	2	10	19	-	20	No EUCAST MIC breakpoint as there is insufficient clinical evidence. BSAC data used.

Table 14. MIC and zone diameter breakpoints for β-haemolytic streptococci

Comments 1-3 relate to urinary tract infections (UTIs) only.
[1] UTI recommendations are for organisms associated with uncomplicated urinary tract infections only. For complicated urinary tract infections and infections systemic recommendations should be used.
[2] If an organism is isolated from multiple sites, for example from blood and urine, interpretation of susceptibility should be made with regard to the systemic site (e.g., if the blood isolate is resistant and the urine isolate susceptible, both should be reported resistant irrespective of the results obtained using interpretative criteria for urine isolates).
[3] Direct susceptibility tests on urine samples may be interpreted only if the inoculum gives semi-confluent growth.

Table 14. MIC and zone diameter breakpoints for β-haemolytic streptococci								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Penicillins								
Penicillin	0.25	-	0.25	1 unit	19	-	20	Susceptibility to other penicillins, carbapenems and cephalosporins can be inferred from the penicillin result.
Macrolides, lincosamides and streptogramins								
Azithromycin	0.5	0.5	0.25	15	19	20-21	22	
Clarithromycin	0.5	0.5	0.25	2	19	20-21	22	
Clindamycin	0.5	-	0.5	2	16	-	17	Organisms that appear resistant to erythromycin, but susceptible to clindamycin should be checked for the presence of inducible MLS_B resistance (see http://www.bsac.org.uk/Resources/BSAC/Testing_for_dissociated_resistance_in_staphylococc12.pdf). **If positive, report as susceptible to clindamycin with a warning that resistance may develop during treatment.**
Erythromycin	0.5	0.5	0.25	5	19	20-21	22	
Telithromycin	0.5	0.5	0.25	15	25	-	26	Zone diameter breakpoints relate to the "wild type" susceptible population as no data are available for the non-susceptible population.

Table 14. MIC and zone diameter breakpoints for β-haemolytic streptococci								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Tetracyclines								
Tetracycline	2	1	1	10	19	-	20	Isolates susceptible to tetracycline are also susceptible to doxycycline and minocycline. Some isolates resistant to tetracycline may be susceptible to minocycline and/or doxycycline.
Tigecycline	0.5	0.5	0.25	15	19	20-24	25	Strains with MIC values above the susceptible breakpoint are very rare or not yet reported. The identification and antimicrobial susceptibility tests on any such isolate must be repeated and if the result is confirmed the isolate must be sent to a reference laboratory. Until there is evidence regarding clinical response for confirmed isolates with MIC above the current resistant breakpoint they should be reported resistant.
Miscellaneous antibiotics								
Co-trimoxazole	2	2	1	1.25/23.75	16	17-19	20	For advice on testing susceptibility to co-trimoxazole see Appendix 1. The MIC breakpoint is based on the trimethoprim concentration in a 1:19 combination with Sulfamethoxazole.
Trimethoprim UTI [1-3] Group B streptococci	**2**	**-**	**2**	**2.5**	**15**	**-**	**16**	
Daptomycin	1	-	1	-	-	-	-	Strains with MIC values above the susceptible breakpoint are very rare or not yet reported. The identification and antimicrobial susceptibility tests on any such isolate must be repeated and if the result is confirmed the isolate sent to a reference laboratory. Until there is evidence regarding the clinical response for confirmed isolates with MIC above the current resistant breakpoint they should be reported resistant. No zone diameter breakpoints are given because disc diffusion susceptibility testing is unreliable.

Table 14. MIC and zone diameter breakpoints for β-haemolytic streptococci								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Miscellaneous antibiotics cont.								
Linezolid	4	4	2	10	19	-	20	Zone diameter breakpoints relate to the MIC breakpoint of 2 mg/L as no data for the intermediate category are currently available.
Nitrofurantoin UTI[1-3] Group B Streptococci	64	-	64	200	18	-	19	

Table 15. MIC and zone diameter breakpoints for *Moraxella catarrhalis*

Table 15. MIC and zone diameter breakpoints for *Moraxella catarrhalis*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Penicillins								
Ampicillin	-	-	-	-	-	-	-	Resistance to ampicillin by production of β-lactamase (BRO-1/2 β-lactamase) may be misidentified by disk diffusion technique and, because β-lactamase production is slow, may give weak results with *in vitro* tests. Since >90% of *M. catarrhalis* strains produce β-lactamase, testing of penicillinase production is discouraged and isolates reported resistant to ampicillin and amoxicillin.
Co-amoxiclav	1	-	1	2/1	18	-	19	
Cephalosporins								
Cefaclor	**0.12**	**-**	**0.12**	30	**37**	**-**	**38**	**MIC breakpoints render all *M. catarrhalis* resistant to cefaclor.**
Cefuroxime	**8**	**8**	**4**	5	**16**	-	**17**	Zone diameter breakpoints relate to the MIC breakpoint of 4 mg//L as no data for the intermediate category are currently available.
Cefuroxime axetil	**4**	**0.25-4**	**0.12**	5	**16**	**17-34**	**35**	
Carbapenems								
Ertapenem	0.5	-	0.5	10	34	-	35	
Quinolones								
Ciprofloxacin	0.5	-	0.5	1	17	-	18	Quinolone resistance is most reliably detected with nalidixic acid discs.
Levofloxacin	1	-	1	1	19	-	20	
Moxifloxacin	0.5	-	0.5	1	17	-	18	
Nalidixic acid **(Screen)**	-	-	-	30	**17**	**-**	**18**	
Ofloxacin	0.5	-	0.5	5	34	-	35	
Macrolides, lincosamides and streptogramins								
Clarithromycin	0.5	0.5	0.25	2	19	20-21	22	
Erythromycin	0.5	0.5	0.25	5	27	-	28	Zone diameter breakpoints relate to the MIC breakpoint of 0.25 mg/L as no data for the intermediate category are currently available. Erythromycin can be used to determine susceptibility to azithromycin and clarithromycin.

Table 15. MIC and zone diameter breakpoints for *Moraxella catarrhalis*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Macrolides, lincosamides and streptogramins cont.								
Telithromycin	0.5	0.5	0.25	15	29	-	30	
Tetracyclines								
Tetracycline	2	2	1	10	21	-	22	No disc diffusion data to distinguish the intermediate category available at present. Isolates susceptible to tetracycline are also susceptible to doxycycline and minocycline. Some isolates resistant to tetracycline may be susceptible to minocycline and/or doxycycline.
Miscellaneous antibiotics								
Chloramphenicol	2	**-**	**2**	10	**29**	**-**	**30**	**Breakpoints relate to the topical use of chloramphenicol.**
Co-trimoxazole	1	1	0.5	1.25/23.75	11	-	12	For advice on testing susceptibility to co-trimoxazole, see Appendix 1. The MIC breakpoint is based on the trimethoprim concentration in a 1:19 combination with sulfamethoxazole.

Table 16. MIC and zone diameter breakpoints for *Neisseria gonorrhoeae*

Table 16. MIC and zone diameter breakpoints for *Neisseria gonorrhoeae*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Penicillins								
Penicillin	1	0.12	0.06	1 unit	17	18-25	26	Always test for β-lactamase.
Cephalosporins								
Cefixime	0.12	-	0.12	5	34	-	35	Results for isolates with reduced zones around ceftriaxone, cefotaxime and cefixime discs should be confirmed by MIC determinations. Although cefuroxime is not recommended for clinical use, it can be used as an indicator antibiotic to detect reduced susceptibility to other oxyimino cephalosporin.
Cefotaxime	0.12	-	0.12	5	29	-	30	
Ceftriaxone	0.12	-	0.12	5	34	-	35	
Cefuroxime (Screen)	-	-	-	5	19	-	20	
Quinolones								
Ciprofloxacin	0.06	0.06	0.03	1	28	-	29	For ciprofloxacin the zone diameter breakpoints relate to the MIC breakpoint of 0.03mg/L as no data for the intermediate category are currently available. Quinolone resistance is generally reliably detected with nalidixic acid; however there are a few isolates that are resistant to ciprofloxacin yet susceptible to nalidixic acid in disc diffusion tests. The mechanism of resistance and the prevalence of these isolates in the UK is still under investigation. Isolates with reduced susceptibility to fluoroquinolones normally have no zone of inhibition with a 30 μg nalidixic acid disc. For organisms with nalidixic acid zone diameters 10-31 mm a ciprofloxacin MIC should be determined if the patient is to be treated with this agent.
Nalidixic acid	-	-	-	30	9	10-31	32	
Macrolides, lincosamides and streptogramins								
Azithromycin	0.5	0.5	0.25	15	27	-	28	Zone diameter breakpoints relate to the MIC breakpoints of >0.5 mg/L as disc diffusion testing will not reliably differentiate between the intermediate and susceptible populations.
Tetracyclines								
Tetracycline	1	1	0.5	10	26	27-31	32	The tetracycline result may be used to infer susceptibility to doxycycline. **Isolates susceptible to tetracycline are also susceptible to minocycline, but some isolates resistant to tetracycline may be susceptible to**

Table 16. MIC and zone diameter breakpoints for *Neisseria gonorrhoeae*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
								minocycline.
Miscellaneous antibiotics								
Spectinomycin	64	-	64	25	13	-	14	

Table 17. MIC and zone diameter breakpoints for *Neisseria meningitidis*

Table 17. MIC and zone diameter breakpoints for *Neisseria meningitidis*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Penicillins								
Ampicillin	-	-	-	2	31	-	32	Ampicillin and amoxicillin are used as indicator antibiotics to detect reduced susceptibility to penicillin. The recommendations given are for this purpose only; ampicillin and amoxicillin should not be used therapeutically. EUCAST MIC breakpoints are S ≤ 0.12 mg/L, R > 1 mg/L. Currently there are no BSAC MIC breakpoints and zone diameter breakpoints relating to the presence of specific mutations in the *penA* gene.
Amoxicillin	-	-	-	2	29	-	30	
Penicillin	0.25	0.12-0.25	0.06	1 unit	14	15-28	29	
Cephalosporins								
Cefotaxime	0.12	-	0.12	5	39	-	40	
Ceftriaxone	0.12	-	0.12	5	39	-	40	
Quinolones								
Ciprofloxacin	0.06	0.06	0.03	1	31	-	32	Quinolone resistance is most reliably detected in tests with nalidixic acid. Isolates with reduced susceptibility to fluoroquinolones have no zone of inhibition with 30 μg nalidixic acid discs. Zone diameter breakpoints relate to the MIC breakpoint of 0.03 mg/L as no data for the intermediate category are currently available.
Miscellaneous antibiotics								
Chloramphenicol	4	4	2	10	19	-	20	Zone diameter breakpoints relate to the MIC breakpoint of 2 mg/L as insufficient data to distinguish the intermediate category are currently available.
Rifampicin	0.25	-	0.25	2	29	-	30	Epidemiological breakpoint based on an MIC breakpoint of 0.25 mg/L.

Table 18. MIC and zone diameter breakpoints for *Haemophilus influenzae*

Table 18. MIC and zone diameter breakpoints for *Haemophilus influenzae*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Penicillins								
Amoxicillin	**2**	-	**2**	2	**13**	**-**	**14**	Always test for β-lactamase; β-lactamase positive isolates should be reported resistant **Breakpoints apply to** β-lactamase **negative isolates only.** Strains may be resistant to penicillins, aminopenicillins and/or cephalosporins due to changes in PBPs (BLNAR, β-lactamase negative ampicillin resistant) and a few strains have both resistance mechanisms (BLPACR, β-lactamase positive, amoxicillin-clavulanate resistant). Isolates susceptible to ampicillin/amoxicillin are also susceptible to piperacillin and piperacillin-tazobactam and isolates susceptible to amoxicillin-clavulanate are also susceptible to piperacillin-tazobactam. Susceptibility to amoxicillin can be inferred from ampicillin.
Ampicillin	1	-	1	2	17	-	18	
Co-amoxiclav	**2**	-	**2**	2/1	**13**	**-**	**14**	
Cephalosporins								
Cefaclor	0.5	-	0.5	30	14	-	15	See Appendix 2. MIC breakpoints render most *H. influenzae* resistant for cefaclor. The disc diffusion test can be used to screen for BLNAR. Isolates with zone diameters<15 mm should be checked for ampicillin and cephalosporin resistance.

Table 18. MIC and zone diameter breakpoints for *Haemophilus influenzae*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Cephalosporins cont.								
Cefotaxime	0.12	-	0.12	5	24	-	25	
Ceftriaxone	0.12	-	0.12	30	24	-	25	
Cefuroxime	2	-	1	5	16	-	17	Zone diameter breakpoints relate to the MIC breakpoint of 1 mg//L as no data for the intermediate category are currently available.
Carbapenems								
Ertapenem	0.5	-	0.5	10	32	-	33	Meropenem is the only carbapenem used for meningitis. For use in meningitis determine the MIC value.
Imipenem	2	-	2	10	22	-	23	
Meropenem **(Infection other than meningitis)**	2	-	2	10	22	-	23	
Meropenem (Meningitis)	**1**	**0.5-1**	**0.25**	-	-	-	-	
Quinolones								
Ciprofloxacin	0.5	-	0.5	1	27	-	28	Quinolone resistance is most reliably detected in tests with nalidixic acid. Strains with reduced susceptibility to fluoroquinolones give no zone of inhibition with a 30μg nalidixic acid disc.
Levofloxacin	1	-	1	1	19	-	20	
Moxifloxacin	0.5	-	0.5	1	17	-	18	
Nalidixic acid	-	-	-	30	-	-	-	
Ofloxacin	0.5	-	0.5	5	26	-	37	
Macrolides, lincosamides and streptogramins								
Azithromycin	4	-	-	15	19	-	-	Correlation between macrolide MICs and clinical outcome is weak for *H. influenzae*. Therefore, breakpoints for macrolides and related antibiotics have been set to categorize "wild type" *H. influenzae* as intermediate. Erythromycin can be used to determine susceptibility to azithromycin and clarithromycin.
Clarithromycin	32	-	-	5	8	-	-	
Erythromycin	16	-	-	5	14	-	-	
Telithromycin	8	-	-	15	15	-	-	
Tetracyclines								
Tetracycline	2	2	1	10	17	18-21	22	Isolates susceptible to tetracycline are also susceptible to doxycycline and minocycline. Some isolates resistant to tetracycline may be susceptible to minocycline and/or doxycycline.

Table 18. MIC and zone diameter breakpoints for *Haemophilus influenzae*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Miscellaneous antibiotics								
Chloramphenicol	**2**	**-**	**2**	10	24	-	25	**The breakpoints have changed but a review of the data indicates that no adjustment of the zone diameter breakpoint is necessary.**
Co-trimoxazole	1	1	0.5	25	17	18-20	21	For advice on testing susceptibility to co-trimoxazole see Appendix 1. The MIC breakpoint is based on the trimethoprim concentration in a 1:19 combination with sulfamethoxazole.

Table 19. MIC and zone diameter breakpoints for *Pasteurella multocida*

	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Penicillins								
Ampicillin	1	-	1	10	29	-	30	
Penicillin	0.12	-	0.12	1 unit	21	-	22	
Cephalosporins								
Cefotaxime	1	-	1	5	33	-	34	
Quinolones								
Ciprofloxacin	1	-	1	1	28	-	29	Quinolone resistance is most reliably detected in tests with nalidixic acid discs.
Nalidixic acid	-	-	-	30	27	-	28	
Tetracyclines								
Tetracycline	1	-	1	10	25	-	26	

Table 20. MIC and zone diameter breakpoints for *Campylobacter* spp.

	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Quinolones								
Ciprofloxacin	1	1	0.5	1	**25**	**-**	**26**	Quinolone resistance is most reliably detected in tests with nalidixic acid discs. The zone diameters for ciprofloxacin relate to an MIC breakpoint of 0.5 mg/L as no data for the intermediate category are currently available.
Nalidixic acid	-	-	-	30	**19**	**-**	**20**	
Macrolides, lincosamides and streptogramins								
Erythromycin	**4**	**-**	**4**	5	**21**	-	22	**The susceptibility of clarithromycin can be inferred from the erythromycin result.**

Table 21. MIC and zone diameter breakpoints for Coryneform organisms

	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Penicillins								
Penicillin	0.12	-	0.12	1 unit	19	-	20	
Quinolones								
Ciprofloxacin	1	1	0.5	1	11	12-16	17	The zone diameters relate to an MIC breakpoint of 0.5 mg/L as no data for the intermediate category are currently available.
Glycopeptides								
Vancomycin	8	8	4	5	19	-	20	The zone diameters relate to an MIC breakpoint of 4 mg/L as no data for the intermediate category are currently available.

Table 22. MIC and zone diameter breakpoints for Gram-negative anaerobes

Table 22. MIC and zone diameter breakpoints for Gram-negative anaerobes								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Penicillins								
Ampicillin	2	1-2	0.5	-	-	-	-	
Amoxicillin	2	1-2	0.5	-	-	-	-	
Co-amoxiclav	8	8	4	30	20	21-28	29	Zone diameter breakpoints are for *B. fragilis* only.
Penicillin	0.5	-	0.25	-	-	-	-	Susceptibility to ampicillin, amoxicillin and piperacillin ± tazobactam can be inferred from the susceptibility to penicillin. *B. fragilis* is inherently resistant to penicillin.
Piperacillin	16	-	16	-	-	-	-	
Piperacillin-tazobactam	16	16	8	75/10	26	-	27	Zone diameter breakpoints are for *B. fragilis* only. The breakpoints are based on the "wild type" susceptible population as there are few clinical data relating MIC to outcome. Organisms that appear resistant in disc diffusion tests should have resistance confirmed by MIC determination and resistant isolates should be sent to the Anaerobe Reference Laboratory in Cardiff. The zone diameter breakpoint relates to an MIC of 8 mg/L as no data for the intermediate category are currently available.
Ticarcillin	16	-	16	-	-	-	-	
Ticarcillin-clavulanate	16	16	8	-	-	-	-	
Carbapenems								
Doripenem	1	-	1	-	-	-	-	
Ertapenem	1	-	1	-	-	-	-	
Imipenem	8	4-8	2	-	-	-	-	
Meropenem	8	4-8	2	10	18	19-25	26	Zone diameter breakpoints are for *B. fragilis* and *B. thetaiotaomicron* only.

Table 22. MIC and zone diameter breakpoints for Gram-negative anaerobes								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Macrolides, lincosamides and streptogramins								
Clindamycin	4	-	4	2	9	-	10	Zone diameter breakpoints are for *B. fragilis* and *B. thetaiotaomicron* only. The breakpoints are based on the "wild type" susceptible population as there are few clinical data relating MIC to outcome. Organisms that appear resistant in disc diffusion tests should heave resistance confirmed by MIC determination and resistant isolates should be sent to the Anaerobe Reference Laboratory in Cardiff.
Miscellaneous antibiotics								
Chloramphenicol	8	-	8	-	-	-	-	
Metronidazole	4	-	4	5	17	-	18	Zone diameter breakpoints are for *B. fragilis* and *B. thetaiotaomicron* only.

Table 23. MIC and zone diameter breakpoints for Gram-positive anaerobes except *Clostridium difficile*

Table 23. MIC and zone diameter breakpoints for Gram-positive anaerobes except *Clostridium difficile*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Penicillins								
Ampicillin	8	8	4	-	-	-	-	
Amoxicillin	8	8	4	-	-	-	-	
Co-amoxiclav	8	8	4	30	31	-	32	The zone diameter breakpoints are for *C. perfringens* only. The zone diameter breakpoint relates to an MIC of 4 mg/L as no data for the intermediate category are currently available.
Penicillin	0.5	0.5	0.25	1 unit	22	-	23	The zone diameter breakpoints are for *C. perfringens* only. The breakpoints are based on the "wild type" susceptible population as there are few clinical data relating MIC to outcome. Organisms that appear resistant in disc diffusion tests should have resistance confirmed by MIC determination and resistant isolates should be sent to the Anaerobe Reference Laboratory in Cardiff. For penicillin the zone diameter breakpoint relates to an MIC of 0.25 mg/L as no data for the intermediate category are currently available. Susceptibility to ampicillin, amoxicillin and piperacillin ± tazobactam can be inferred from susceptibility to penicillin.

Table 23. MIC and zone diameter breakpoints for Gram-positive anaerobes except *Clostridium difficile*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Penicillins cont.								
Piperacillin	16	16	8	-	-	-	-	
Piperacillin-tazobactam	16	16	8	75/10	29	-	30	The zone diameter breakpoints are for *C. perfringens* only. The breakpoints are based on the "wild type" susceptible population as there are few clinical data relating MIC to outcome. Organisms that appear resistant in disc diffusion tests should have resistance confirmed by MIC determination and resistant isolates should be sent to the Anaerobe Reference Laboratory in Cardiff. For piperacillin-tazobactam the zone diameter breakpoint relates to an MIC of 8 mg/L as no data for the intermediate category are currently available.
Ticarcillin	16	16	8	-	-	-	-	
Ticarcillin-clavulanate	16	16	8	-	-	-	-	
Carbapenems								
Doripenem	1	-	1	-	-	-	-	
Ertapenem	1	-	1	-	-	-	-	
Imipenem	8	4-8	2	-	-	-	-	
Meropenem	8	4-8	2	10	18	19-25	26	Zone diameter breakpoints are for *C. perfringens* only.
Glycopeptides								
Vancomycin	2	-	2	-	-	-	-	

Table 23. MIC and zone diameter breakpoints for Gram-positive anaerobes except *Clostridium difficile*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Macrolides, lincosamides and streptogramins								
Clindamycin	4	-	4	2	9	-	10	Zone diameter breakpoints are for *C. perfringens* only. The breakpoints are based on the "wild type" susceptible population as there are few clinical data relating MIC to outcome. Organisms that appear resistant in disc diffusion tests should heave resistance confirmed by MIC determination and resistant isolates should be sent to the Anaerobe Reference Laboratory in Cardiff.
Miscellaneous antibiotics								
Chloramphenicol	8	-	8	-	-	-	-	
Metronidazole	4	-	4	5	17	-	18	Zone diameter breakpoints are for *C. perfringens* only. There is no evidence for changing the epidemiological zone diameter breakpoint in line with the change in MIC breakpoint.

Table 24. MIC and zone diameter breakpoints for *Clostridium difficile*

Table 24. MIC and zone diameter breakpoints for *Clostridium difficile*								
	MIC breakpoint (mg/L)				Interpretation of zone diameters (mm)			
Antibiotic	R >	I	S ≤	Disc content (μg)	R ≤	I	S ≥	Comment
Daptomycin	**4**	**-**	**-**	**-**	**-**	**-**	**-**	**Not used clinically. May be tested for epidemiological purposes only. MIC breakpoint based on the ECOFF for the "wild type" population.**
Fusidic acid	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**Not used clinically. May be tested for epidemiological purposes only. MIC breakpoint based on the ECOFF for the "wild type" population.**
Metronidazole	**2**	**-**	**2**	**-**	**-**	**-**	**-**	**The breakpoints are based on epidemiological "cut-off" values (ECOFFs) which distinguish "wild-type" isolates from those with reduced susceptibility.**
Moxifloxacin	**4**	**-**	**-**	**-**	**-**	**-**	**-**	**Not used clinically. May be tested for epidemiological purposes only. MIC breakpoint based on the ECOFF for the "wild type" population.**
Tigecycline	**0.25**	**-**	**-**	**-**	**-**	**-**	**-**	**Not used clinically. May be tested for epidemiological purposes only. MIC breakpoint based on the ECOFF for the "wild type" population.**
Rifampicin	**0.004**	**-**	**-**	**-**	**-**	**-**	**-**	**Not used clinically. May be tested for epidemiological purposes only. MIC breakpoint based on the ECOFF for the "wild type" population.**
Vancomycin	**2**	**-**	**2**	**-**	**-**	**-**	**-**	**The breakpoints are based on epidemiological "cut-off" values (ECOFFs) which distinguish "wild-type" isolates from those with reduced susceptibility.**

Appendix 1: Advice on testing the susceptibility to co-trimoxazole

Breakpoints for testing susceptibility to co-trimoxazole are provided. However, the following recommendations from the UK Committee on the Safety of Medicines (CSM) should be noted.

”Co-trimoxazole should be limited to the role of drug of choice in *Pneumocyctis carinii* pneumonia, it is also indicated for toxoplasmosis and nocardiasis. It should now only be considered for use in acute exacerbations of chronic bronchitis and infections of the urinary tract when there is good bacteriological evidence of sensitivity to co-trimoxazole and good reason to prefer this combination to a single antibiotic; similarly it should only be used in acute otitis media in children when there is good reason to prefer it. Review of the safety of co-trimoxazole using spontaneous adverse drug reaction data has indicated that the profile of reported adverse reactions with trimethoprim is similar to that with co-trimoxazole; blood and generalised skin disorders are the most serious reactions with both drugs and predominantly have been reported to occur in elderly patients. A recent large post-marketing study has demonstrated that such reactions are very rare with co-trimoxazole; the study did not distinguish between co-trimoxazole and trimethoprim with respect to serious hepatic, renal, blood or skin disorders.”

Appendix 2: Efficacy of cefaclor in the treatment of respiratory infections caused by *Haemophilus influenzae*

Concerns have been expressed, particularly by laboratories moving from Stokes' method to the BSAC disc diffusion method, about the interpretation of susceptibility of *Haemophilus influenzae* to cefaclor. When using Stokes' method the majority of isolates appeared susceptible; but with the BSAC disc diffusion method most isolates are now reported resistant. The following comments explain the BSAC rationale for interpretation of cefaclor susceptibility.

Cefaclor pharmacokinetics
Cefaclor is dosed at 250-500 mg TDS po: 250 mg TDS is probably the most common dose but data is absent to confirm this. The expected C_{max} for 250 mg is 5-10 mg/L and 10-20 mg/l for 500 mg; the half life is 1 h; drug concentration in blood is <1 mg/L at 4 h and the protein binding is 25-50%. Tissue penetration is similar to other β-lactams.

Cefaclor potency against Haemophilus influenzae
Data from the BSAC surveillance programme 2003-2004 (n= 899) indicates that the cefaclor MIC range is 0.12-128 mg/L; MIC_{50} 2 mg/L; MIC_{90} 8 mg/L.

Pharmacodynamics
An average patient with an *Haemophilus influenzae* infection will have a free drug Time>MIC of 25% with 250 mg dosing and 37% with 500 mg dosing. A conservative Time>MIC target for cephalosporins in community practice is 40-50%, but this is not achieved with cefaclor. Therefore, it is likely that cefaclor will have at best borderline activity against *Haemophilus influenzae*.

Conclusion
The pharmacodynamic data indicate that cefaclor has borderline activity against *Haemophilus influenzae*, even for community use. The outcome of infection will be difficult to predict and susceptibility testing is likely to be of limited value.

Acknowledgment

The BSAC acknowledges the assistance of the Swedish Reference Group for Antibiotics (SRGA) in supplying some breakpoint data for inclusion in this document.

References

1. Moosdeen, F., Williams, J.D. & Secker, A. (1988). Standardization of inoculum size for disc susceptibility testing: a preliminary report of a spectrophotometric method. J. Antimicrob Chemother **21**, 439-43.

Additional information

1. Susceptibility testing of *Helicobacter pylori*

Disc diffusion methods are not suitable for testing *Helicobacter pylori* as this species is slow growing and results may not be accurate. The recommended method of susceptibility testing is Etest (follow technical guide instructions).

Suspend colonies from a 2-3 day culture on a blood agar plate in sterile distilled water and adjust the density to equal a McFarland 3 standard.

Use a swab dipped in the suspension to inoculate evenly the entire surface of the plate. The medium of choice is Mueller-Hinton agar or Wilkins-Chalgren agar with 5-10% horse blood.

Allow the plate to dry and apply Etest strip.

Incubate at 35°C in microaerophilic conditions for 3-5 days.
Read the MIC at the point of complete inhibition of all growth, including hazes and isolated colonies. Tentative interpretative criteria for MICs are given in Table 1.

Table 1: **MIC breakpoints for *Helicobacter pylori* based on epidemiological "cut-off" values (ECOFFs), which distinguish "wild-type" isolates from those with reduced susceptibility**

	MIC breakpoint (mg/L)		
Antimicrobial agent	**R >**	**I**	**S ≤**
Amoxicillin	**0.12**	**-**	**0.12**
Clarithromycin	**0.5**	**0.5**	**0.25**
Levofloxacin	**1**	**-**	**1**
Tetracycline	**1**	**-**	**1**
Metronidazole	**8**	**-**	**8**
Rifampicin	**1**	**-**	**1**

2. Susceptibility testing of *Brucella* species

Brucella spp. are Hazard Group 3 pathogens and all work must be done in containment level 3 accommodation. The antimicrobial agents most commonly used for treatment are doxycycline, rifampicin, ciprofloxacin, tetracycline and streptomycin and, from the limited information available, there is little or no resistance to these drugs. *Brucella* spp. are uncommon isolates and interpretative standards are not available. Since *Brucella* spp. are highly infectious, susceptibility testing in routine laboratories is not recommended.

3. Susceptibility testing of *Legionella* species

Legionella spp. are slow growing and have particular growth requirements. Disc diffusion methods for susceptibility testing are unsuitable. Susceptibility should be determined by agar dilution MICs on buffered yeast extract agar with 5% water-lysed horse blood. The antimicrobial agents commonly used for treatment are macrolides, rifampicin and fluoroquinolones. Validated MIC breakpoints are not established for

Legionella spp. If results for test isolates are within range of the normal wild type distribution, given in table 2, clinical susceptibility may be assumed.

Table 2: MIC ranges for wild type *Legionella* spp.

Antimicrobial agent	MIC range for wild-type *Legionella* spp. (mg/L)
Erythromycin	0.06-0.5
Clarithromycin	0.004-0.06
Rifampicin	0.004-0.06
Ciprofloxacin	0.016-0.06

4. Susceptibility testing *Listeria* spp.

For susceptibility testing *Listeria* spp. an MIC determination is advised on Iso-Sensitest agar with incubation at 35-37^{0}C in air. If a gradient method is used the test should be undertaken following the manufacturer's instructions. In Table 3 the MIC ranges and cut offs for "wild type" strains are shown and these can be used as an aid to interpreting susceptibility.

Table 3: MIC ranges for "wild type" *Listeria* spp.

Antimicrobial agent	MIC range (mg/L)	MIC cut off (mg/L)	Comment
Ampicillin	0.12-4	**≤1**	No resistance described
Penicillin	0.015-2	**≤1**	
Meropenem	-	**≤1**	
Daptomycin	1-4	≤4	
Erythromycin	0.12-1	≤1	Resistance very rare ≤ 0.5%
Gentamicin	0.06-1	≤1	
Linezolid	1-4	≤4	
Tetracycline	0.06-1	≤1	Resistance rare 0%
Trimethoprim	0.06-1	≤1	
Co-trimoxazole	**-**	**≤ 0.06**	**The MIC breakpoint is based on the trimethoprim concentration in a 1:19 combination with sulfamethoxazole.** **For advice on testing susceptibility to co-trimoxazole, see Appendix 1.**
Vancomycin	0.5-4	≤4	

5. Susceptibility testing of topical antibiotics

MIC breakpoints specifically for topical antibiotics are not given because there are no pharmacological, pharmacodynamic or clinical response data on which to base recommendations. [Relevant data would be gratefully received].

6. Development of MIC and zone diameter breakpoints

All breakpoints are subject to review in the light of additional data and any data relating to breakpoints, control zone ranges or any other aspect of antimicrobial susceptibility testing would be welcome (contact the Working Party secretary or any member listed at the front of this document).

The BSAC is part of the European Committee on Antimicrobial Susceptibility Testing (EUCAST) and is actively involved in the process of harmonization of MIC breakpoints in Europe. This process will undoubtedly lead to some small breakpoint adjustments, and these will be incorporated into the BSAC method as European breakpoints are agreed.

The BSAC has a mechanism to modify and publish changes to breakpoints on an annual basis via the BSAC www site (www.bsac.org.uk). Any changes will be dated.

Ad hoc modifications to breakpoints by users are not acceptable.

Control of Antimicrobial Susceptibility Testing

1. Control strains

Control strains include susceptible strains to monitor test performance (not for the interpretation of susceptibility), and resistant strains to confirm that the method will detect particular mechanisms of resistance, for example, *Haemophilus influenzae* ATCC 49247 is a β-lactamase negative, ampicillin resistant strain (see table 2 of Disc Diffusion Method). Tables 2-6 provide zone diameters for recommended control organisms under a range of test conditions.

Control strains can be purchased from the National Collection of Type Cultures (NCTC; HPA Centre for Infections, 61 Colindale Avenue, London NW9 5HT). Alternatively, some may be obtained commercially (see section on suppliers)

2. Maintenance of control strains

Store control strains by a method that minimises the risk of mutations, for example, at -70^0C, on beads in glycerol broth. Ideally, two vials of each control strain should be stored, one as an ”in-use” supply, the other for archiving. Every week a bead from the ”in-use” vial should be subcultured on to appropriate non-selective media and checked for purity. From this pure culture, prepare one subculture for each of the following 7 days. Alternatively, for fastidious organisms that will not survive on plates for 7 days, subculture the strain daily for no more than 6 days.

3. Calculation of control ranges for disc diffusion tests

The acceptable ranges for the control strains have been calculated by combining zone diameter data from `field studies' and from multiple centres supplying their daily control data, from which cumulative distributions of zones of inhibition have been prepared. From these distributions, the 2.5 and 97.5 percentiles were read to provide a range that would contain 95% of observations. If distributions are normal, these ranges correspond to the mean $\pm$ 1.96 SD. The percentile ranges obtained by this method are, however, still valid even if the data do not show a normal distribution.

4. Frequency of routine testing with control strains

When the method is first introduced, daily testing is required until there are acceptable readings from 20 consecutive days (this also applies when new agents are introduced or when any test component changes). This provides sufficient data to support once weekly testing.

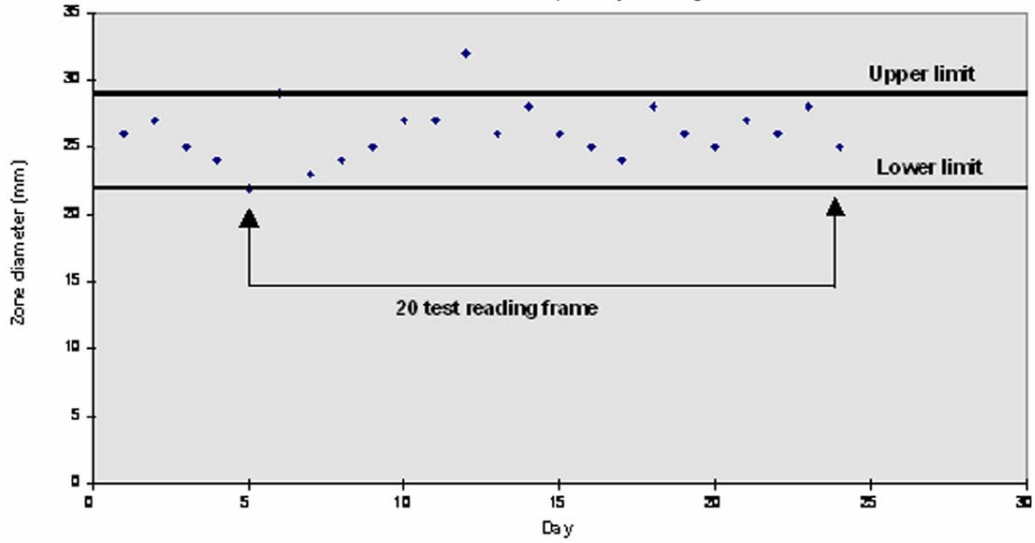
5. Use of control data to monitor the performance of disc diffusion tests

Use a reading frame of 20 consecutive results (remove the oldest result when adding a new one to make a total of 20) as illustrated in Figure 1. Testing is acceptable if no more than1 in every 20 results is outside the limits of acceptability. If 2 or more results fall out of the acceptable range this requires immediate investigation.

Look for trends within the limits of acceptability e.g. tendency for zones to be at the limits of acceptability; tendency for zones to be consistently above or below the mean;

gradual drift in zone diameters. Quality Assurance will often pick up trends before the controls go out of range.

Figure 1. Use of control strain to monitor performance of disc diffusion susceptibility testing.



6. Recognition of atypical results for clinical isolates

Atypical results with clinical isolates may indicate problems in testing that may or may not be reflected in zone diameters with control strains.

An organism with inherent resistance appears susceptible e.g. *Proteus* spp. susceptible to colistin or nitrofurantoin.

Resistance is seen in an organism when resistance has previously not been observed, e.g. penicillin resistance in Group A streptococci.

Resistance is seen in an organism when resistance is rare or has not been seen locally, e.g. vancomycin resistance in *Staphylococcus aureus*.

Incompatible susceptibilities are reported, e.g. a methicillin resistant staphylococcus reported susceptible to a β-lactam antibiotic.

In order to apply such rules related to atypical results it is useful to install an `expert' system for laboratory reporting to avoid erroneous interpretation.

7. Investigation of possible sources of error

If the control values are found to be outside acceptable limits on more than one occasion during a reading frame of twenty tests, investigation into the possible source of error is required. Possible problem areas are indicated in table 1.

Table 1: Potential sources of error in disc diffusion antimicrobial susceptibility testing.

Possible source of error	Detail to check
Test conditions	Excessive pre-incubation before discs applied Excessive pre-diffusion before plates incubated Incorrect incubation temperature Incorrect incubation atmosphere Incorrect incubation time Inadequate illumination of plates when reading Incorrect reading of zone edges
Medium	Required susceptibility testing agar not used Not prepared as required by the manufacturer's instructions Batch to batch variation Antagonists present (e.g. with sulphonamides and trimethoprim) Incorrect pH Incorrect divalent cation concentration Incorrect depth of agar plates Agar plates not level Expiry date exceeded
Antimicrobial discs	Wrong agent or content used Labile agent possibly deteriorated Light sensitive agent left in light Incorrect storage leading to deterioration Disc containers opened before reaching room temperature Incorrect labelling of disc dispensers Expiry date exceeded
Control strains	Contamination Mutation Incorrect inoculum density Uneven inoculation Old culture used

8. Reporting susceptibility results when controls indicate problems

Microbiologists must use a pragmatic approach, as results from repeat testing are not available on the same day. If results with control strains are out of range the implications for test results need to be assessed.

Control results out of range
If control zones are below range but test results are susceptible, or control zones are above range but test results are resistant, investigate possible sources of error but report the test results. Otherwise it may be necessary to suppress reports on affected agents, investigate and retest.

Atypical results
If results are atypical with clinical isolates, the purity of the isolate and identification should be confirmed and the susceptibility repeated. Suppress the results for individual agents and retest.

Table 2: Acceptable zone diameter (mm) ranges for control strains on Iso-Sensitest agar, plates incubated at 35-37 ^{0}C in air for 18-20 h.

Antimicrobial agent	Disc content (μg unless stated)	*Escherichia coli*			*Pseudomonas aeruginosa*		*Staphylococcus aureus*		*Enterococcus faecalis*
		NCTC 10418	ATCC 25922	NCTC 11560[1]	NCTC 10662	ATCC 27853	NCTC 6571	ATCC 25923	ATCC 29212
Amikacin	30	24-27	23-27	-	21-30	26-32	25-30	25-29	-
Ampicillin	10	21-26	16-22	-	-	-	-	-	26-35
Ampicillin	25	24-30	21-28	-	-	-	42-50	40-46	-
Amoxicillin	10	20-24	13-18	-	-	-	-	-	-
Aztreonam	30	39-44	36-40	-	27-30	26-30	-	-	-
Azithromycin	15	-	-	-	-	-	27-33	25-30	15-21
Carbenicillin	100	-	-	-	20-25	18-23	-	-	-
Cefamandole	30	32-36	35-39	-	-	-	-	-	-
Cefepime	30	38-43	37-42	-	-	-	-	-	-
Cefepime-clavulanic acid	30/10	38-43	37-42	-	-	-	-	-	-
Cefixime	5	32-36	27-30	-	-	-	-	-	-
Cefoxitin	30	28-33	26-30	-	-	-	-	-	-
Cefotaxime	30	36-45	34-44	-	20-29	20-24	-	-	-
Cefotaxime-clavulanic acid	30/10	39-44	37-42	-	-	-	-	-	-
Cefotetan	30	36-41	34-38	-	-	-	-	-	-
Cefpodoxime	10	29-36	25-31	-	-	-	-	-	-
Cefpodoxime-clavulanic acid	10/1	29-36	25-31	-	-	-	-	-	-
Cefpirome	30	34-43	36-43	-	-	-	-	-	-
Ceftazidime	30	32-40	31-39	-	29-37	27-35	-	-	-
Ceftazidime-clavulanic acid	30/10	31-39	30-36	-	-	-	-	-	-
Ceftizoxime	30	44-49	40-44	-	-	-	-	-	-
Ceftriaxone	30	41-46	37-42	-	-	-	-	-	-
Cefuroxime	30	25-32	24-29	-	-	-	-	-	-
Cefalexin	30	21-28	16-21	-	-	-	-	-	-

Antimicrobial agent	Disc content (μg unless stated)	*Escherichia coli*			*Pseudomonas aeruginosa*		*Staphylococcus aureus*		*Enterococcus faecalis*
		NCTC 10418	ATCC 25922	NCTC 11560[1]	NCTC 10662	ATCC 27853	NCTC 6571	ATCC 25923	ATCC 29212
Cefradine	30	19-25	16-22	-	-	-	-	-	-
Cephalothin	30	22-26	17-21	-	-	-	-	-	-
Chloramphenicol	10	21-27	20-29	-	-	-	20-26	19-27	-
Ciprofloxacin	1	31-40	31-37	-	21-28	24-30	25-32	17-22	14-19
Ciprofloxacin	5	-	-	-	29-37	31-37	-	-	21-27
Clarithromycin	2	-	-	-	-	-	25-30	24-28	-
Clindamycin	2	-	-	-	-	-	30-35	26-33	No zone
Co-amoxiclav	3	-	-	-	-	-	32-38	27-32	-
Co-amoxiclav	30	18-31	20-26	12-18	-	-	42-50	37-44	-
Colistin	25	15-19	16-20	-	17-20	16-20	-	-	-
Cotrimoxazole	25	33-38	28-34	-	-	-	-	31-35	-
Cotrimoxazole incubation @ 30^0C	25	35-39	31-34	-	-	-	-	-	-
Doripenem	10	-	-	-	33-37	41-45	-	-	-
Doxycycline	30	-	-	-	-	-	35-40	33-37	-
Ertapenem	10	35-41	35-39	-	-	-	-	-	-
Erythromycin	5	-	-	-	-	-	22-31	22-29	-
Fosfomycin trometamol/G6P	200/50	29-33	36-41	-	-	-	25-32	25-30	27-31
Fusidic acid	10	-	-	-	-	-	32-40	30-37	-
Gentamicin	10	21-27	21-27	-	20-26	22-28	24-30	22-29	-
Gentamicin	200	-	-	-	-	-	-	-	22-27
Imipenem	10	32-37	33-37	-	20-27	23-28	-	-	28-32
Levofloxacin	1	30-33	28-34	-	-	-	-	-	-
Levofloxacin	5	-	-	-	22-29	23-29	-	-	-
Linezolid	10	-	-	-	-	-	26-33	26-30	24-29
Mecillinam	10	34-39	30-35	-	-	-	-	-	-
Meropenem	10	38-42	27-39	-	26-33	32-39	-	-	22-28
Mezlocillin	75	31-36	27-32	-	-	-	-	-	-
Minocycline	30	-	-	-	-	-	34-39	33-36	-

Antimicrobial agent	Disc content (μg unless stated)	*Escherichia coli*			*Pseudomonas aeruginosa*		*Staphylococcus aureus*		*Enterococcus faecalis*
		NCTC 10418	ATCC 25922	NCTC 11560[1]	NCTC 10662	ATCC 27853	NCTC 6571	ATCC 25923	ATCC 29212
Moxifloxacin	1	31-35	29-33	-	-	-	33-40	33-38	-
Moxifloxacin	5	-	-	-	19-24	23-27	-	-	-
Mupirocin	5	-	-	-	-	-	26-35	24-34	-
Mupirocin	20	-	-	-	-	-	30-38	27-35	-
Nalidixic acid	30	28-36	26-32	-	-	-	-	-	-
Neomycin	10	-	-	-	-	-	18-22	21-27	-
Netilmicin	10	22-27	22-26	-	17-20	20-24	-	22-28	-
Nitrofurantoin	200	25-30	23-27	-	-	-	21-25	20-26	-
Norfloxacin	2	34-37	32-36	-	-	-	-	-	-
Ofloxacin	5	31-37	31-38	-	18-26	18-25	-	-	
Penicillin	1 unit	-	-	-	-	-	32-40	28-36	-
Piperacillin	75	30-35	27-32	-	27-35	27-34	-	-	-
Pip/tazobactam	85	30-35	26-31	-	28-35	28-35	-	-	26-32
Quinupristin-Dalfopristin	15	-	-	-	-	-	27-31	-	12-19
Rifampicin	2	-	-	-	-	-	27-39	29-36	-
Streptomycin	10	18-24	17-22	-	-	-	-	-	-
Streptomycin	300	-	-	-	-	-	-	-	20-24
Teicoplanin	30	-	-	-	-	-	17-23	16-20	19-25
Tetracycline	10	23-29	22-28	-	-	-	31-40	26-35	9-13
Ticarcillin	75	32-35	27-30	-	24-28	23-27	-	-	-
Ticarcillin-clavulanic acid	85	33-37	27-31	-	25-29	24-27	-	-	-
Tigecycline	15	29-32	28-32	-	-	-	29-34	27-30	26-31
Tobramycin	10	24-27	23-27	-	23-30	26-32	26-31	29-35	-
Trimethoprim	2.5	30-37	25-31	-	-	-	25-30	20-28	28-35
Trimethoprim	5	-	-	-	-	-	24-34	-	-
Vancomycin	5	-	-	-	-	-	14-20	13-17	13-19

1 = β-Lactamase producing strain

Table 3: Acceptable zone diameter (mm) ranges for control strains on Iso-Sensitest agar supplemented with 5% defibrinated horse blood, with or without the addition of NAD, plates incubated at 35-37^{0}C in air for 18-20 h.

Antimicrobial agent	Disc content (μg unless stated)	*Staphylococcus aureus*		Group A streptococci	
		NCTC 6571	ATCC 25923	NCTC 8198	ATCC 19615
Clindamycin	2	-	-	25-28	29-35
Erythromycin	5	**26-33**	23-29	-	-
Penicillin	1 unit	30-41	27-35	-	-
Tetracycline	10	30-38	28-36	-	-

Table 4: Acceptable zone diameter ranges for control strains for detection of methicillin/oxacillin/cefoxitin resistance in staphylococci (methicillin/oxacillin incubated at 30^{0}C; cefoxitin incubated at 35^{0}C).

Antimicrobial agent	Medium	Disc content (μg)	*Staphylococcus aureus*		
			NCTC 6571	ATCC 25923	NCTC 12493[a]
Methicillin	Columbia/Mueller Hinton agar + 2% NaCl	5	18-30	18-28	No zone
Oxacillin	Columbia/Mueller Hinton agar + 2% NaCl	1	19-30	19-29	No zone
Cefoxitin	ISA	10	26-31	24-29	10-20

[a] Methicillin/oxacillin/cefoxitin- resistant strain.

Table 5: Acceptable zone diameter (mm) ranges for control strains on Iso-Sensitest agar supplemented with 5% defibrinated horse blood and NAD, plates incubated at 35-37^{0}C in 10% CO_2 /10% H_2/80% N_2 for 18-20 h.

Antimicrobial agent	Disc content (μg unless stated)	*Bacteroides fragilis* NCTC 9343	*Bacteroides thetaiotaomicron* ATCC 29741	*Clostridium perfringens* NCTC 8359
Clindamycin	2	13-27	11-25	23-28
Co-amoxiclav	30	43-49	-	40-45
Meropenem	10	42-50	36-43	39-45
Metronidazole	5	34-43	26-40	11-23
Penicillin	1 unit	6	6	26-30
Piperacillin/tazobactam	75/10	41-48	-	37-43

Table 6: Acceptable zone diameter (mm) ranges for control strains on Iso-Sensitest agar supplemented with 5% defibrinated horse blood with or without the addition of NAD, plates incubated at 35-37^{0}C in 4-6% CO_2 for 18-20 h.

Antimicrobial agent	Disc content (μg unless stated)	*Pasteurella multocida*	*Neisseria gonorrhoeae* (with NAD)	*Staphylococcus aureus*		*Haemophilus influenzae* (with NAD)		*Streptococcus pneumoniae*
		NCTC 8489	NCTC 12700	NCTC 6571	ATCC 25923	NCTC 11931	ATCC 49247[a]	ATCC 49619
Amoxicillin	2	-	-	29-34	-	20-26	No zone	-
Ampicillin	2	-	-	-	-	22-30	6-13	-
Ampicillin	10	32-37	-	-	-	-	-	-
Azithromycin	15	-	30-40	-	-	28-32	23-27	25-30
Cefaclor	30	-	-	-	-	29-38	No zone	26-33
Cefixime	5	-	33-44	-	-	-	-	-
Cefotaxime	5	35-41	32-44	26-32	-	33-45	27-38	27-35
Ceftazidime	30	-	-	-	-	39-46	36-41	-
Ceftizoxime	30	-	-	-	-	-	-	36-44
Ceftriaxone	5	-	33-47	-	-	47-54	38-44	-
Ceftriaxone	30	-	-	-	-	-	-	38-47
Cefuroxime	5	-	23-32	22-29	24-29	22-28	6-16	-
Chloramphenicol	10	-	-	21-26	-	30-40	30-38	21-29
Ciprofloxacin	1	31-37	40-50	22-29	18-23	32-40	33-44	14-21
Clarithromycin	2	-	-	-	-	6-10	No zone	26-31
Clindamycin	2	-	-	21-25	-	-	-	-
Co-amoxiclav	3	-	-	**29-36**	-	20-27	10-20	-
Co-trimoxazole	25	-	-	-	-	40-47	38-42	21-25
Ertapenem	10	-	-	-	-	30-38	25-34	35-40
Erythromycin	5	-	20-29	25-29	-	12-23	9-16	23-36
Imipenem	10	-	-	-	-	32-39	31-36	-
Levofloxacin	1	-	-	-	-	38-43	35-41	17-21
Linezolid	10	-	-	22-26	-	-	-	-
Meropenem	10	-	-	-	-	38-45	33-39	-
Moxifloxacin	1	-	-	-	-	36-42	33-39	24
Nalidixic acid	30	-	32-40	9-17	9-17	33-38	33-39	-
Ofloxacin	5	-	-	-	-	39-49	38-44	21-26
Oxacillin	1	-	-	-	-	-	-	8-16
Penicillin	1 unit	24-28	12-20	37-44	29-36	-	-	-

Antimicrobial agent	Disc content (μg unless stated)	*Pasteurella multocida*	*Neisseria gonorrhoeae* (with NAD)	*Staphylococcus aureus*		*Haemophilus influenzae* (with NAD)		*Streptococcus pneumoniae*
		NCTC 8489	NCTC 12700	NCTC 6571	ATCC 25923	NCTC 11931	ATCC 49247[a]	ATCC 49619
Quinupristin-Dalfopristin	15	-	-	-	-	-	-	21-29
Rifampicin	2	-	26-34	32-37	-	-	-	-
Rifampicin	5	-	-	-	-	-	-	28-35
Spectinomycin	25	-	17-23	-	-	-	-	-
Teicoplanin	30	-	-	14-19	-	-	-	-
Telithromycin	15	-	-	-	-	26-31	22-26	33-40
Tetracycline	10	29-34	27-35	33-40	27-34	27-35	9-14	26-36
Tigecycline	15	-	-	27-30	24-28	-	-	26-30
Trimethoprim	2.5	-	-	-	-	30-40	28-36	-
Vancomycin	5	-	-	12-16	-	-	-	-

[a] β-Lactamase-negative, ampicillin-resistant strain

9. Control of MIC determination

Tables 7-10 provide target MIC (mg/L) values for recommended control strains by BSAC methodology.[1,2] MICs should be within one two-fold dilution of the target values **i.e. target MIC 1 mg/L acceptable range 0.5 – 2 mg/L**.

Table 7: Target MICs (mg/L) for *Haemophilus influenzae*, *Enterococcus faecalis*, *Streptococcus pneumoniae*, *Bacteroides fragilis* and *Neisseria gonorrhoeae* control strains by BSAC methods

Antimicrobial agent	*Haemophilus influenzae*		*Enterococcus faecalis*	*Streptococcus pneumoniae*	*Bacteroides fragilis*	*Neisseria gonorrhoeae*
	NCTC 11931	ATCC 49247	ATCC 29212	ATCC 49619	NCTC 9343	ATCC 49226
Amikacin	-	-	128	-	-	-
Amoxicillin	0.5	4	0.5	0.06	32	0.5
Ampicillin	-	-	1	0.06	32	-
Azithromycin	2	2	-	0.12	-	-
Azlocillin	-	-	-	-	4	-
Aztreonam	-	-	>128	-	2	-
Cefaclor	-	128	>32	2	>128	-
Cefamandole	-	-	-	-	8	-
Cefixime	0.03	0.25	-	1	64	-
Cefotaxime	-	0.25	32	0.06	4	-
Cefoxitin	-	-	-	-	4	-
Cefpirome	0.06	0.5	16		16	-
Cefpodoxime	0.12	0.5	>32	0.12	32	-
Ceftazidime	0.12	-	>32	-	8	-
Ceftriaxone	-	-	>32	0.06	4	-
Cefuroxime	2	16	>32	0.25	32	-
Cephadroxil	-	-	>32	-	32	-
Cephalexin	-	-	>32	-	64	-
Cephalothin	-	-	16	-	-	-
Chloramphenicol	-	-	4	4	4	-
Ciprofloxacin	0.008	0.008	1	1	2	0.004
Clarithromycin	8	4	-	0.03	0.25	0.5
Clindamycin	-	-	8	0.12	0.5	-
Co-amoxiclav	0.5	8	0.5	0.06	0.5	0.5
Cotrimoxazole	-	1	2	4	-	-
Dalfopristin/ quinupristin	-	-	1	0.5	16	-
Enoxacin	-	-	-	-	1	-
Ertapenem	0.12	0.5	-	0.12	0.25	-
Erythromycin	8	8	4	0.12	1	0.5
Faropenem	-	-	-	0.06	1	-
Fleroxacin	-	-	-	-	4	-
Flucloxacillin	-	-	-	-	16	-
Fucidic acid	-	-	2	-	-	-
Gatifloxacin	0.008	-	0.25	0.25	0.5	0.004
Gemifloxacin	0.12	-	0.03	0.03	0.25	0.002
Gentamicin	-	-	8	-	128	-
Grepafloxacin	-	0.004	-	0.25	-	-
Imipenem	-	-	0.5	-	0.06	-
Levofloxacin	0.008	0.015	1	0.5	0.5	0.008
Linezolid	-	-	**1**	2	4	-
Loracarbef	-	128	>32	2	>128	-
Mecillinam	-	-	>128	-	>128	-
Meropenem	-	-	2	-	0.06	-

Antimicrobial agent	*Haemophilus influenzae*		*Enterococcus faecalis*	*Streptococcus pneumoniae*	*Bacteroides fragilis*	*Neisseria gonorrhoeae*
	NCTC 11931	ATCC 49247	ATCC 29212	ATCC 49619	NCTC 9343	ATCC 49226
Metronidazole	-	-	-	-	0.5	-
Moxalactam	-	-	-	-	0.25	-
Moxifloxacin	0.03	0.03	0.25	0.5	-	0.004
Naladixic acid	-	1	-	>128	64	-
Nitrofurantoin	-	-	8	-	-	-
Norfloxacin	-	-	2	-	16	-
Ofloxacin	-	-	2	-	1	-
Oxacillin	-	-	-	1	-	-
Pefloxacin	-	-	-	-	1	-
Penicillin	-	4	2	0.5	16	-
Piperacillin	-	-	2	-	2	-
Rifampicin	-	-	2	0.03	-	-
Roxithromycin	16	16	-	0.12	2	-
Rufloxacin	-	-	-	-	16	-
Sparfloxacin	-	0.002	-	0.25	1	-
Teicoplanin	-	-	0.25	-	-	-
Telithromycin	1	2	0.008	0.008	-	0.03
Tetracycline	-	16	16	0.12	0.5	-
Ticarcillin	-	-	-	-	4	-
Tigecycline	-	-	0.12	0.06	-	-
Tobramycin	-	-	16	-	-	-
Trimethoprim	-	-	0.25	4	16	-
Trovafloxacin	0.008	0.002	0.06	0.12	0.12	-
Vancomycin	-	-	2	0.25	16	-

Table 8: Target MICs (mg/L) for *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* control strains by BSAC methods

Antimicrobial agent	*Escherichia coli*		*Pseudomonas aeruginosa*		*Staphylococcus aureus*		
	NCTC 10418	ATCC 25922	NCTC 10662	ATCC 27853	NCTC 6571	ATCC 25923	ATCC 29213
Amikacin	0.5	1	2	2	1	-	2
Amoxicillin	2	4	>128	>128	0.12	0.25	0.5
Ampicillin	2	4	>128	>128	0.06	-	-
Azithromycin	-	-	-	-	0.12	0.12	0.12
Azlocillin	4	-	4	-	0.25	-	-
Aztreonam	0.03	0.25	4	2	>128	-	>128
Carbenicillin	2	-	32	-	0.5	-	-
Cefaclor	1	2	>128	>128	1	-	1
Cefamandole	0.25	-	>128	>128	0.25	-	-
Cefixime	0.06	0.25	16	-	8	8	16
Cefotaxime	0.03	0.06	8	8	0.5	-	1
Cefotetan	0.06	-	>128	>128	4	-	-
Cefoxitin	4	-	>128	>128	2	**2**	-
Cefpirome	0.03	0.03	4	1	0.25	-	0.5
Cefpodoxime	0.25	0.25	128	>128	1	4	2
Ceftazidime	0.06	0.25	1	1	4	-	8
Ceftizoxime	0.008	-	-	-	2	-	-
Ceftriaxone	0.03	0.06	8	8	1	-	2
Cefuroxime	2	4	>128	>128	0.5	1	1
Cephadroxil	8	8	>128	>128	1	-	2
Cephalexin	4	8	>128	>128	1	-	4
Cephaloridine	-	-	>128	>128	0.06	-	-
Cephalothin	4	8	>128	>128	0.5	-	0.25
Cephradine	-	-	>128	>128	2	-	-
Chloramphenicol	2	4	128	-	2	-	2
Ciprofloxacin	0.015	0.015	0.25	0.25	0.12	0.5	0.5
Clarithromycin	-	-	-	-	0.12	0.12	0.12
Clindamycin	-	-	-	-	0.06	0.12	0.06
Co-amoxiclav	2	4	>128	128	0.12	0.12	0.25
Colistin	0.5	-	2	**4**	128	-	-
Cotrimoxazole	0.25	0.25	-	-	-	-	2
Dalfopristin/ Quinupristin	-	-	-	-	0.12	0.25	0.25
Daptomycin Mueller Hinton	-	-	-	-	**1**	**2**	-
Dirythromycin	-	-	-	-	1	-	1
Doripenem	**0.008**	**0.008**	**0.5**	**0.25**	-	-	-
Doxycycline	-	-	-	-	0.06	0.12	-
Enoxacin	0.25	-	1	-	0.5	-	-
Ertapenem	0.008	0.015	-	-	-	-	-
Erythromycin	-	-	-	-	0.12	0.5	0.25
Farapenem	0.25	-	>128	>128	0.12	-	-
Fleroxacin	0.06	0.12	1	-	0.5	-	-
Flucloxacillin	-	-	>128	>128	0.06	-	-
Flumequine	2	-	>128	>128	-	-	-
Fosfomycin	4	-	>128	>128	8	-	-
Fusidic acid	>128	-	-	-	0.06	0.12	0.06
Gatifloxacin	0.015	0.015	1	1	0.03	0.12	0.12
Gemifloxacin	0.008	0.008	0.25	0.25	0.015	0.03	0.03
Gentamicin	0.25	0.5	1	1	0.12	0.25	0.25
Grepafloxacin	0.03	0.03	0.5	-	0.03	-	-
Imipenem	0.06	0.12	2	1	0.015	-	0.015

Antimicrobial agent	*Escherichia coli*		*Pseudomonas aeruginosa*		*Staphylococcus aureus*		
	NCTC 10418	ATCC 25922	NCTC 10662	ATCC 27853	NCTC 6571	ATCC 25923	ATCC 29213
Kanamycin	1	-	1	-	2	-	-
Levofloxacin	0.03	0.03	0.5	0.5	0.12	0.25	0.25
Linezolid	-	-	-	-	0.5	1	-
Lomefloxacin	-	-	-	-	0.5	-	-
Loracarbef	0.5	1	>128	>128	0.5	-	1
Mecillinam	0.12	0.12	8	-	8	-	64
Meropenem	0.015	0.008	2	0.25	0.03	-	0.06
Methicillin	-	-	>128	>128	1	2	2
Mezlocillin	2	-	8	-	0.5	-	-
Minocycline	-	-	-	-	0.06	0.06	-
Moxalactam	0.03	-	8	-	8	-	-
Moxifloxacin	0.03	0.03	2	2	0.06	0.06	0.06
Mupirocin	-	-	-	-	0.25	0.25	0.12
Nalidixic acid	2	4	>128	>128	>128	128	128
Neomycin	-	-	32	-	0.12	-	-
Netilmicin	-	-	1	0.5	-	-	-
Nitrofurantoin	4	8	-	-	8	-	16
Norfloxacin	0.06	0.06	1	1	0.25	-	1
Ofloxacin	0.06	0.03	1	1	0.25	-	0.5
Oxacillin	-	-	>128	>128	0.25	0.25	0.5
Pefloxacin	0.06	-	0.5	-	0.25	-	-
Penicillin	-	-	>128	>128	0.03	0.03	0.12
Piperacillin	0.5	2	4	2	0.25	-	1
Piperacillin/ tazobactam	**0.5**	**2**	**4**	**4**	-	-	-
Rifampicin	16	-	-	-	0.004	0.015	0.004
Roxithromycin	-	-	-	-	0.25	0.5	0.5
Rufloxacin	0.5	-	8	-	1	-	-
Sparfloxacin	0.015	0.015	0.5	0.5	0.03	-	-
Sulphonamide	16	-	>128	>128	64	-	-
Sulphamethoxazole	**0.06**	**0.12**	-	-	-	-	-
Teicoplanin	-	-	-	-	0.25	1	1
Telithromycin	-	-	-	-	0.03	0.06	0.06
Temocillin	2	-	>128	-	128	-	-
Tetracycline	1	2	-	32	0.06	**0.06**	0.5
Ticarcillin	1	-	16	-	0.5	-	-
Ticarcillin/ 4mg/L clavulanate	-	-	32	16	-	-	-
Tigecycline	0.12	0.12	-	-	0.12	-	-
Tobramycin	0.25	0.5	0.5	0.5	0.12	-	0.5
Trimethoprim	0.12	0.25	32	-	0.25	-	0.5
Trovafloxacin	0.015	0.015	0.5	0.5	0.015	0.03	0.03
Vancomycin	-	-	-	-	0.5	0.5	1

Table 9: Target MICs (mg/L) for *Pasteurella multocida* control strain by BSAC methods

Antimicrobial agents	*Pasteurella multocida* NCTC 8489
Ampicillin	0.12
Cefotaxime	0.004
Ciprofloxacin	0.008
Penicillin	0.12
Tetracycline	0.25

Table 10: Target MICs (mg/L) for anaerobic control strains by BSAC methods on Iso-Sensitest agar supplemented with 5% defibrinated horse blood and 20 mg/L NAD

Antimicrobial agent	*Bacteroides fragilis* NCTC 9343	*Bacteroides thetaiotaomicron* ATCC 29741	*Clostridium perfringens* NCTC 8359
Clindamycin	0.5	2	0.06
Co-amoxiclav (2:1 ratio)	0.5	0.5	≤ 0.06
Meropenem	0.06	0.12	≤ 0.015
Metronidazole	0.5	4	8
Penicillin	16	16	0.06
Piperacillin/tazobactam (fixed 4 mg/L tazobactam)	≤ 0.12	8	0.5

Table 11: Target MICs (mg/L) for Group A streptococci control strains by BSAC methods

	Group A streptococci	
Antimicrobial agent	NCTC 8198	ATCC 19615
Clindamycin	0.03	0.06

References

1. Andrews, J.M. Determination of minimum inhibitory concentrations. Journal of Antimicrobial Chemotherapy, Suppl S1 to Volume 48 July 2001.

2. Andrews, J. M., Jevons, G., Brenwald, N. and Fraise, A. for the BSAC Working Party on Sensitivity Testing. Susceptibility testing *Pasteurella multocida* by BSAC standardized methodology. *Journal of Antimicrobial Chemotherapy*.

Suppliers

Reagent	Suppliers (others may be available)
ISA	CM471, Thermo Fisher, Basingstoke, UK
Columbia agar	CM331, Thermo Fisher, Basingstoke, UK
Mueller Hinton agar	CM337, Thermo fisher, Basingstoke, UK
NAD	Mast Group, Merseyside, UK
McFarland turbidity standards	bioMérieux, Basingstoke, UK
Control strains	NCTC, Colindale, London Thermo Fisher, Basingstoke, UK Mast Laboratories, Merseyside, UK Becton Dickinson, Oxford, UK TCS Biosciences Ltd. Buckingham, UK

Useful web sites

BSAC	British Society for Antimicrobial Chemotherapy	http://www.bsac.org.uk
SRGA	The Swedish Reference Group for Antibiotics	http://www.srga.org
CDC	Centre for Disease Control (Atlanta, USA)	http://www.cdc.gov
WHO	World Health Organisation (Geneva, Switzerland)	http://www.who.int
CLSI	Clinical and Laboratory Standards Institute	http://www.clsi.org
NEQAS	National External Quality Assessment Scheme	http://www.ukneqas.org.uk
NCTC	National Collection of Type Cultures	http://www.ukncc.co.uk
JAC	The Journal of Antimicrobial Chemotherapy	http://www.jac.oupjournals.org
EUCAST	European Committee on Antimicrobial Susceptibility Testing	http://www.eucast.org