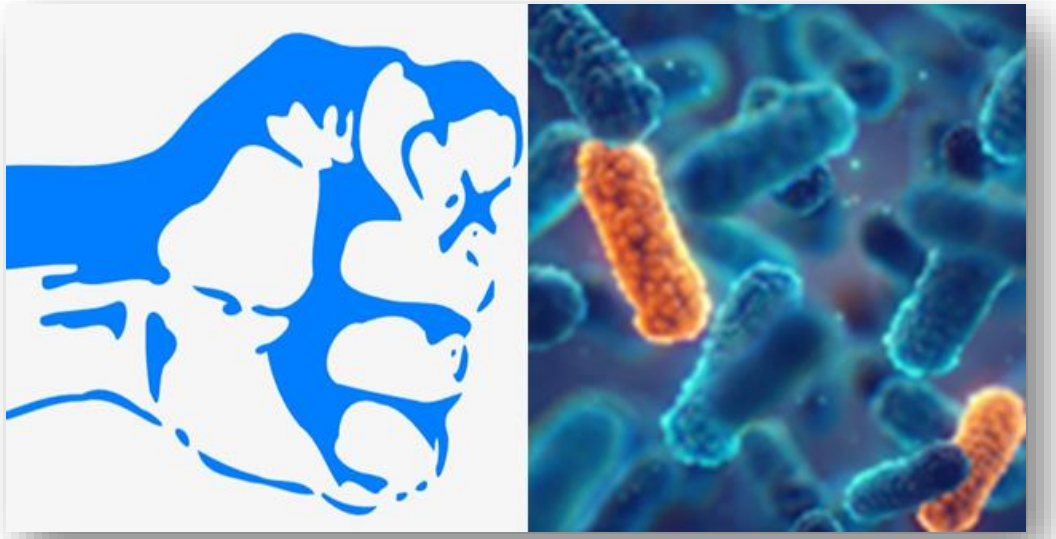
ΔΙΑΤΜΗΜΑΤΙΚΟ ΠΡΟΓΡΑΜΜΑ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ

«ΕΦΑΡΜΟΓΕΣ ΤΗΣ ΒΙΟΛΟΓΙΑΣ ΣΤΗΝ ΙΑΤΡΙΚΗ»

Μάθημα: Μικροβιολογία και Δημόσια Υγεία



Μέθοδοι διάγνωσης της μικροβιακής αντοχής

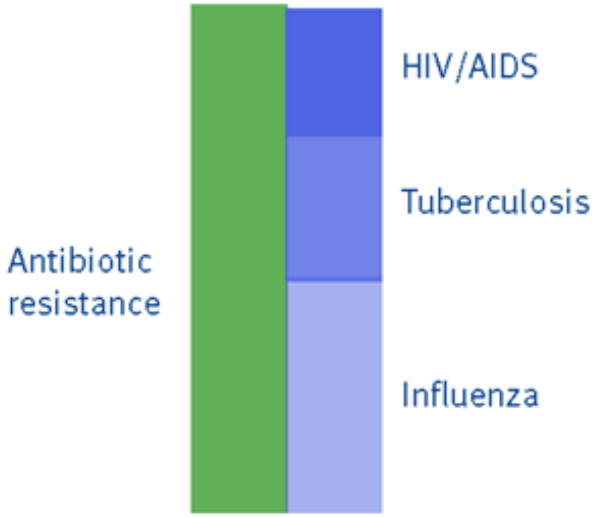
Ολυμπία Ζαρκωτού,

Διευθύντρια Μικροβιολογικού Τμήματος, Γ.Ν. Πειραιά «Τζάνειο»

Antibiotic resistance: a growing threat to human health

Antibiotic resistance is the ability of bacteria to combat the action of one or more antibiotics. Bacteria, not humans or animals, become antibiotic-resistant.

In Europe, the health impact of antibiotic resistant infections is comparable to that of influenza, tuberculosis and HIV/AIDS combined.

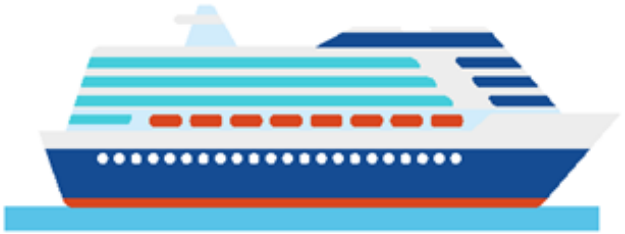


More than 35000 deaths

Each year, more than 35 000 people die from antibiotic-resistant infections in the European Union, Iceland and Norway. This is **equivalent to the number of passengers on 13 cruise ships.**

Antibiotic resistance is a silent pandemic and a growing threat to human health.

13 cruise ships



Over 70 %

healthcare-associated infections

Over 70% of the health impact of antibiotic-resistant infections is directly linked to healthcare-associated infections. This could be minimized through adequate infection prevention and control measures, as well as antibiotic stewardship in healthcare settings.

Increasing burden

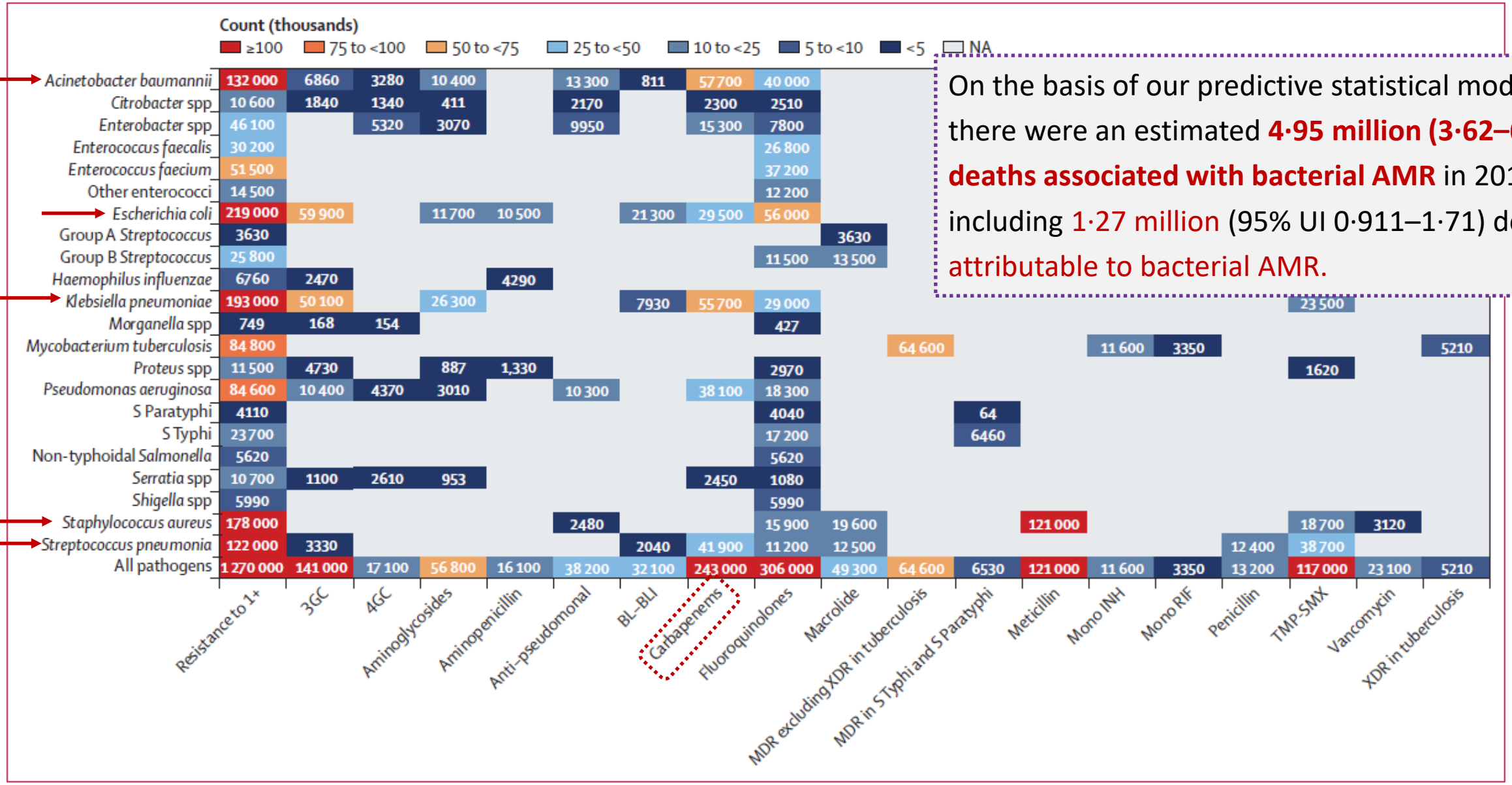
Resistance to antibiotics that are used as last line for treatment of infections, such as the carbapenems, has the highest health impact.

Between 2016 and 2020, the overall number of deaths caused by antibiotic-resistant bacteria under study has increased.

For carbapenem-resistant *Klebsiella pneumoniae* and *Acinetobacter* spp, commonly causing healthcare-associated infections, the number of attributable deaths increased by approximately 50%.

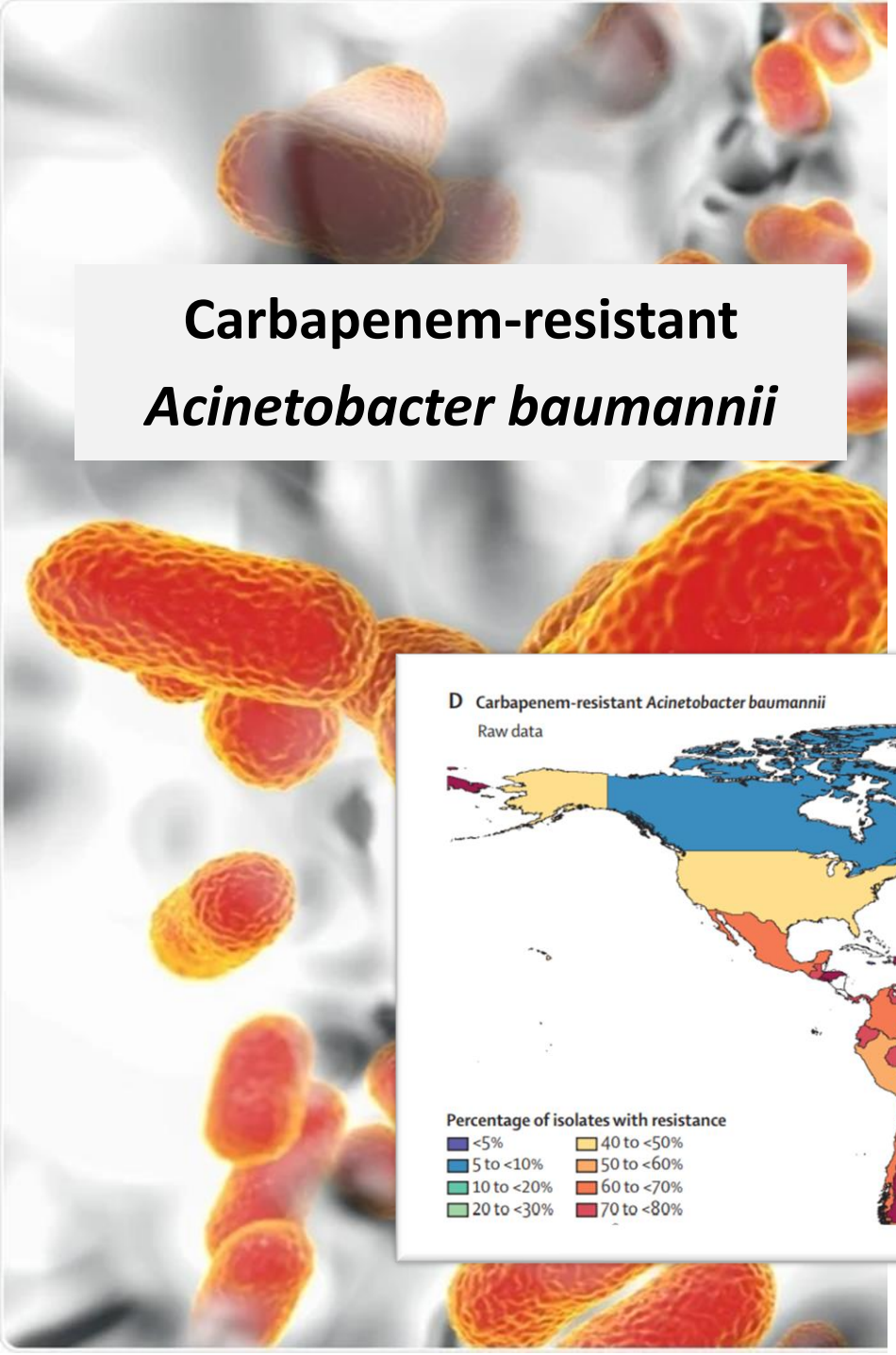
https://antibiotic.ecdc.europa.eu/en/publications-data/antibiotic-resistance-growing-threat-human-health

Global deaths (counts) attributable to bacterial AMR by pathogen–drug combination, 2019

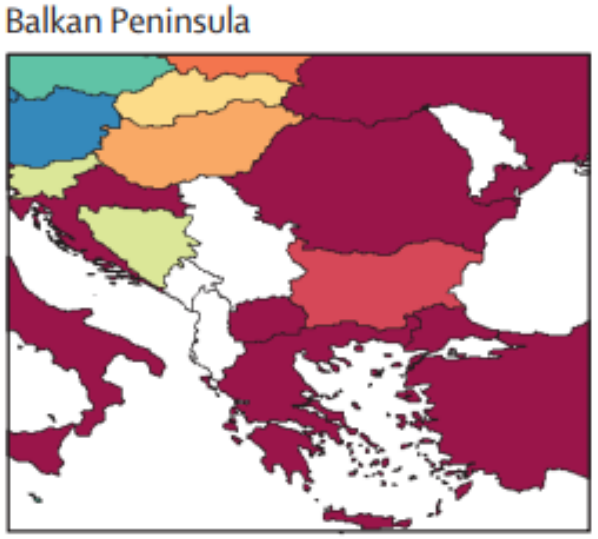


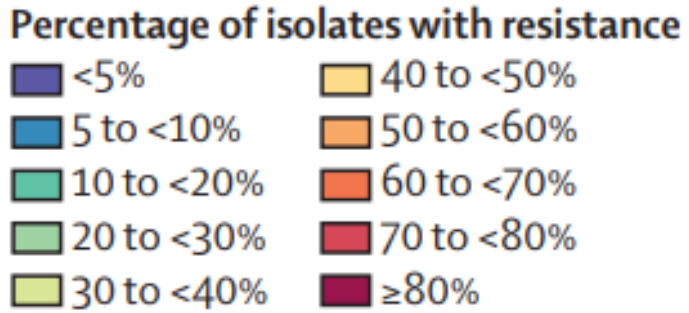
On the basis of our predictive statistical models, there were an estimated **4·95 million (3·62–6·57) deaths associated with bacterial AMR** in 2019, including 1·27 million (95% UI 0·911–1·71) deaths attributable to bacterial AMR.

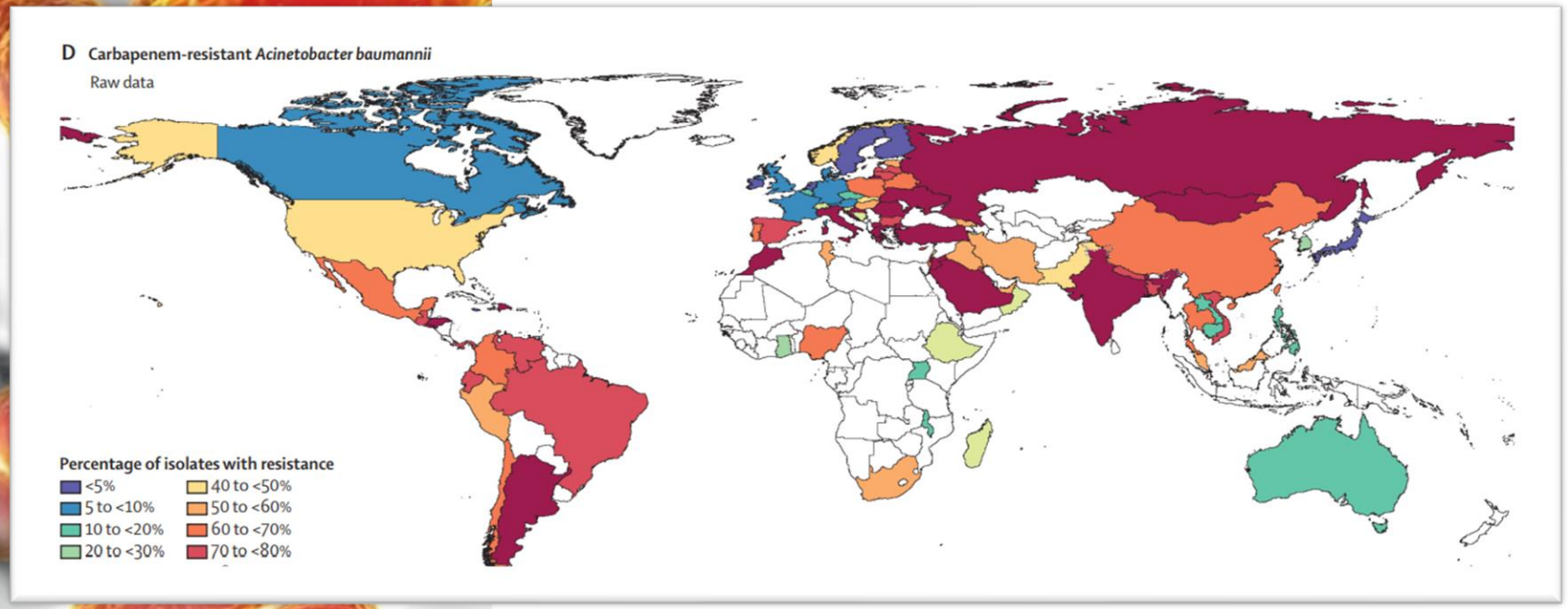
Antimicrobial Resistance Collaborators. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. Lancet. 2022;399(10325):629-655.



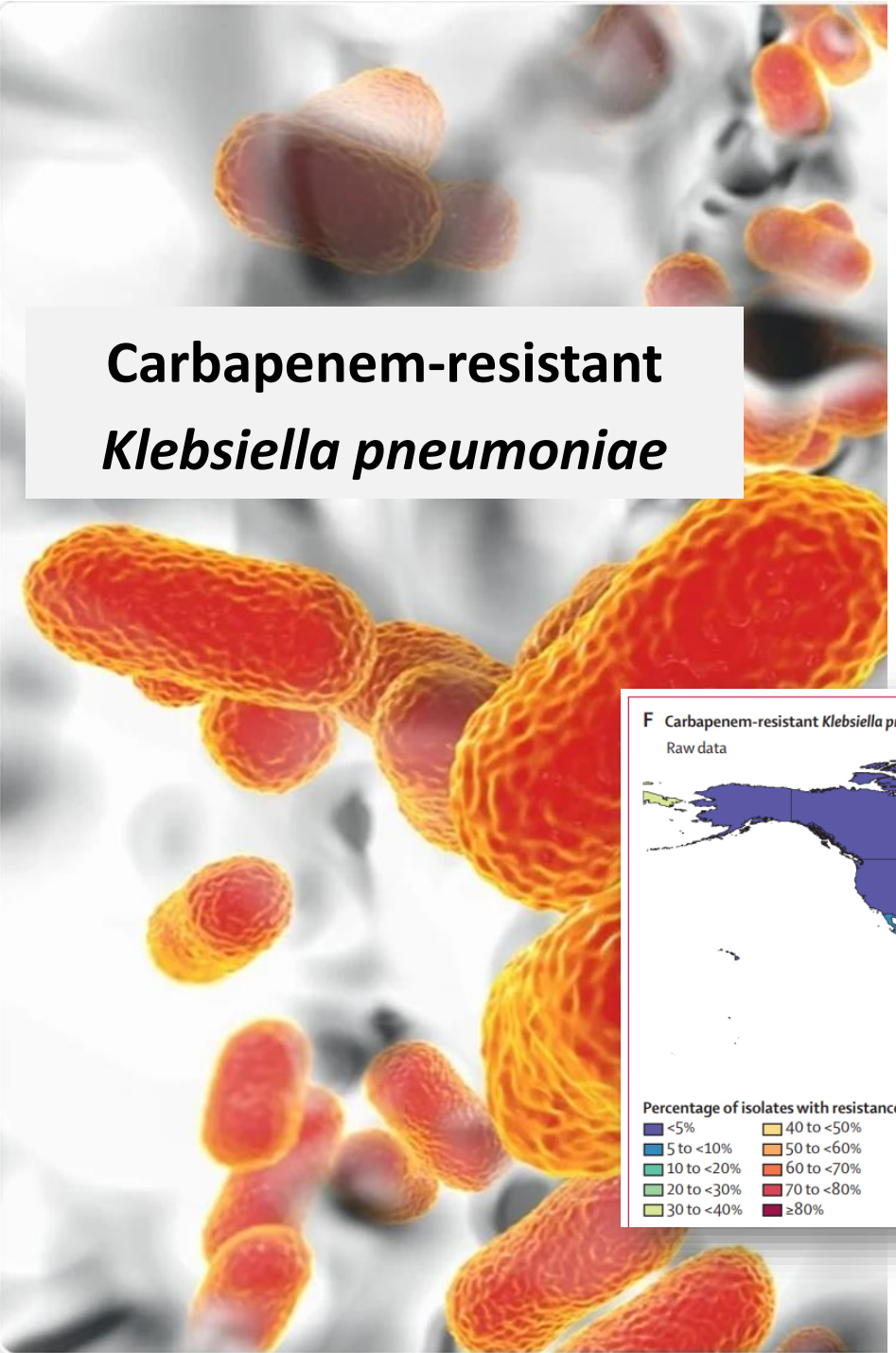
Carbapenem-resistant *Acinetobacter baumannii*





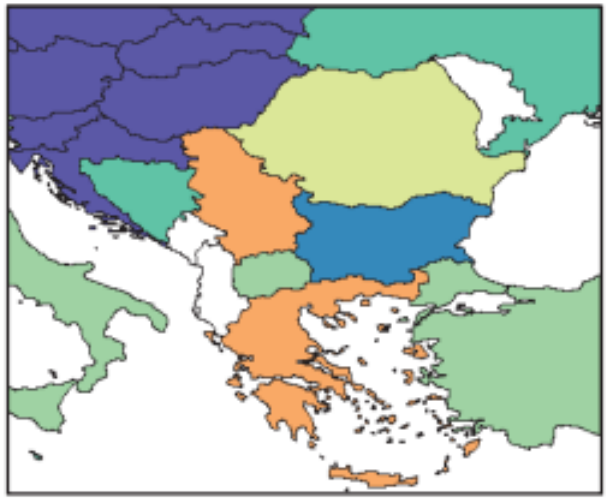


Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. Lancet, 2022, 399: 629-55



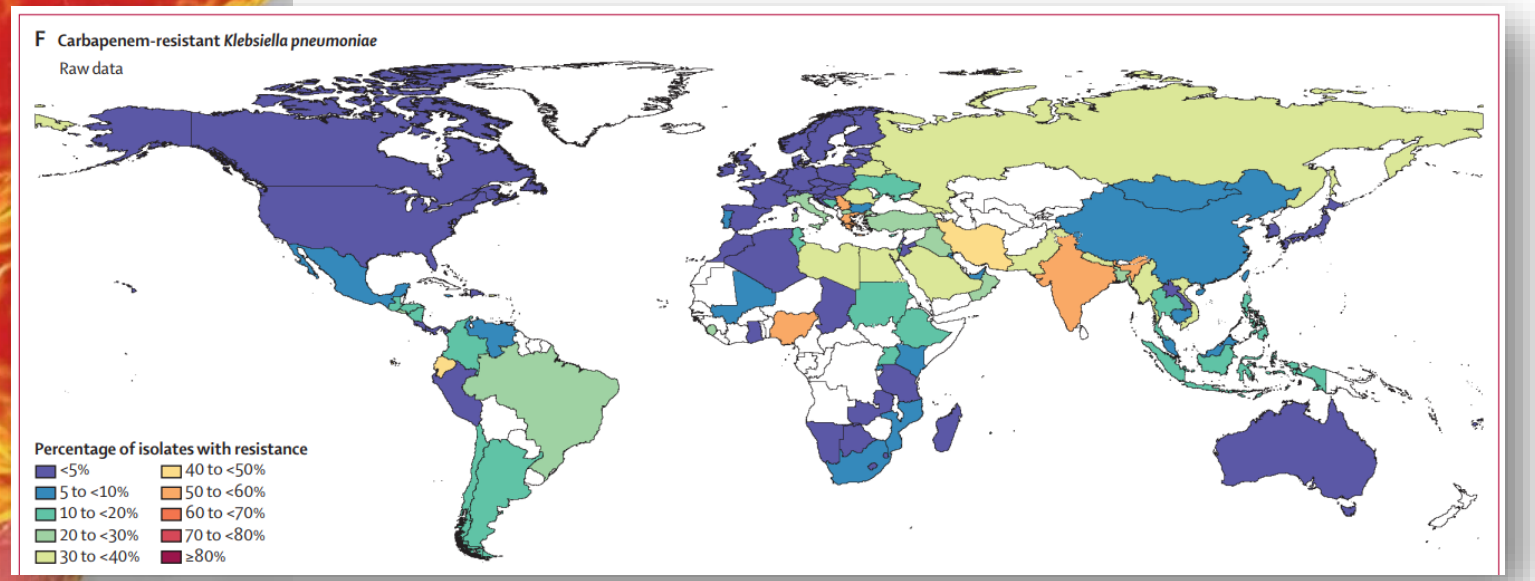
Carbapenem-resistant *Klebsiella pneumoniae*

Balkan Peninsula



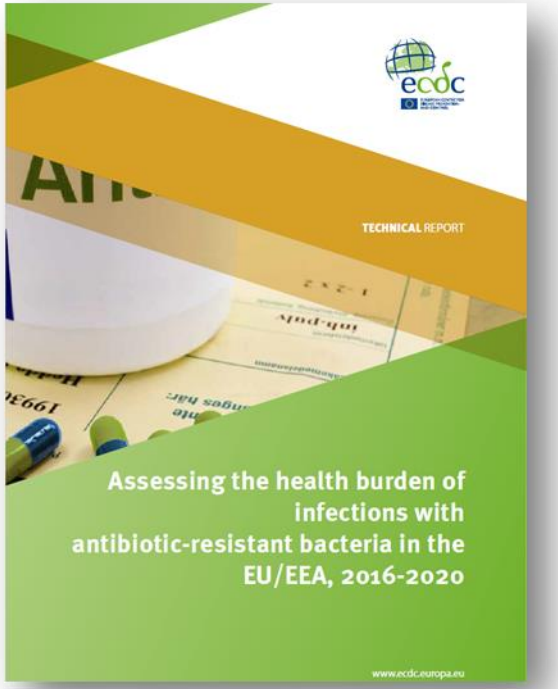
Percentage of isolates with resistance

- <5%
- 5 to <10%
- 10 to <20%
- 20 to <30%
- 30 to <40%
- 40 to <50%
- 50 to <60%
- 60 to <70%
- 70 to <80%
- ≥80%

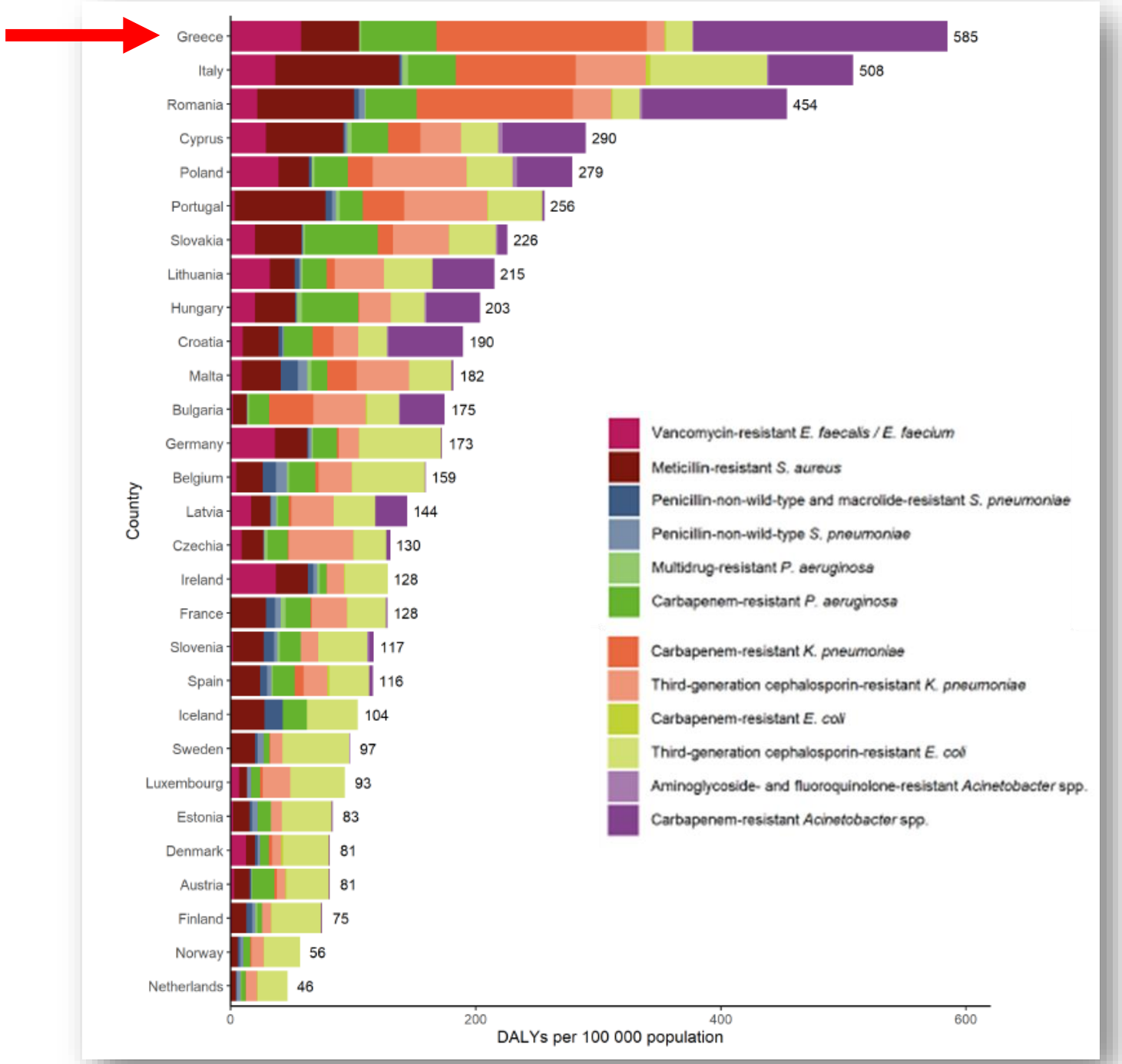


Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. Lancet, 2022, 399: 629-55

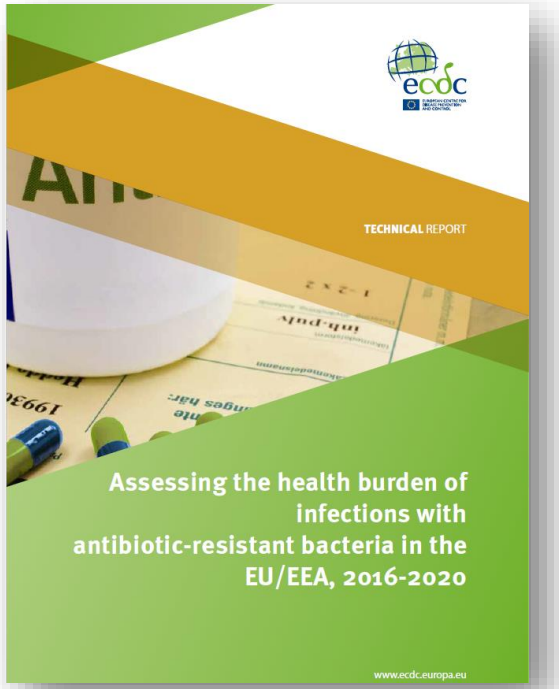
Estimations of the burden of infections with antibiotic-resistant bacteria presented as disability-adjusted life years (DALYs) per 100 000 population by country*, EU/EEA, 2020

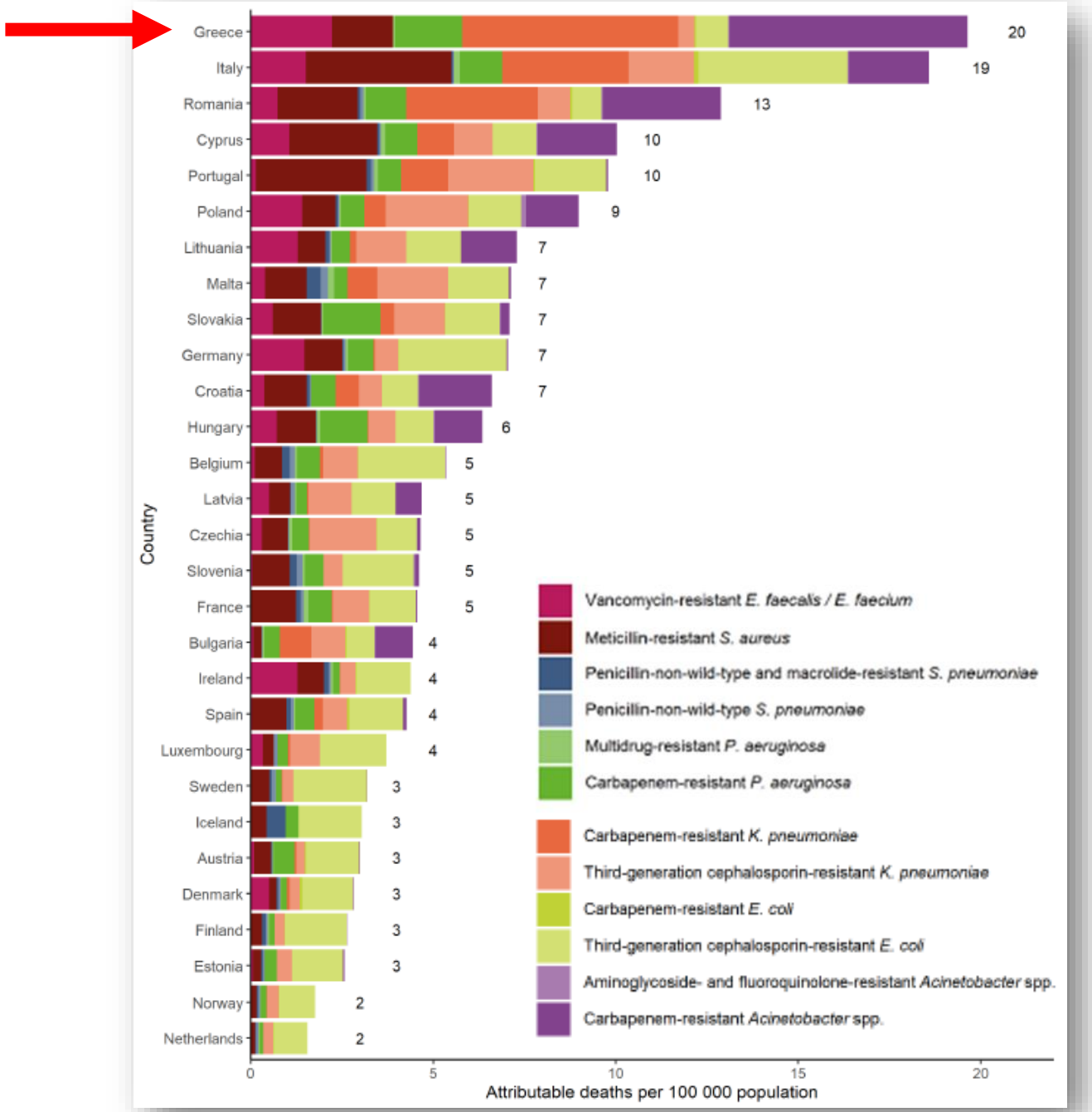


Assessing the health burden of infections with antibiotic-resistant bacteria in the EU/EEA, 2016-2020. Stockholm: ECDC; 2022.



Estimations of the burden of infections with antibiotic-resistant bacteria presented as attributable deaths per 100 000 population by country*, EU/EEA, 2020

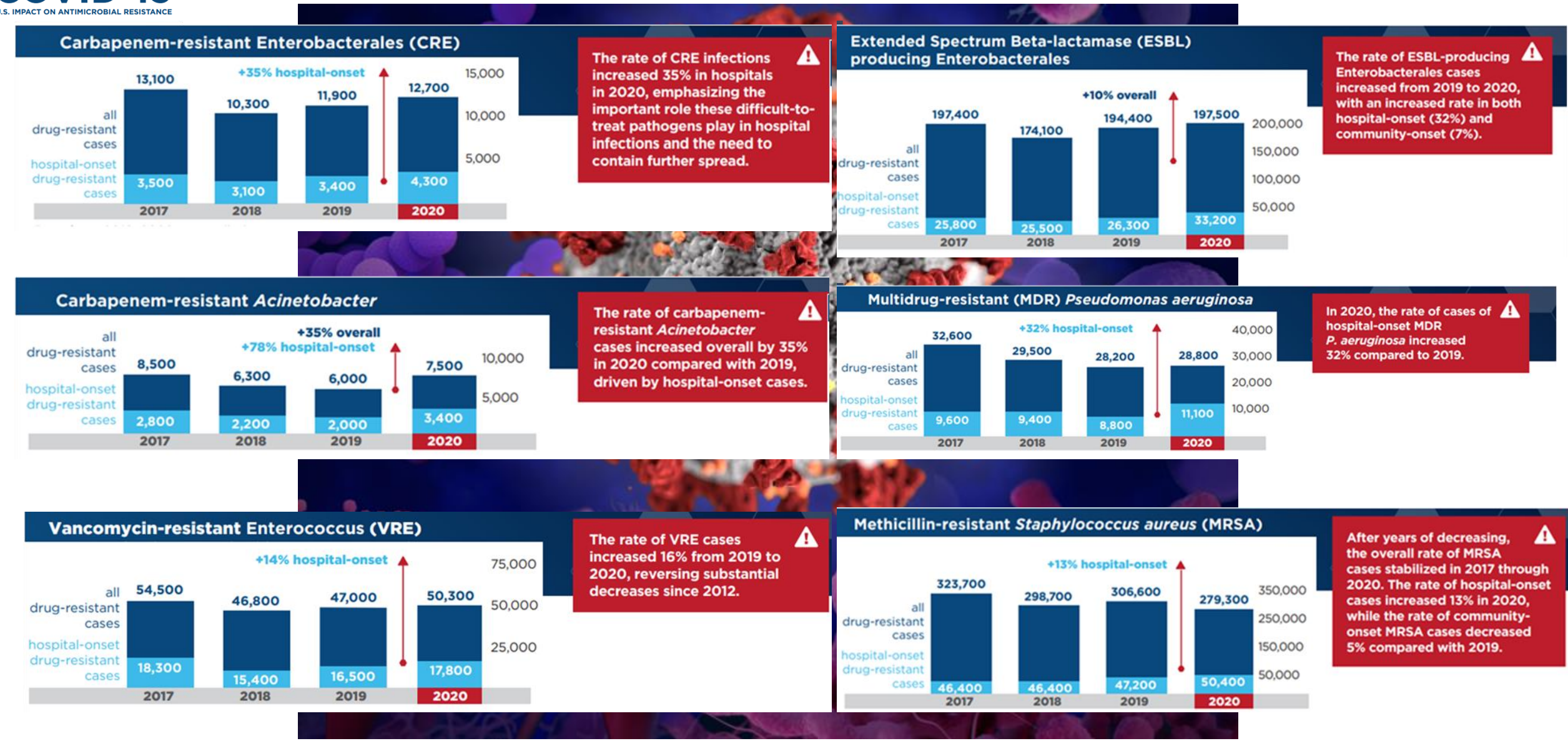




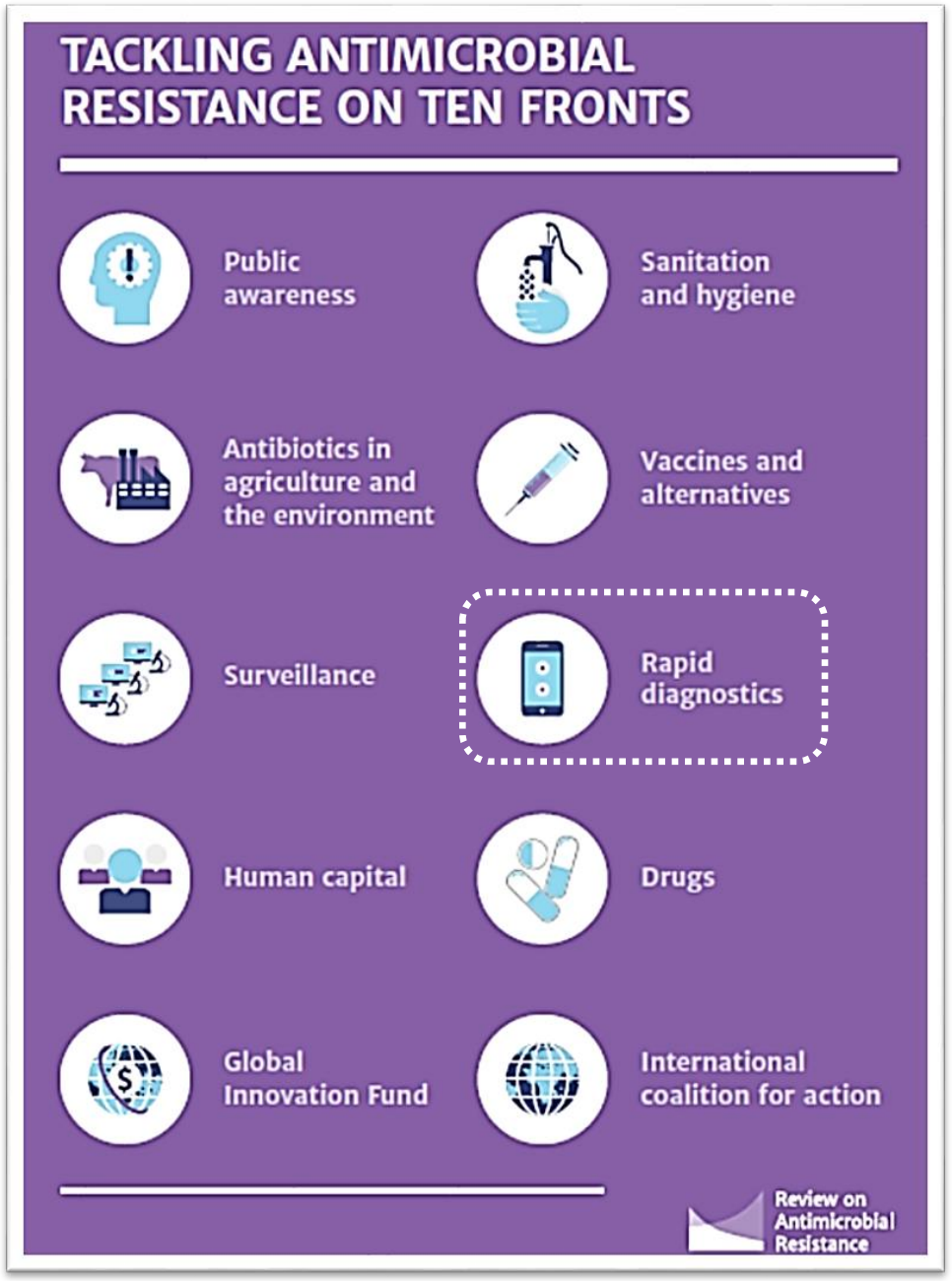
Assessing the health burden of infections with antibiotic-resistant bacteria in the EU/EEA, 2016-2020. Stockholm: ECDC; 2022.

2022 SPECIAL REPORT
COVID-19
U.S. IMPACT ON ANTIMICROBIAL RESISTANCE

COVID-19 Impacts on 18 Antimicrobial-Resistant Bacteria and Fungi: Threat Estimates



CDC. COVID-19: U.S. Impact on Antimicrobial Resistance, Special Report 2022. Atlanta, GA: U.S. Department of Health and Human Services, CDC; 2022. https://www.cdc.gov/drugresistance/covid19.html



'Tackling drug-resistant infections globally: Final report and recommendations'. The review on antimicrobial resistance; May 2016

A European One Health Action Plan against Antimicrobial Resistance (AMR). European Commission, 2017.

Σύσταση του Συμβουλίου σχετικά με την ενίσχυση των δράσεων της ΕΕ για την καταπολέμηση της μικροβιακής αντοχής στο πλαίσιο της προσέγγισης «Μία υγεία» 2023/C 220/01

https://eur-lex.europa.eu/legal-content/EL/TXT/?uri=CELEX:32023H0622(01)

‘Best buy’ interventions to tackle AMR

- improving hygiene in healthcare facilities, including promotion of handwashing
- stewardship programmes promoting more prudent use of antibiotics to end decades of over-prescription

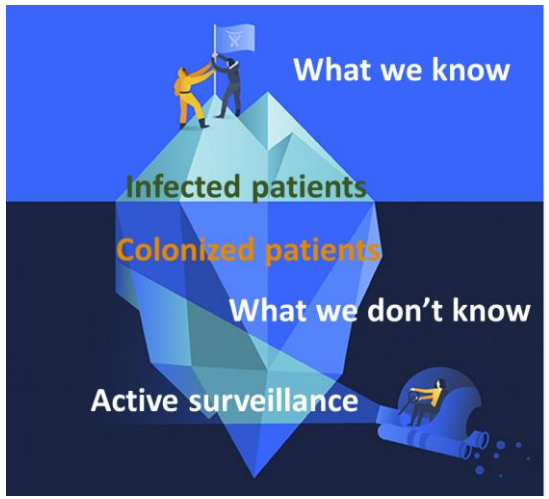
These will decrease the health burden of AMR – measured in DALYs – by about 40%

- **use of rapid diagnostic tests**
- delayed prescription
- public awareness campaigns

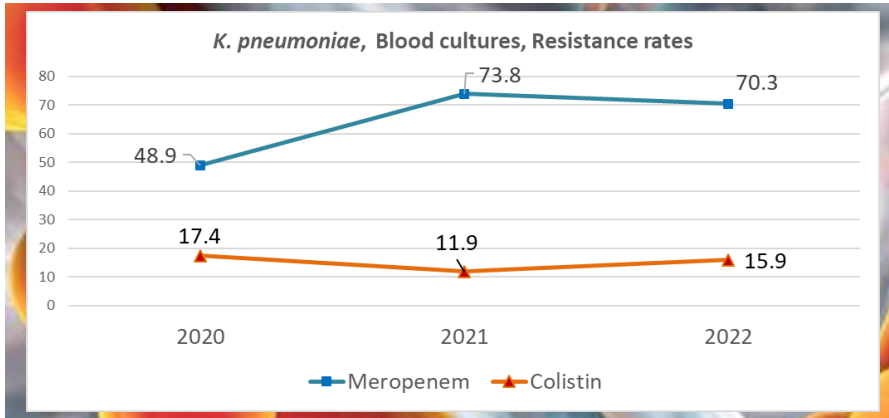
Source: OECD (2018), Stemming the Superbug Tide: Just a Few Dollars More. Available at: oe.cd/amr-2018.

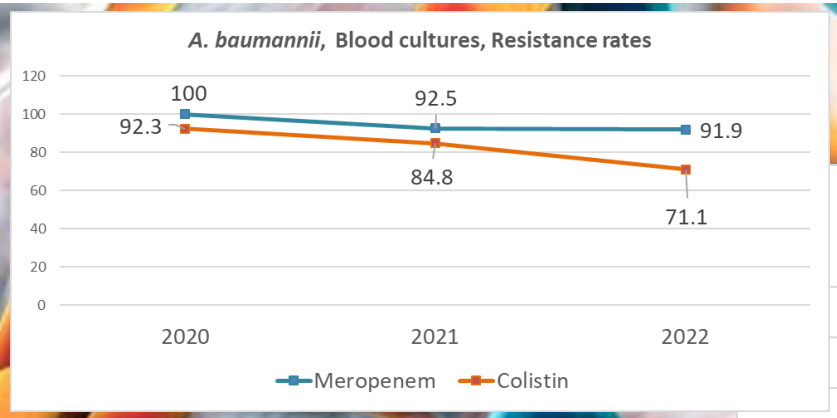
Μικροβιολογικό εργαστήριο και ανίχνευση αντοχής

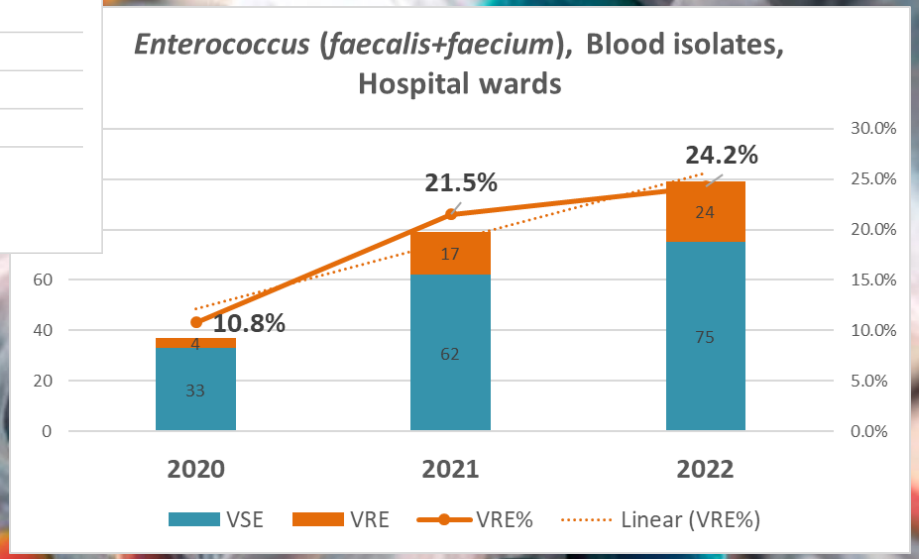
Πληροφορία

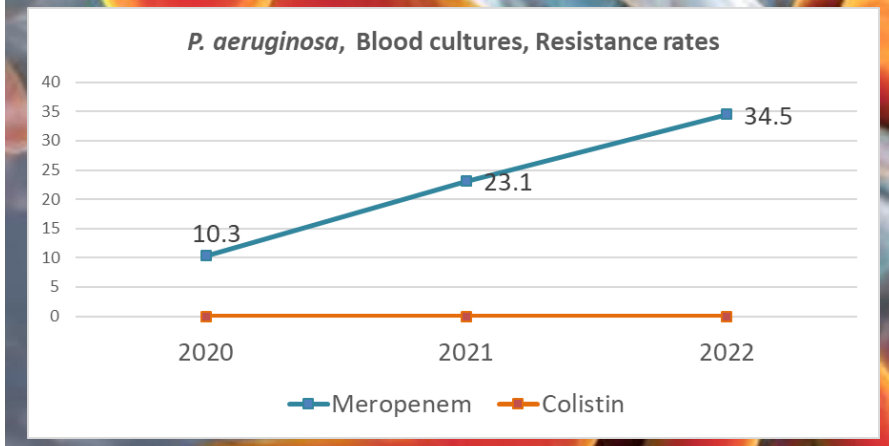


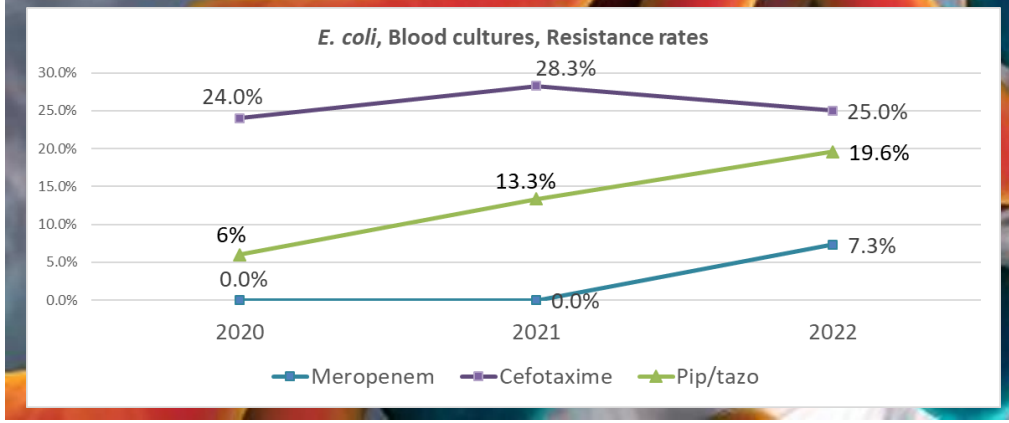
Παράδειγμα CASR: Τζάνειο, Κλινικά Τμήματα εκτός ΜΕΘ

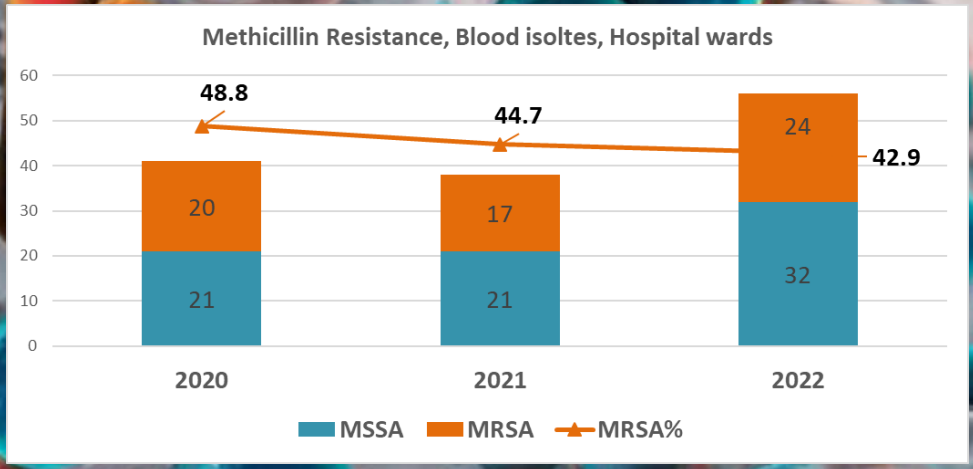


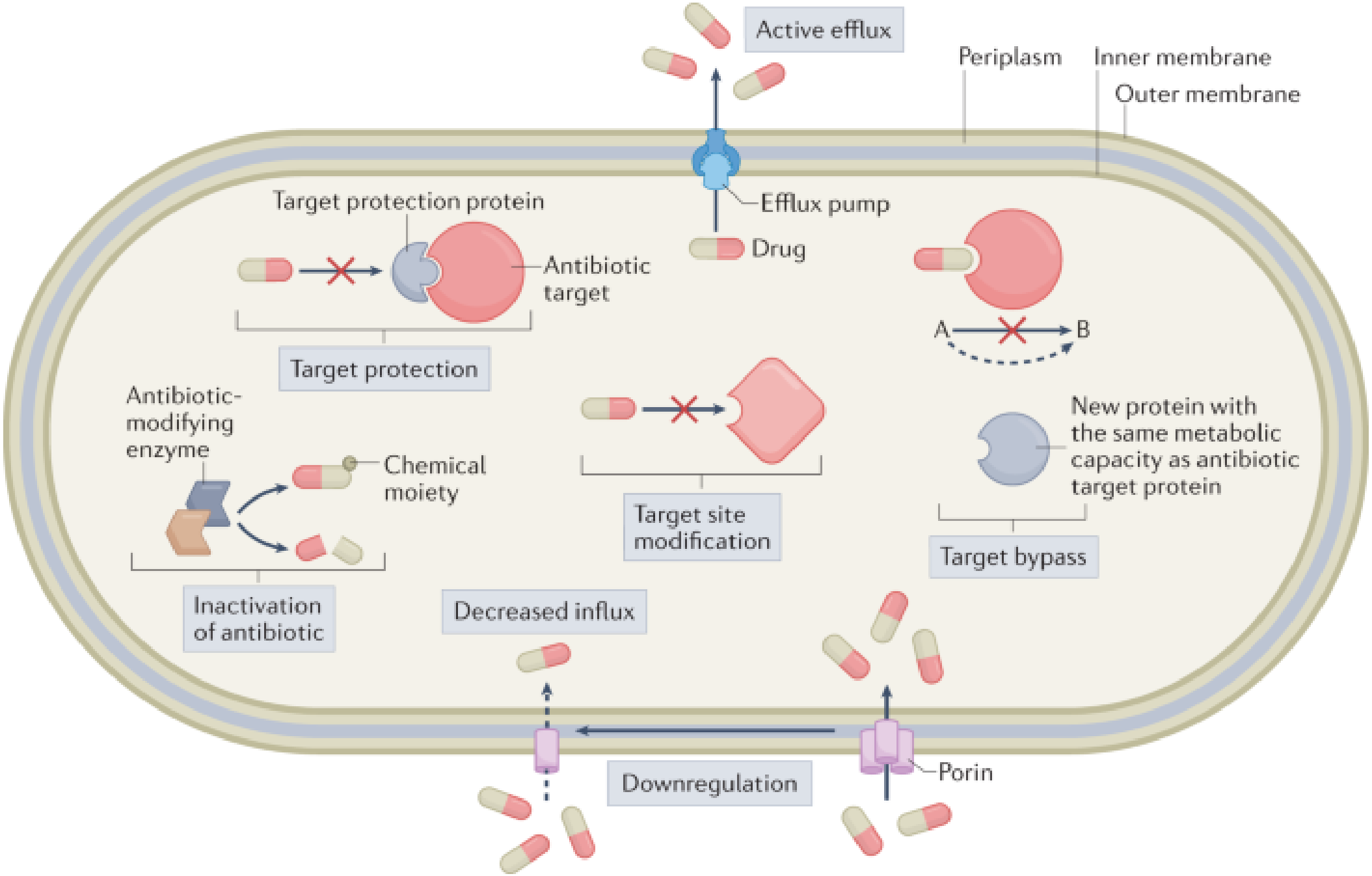






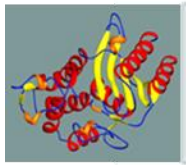






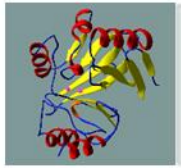
Darby EM et al. Nat Rev Microbiol. 2023;21(5):280-295.

β-λακταμάσες



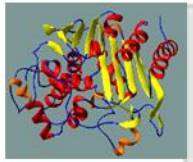
Ambler Class A

- Penicillinases
- TEM
- SHV
- CTX-M
- KPC
- GES
- IMI
- NMC-A



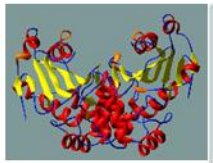
Ambler Class B

- VIM
- IMP
- NDM
- GIM



Ambler Class C

- AmpC



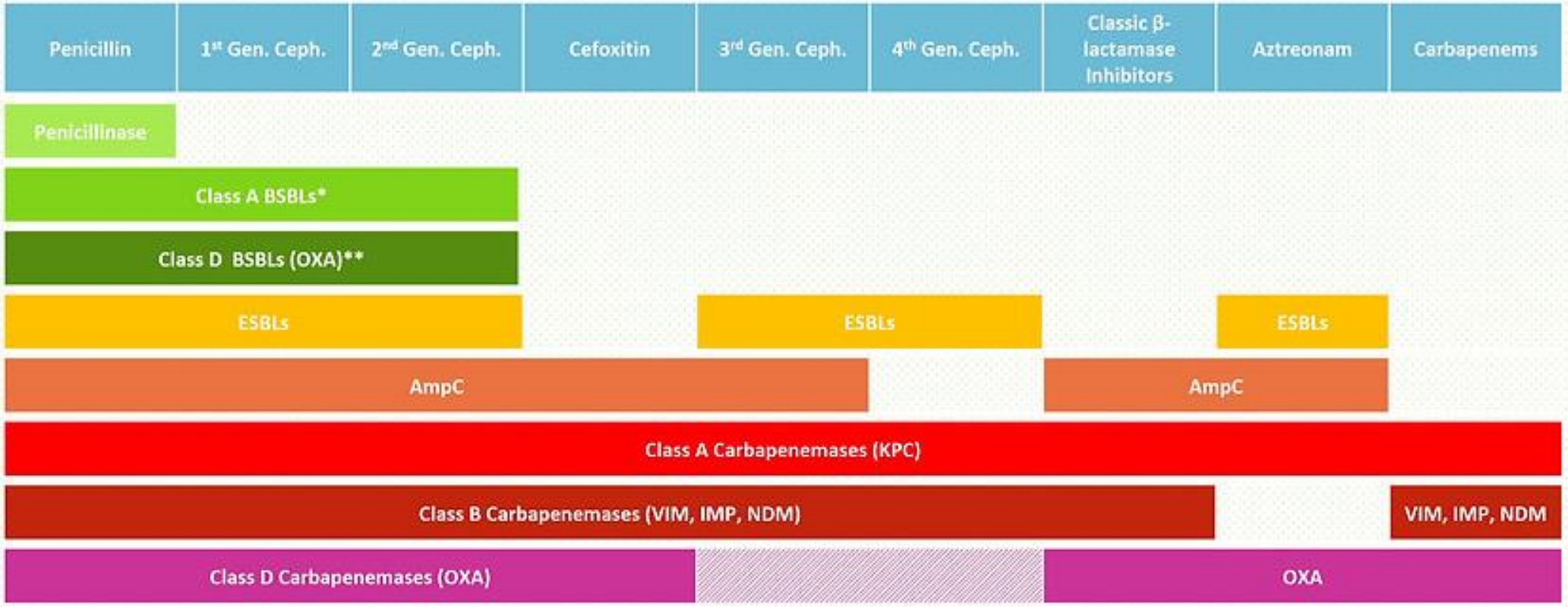
Ambler Class D

- OXA
- OXA-48
- OXA-23
- OXA-58
- OXA-40

- narrow-spectrum
- ESBL
- broad-spectrum
- carbapenemase

Noster J, Thelen P, Hamprecht A. Antibiotics. 2021; 10(9):1140.
Με τροποποίηση

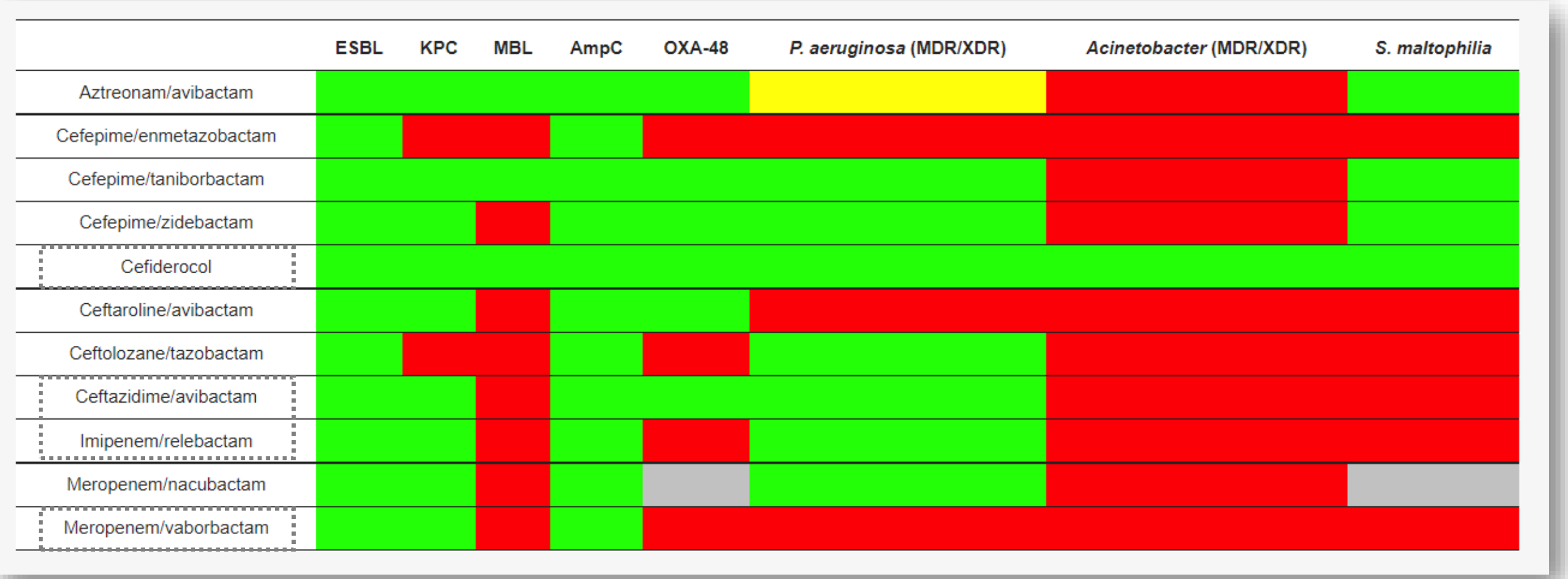
β- λακταμάσες: υδρολυτικό φάσμα



*including benzylpenicillins, aminopenicillins, carboxypenicillins, ureidopenicillin, narrow spectrum cephalosporins (cefazolin and cefuroxime and others)

**BSBL substrates plus oxacillin, nafcillin, and dicloxacillin

β- λακταμάσες και νεότερα αντιβιοτικά



Μέθοδοι ανίχνευσης της αντοχής

Phenotypic methods

Constrained by bacterial growth time

Dilution — 48 h

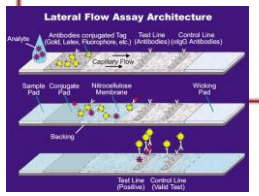
Diffusion — 48 h

Gradient test — 48 h

Chromogenic media — 24 h

Automated devices — > 20 h

LFIA



Molecular-based methods

PCR — Gene 1 Gene 2 ··· Gene N

qPCR

} several h

Cycle sequencing — 24 - 48 h

NGS — several days

** estimated time depend on a sample analysed (clinical specimen vs. isolated bacterial culture)*

Mass spectrometry

MALDI–TOF MS

Incubation (antibiotic + sample)

Matrix

several h

** estimated time depend on a sample analysed (clinical specimen vs. isolated bacterial culture)*

Gajic I et al. Antibiotics (Basel). 2022;11(4):427.

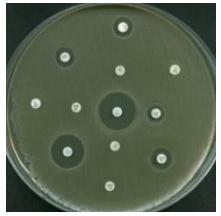
Table 1. Differences between phenotypic and genotypic resistance detection methods

Characteristic	Phenotypic methods	Genotypic methods
Question to be answered	Does the antibiotic inhibit bacterial growth at clinically relevant concentrations?	Is a gene or mutation associated with antibiotic resistance present?
Turn-around time	Slow	Fast 
Inoculum needed	High	Low
Provides information about resistance mechanism	No	Yes
Predicts antibiotic susceptibility and resistance	Yes	Sometimes. Only detects a gene or mutation associated with resistance; this may not correlate with phenotypic resistance in all isolates (e.g. if a gene is not expressed). If a singular genotypic resistance type is associated with resistance to a particular antibiotic in a particular bacterial species, its absence infers susceptibility. However, when there is more than one genotypic resistance type associated with resistance, such an inference may not always be correct.
Provides MIC	Yes	No
Cost	Moderate 	High

Banerjee R, Patel R. JAC Antimicrob Resist. 2023;5(1):dlad018.

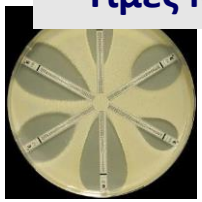
Κλινικό δείγμα

ID /AST



Ζώνες αναστολής

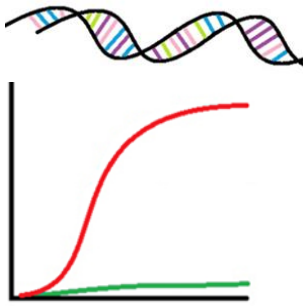
Τιμές MIC



Pheno R Μηχανισμός;

TAT= 48-72 h

CIDT

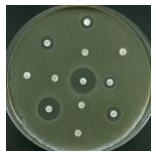
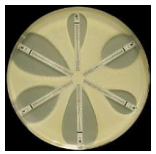
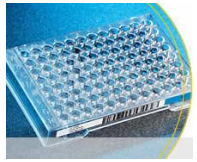


ID / Ανίχνευση γονιδίων αντοχής

TAT= 1-4 h

Διάγνωση Κατάλληλη αγωγή

AST


Ταχύτητα

αξιοπιστία

επαναληψιμότητα

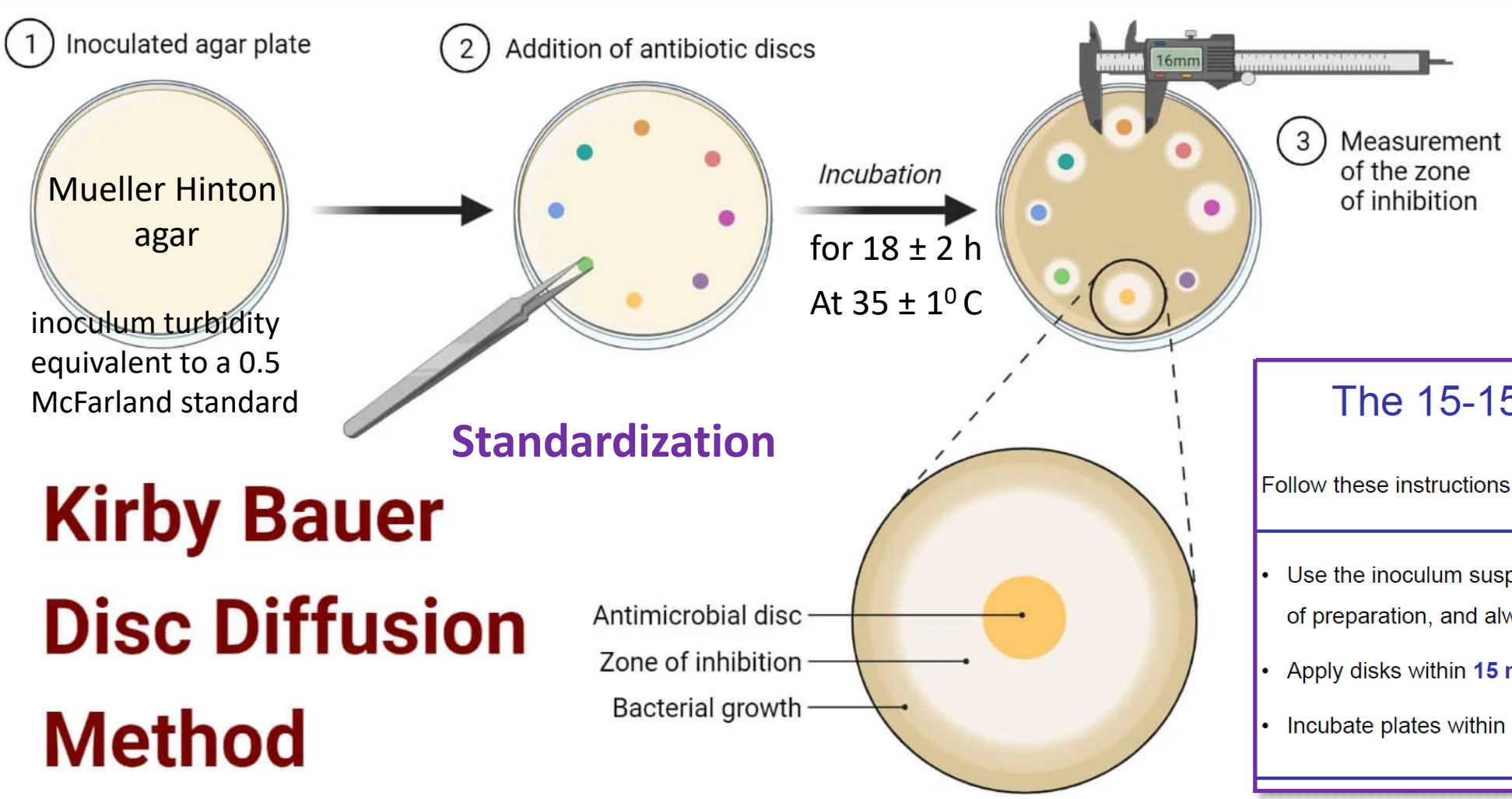
Προαγωγή της φροντίδας του ασθενούς

Διασφάλιση συνταγαγρόφησης του κατάλληλου ΑΒ

Προαγωγή της ορθολογικής χρήσης ΑΒ

Ανίχνευση μηχανισμών αντοχής
Εφαρμογή μέτρων για περιορισμό της διασποράς

Φαινοτυπικές μέθοδοι: Μέθοδος διάχυσης των δίσκων (Kirby-Bauer)



The 15-15-15 minute rule

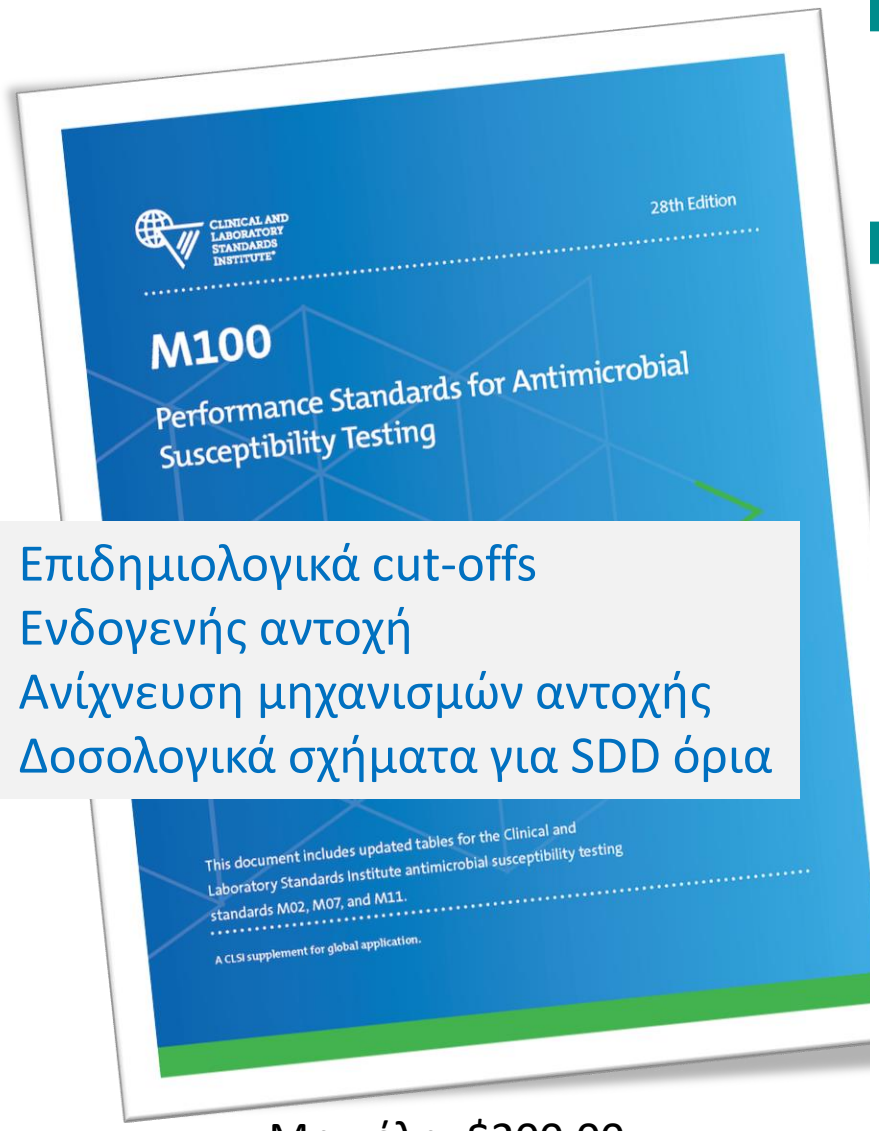
Follow these instructions for disk diffusion:

- Use the inoculum suspension optimally within **15 minutes** of preparation, and always within 60 minutes.
- Apply disks within **15 minutes** of inoculation.
- Incubate plates within **15 minutes** of disk application.

EUCAST disk diffusion method for AST. Version 11.0, January 2023.

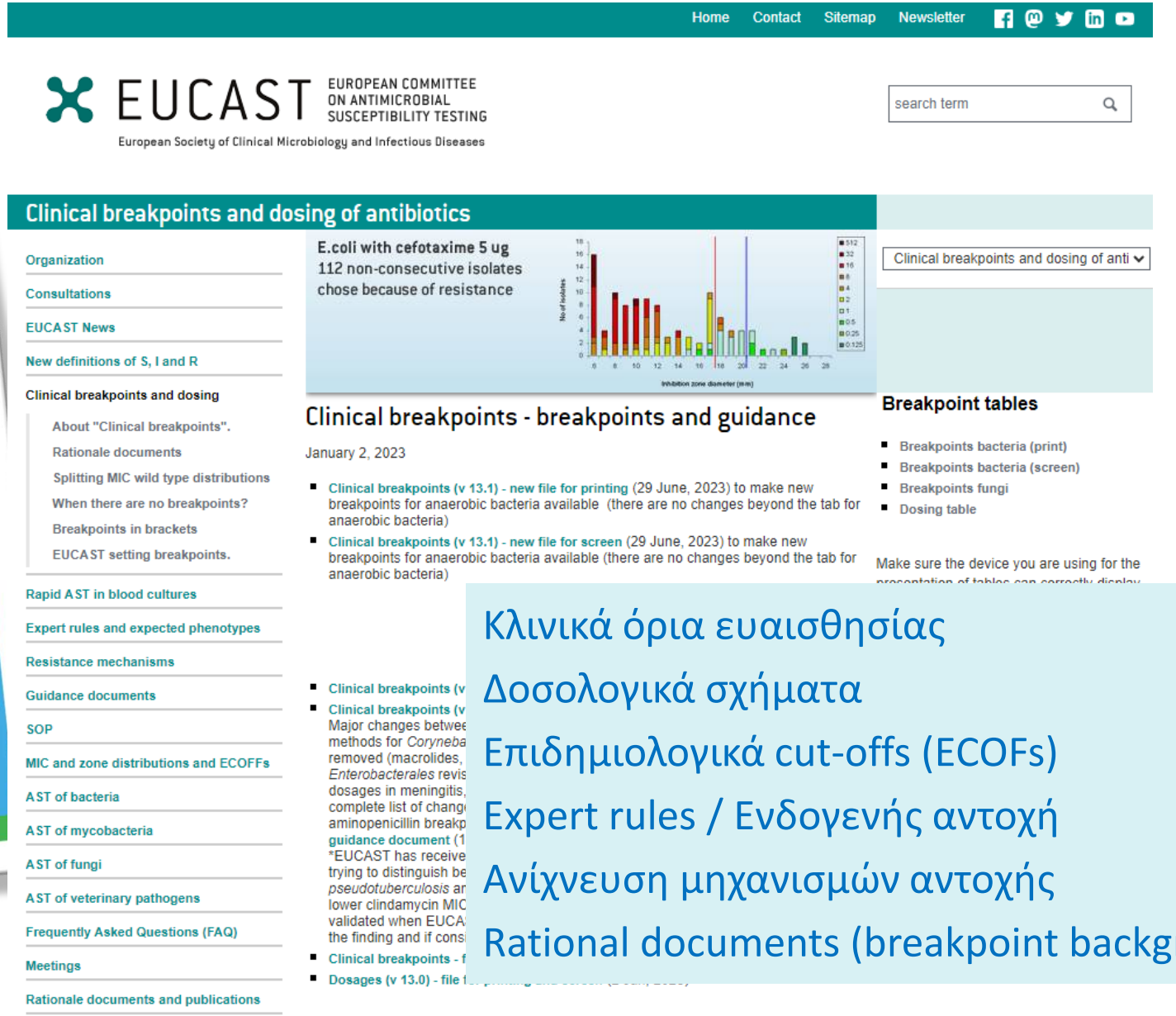
Bauer A.W., Kirby W.M.M., Sherris J.C. and Turck M. 1966.
Antibiotic susceptibility testing by a standardized single disk method. Am. J. Clin. Pathol. 45:493-496

Έλεγχος ευαισθησίας και ερμηνεία των αποτελεσμάτων



Επιδημιολογικά cut-offs
Ενδογενής αντοχή
Ανίχνευση μηχανισμών αντοχής
Δοσολογικά σχήματα για SDD όρια

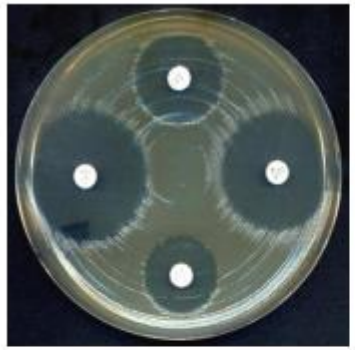
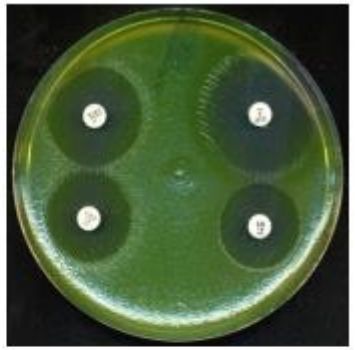
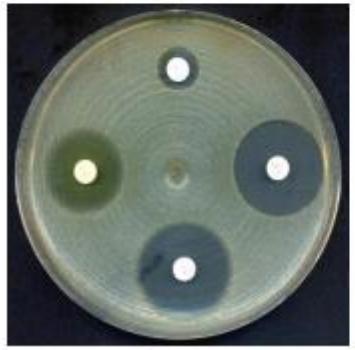
Μη μέλη: $200.00



Κλινικά όρια ευαισθησίας
Δοσολογικά σχήματα
Επιδημιολογικά cut-offs (ECOFs)
Expert rules / Ενδογενής αντοχή
Ανίχνευση μηχανισμών αντοχής
Rational documents (breakpoint background)

Μέθοδος διάχυσης των δίσκων Kirby-Bauer

S, I, R


Enterobacterales* — **EUCAST Clinical Breakpoint Tables v. 13.1, valid from 2023-06-29**

Expert Rules and Expected Phenotypes

For abbreviations and explanations of breakpoints, see the Notes sheet

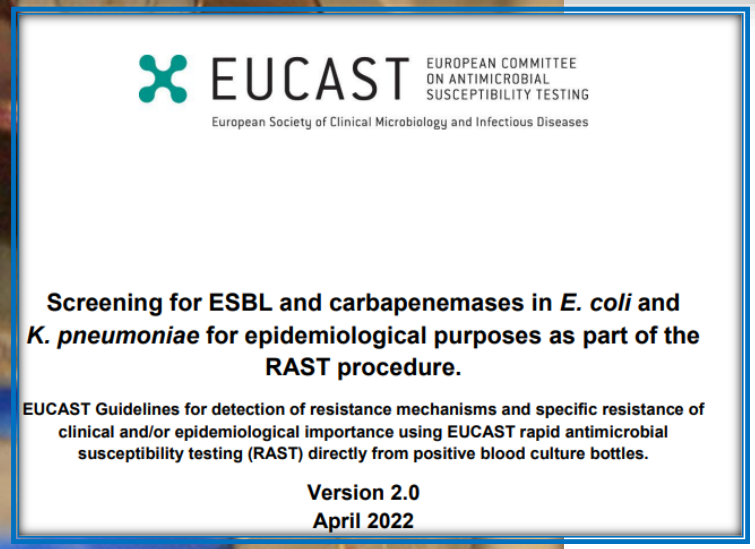
Carbapenems[1]	MIC breakpoints (mg/L)			Disk content	Zone diameter breakpoints (mm)			Notes
	S ≤	R >	ATU	(µg)	S ≥	R <	ATU	Numbered notes relate to general comments and/or MIC breakpoints. Lettered notes relate to the disk diffusion method.
Doripenem	1	2		10	24	21		1. Some isolates that produce carbapenemase are categorised as susceptible with the current breakpoints and should be reported as tested, i.e. the presence or absence of a carbapenemase does not in itself influence the categorisation of susceptibility. Carbapenemase detection and characterisation are recommended for public health and infection control purposes. For carbapenemase screening, a meropenem screening cut-off of >0.125 mg/L (zone diameter <28 mm) is recommended.
Ertapenem	0.5	0.5		10	25	25		
Imipenem, *Enterobacterales* except *Morganellaceae*	2	4		10	22	19		
Imipenem[2], *Morganellaceae*	0.001	4		10	50	19		
Imipenem-relebactam, *Enterobacterales* except *Morganellaceae*	2[3]	2[3]		10-25	22	22	20-22	2. The intrinsically low activity of imipenem against *Morganella morganii*, *Proteus* spp. and *Providencia* spp. requires the high exposure of imipenem. 3. For susceptibility testing purposes, the concentration of relebactam is fixed at 4 mg/L. 4. For susceptibility testing purposes, the concentration of vaborbactam is fixed at 8 mg/L.
Meropenem (indications other than meningitis)	2	8		10	22	16		
Meropenem (meningitis)	2	2		10	22	22		A. For isolates in the ATU, if resistant to meropenem report resistant to meropenem-vaborbactam. If not resistant to meropenem, investigate further.
Meropenem-vaborbactam	8[4]	8[4]		20-10	20	20	15-19[A]	

Monobactams	MIC breakpoints (mg/L)			Disk content	Zone diameter breakpoints (mm)			Notes
	S ≤	R >	ATU	(µg)	S ≥	R <	ATU	Numbered notes relate to general comments and/or MIC breakpoints. Lettered notes relate to the disk diffusion method.
Aztreonam[1]	1	4		30	26	21		1. The aztreonam breakpoints for *Enterobacterales* will detect clinically important resistance mechanisms (including ESBL). Some isolates that produce beta-lactamases are susceptible to aztreonam with these breakpoints and should be reported as tested, i.e. the presence or absence of an ESBL does not in itself influence the categorisation of susceptibility. ESBL detection and characterisation are recommended for public health and infection control purposes.

Fluoroquinolones	MIC breakpoints (mg/L)			Disk content	Zone diameter breakpoints (mm)			Notes
	S ≤	R >	ATU	(µg)	S ≥	R <	ATU	Numbered notes relate to general comments and/or MIC breakpoints. Lettered notes relate to the disk diffusion method.
Ciprofloxacin, *Salmonella* spp.[1]	0.06	0.06			Note[A]	Note[A]		1. There is clinical evidence for ciprofloxacin to indicate a poor response in systemic infections caused by *Salmonella* spp. with low-level ciprofloxacin resistance (MIC >0.06 mg/L). The available data relate mainly to *Salmonella* Typhi but there are also case reports of poor response with other *Salmonella* species. 2/B. In meningitis, where low-level ciprofloxacin resistance must be excluded, either perform an MIC test, or infer susceptibility from the pefloxacin 5 µg screening test.
Ciprofloxacin (indications other than meningitis)	0.25	0.5	0.5	5	25	22	22-24	
Ciprofloxacin (meningitis)[2]	0.125	0.125			Note[B]	Note[B]		
Pefloxacin (screen only)	NA	NA		5	24[A,B,C]	24[A,B,C]		A. Tests with a ciprofloxacin 5 µg disk will not reliably detect low-level resistance in *Salmonella* spp. Perform an MIC test, or infer susceptibility from the pefloxacin 5 µg screening test. C. The pefloxacin screening test can also be used to detect fluoroquinolone resistance mechanisms in other *Enterobacterales* such as *E. coli*, *K. pneumoniae* and *Shigella* spp. D. A disk diffusion test awaits action from the responsible pharmaceutical company.
Delafloxacin, *E. coli*	0.125	0.125			Note[D]	Note[D]		
Levofloxacin	0.5	1		5	23	19		
Moxifloxacin	0.25	0.25		5	22	22		
Nalidixic acid (screen only)	NA	NA			NA	NA		
Norfloxacin (uncomplicated UTI only)	0.5	0.5		10	24	24		
Ofloxacin	0.25	0.5		5	24	22		

The European Committee on Antimicrobial Susceptibility Testing. Breakpoint tables for interpretation of MICs and zone diameters. Version 13.1, 2023. http://www.eucast.org.

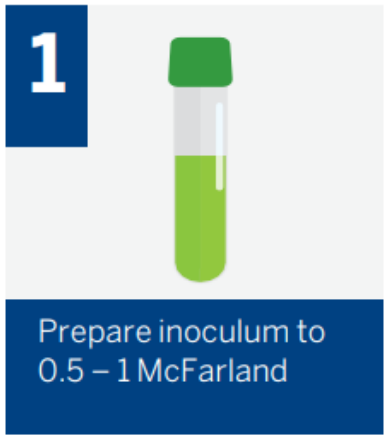
EUCAST, Rapid AST

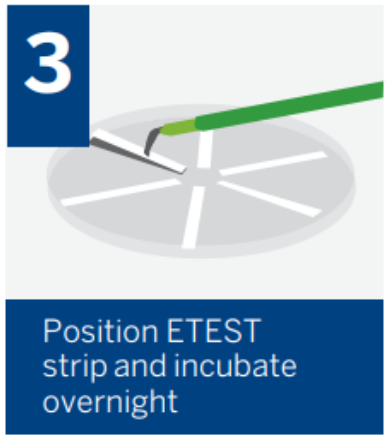


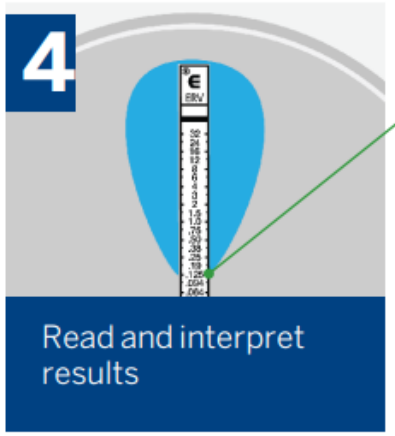
- Χρήση με φιάλες BACTEC (BD), BacT/ALERT (bioMérieux) και VersaTREK (Thermo Fisher)
- 0 – 18 h μετά τη θετικοποίηση της φιάλης
- Απευθείας ενοφθαλμισμός (MH, MH-F) με 125±25 μl από τη θετική φιάλη
- Το μικροβιακό είδος **πρέπει να είναι γνωστό** πριν την ερμηνεία των αποτελεσμάτων

Organism	Incubation time	Medium
Escherichia coli *Klebsiella pneumoniae* *Staphylococcus aureus*	4, 6 and 8 hours 16-20 hours	MH
Pseudomonas aeruginosa	6 and 8 hours 16-20 hours	MH
Acinetobacter baumannii *Enterococcus faecalis* *Enterococcus faecium*	4, 6 and 8 hours	MH
Streptococcus pneumoniae	4, 6 and 8 hours 16-20 hours	MH-F

Ταινίες διαβαθμισμένης συγκέντρωσης αντιβιοτικών





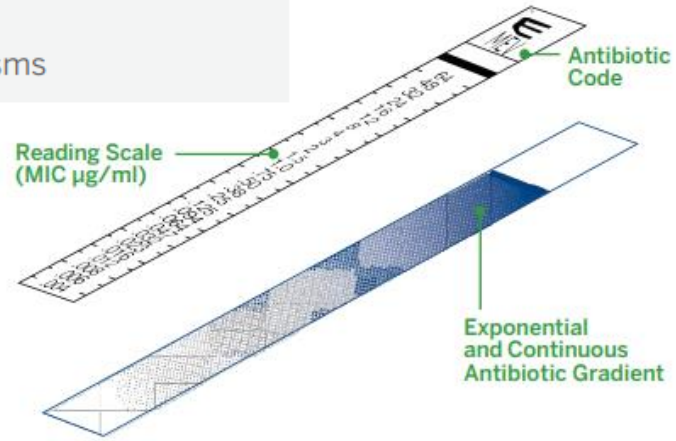


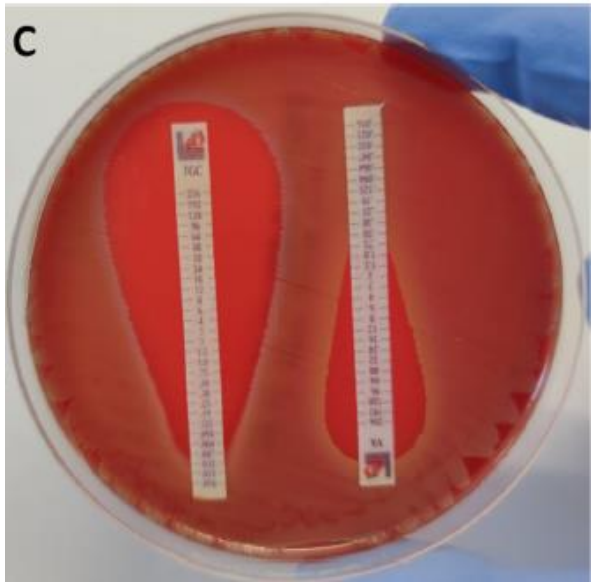
The MIC value is read from the scale in terms of µg/mL at complete inhibition of bacterial growth, where the pointed end of the ellipse intersects the strip.

SET UP TIME:
< 5 Minutes

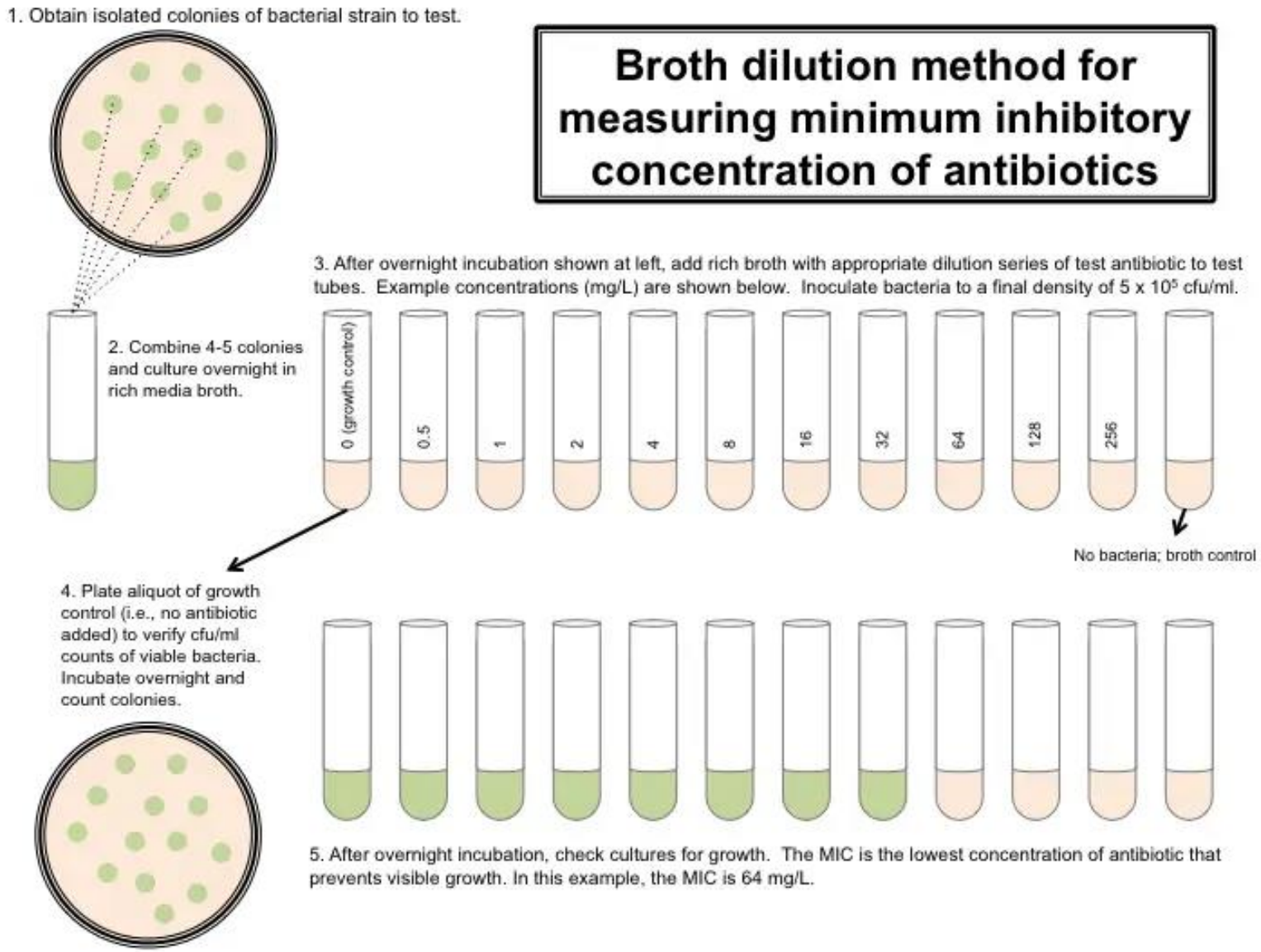
TIME TO RESULT:
16 – 20 hours for most organisms

Τιμή MIC



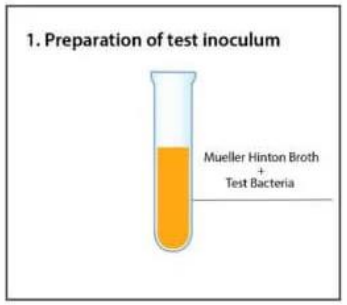


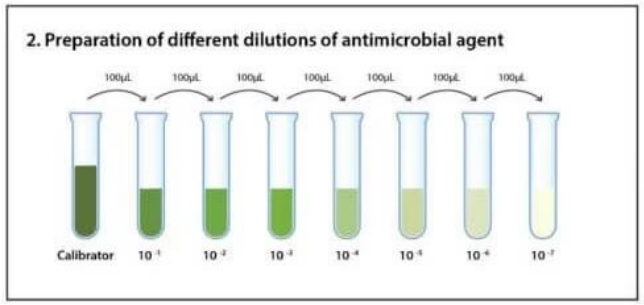
Μέθοδος μακροαραιώσεων σε ζωμό

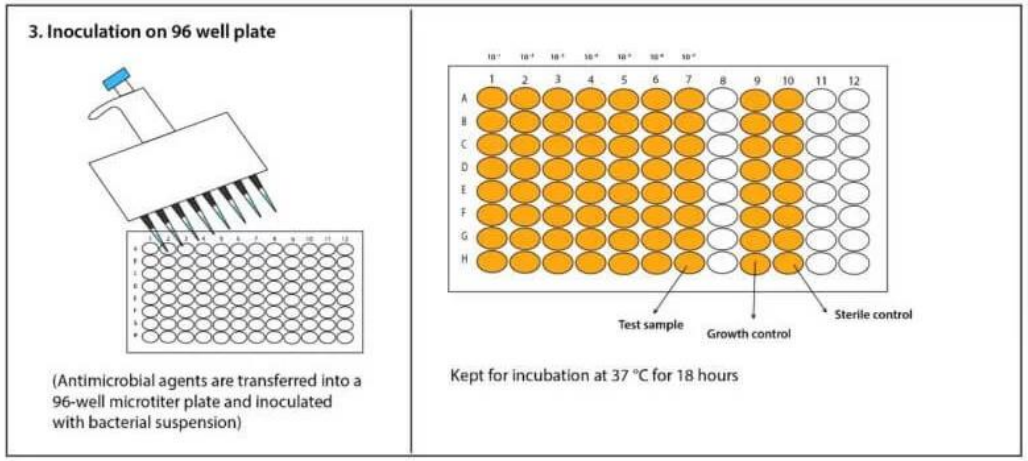


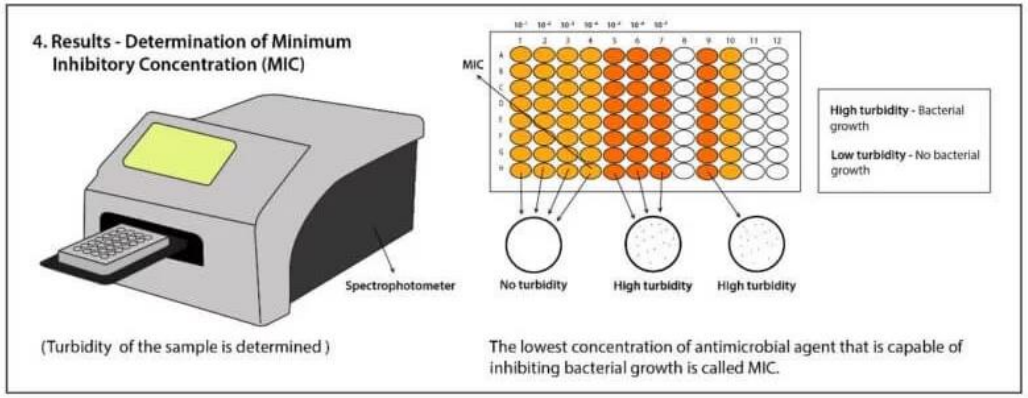
Μέθοδος μικροαραίωσης σε ζωμό (BMD)

Correct inoculum
5 x 10^5 CFU/ml





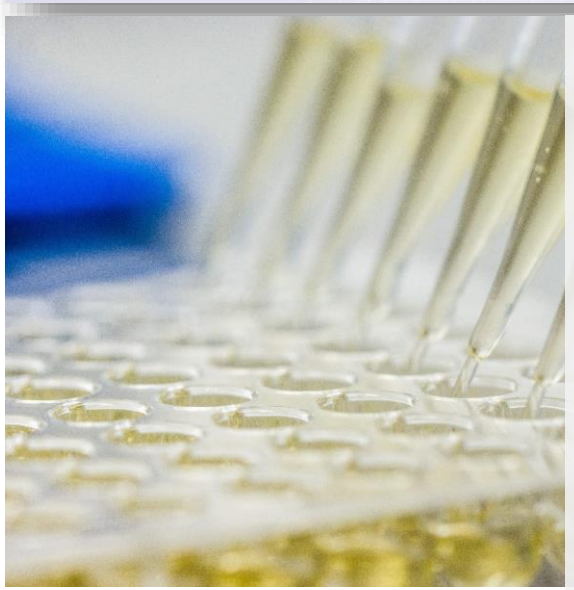




EUCAST EUROPEAN COMMITTEE ON ANTIMICROBIAL SUSCEPTIBILITY TESTING
European Society of Clinical Microbiology and Infectious Diseases

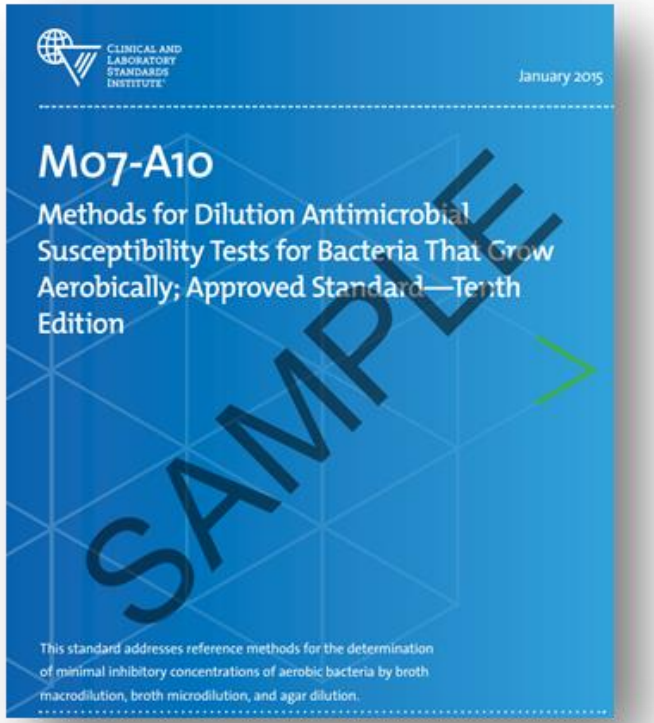
Version 4.0, January 2022

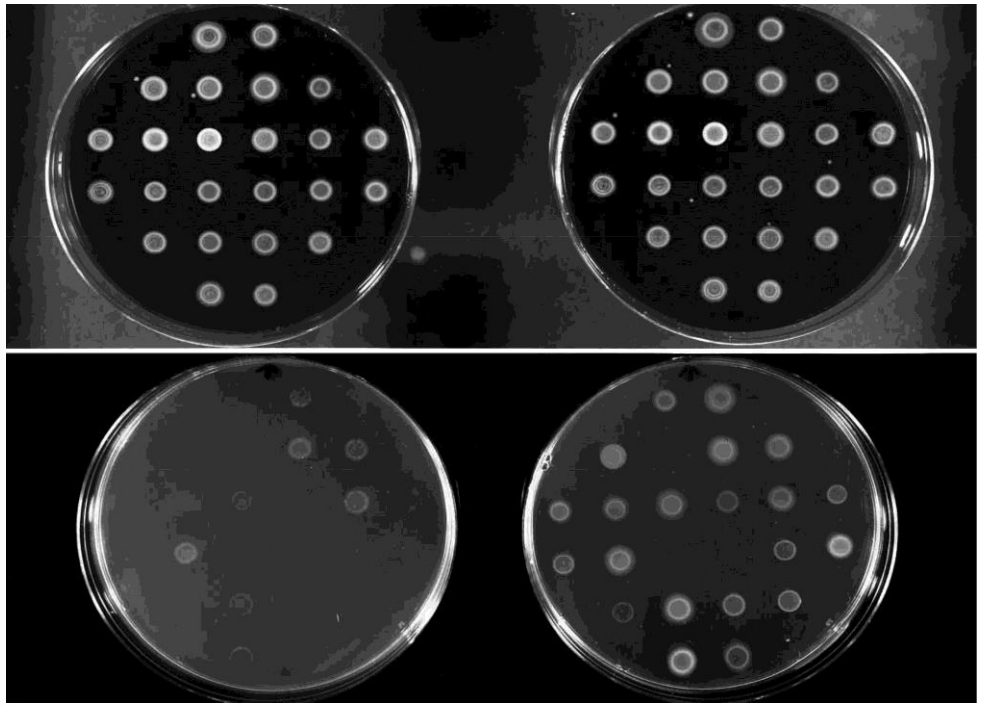
EUCAST reading guide for broth microdilution



- BMD is the reference method for AST of rapidly growing aerobic bacteria, except for mecillinam and fosfomycin, where agar dilution is the reference method.
- EUCAST recommends testing according to the International Standard ISO 20776-1 (with the use of MH-F broth for fastidious organisms).

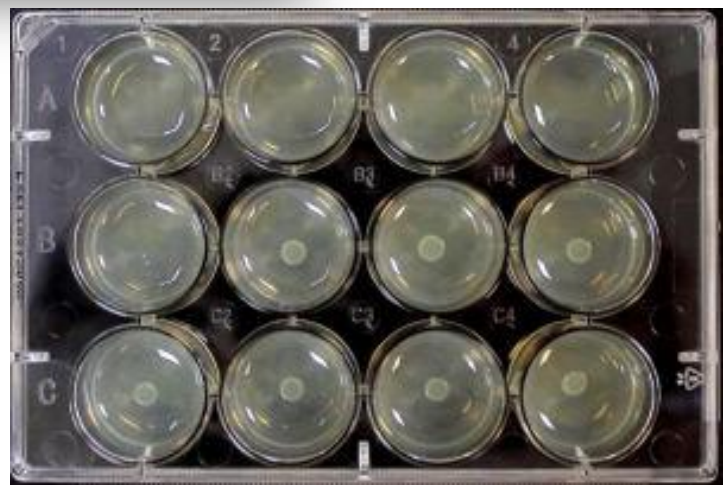
Μέθοδος αραίωσης σε άγαρ (agar dilution)



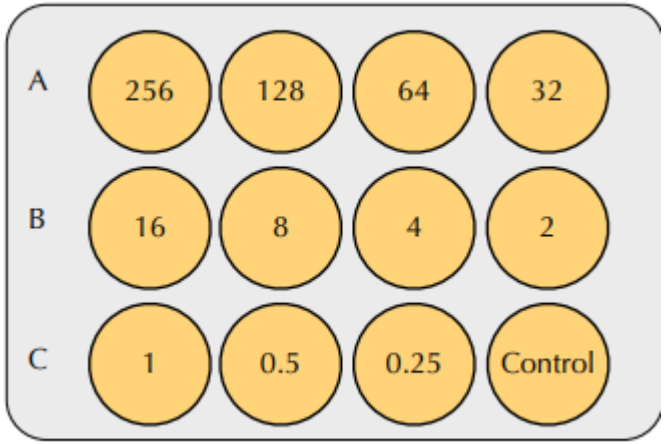


mecillinam and fosfomycin:
agar dilution is
the reference method

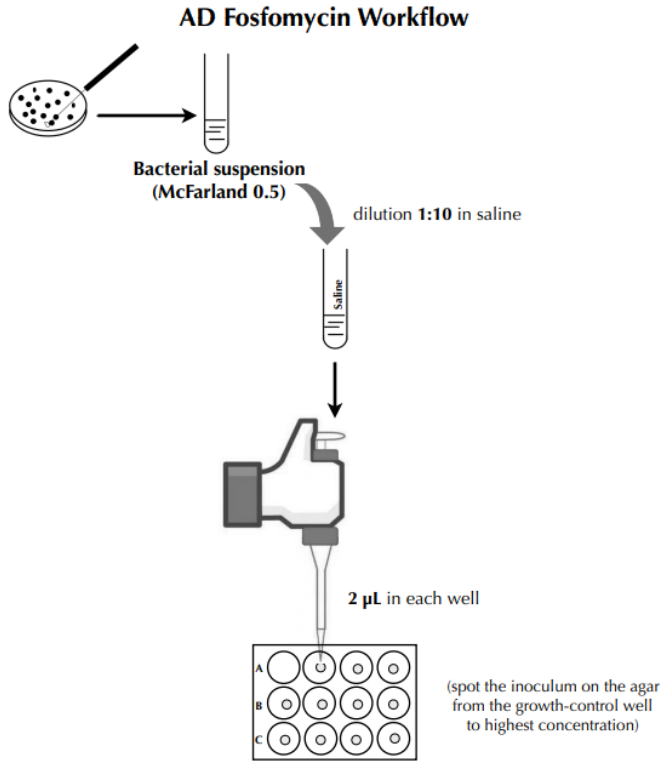
Fosfomycin Agar Dilution Panel, Liofilchem



Fosfomycin MIC range: 0.25 - 256 μg/mL



Growth-control: No antimicrobial agent in the well.



Αυτοματοποιημένα συστήματα

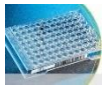
Detection of AMR facilitated by Advanced Expert System (AES).

The instruments read the kinetics of the growth using an optical system with photometer/ multichannel fluorimeter readings to assess fluorescence / turbidity /colorimetric signals

- Each of the systems has inherent advantages and limitations
- Results can vary widely by antimicrobial drugs, software versions, and cards
- Some of the systems are not reliable for correct categorization of susceptibility for certain drugs, leading to wrong classifications.
- Software updates and synchronization of breakpoints according to the current standards are mandatory.
- Panels usually contain only several concentrations of each antimicrobial agent, and the resulting MIC is not always given as an exact value.

Gajic I et al. Antibiotics (Basel). 2022;11(4):427.

Advantages and disadvantages of the common methods of antimicrobial susceptibility testing

Method	Advantage	Disadvantage	Comments
Broth dilution 	Well-standardised Harmonised Commercially available tests are easy to perform	Time-consuming Individual mistakes	Quantitative **
Agar Dilution	Well-standardised Suitable for testing a large number of isolates	Time-consuming Limited concentration of antimicrobial agents	Quantitative Possible automation in part
Disk diffusion 	Simple to perform Low cost Simple and fast interpretation The high number of test antibiotics per test High flexibility in antibiotic selection Detection of resistance patterns Mass use and the possibility of automatisation A number of a different use (AST, identification, screening, etc.) Detection of heteroresistant population or contamination	Time-consuming No MIC value The inability for some antibiotics to be tested	Qualitative *
Gradient test	Convenient and flexible Simple to perform Does not require expertise Detection of resistance patterns	Relatively expensive Relatively long incubation	Quantitative
Automated systems	Simple to perform	Relatively expensive	Semi-quantitative ***

Όχι τιμές MIC

Gajic I et al. Antibiotics (Basel). 2022;11(4):427.

Antibiotic resistance threats

Carbapenem-resistant
Enterobacterales (CRE)

Extended-spectrum cephalosporin resistance in Enterobacterales suggestive of extended- spectrum β-lactamase **(ESBL)** production

Multidrug-resistant (MDR)
Pseudomonas aeruginosa

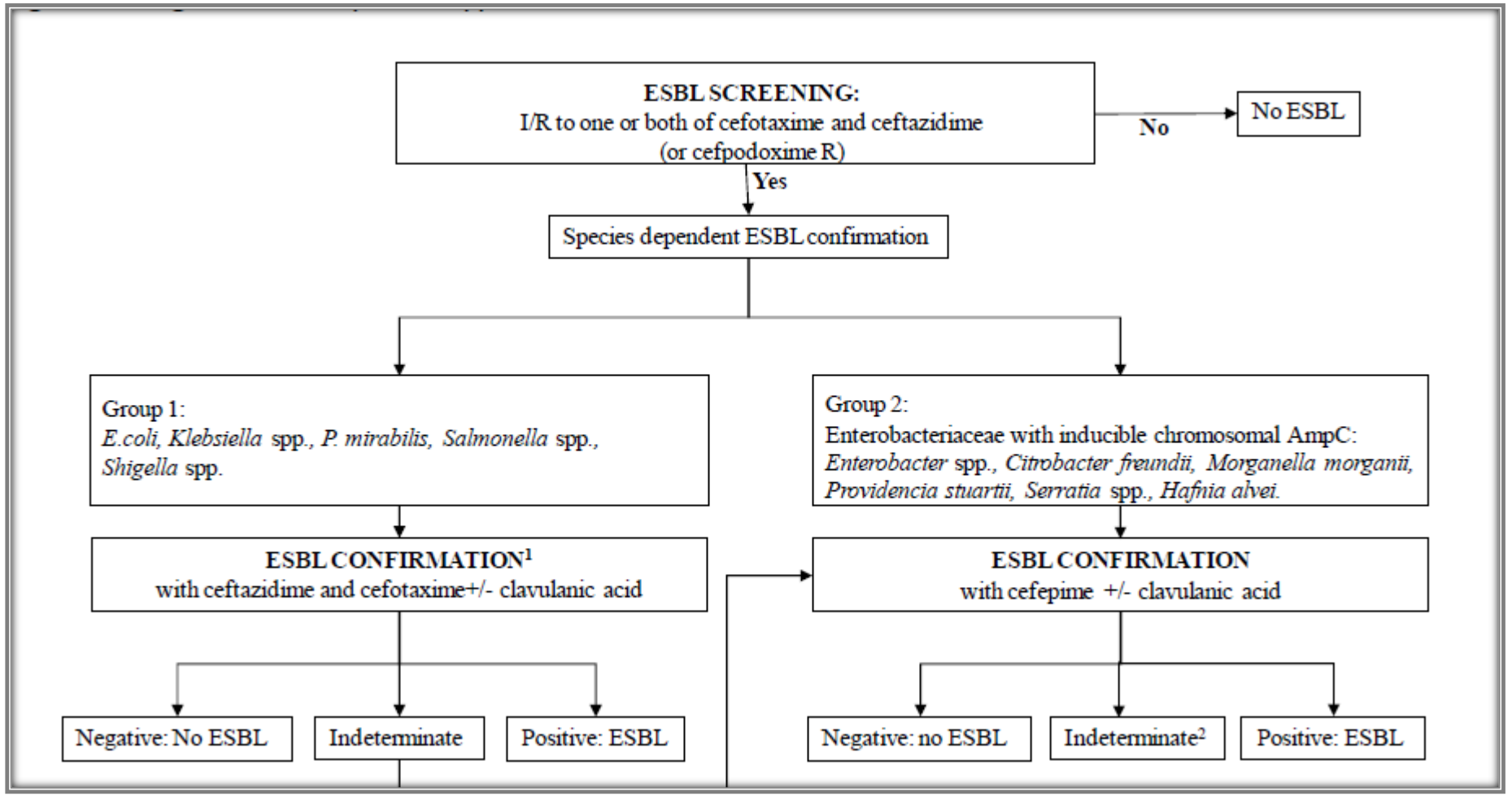
Carbapenem-resistant
Acinetobacter species

Methicillin-resistant
Staphylococcus aureus (MRSA)

Vancomycin-resistant
Enterococcus (VRE)

CDC, Antibiotic Resistance Threats in the United States

Αλγόριθμος για φαινοτυπική ανίχνευση ESBLs σε *Enterobacterales*



[1]If cefoxitin has an MIC >8 mg/L, perform cefepime+/- clavulanic acid confirmation test

If confirmation with cefepime +/- clavulanic acid is still indeterminate, genotypic testing is required.

EUCAST guidelines for detection of resistance mechanisms and specific resistances of clinical and/or epidemiological importance. Version 2.01. July 2017

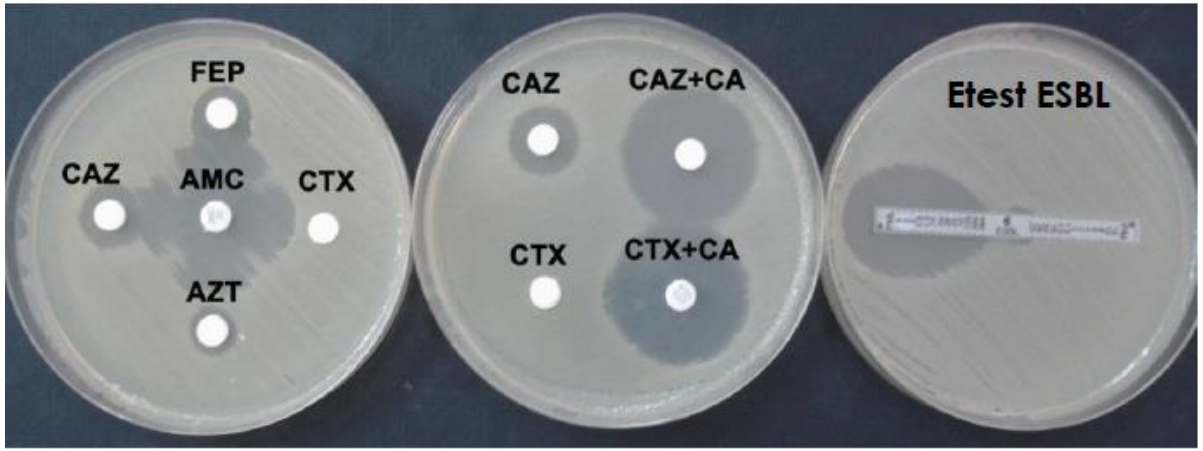
Φαινοτυπική ανίχνευση ESBL

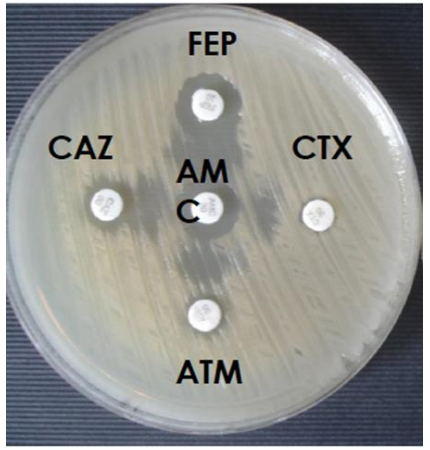
Bionumber: 0405610450106601
Organism Quantity:

Selected Organism: Escherichia coli

Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
ESBL	POS	+	Ertapenem	<= 0.12	S
Temocillin			Imipenem	<= 0.25	S
Urine	<= 4	I	Meropenem		
Other	<= 4		Meningitis	<= 0.25	S
Ampicillin	>= 32	R	Other	<= 0.25	S
Amoxicillin/Clavulanic Acid	8	S	Amikacin	2	S
Piperacillin/Tazobactam	<= 4	S	Gentamicin	<= 1	S
Cefuroxime	>= 64	R	Tobramycin	<= 1	S
efuroxime Axetil	>= 64	R	Ciprofloxacin		
Cefoxitin	<= 4	IE	Meningitis	0.5	
Cefditoren			Other	0.5	I
Cefixime	>= 4	R	Levofloxacin	1	I
Cefotaxime			Moxifloxacin	0.5	R
Meningitis	>= 64	R	Minocycline	(-)	(-)
Other	>= 64	R	Tetracycline	(-)	(-)
Ceftazidime	8	R	Tigecycline	<= 0.5	S
Ceftriaxone			Fosfomycin		
Meningitis	>= 64	R	Oral	<= 16	
Other	>= 64	R	Other	<= 16	S
Ceftazidime/Avibactam	<= 0.12	S	Nitrofurantoin	<= 16	S
Ceftolozane/Tazobactam	<= 0.25	S	Chloramphenicol	4	IE
Cefepime	2	I	Colistin	<= 0.5	S
Aztreonam	16	R	Trimethoprim/ Sulfamethoxazole	<= 20	S

DDST **CDT** **Etest ESBL**



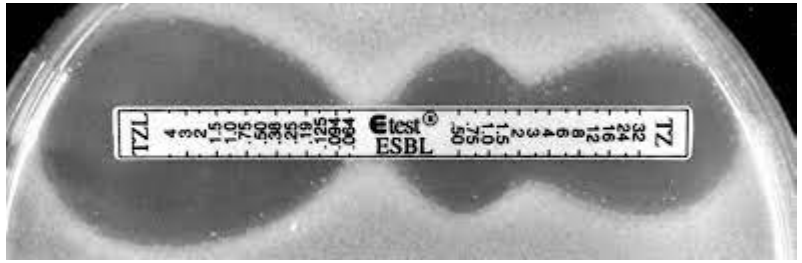


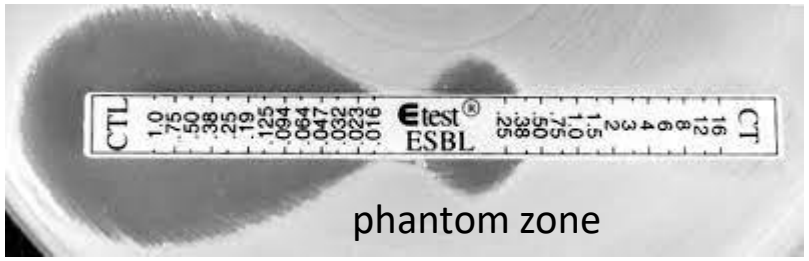
≥5 mm increase in inhibition zone

MIC ratio ≥8 or if a phantom zone or deformed ellipse is present

Φαινοτυπική ανίχνευση ESBL

Etest ESBL



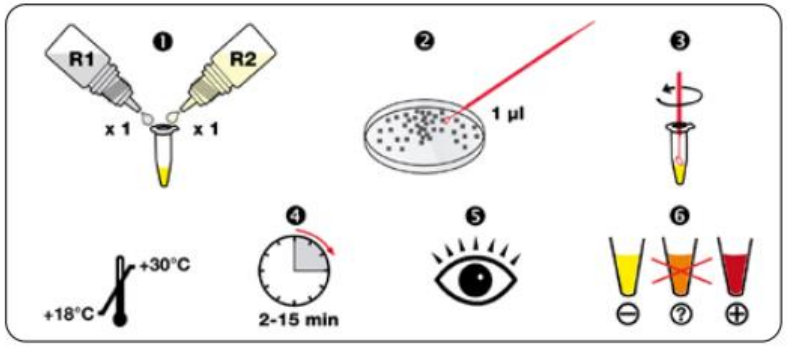


phantom zone

Reduction of MIC 8 times by clavulanate

Χρωματομετρικές μέθοδοι

β LACTA™ test

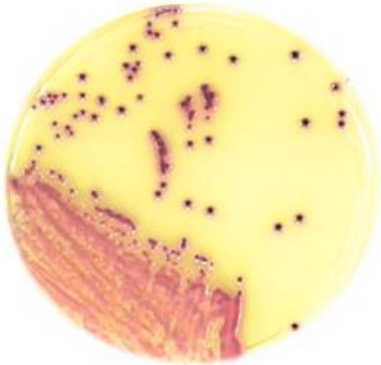


directly with isolated colonies or with bacterial pellets from positive blood cultures or urines

Se: 98%
Sp: 100%

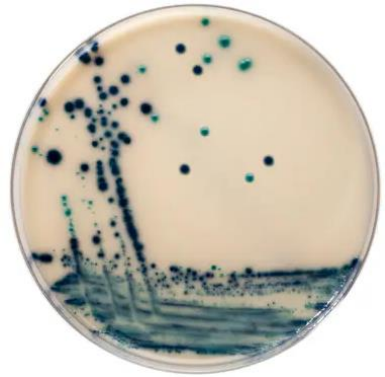
Χρωμογόνα υλικά

Liofilchem®
Chromatic ESBL



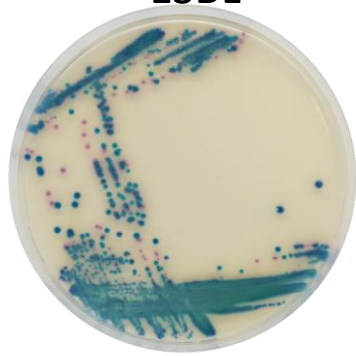
Escherichia coli DSM 22311

Brilliance™
ESBL Agar



CHROMID® ESBL

CHROMagar™
ESBL



EUCAST guidelines for detection of resistance mechanisms and specific resistances of clinical and/or epidemiological importance. Version 2.01. July 2017

Del Corpo O et al. Clin Microbiol Infect. 2023 Sep 16:S1198-743X(23)00425-1.

Vitek reports

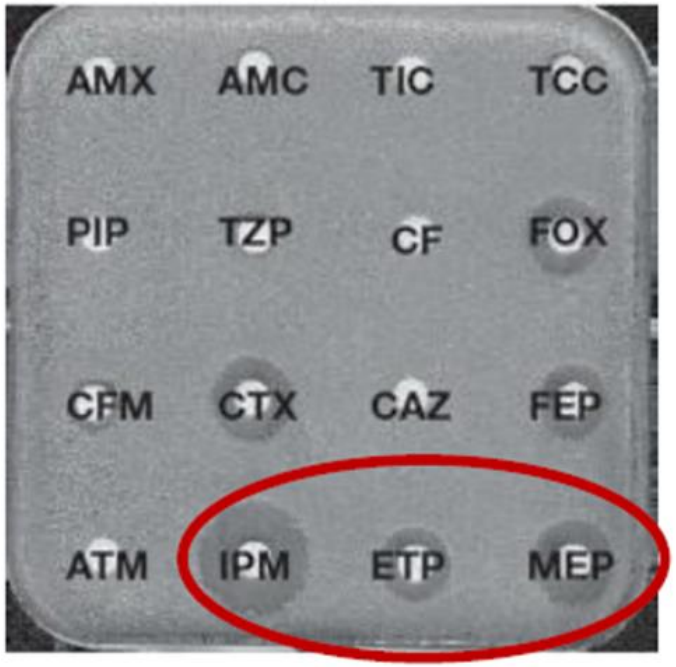
Organism Quantity: **Selected Organism: Klebsiella pneumoniae**

Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
ESBL	NEG	-	Ertapenem	>= 8	R
Temocillin			Imipenem	>= 16	R
Urine	>= 32	R	Meropenem		
Other	>= 32		Meningitis	>= 16	R
Ampicillin	>= 32	R	Other	>= 16	R
Amoxicillin/Clavulanic Acid	>= 32	R	Amikacin	16	R
Piperacillin/Tazobactam	>= 128	R	Gentamicin	>= 16	R
Cefuroxime	>= 64	R	Tobramycin	>= 16	R
Cefuroxime Axetil	>= 64	R	Ciprofloxacin		
Cefoxitin	>= 64	IE	Meningitis	>= 4	
Cefditoren			Other	>= 4	R
Cefixime	>= 4	R	Levofloxacin	>= 8	R
Cefotaxime			Moxifloxacin	>= 8	R
Meningitis	>= 64	R	Minocycline	(-)	(-)
Other	>= 64	R	Tetracycline	(-)	(-)
Ceftazidime	>= 64	R	Tigecycline	2	R
Ceftriaxone			Fosfomycin		
Meningitis	>= 64	R	Oral	128	R
Other	>= 64	R	Other	128	R
Ceftazidime/Avibactam	4	S	Nitrofurantoin		
Ceftolozane/Tazobactam	>= 32	R	Chloramphenicol	>= 64	IE
Cefepime	>= 32	R	Colistin	>= 16	R
Aztreonam	>= 64	R	Trimethoprim/ Sulfamethoxazole	>= 320	R

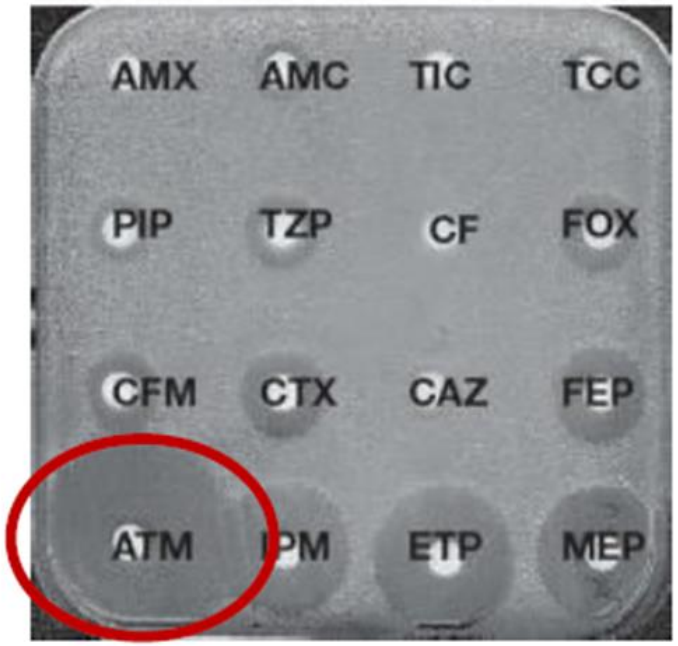
Organism Quantity: **Selected Organism: Klebsiella pneumoniae**

Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
ESBL	NEG	-	Ertapenem	>= 8	R
Temocillin			Imipenem	>= 16	R
Urine	>= 32	R	Meropenem		
Other	>= 32		Meningitis	>= 16	R
Ampicillin	>= 32	R	Other	>= 16	R
Amoxicillin/Clavulanic Acid	>= 32	R	Amikacin	4	S
Piperacillin/Tazobactam	>= 128	R	Gentamicin	>= 16	R
Cefuroxime	>= 64	R	Tobramycin	8	R
Cefuroxime Axetil	>= 64	R	Ciprofloxacin		
Cefoxitin	>= 64	IE	Meningitis	>= 4	
Cefditoren			Other	>= 4	R
Cefixime	>= 4	R	Levofloxacin	>= 8	R
Cefotaxime			Moxifloxacin	>= 8	R
Meningitis	>= 64	R	Minocycline	(-)	(-)
Other	>= 64	R	Tetracycline	(-)	(-)
Ceftazidime	>= 64	R	Tigecycline	1	R
Ceftriaxone			Fosfomycin		
Meningitis	>= 64	R	Oral	<= 16	
Other	>= 64	R	Other	<= 16	S
Ceftazidime/Avibactam	>= 16	R	Nitrofurantoin		
Ceftolozane/Tazobactam	>= 32	R	Chloramphenicol	16	IE
Cefepime	>= 32	R	Colistin	<= 0.5	S
Aztreonam	>= 64	R	Trimethoprim/ Sulfamethoxazole	<= 20	S

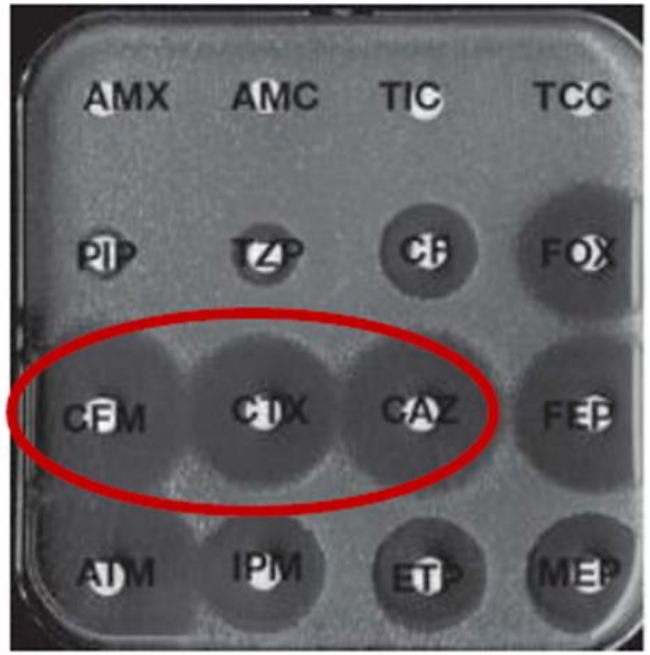
Ανίχνευση παραγωγής καρβαπενεμασών στα Εντεροβακτηριακά: πληροφορίες από το αντιβιόγραμμα



KPC / ESBL +/- [Caz-avi S]
MBL / ESBL + [Caz-avi R]
OXA-48 / ESBL +
Co-production of …



MBL
ESBL negative



OXA-48
ESBL negative

Ανίχνευση μηχανισμών αντοχής: CRE

Clinical breakpoints and **screening cut-off values** for carbapenemase-producing Enterobacteriaceae (according to EUCAST methodology)

Carbapenem	MIC (mg/L)		Disk diffusion zone diameter (mm) with 10 µg disks	
	S/I breakpoint	Screening cut-off	S/I breakpoint	Screening cut-off
Meropenem[1]	≤2	>0.125	≥22	<28[2]
Ertapenem[3]	≤0.5	>0.125	≥25	<25

[1]Best balance of sensitivity and specificity

[2]Isolates with 25-27 mm only need to be investigated for carbapenemase-production if they are resistant to piperacillin-tazobactam and/or temocillin (temocillin contributes more to the specificity).

Investigation for carbapenemases is always warranted if zone diameter of meropenem is <25 mm.

[3]High sensitivity but low specificity. Can be used as an alternative screening agent, but isolates with ESBL and AmpC may be resistant without having carbapenemases.

Phenotypic methods

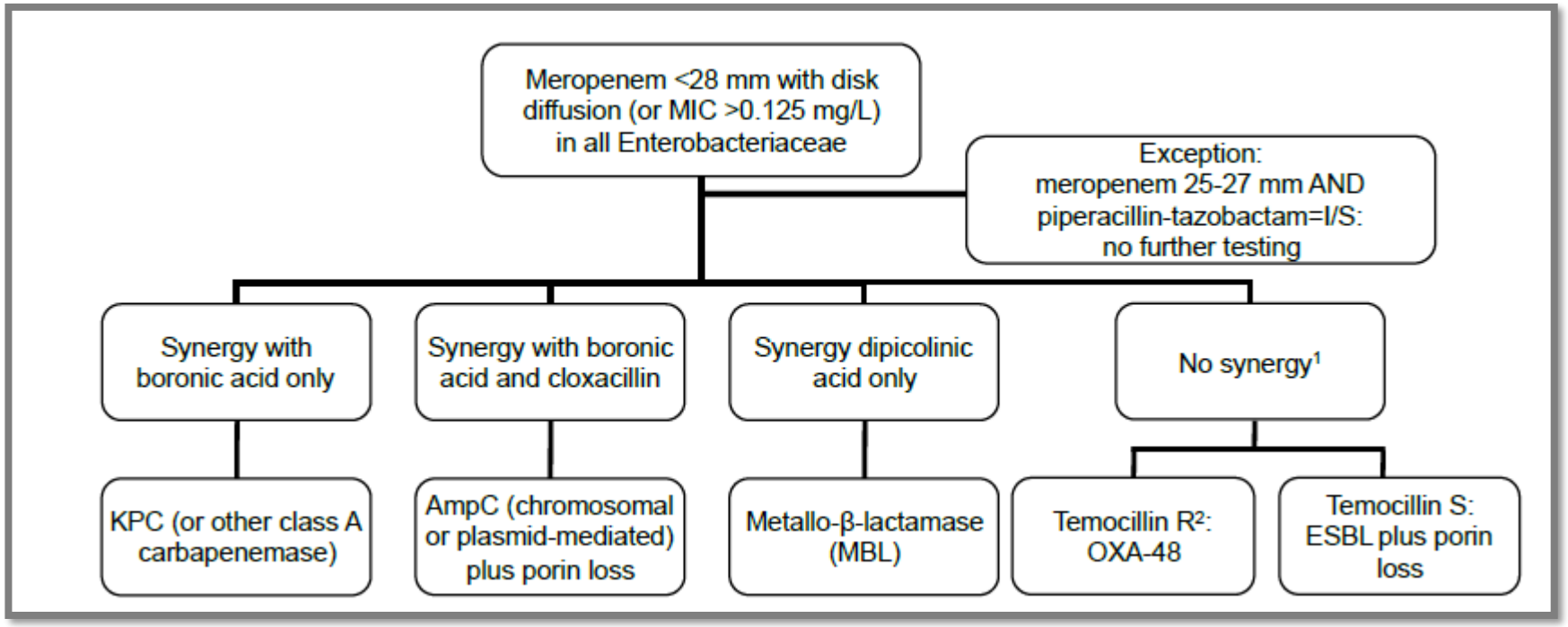
- combination disk test methods
- colorimetric assays based on hydrolysis of carbapenems

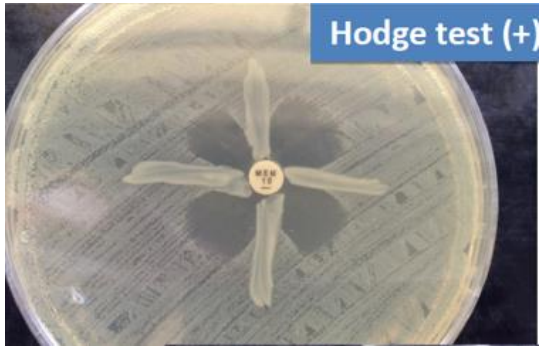
- other methods detecting carbapenem hydrolysis
- lateral flow assays

EUCAST guidelines for detection of resistance mechanisms and specific resistances of clinical and/or epidemiological importance. Version 2.01. July 2017

Ανίχνευση μηχανισμών αντοχής: CRE

Φαινοτυπικός αλγόριθμος για ανίχνευση παραγωγής καρβαπενεμασών στα Εντεροβακτηριακά



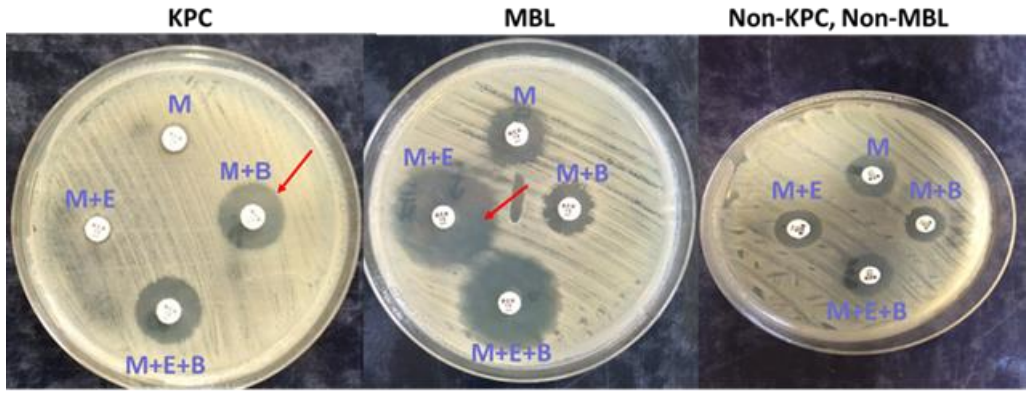


Use of the modified cloverleaf (Hodge) test is **not currently recommended** as results are difficult to interpret, the specificity is poor, and in some cases the sensitivity is also suboptimal

[1]Combination of several carbapenemases can also contribute to no synergy – e.g. MBL and KPC in combination. Molecular testing is usually necessary in such cases

[2]High-level temocillin resistance (>128 mg/L, zone diameter <11 mm) is a phenotypic marker of OXA-48

EUCAST guidelines for detection of resistance mechanisms and specific resistances of clinical and/or epidemiological importance. Version 2.01. July 2017



Journal of Antimicrobial Chemotherapy (2008) **62**, 1257–1260
doi:10.1093/jac/dkn364
Advance Access publication 4 September 2008

JAC

First occurrence of KPC-2-possessing *Klebsiella pneumoniae* in a Greek hospital and recommendation for detection with boronic acid disc tests

Athanassios Tsakris[1]*, Ioulia Kristo[2], Aggeliki Poulou[3], Fani Markou[3], Alexandros Ikonomidis[2] and Spyros Pournaras[2]

JOURNAL OF CLINICAL MICROBIOLOGY, Feb. 2009, p. 362–367 Vol. 47, No. 2
0095-1137/09/$08.00+0 doi:10.1128/JCM.01922-08

Evaluation of Boronic Acid Disk Tests for Differentiating KPC-Possessing *Klebsiella pneumoniae* Isolates in the Clinical Laboratory▽

Athanassios Tsakris,[1]* Ioulia Kristo,[2] Aggeliki Poulou,[3] Katerina Themeli-Digalaki,[4] Alexandros Ikonomidis,[2] Dimitra Petropoulou,[5] Spyros Pournaras,[2] and Danai Sofianou[6]

JOURNAL OF CLINICAL MICROBIOLOGY, Nov. 2009, p. 3420–3426 Vol. 47, No. 11
0095-1137/09/$12.00 doi:10.1128/JCM.01314-09

Use of Boronic Acid Disk Tests To Detect Extended-Spectrum β-Lactamases in Clinical Isolates of KPC Carbapenemase-Possessing *Enterobacteriaceae*▽

Athanassios Tsakris,[1]* Aggeliki Poulou,[2] Katerina Themeli-Digalaki,[3] Evangelia Voulgari,[1] Theodore Pittaras,[1] Danai Sofianou,[4] Spyros Pournaras,[5] and Dimitra Petropoulou[6]

J Antimicrob Chemother 2010; **65**: 1319–1321
doi:10.1093/jac/dkq124 Advance Access publication 15 April 2010

Journal of Antimicrobial Chemotherapy

Inhibitor-based methods for the detection of KPC carbapenemase-producing Enterobacteriaceae in clinical practice by using boronic acid compounds

Spyros Pournaras[1], Aggeliki Poulou[2] and Athanassios Tsakris[3]*

JOURNAL OF CLINICAL MICROBIOLOGY, Aug. 2011, p. 2804–2809 Vol. 49, No. 8
0095-1137/11/$12.00 doi:10.1128/JCM.00666-11

2011;49(8):2804-9.

Comparative Evaluation of Combined-Disk Tests Using Different Boronic Acid Compounds for Detection of *Klebsiella pneumoniae* Carbapenemase-Producing *Enterobacteriaceae* Clinical Isolates▽

Athanassios Tsakris,[1]* Katerina Themeli-Digalaki,[2] Aggeliki Poulou,[1,3] Georgia Vrioni,[1] Evangelia Voulgari,[1] Vasiliki Koumaki,[1] Antonella Agodi,[4] Spyros Pournaras,[5] and Danai Sofianou[6]

JCM Journals.ASM.org

2014;52(5):1483-9.

Modified CLSI Extended-Spectrum β-Lactamase (ESBL) Confirmatory Test for Phenotypic Detection of ESBLs among *Enterobacteriaceae* Producing Various β-Lactamases

Aggeliki Poulou,[a,b] Evgenia Grivakou,[a] Georgia Vrioni,[a] Vassiliki Koumaki,[a] Theodoros Pittaras,[a] Spyros Pournaras,[a] Athanassios Tsakris[a]
Department of Microbiology, Medical School, University of Athens, Athens, Greece[a]; Department of Microbiology, General Hospital of Serres, Serres, Greece[b]

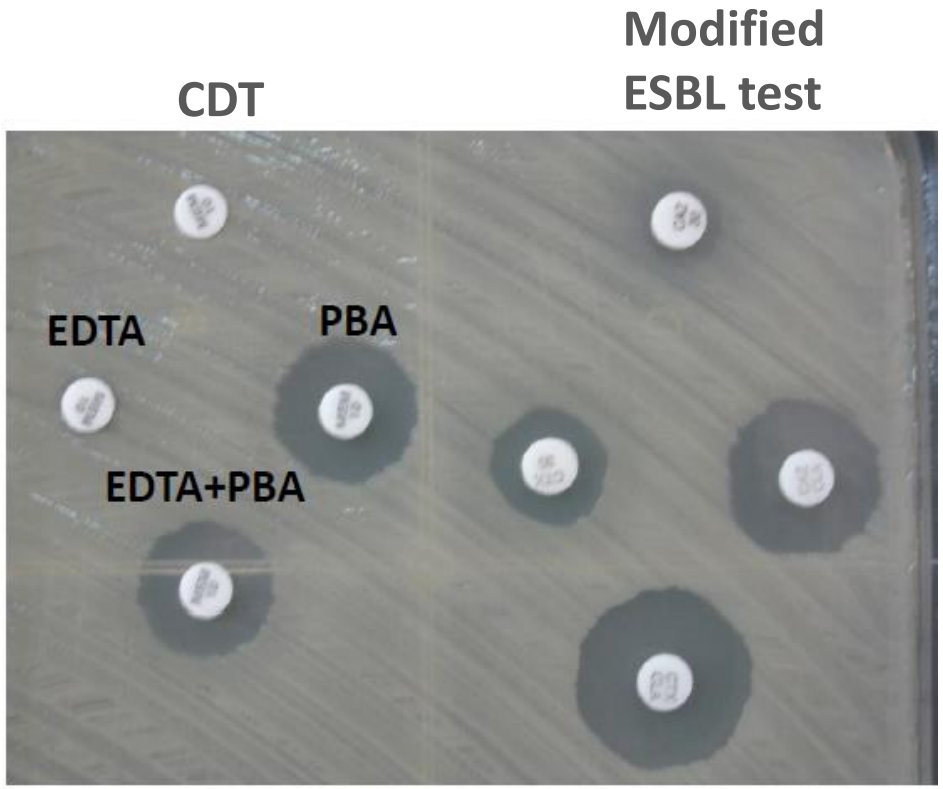
JCM Journals.ASM.org

2013;51(9):2986-90.

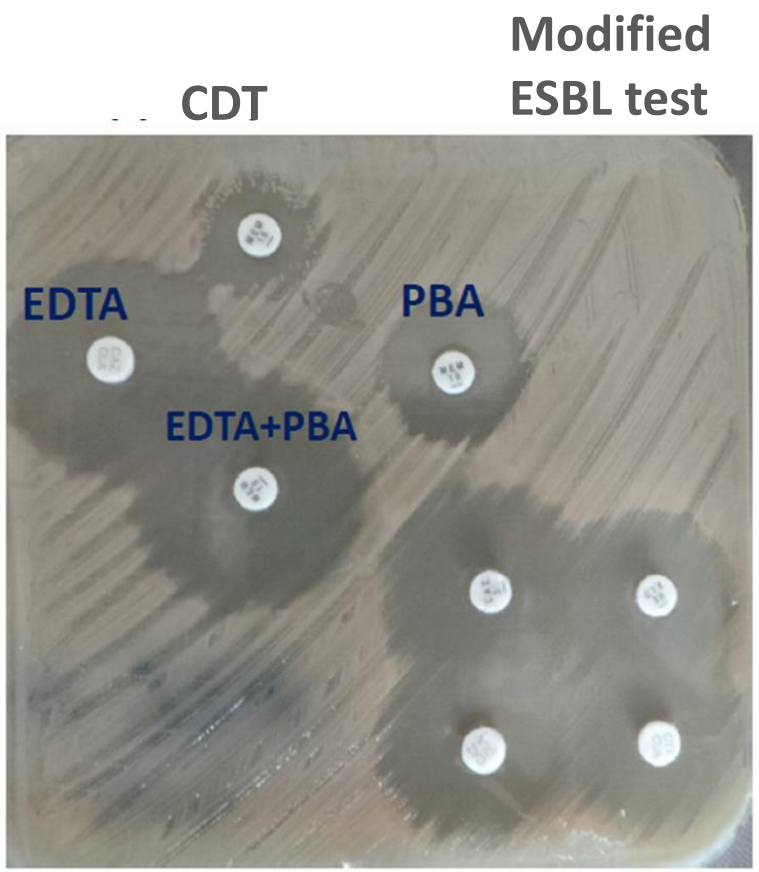
A Combined Disk Test for Direct Differentiation of Carbapenemase-Producing *Enterobacteriaceae* in Surveillance Rectal Swabs

Spyros Pournaras,[a] Olympia Zarkotou,[a,b] Aggeliki Poulou,[a,c] Ioulia Kristo,[d] Georgia Vrioni,[a] Katerina Themeli-Digalaki,[b] Athanassios Tsakris[a]
Department of Microbiology, Medical School, University of Athens, Athens, Greece[a]; Department of Microbiology, Tzaneio General Hospital, Piraeus, Greece[b]; Department of Microbiology, Serres General Hospital, Serres, Greece[c]; Department of Microbiology, Faculty of Medicine, University of Thessaly, Larissa, Greece[d]

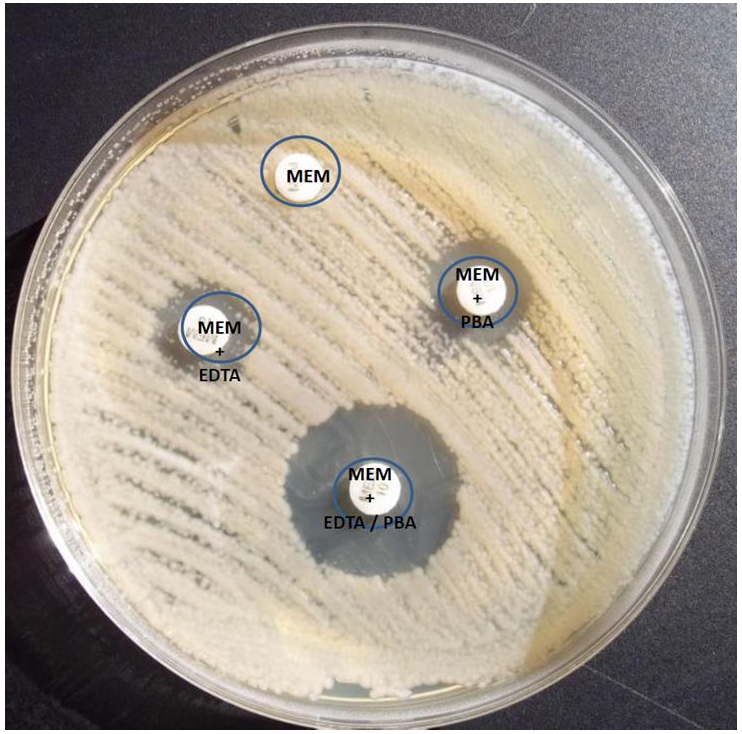
Φαινοτυπική ανίχνευση καρβαπενεμασών στα Εντεροβακτηριακά



KPC



MBL



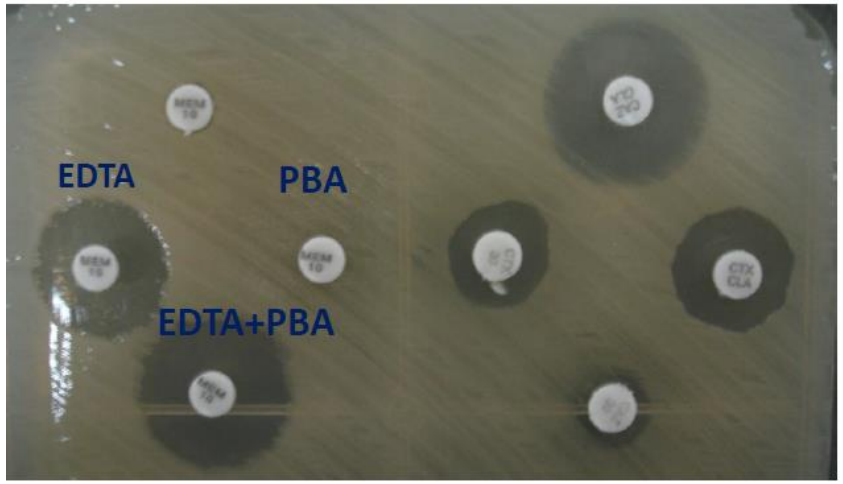
KPC+MBL

Φαινοτυπική ανίχνευση καρβαπενεμασών στα Εντεροβακτηριακά: MBL

CDT

Αλγόριθμος καρβαπεμενασών

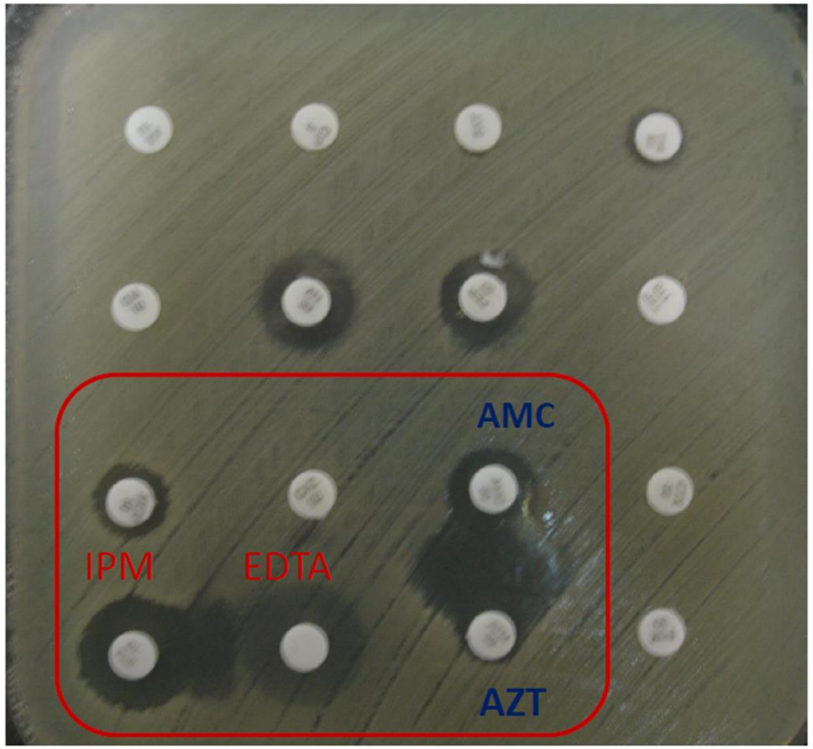
Modified CLSI ESBL test



MBL positive (NDM-1)

ESBL positive

DDST



MBL positive

ESBL positive

Etest MBL

Different growth-inhibition patterns:

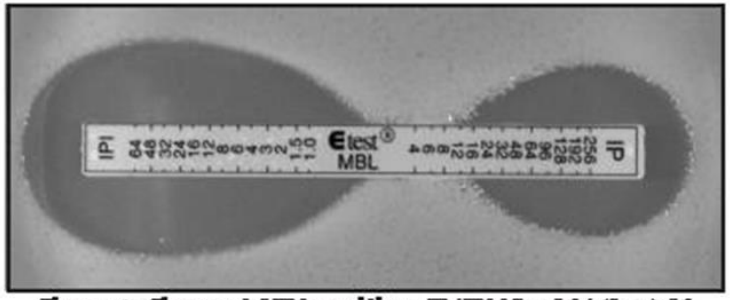


Figure 2. Clear cut MBL positive: IP/IPI IC = 16/<1 = >16

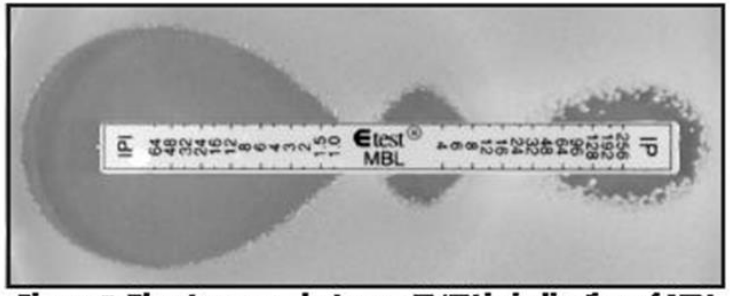


Figure 3. Phantom zone between IP/IPI is indicative of MBL

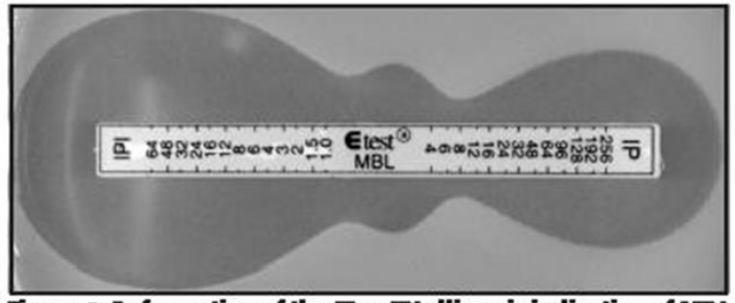
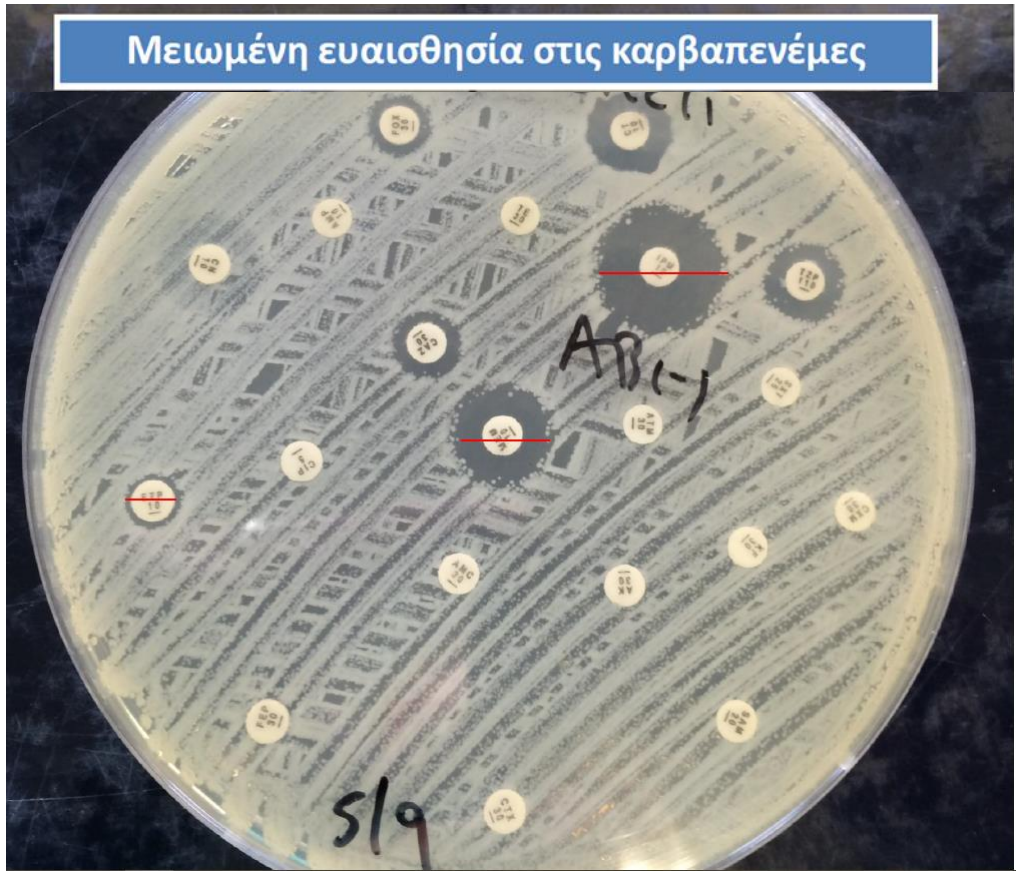
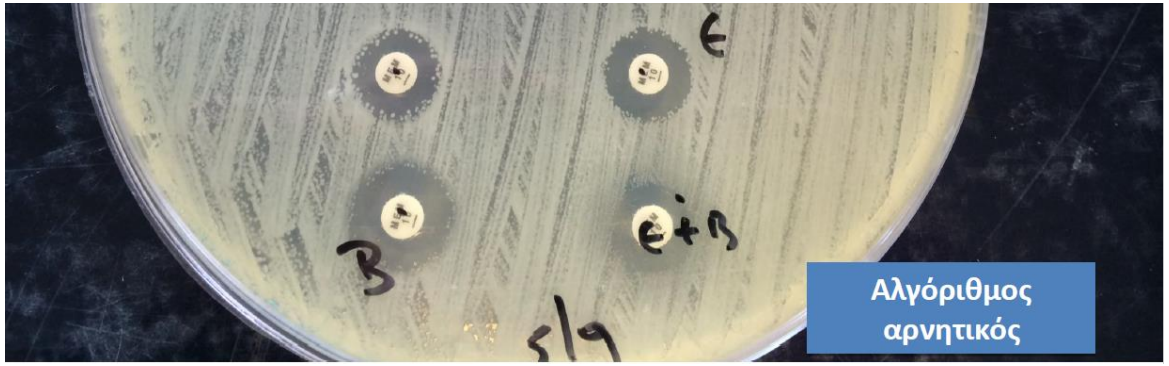
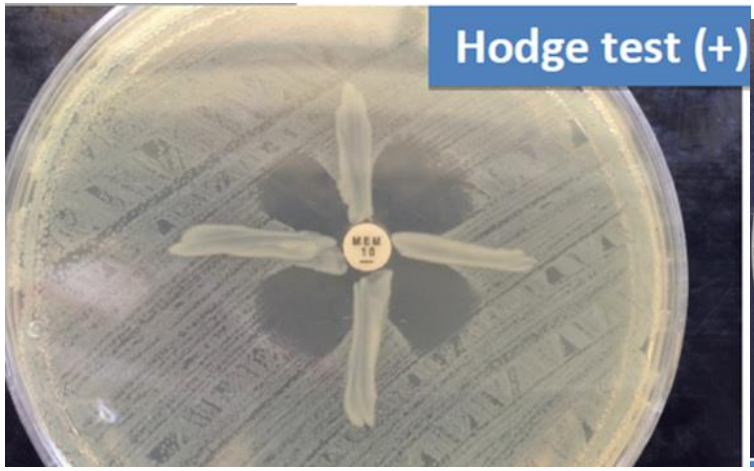


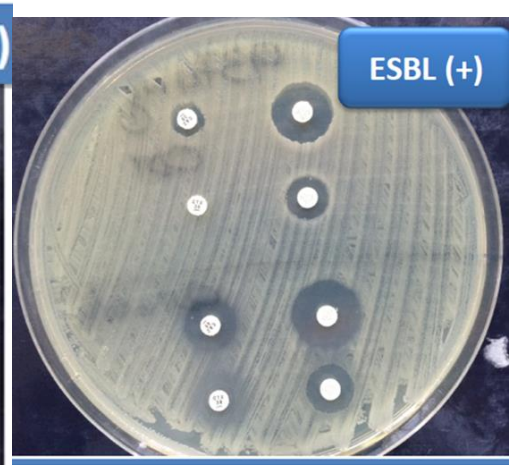
Figure 4. Deformation of the IP or IPI ellipse is indicative of MBL

Φαινοτυπική ανίχνευση καρβαπενεμασών στα Εντεροβακτηριακά









VIM (-)	KPC (-)	**OXA-48 (+)**	**CTX-M (+)**	TEM (+)	NDM (-)	**SHV (+)**

E. coli

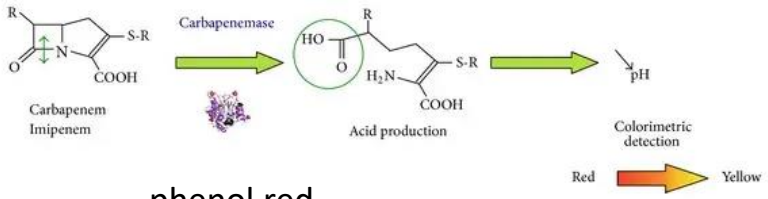
Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
ESBL	POS	+	Ertapenem	0.25	S
Temocillin			Imipenem	<= 0.25	S
Urine	>= 32	R	Meropenem		
Other	>= 32		Meningitis	<= 0.25	S
Ampicillin	>= 32	R	Other	<= 0.25	S
Amoxicillin/Clavulanic Acid	>= 32	R	Amikacin	2	S
Piperacillin/Tazobactam	>= 128	R	Gentamicin	<= 1	S
Cefuroxime	>= 64	R	Tobramycin	<= 1	S
Cefuroxime Axetil	>= 64	R	Ciprofloxacin		
Cefoxitin	<= 4	IE	Meningitis	0.5	
Cefditoren			Other	0.5	I
Cefixime	>= 4	R	Levofloxacin	I	I
Cefotaxime			Moxifloxacin	0.5	R
Meningitis	>= 64	R	Minocycline	(-)	(-)
Other	>= 64	R	Tetracycline	(-)	(-)
Ceftazidime	32	R	Tigecycline	<= 0.5	S
Ceftriaxone			Fosfomycin		
Meningitis	>= 64	R	Oral	<= 16	
Other	>= 64	R	Other	<= 16	S
Ceftazidime/Avibactam	<= 0.12	S	Nitrofurantoin		
Ceftolozane/Tazobactam	8	R	Chloramphenicol	16	IE
Cefepime	>= 32	R	Colistin	<= 0.5	S
Aztreonam	>= 64	R	Trimethoprim/ Sulfamethoxazole	>= 320	R

(-)= Susceptibility testing not recommended; species is a poor target for therapy IE= Insufficient Evidence that species is good target for therapy; MIC may be reported without interpretation

Φαινοτυπική ανίχνευση καρβαπενεμασών στα Εντεροβακτηριακά

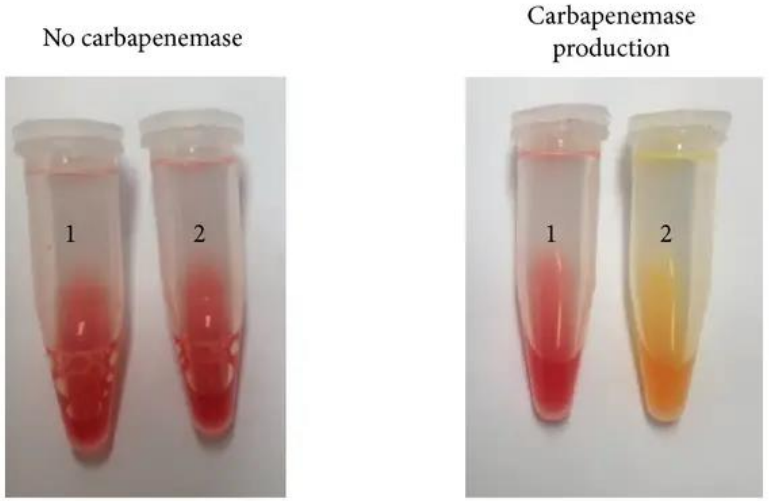
Χρωματομετρικές μέθοδοι (colorimetric tests)

Carba NP Test



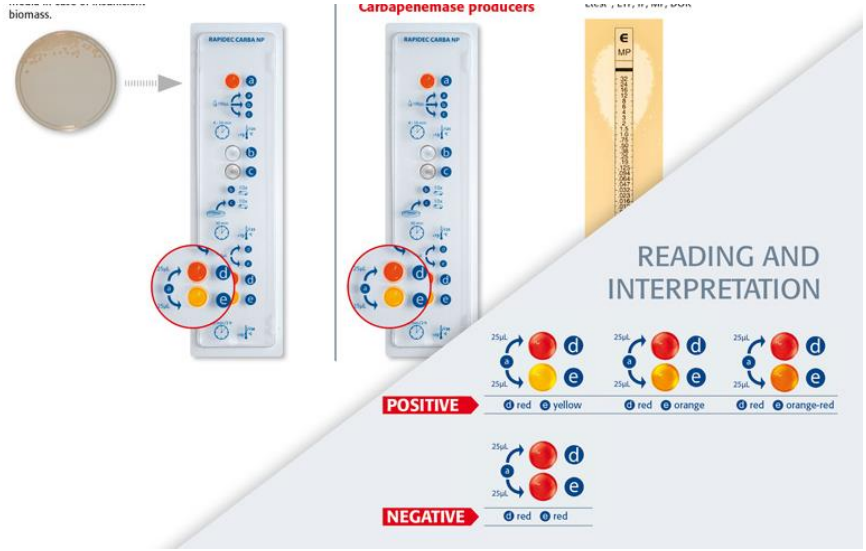
phenol red

(a)



(1) Revealing solution (internal negative control)
(2) Revealing solution + imipenem

(b)



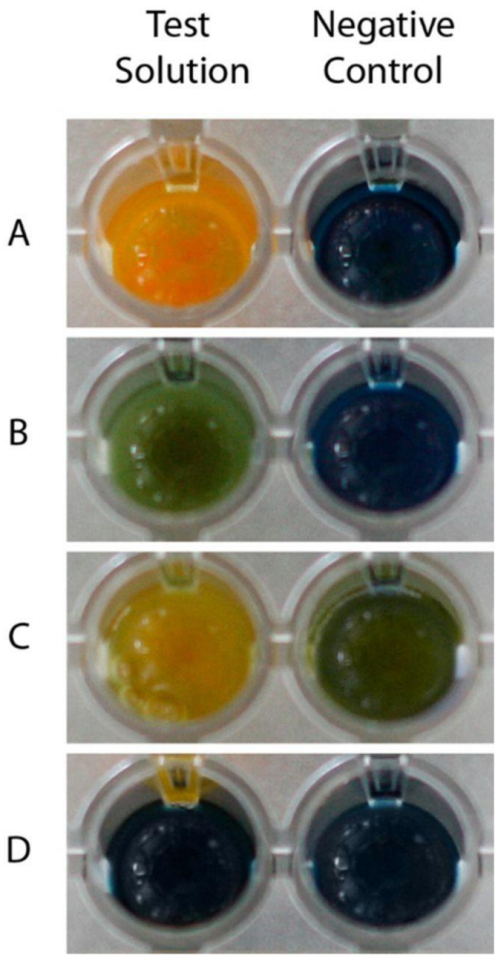
Sensitivity: 73–100% for most carbapenemases

Performed poorly for OXA-48 enzyme

Nordmann P, Poirel L, Dortet L. Emerg Infect Dis. 2012;18:1503-7.
Dortet L, Poirel L, Nordmann P. Antimicrob Agents Chemother. 2012;56:6437-40.
Dortet L et al. J Antimicrob Chemother. 2015 ; 70):3014-22.
Kabir MH et al. J Antimicrob Chemother. 2016 ;71:1213-6.
Noël A et al. J Clin Microbiol. 2017;55(2):510-518
Pasteran F et al. J Clin Microbiol. 2015 ;53(6):1996-8.

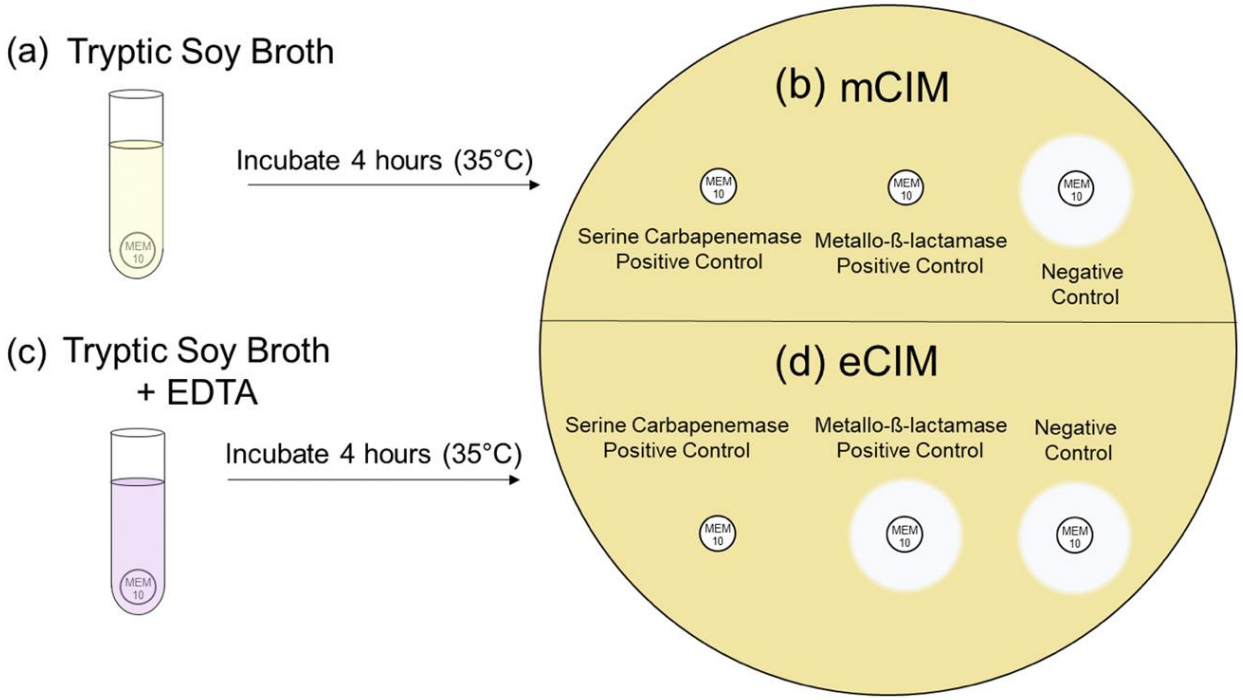
Blue-Carba Test

indicator bromothymol blue

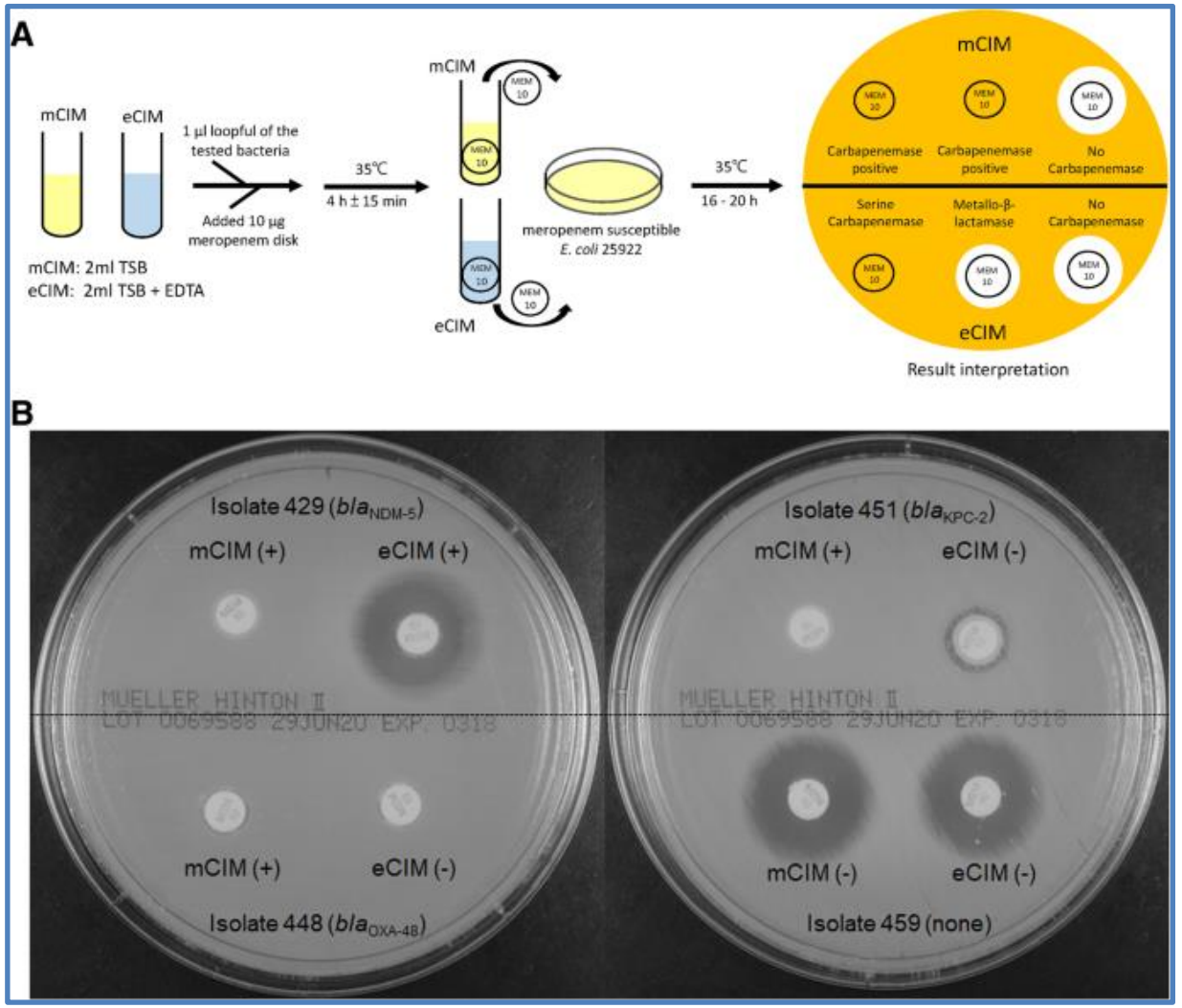


Screening test: Carbapenemase Inactivation Methods (mCIM/eCIM)

The Carbapenemase Inactivation Methods (mCIM/eCIM) are Currently Recommended by CLSI



Tamma PD, Simner PJ. J Clin Microbiol. 2018;56(11):e01140–18.
https://asm.org/Articles/2019/May/Opening-the-Black-Box-Phenotypic-Carbapenemase-Det



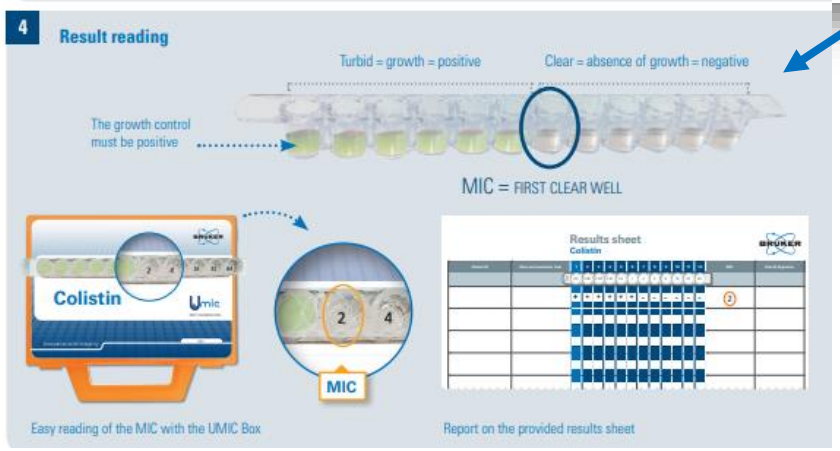
van der Zwaluw K et al. PLoS One. 2015;10(3):e0123690
Yamada K et al. J Microbiol Methods. 2016;128:48-51.
Tijet N, Patel SN, Melano RG. J Antimicrob Chemother. 2016 ;71(1):274-6.

Vitek reports

Bionumber: 0201010103500210
Organism Quantity:

Selected Organism: Acinetobacter baumannii complex

Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
ESBL			Imipenem	>= 16	R
Temocillin			Meropenem		
Ampicillin	(-)	(-)	Meningitis	>= 16	R
Amoxicillin/Clavulanic Acid			Other	>= 16	R
Piperacillin/Tazobactam	>= 128	IE	Amikacin	>= 64	R
Cefuroxime	(-)	(-)	Gentamicin	>= 16	R
efuroxime Axetil	(-)	(-)	Tobramycin	>= 16	R
Cefoxitin	(-)	(-)	Ciprofloxacin	>= 4	R
Cefditoren			Levofloxacin	4	R
Cefixime	(-)	(-)	Moxifloxacin	(-)	(-)
Cefotaxime	(-)	(-)	Minocycline	2	IE
Ceftazidime	(-)	(-)	Tetracycline	(-)	(-)
Ceftriaxone	(-)	(-)	Tigecycline	4	IE
Ceftazidime/Avibactam			Fosfomycin	(-)	(-)
Ceftolozane/Tazobactam			Nitrofurantoin	(-)	(-)
Cefepime	(-)	(-)	Chloramphenicol	(-)	(-)
Aztreonam	(-)	(-)	Colistin	<= 0.5	S
Ertapenem			Trimethoprim/ Sulfamethoxazole	>= 320	R



Organism Quantity:

Selected Organism: Pseudomonas aeruginosa

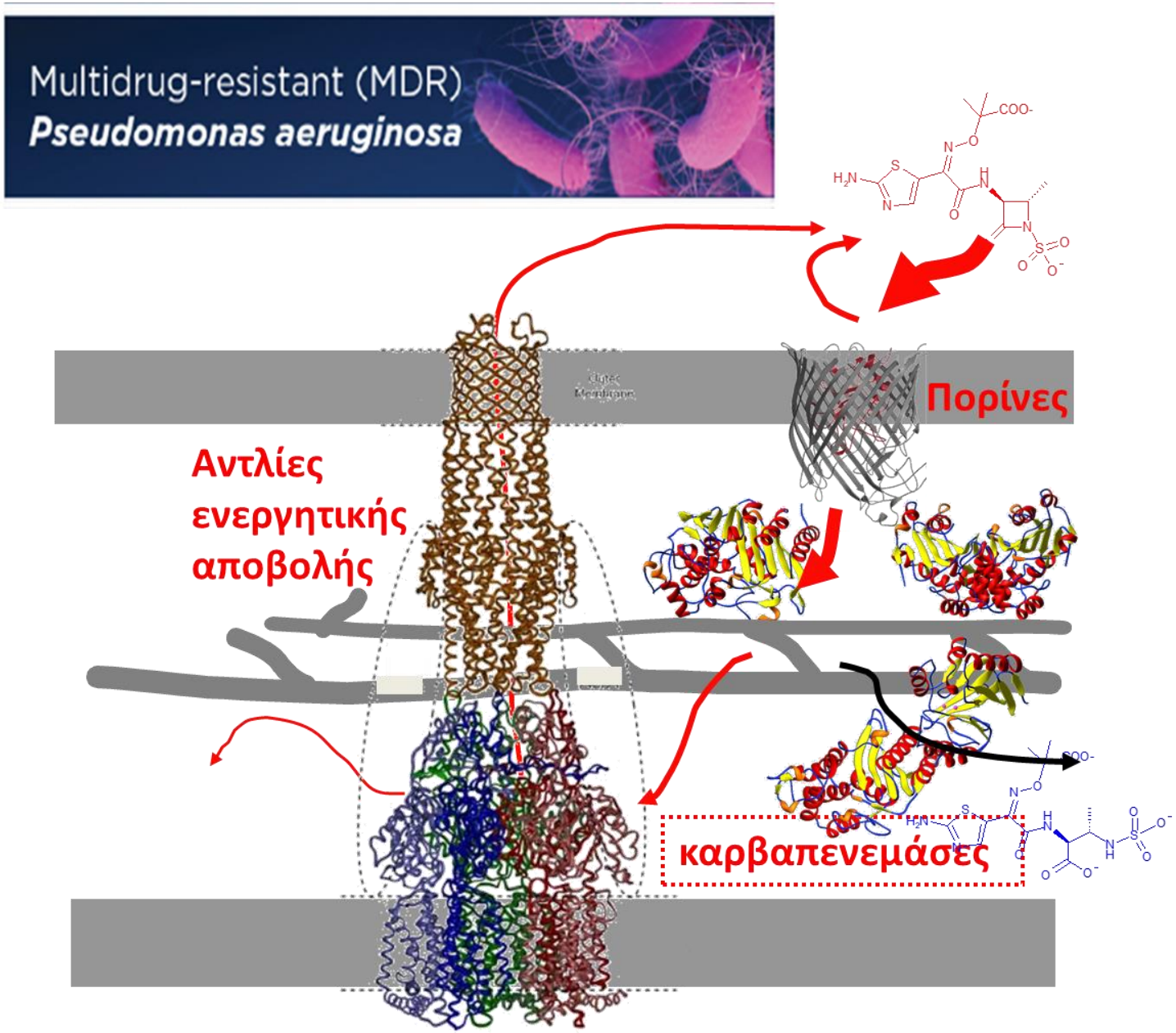
Comments:	Colistin S results / Gram negative bacilli: perform an alternative method of testing prior to reporting results.

Identification Information	
Organism Origin	Technologist
Selected Organism	Pseudomonas aeruginosa
	Entered: Sep 15, 2023 13:42 EEST **By:** LabTech
Analysis Messages:	

Susceptibility Information	**Card:**	AST-N318	**Lot Number:**	7582293203	**Expires:** Mar 7, 2024 12:00 EET
	Status:	Final	**Analysis Time:**	9.27 hours	**Completed:** Sep 15, 2023 22:42 EEST

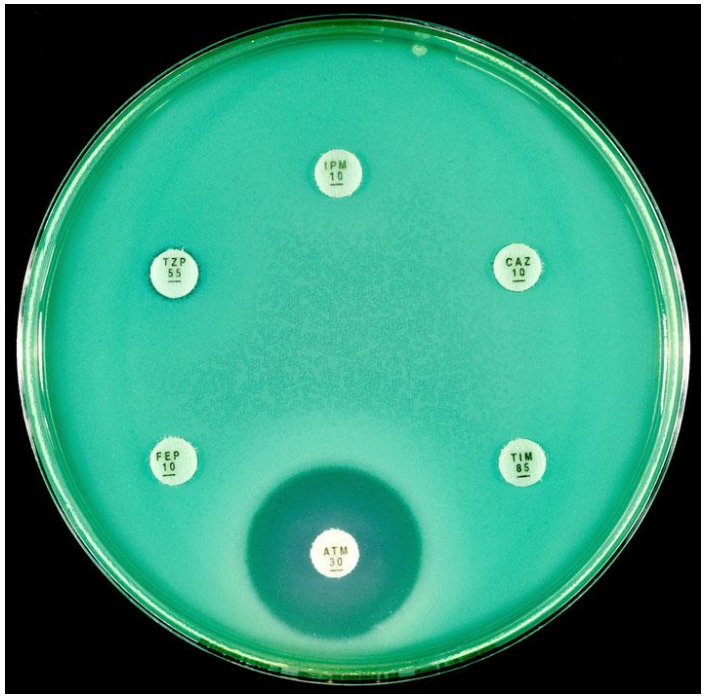
Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
+Ampicillin		(-)	Meropenem		
Ampicillin/Sulbactam			Meningitis	>= 16	R
Piperacillin/Tazobactam	>= 128	R	Other	>= 16	R
Cefoxitin			Amikacin	>= 64	R
+Cefotaxime		(-)	Gentamicin	>= 16	IE
Ceftazidime	>= 64	R	Ciprofloxacin	>= 4	R
Ceftriaxone	(-)	(-)	Levofloxacin	>= 8	R
+Ceftolozane/Tazobactam			Tigecycline	(-)	(-)
Cefepime	>= 64	R	Fosfomycin	(-)	(-)
Aztreonam	>= 64	R	Colistin	2	S
+Ertapenem		(-)	Trimethoprim/ Sulfamethoxazole	(-)	(-)
Imipenem	>= 16	R			

P. aeruginosa και αντοχή στις καρβαπενέμες



Τάξη	Ένζυμα
A	KPC GES
D	OXA (OXA-40, -50 -198)
B	VIM IMP NDM SPM GIM, AIM, FIM

P. aeruginosa και φαινοτυπική ανίχνευση MBL



Δεν υπάρχουν προτυποποιημένες δοκιμασίες

Οι δοκιμασίες στηρίζονται στη χρήση χηλικών παραγόντων EDTA, MPA, DPA

All phenotypic combined disk tests lacked either sensitivity or specificity for the detection of MBL in *P. aeruginosa*

μεθοδολογία
(DDST, CDT, Etest MBL)
το β-λακταμικό υπόστρωμα
το είδος του αναστολέα
ποσότητα του αναστολέα
χαρακτηριστικά των στελεχών

Συνήθως

- υψηλού επιπέδου αντοχή σε IMP και MEM
- υψηλού επιπέδου αντοχή στην CAZ
- ευαισθησία στην αζτρεονάμη και ουρεϊδοπενικιλλίνες ποικίλλει
- συνυπάρχει αντοχή στις αμινογλυκοσίδες

FP: επίδραση του EDTA
στη διαπερατότητα της μεμβράνης
επίδραση του Zn
στην έκφραση της OprD
Συγκέντρωση ιόντων Zn στο MH
FN: χαμηλού επιπέδου αντοχή

CDT

EDTA 292 μg (10 μl EDTA 0.1 M)

Δd > 4 mm

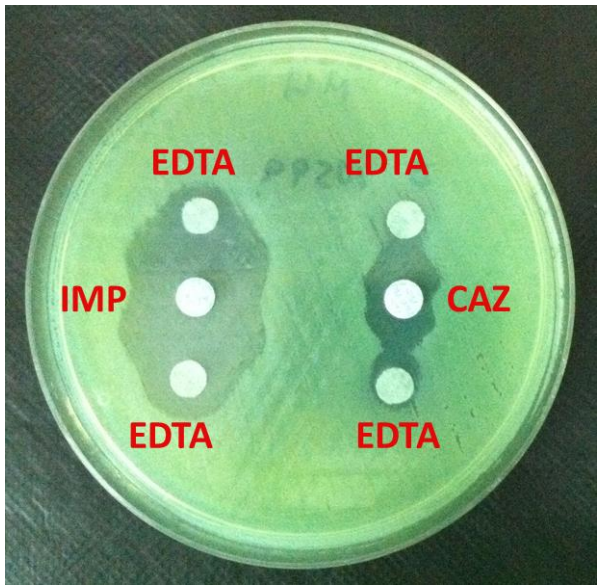
EDTA 750 μg, Δd ≥ 6 mm

100% SN και SP

DPA 835 μg, Δd ≥ 5 mm

SN=93,2% SP= 97,1%

DDST

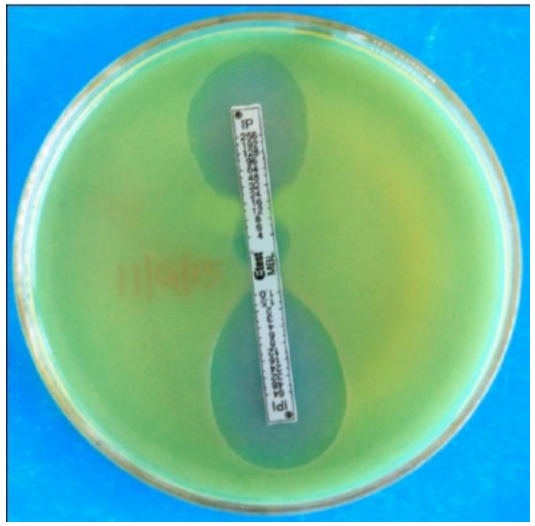


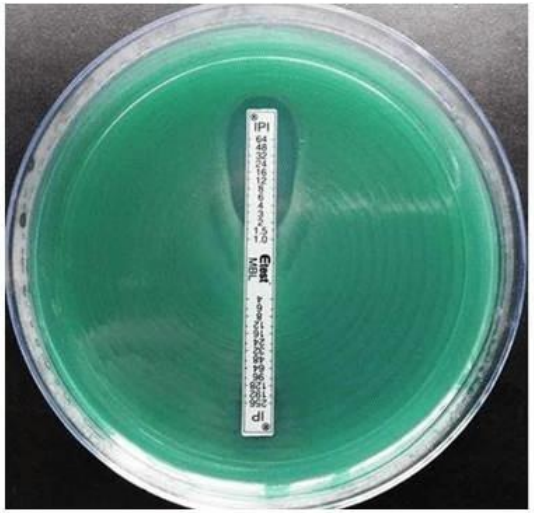
EDTA 292 μg

5 μl MPA 1.4 Mm

DPA 250 μg

Etest MBL, bioMerieux

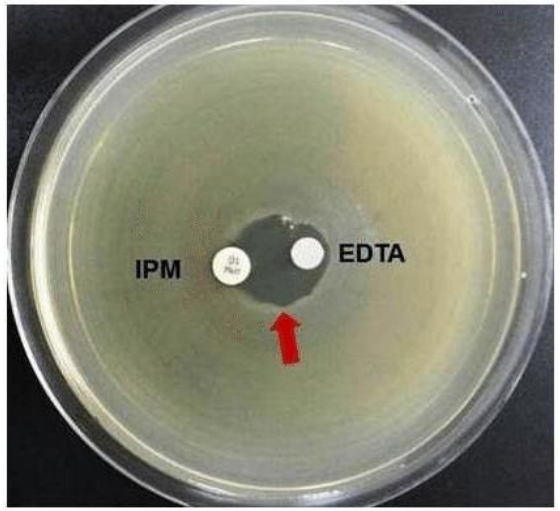




IP/ IPI ≥ 8

παρουσία ζώνης-φάντασμα

παραμόρφωση των ελλείψεων IP ή IPI



For *P. aeruginosa* the MBL Etest® as well as disk-based assays have been used for several decades, but are hampered **by poor specificity**.

EUCAST guidelines for detection of resistance mechanisms and specific resistances of clinical and/or epidemiological importance

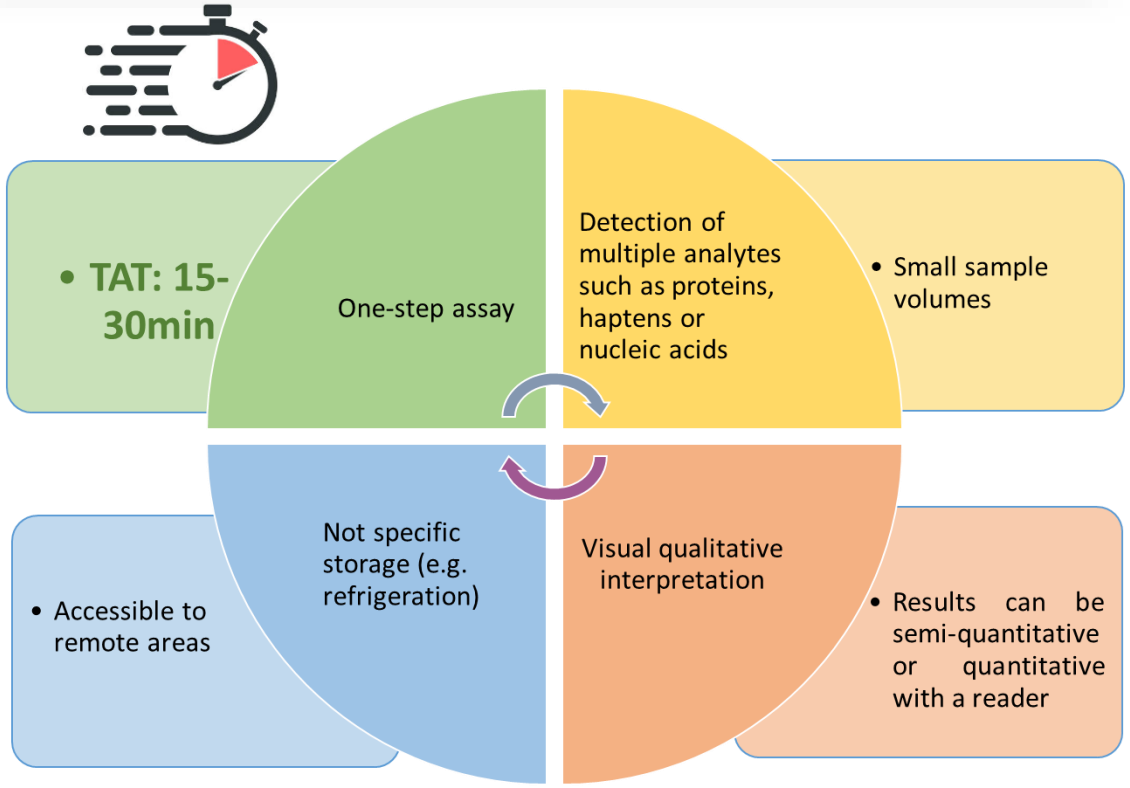
diagnostics 2022; 12(7):1744.

MDPI

Review

The Revolution of Lateral Flow Assay in the Field of AMR Detection

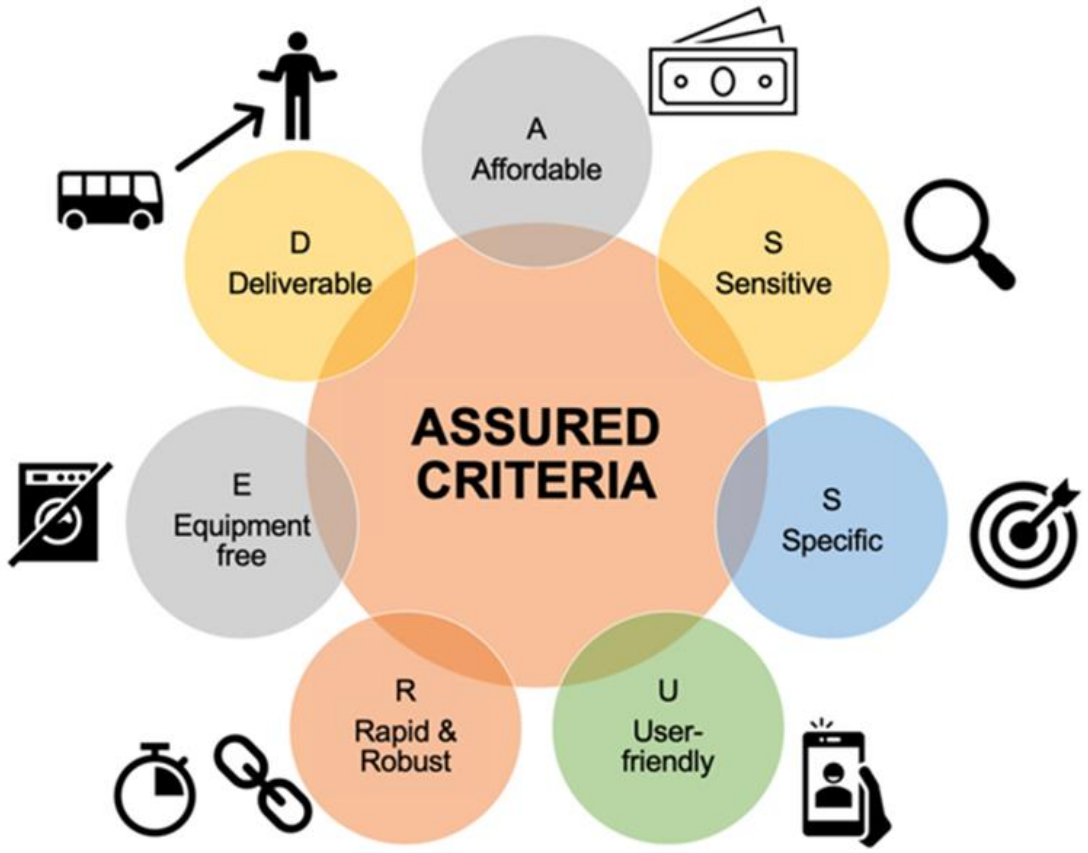
Hervé Boutal [1], Christian Moguet [1], Lilas Pommiès [1], Stéphanie Simon [1], Thierry Naas [2,3,4] and Hervé Volland [1,*]



LFIA performance relies mostly on antibody affinity and specificity

World Health Organization

an ideal PoC test



PBC

Se: 98%

Sp: 100%

Del Corpo O et al. Clin Microbiol Infect. 2023 Sep 16:S1198-743X(23)00425-1.

Εντεροβακτηριακά με μειωμένη ευαισθησία στις καρβαπενέμες

Στέλεχος από αίμα
ή
Πρώτη απομόνωση CRE από τον ασθενή από οποιοδήποτε κλινικό δείγμα

LFIA

Αρνητικό

CIM
eCIM

Αρνητικό

Πιθανή απώλεια πορινών
ΑΠΟΣΤΟΛΗ ΣΤΟ ΚΕΝΤΡΟ ΑΝΑΦΟΡΑΣ

Θετικό

Αναφορά στην κλινική
Ενημέρωση ΝΕΛ

Απομόνωση CRE από ασθενή με προηγούμενες απομονώσεις CRE στην παρούσα νοσηλεία

Αλγόριθμος ανίχνευσης παραγωγής καρβαπενεμασών

Αλγόριθμος θετικός για MBL

LFIA

Αλγόριθμος αρνητικός

Αλγόριθμος ανίχνευσης παραγωγής καρβαπενεμασών

MER+PBA (+)
MER+EDTA +PBA(+)

Παραγωγή
KPC

MER+PBA (-)
MER+EDTA (-)
MER+EDTA+PBA (+)

Παραγωγή
KPC + MBL (VIM/NDM)

MER+EDTA (+)
MER+EDTA+PBA (+)

Παραγωγή MBL
(VIM/NDM)

Η ταυτόχρονη παραγωγή ESBL ανιχνεύεται με την τροποποιημένη δοκιμασία CLSI για ανίχνευση ESBL

Αλγόριθμος
αρνητικός

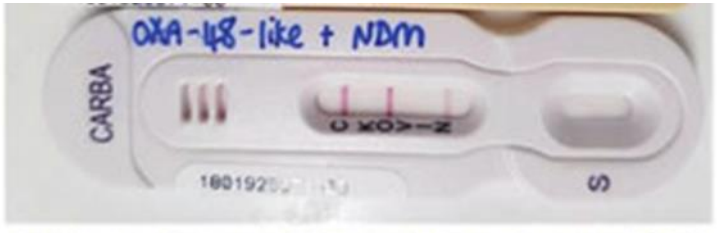
LFIA

Αρνητικό

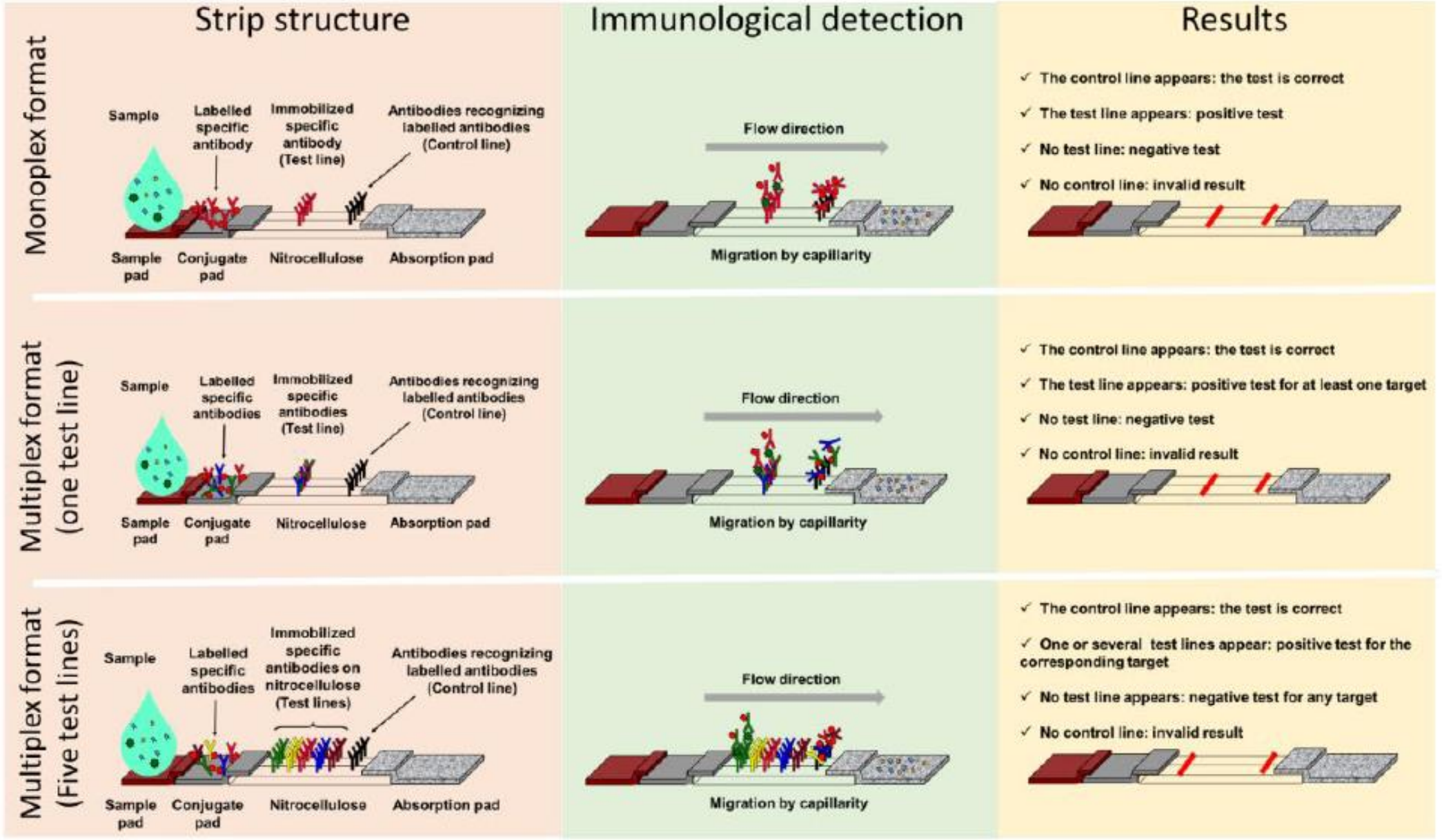
CIM
eCIM

Αρνητικό

Πιθανή απώλεια πορινών
ΑΠΟΣΤΟΛΗ ΣΤΟ ΚΕΝΤΡΟ ΑΝΑΦΟΡΑΣ



Lateral flow assay formats

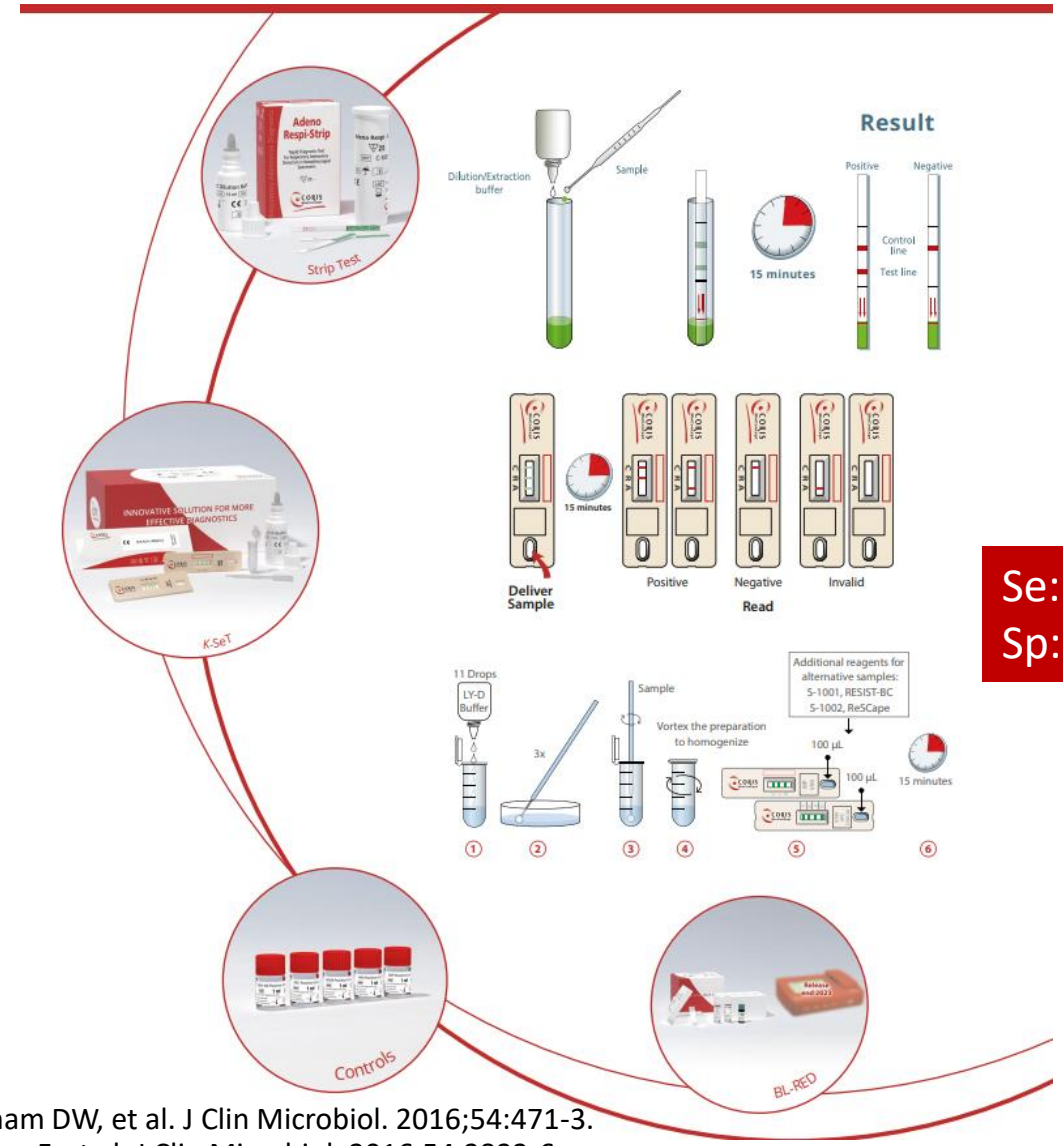


Boutal H et al. Diagnostics. 2022; 12(7):1744.

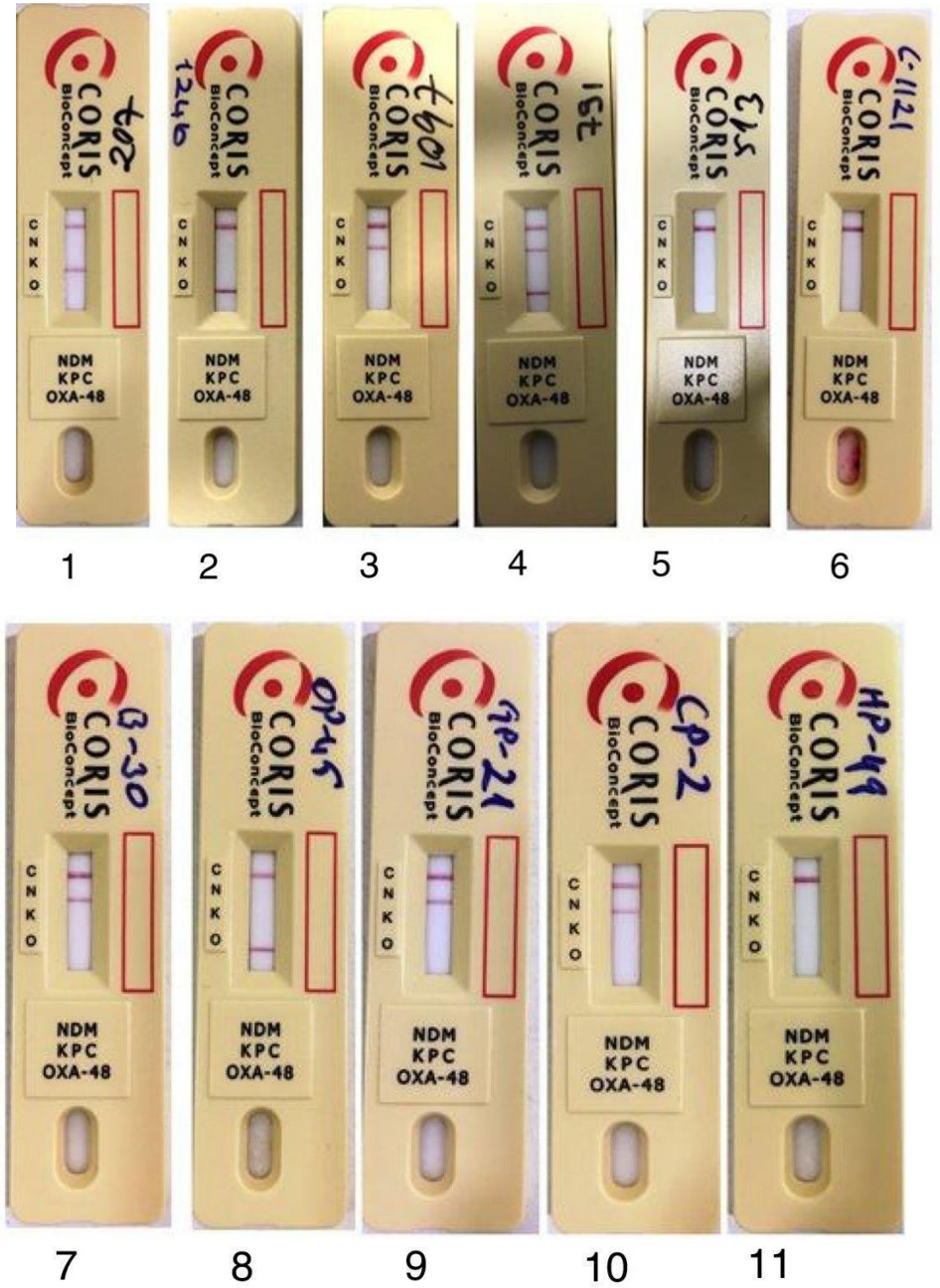
ACCESSORIES TO ACCELERATE RESIST RANGE RESULTS

PRODUCT NAME	DESCRIPTION
RESIST-BC	Reagents kit for blood culture 1 RBCL solution, 1 MS buffer, 1 Washing buffer
ReSCape	Culture reagent kit on rectal swab 20 CProBE MEDIUM tubes, 2 Selective Mix vials, 2 Water v

Targets	Technology	Product	Other identifications
Beta Lactamases	Electrochemistry	BL-RED 25	
OXA-48-like	Lateral flow	OXA-48 *K*-SeT	
	Lateral flow	O.K.N.V.I. RESIST-5	KPC, NDM, VIM, IMP
	Lateral flow	RESIST-3 O.O.K. *K*-SeT	OXA-163-like, KPC
	Lateral flow	RESIST-3 O.K.N. *K*-SeT	KPC, NDM
	Reagents	RESIST-BC	Carbapenemases: KPC, NDM, VIM, IMP, OXA-40/58
	Reagents	ReSCape	Carbapenemases: KPC, NDM, VIM, IMP, OXA-40/58
KPC	Lateral flow	O.K.N.V.I. RESIST-5	OXA-48-like, NDM, VIM, IMP
	Lateral flow	RESIST-3 O.O.K. *K*-SeT	OXA-48-like, OXA-163-like
	Lateral flow	RESIST-3 O.K.N. *K*-SeT	OXA-48-like, NDM
	Reagents	RESIST-BC	Carbapenemases: OXA-48-like, NDM, VIM, IMP, OXA-40/58
	Reagents	ReSCape	Carbapenemases: OXA-48-like, NDM, VIM, IMP, OXA-40/58
OXA-163-like	Lateral flow	RESIST-3 O.O.K. *K*-SeT	OXA-48-like, KPC
NDM	Lateral flow	O.K.N.V.I. RESIST-5	OXA-48-like, KPC, VIM, IMP
	Lateral flow	RESIST-3 O.K.N. *K*-SeT	OXA-48-like, KPC
	Reagents	RESIST-BC	Carbapenemases: OXA-48-like, KPC, VIM, IMP, OXA-40/58
	Reagents	ReSCape	Carbapenemases: OXA-48-like, KPC, VIM, IMP, OXA-40/58
	Lateral flow	RESIST ACINETO	OXA-23-like, OXA-40/58
OXA-23-like	Lateral flow	OXA-23 *K*-SeT	
	Lateral flow	RESIST ACINETO	OXA-40/58, NDM
VIM	Lateral flow	O.K.N.V.I. RESIST-5	OXA-48-like, KPC, NDM, IMP
	Reagents	RESIST-BC	Carbapenemases: OXA-48-like, KPC, NDM, IMP, OXA-40/58
	Reagents	ReSCape	Carbapenemases: OXA-48-like, KPC, NDM, IMP, OXA-40/58
IMP	Lateral flow	O.K.N.V.I. RESIST-5	OXA-48-like, KPC, NDM, VIM
	Lateral flow	IMP *K*-SeT	
	Reagents	RESIST-BC	Carbapenemases: OXA-48-like, KPC, NDM, VIM, OXA-40/58
	Reagents	ReSCape	Carbapenemases: OXA-48-like, KPC, NDM, VIM, OXA-40/58
Carbapenemases	Reagents	RESIST-BC	Carbapenemases: OXA-48-like, KPC, NDM, VIM, IMP, OXA-40/58
	Reagents	ReSCape	Carbapenemases: OXA-48-like, KPC, NDM, VIM, IMP, OXA-40/58
OXA-40/58	Reagents	RESIST-BC	Carbapenemases: OXA-48-like, KPC, NDM, VIM, IMP
	Reagents	ReSCape	Carbapenemases: OXA-48-like, KPC, NDM, VIM, IMP
	Lateral flow	RESIST ACINETO	OXA-23-like, NDM
Group 1 (CTX-M-15,...)	Lateral flow	RESIST CTX-M	Group 9 (CTX-M-14,...)
Group 9 (CTX-M-14,...)	Lateral flow	RESIST CTX-M	Group 1 (CTX-M-15,...)



Se: 98 -100%
Sp: 100%

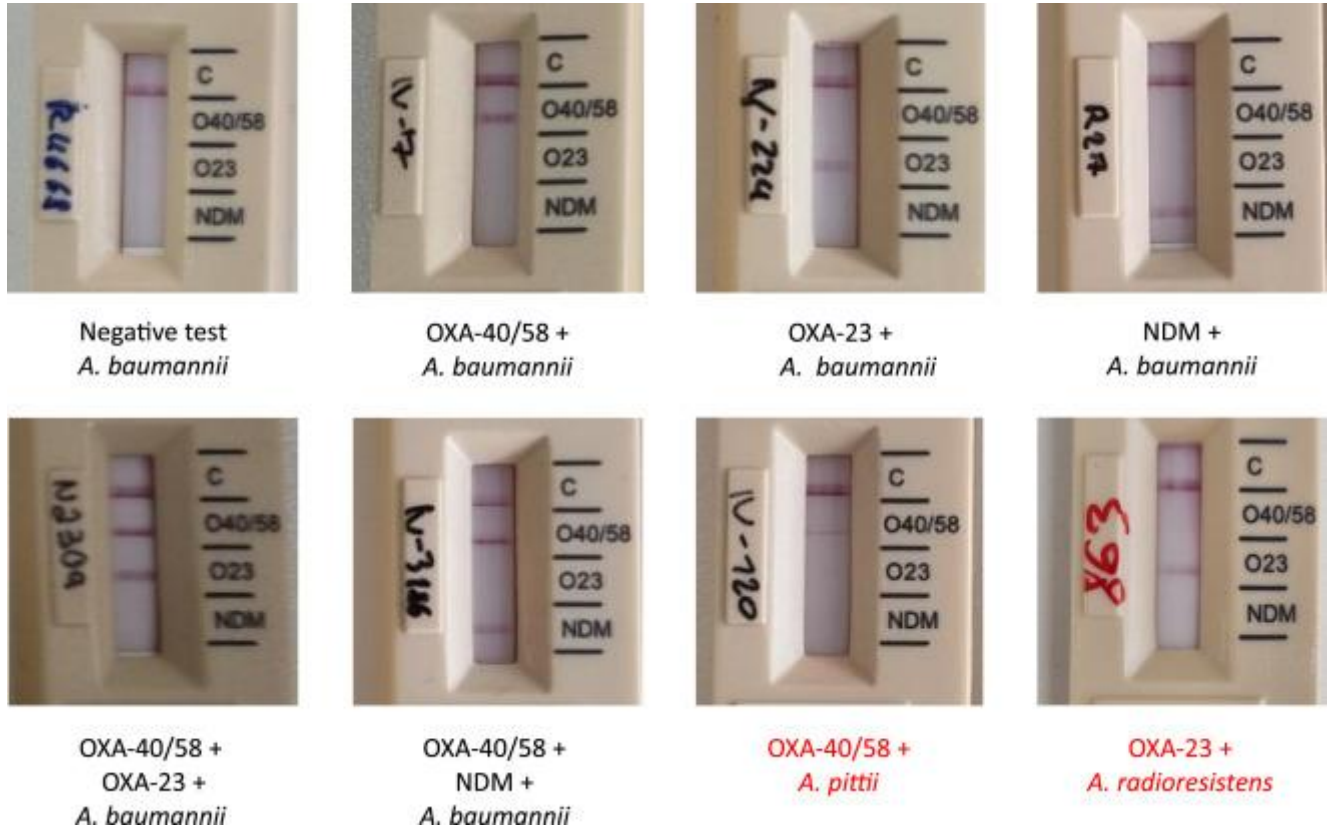


Wareham DW, et al. J Clin Microbiol. 2016;54:471-3.
Pasteran F, et al. J Clin Microbiol. 2016;54:2832-6.
Glupczynski Y et al. J Antimicrob Chemother. 2017;72(7):1955-1960.
Greissl C et al. Eur J Clin Microbiol Infect Dis. 2019;38(2):331-335.
Song W et al. Ann Lab Med. 2020;40(3):259-263.
Sadek M et al. Diagn Microbiol Infect Dis. 2022;104(4):115761.
Bouvier M et al. Diagn Microbiol Infect Dis. 2023;107(3):116043.

Ανίχνευση καρβαπενεμασών σε στελέχη *Acinetobacter*

N = 174 well-characterized carbapenemase and non-carbapenemase producing isolates belonging to various *Acinetobacter* species

149 *A. baumannii*, 11 *A. pittii*, four *A. radioresistens*, three *A. ursingii*, two *A. calcoaceticus*, two *A. nosocomialis*, one *A. bereziniae*, one *A. lwoffii* and one *A. junii*.



Negative test
A. baumannii

OXA-40/58 +
A. baumannii

OXA-23 +
A. baumannii

NDM +
A. baumannii

OXA-40/58 +
OXA-23 +
A. baumannii

OXA-40/58 +
NDM +
A. baumannii

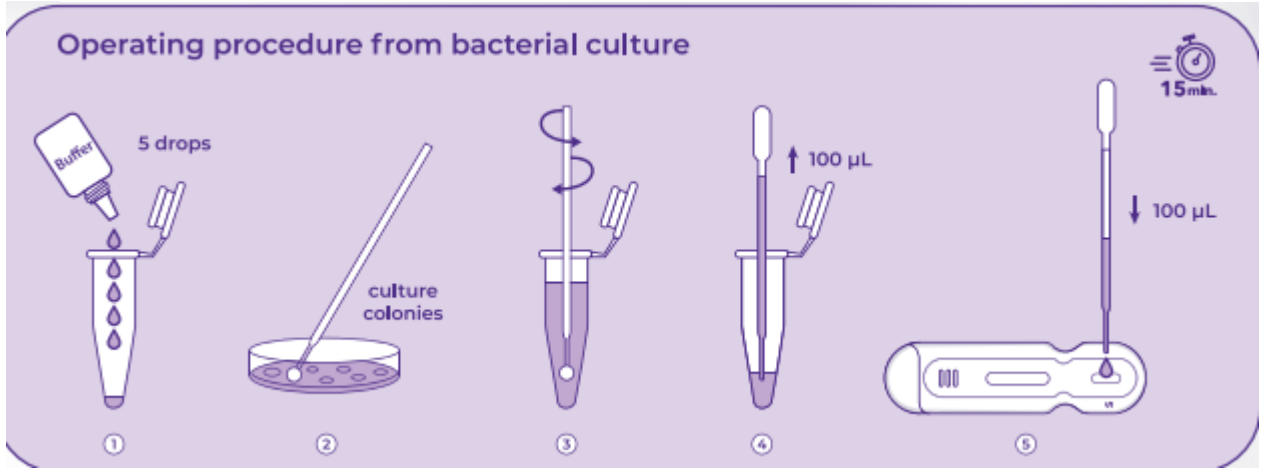
OXA-40/58 +
A. pittii

OXA-23 +
A. radioresistens

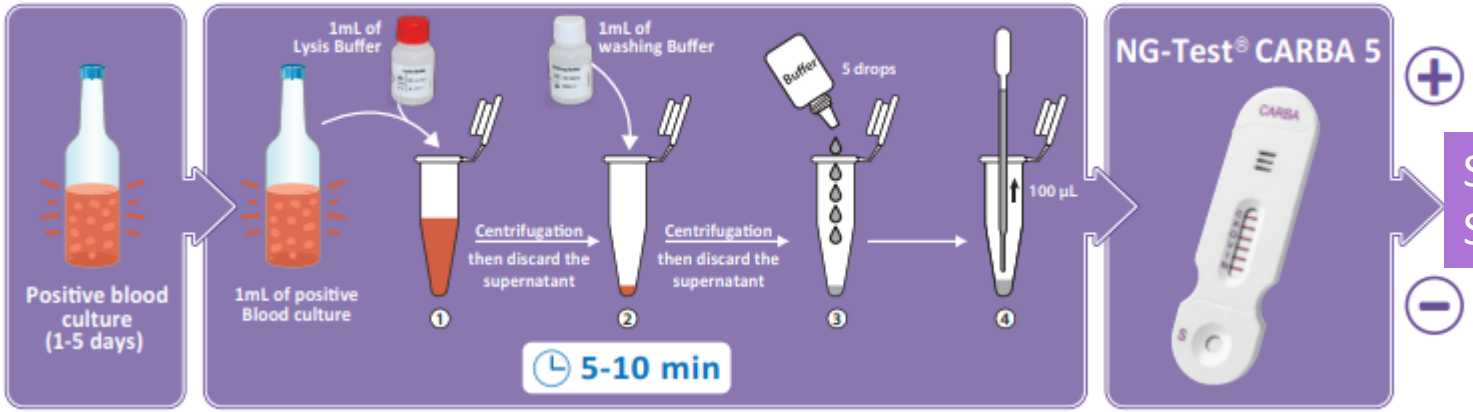
Overall sensitivity and specificity:100% and 96%
PPA and NPA 91% and 100%.

After exclusion of *A. pittii* and *A. radioresistens* results, sensitivity, specificity, PPA and NPA were 100%.

Bouvier M et al. Diagn Microbiol Infect Dis. 2023 Nov;107(3):116043.



IDENTIFICATION PROCESS FROM DIRECT BLOOD CULTURE: 20–40 min protocol



Se: 100%
Sp: 100%

Bodendoerfer E et al. J Antimicrob Chemother. 2019;74(6):1749-1751.

NG•TEST®/CARBA-5

Se: 97 -100%
Sp: 95-100%

CE FDA

Boutal H et al. J Antimicrob Chemother. 2018;73:909-15.
Han R et al. Front Microbiol. 2021;11:609856.
Volland H, et al. Antimicrob Agents Chemother. 2019;64(1):e01940-19.

NG•TEST®/CTX-M Multi

Rapid detection of Extended Spectrum Beta-Lactamase (ESBL)

Se: 100%
Sp: 100%

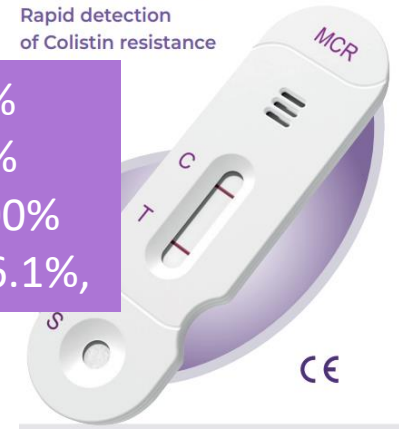
CE

Bernabeu S et al. Diagnostics (Basel). 2020;10(10):764.
Bianco G, et al. J Hosp Infect. 2020;105(2):341-343.
Boattini M et al. Eur J Clin Microbiol Infect Dis. 2021;40(7):1495-1501.

NG•TEST®/MCR-1

Rapid detection of Colistin resistance

Se: 100%
Sp: 100%
²PPA: 100%
²NPA: 96.1%,



CE

Volland H et al. J Clin Microbiol. 2019;57:e01454-18.
Fenwick AJ et al. J Clin Microbiol. 2020;58(4):e01823-19.

LFIA και ανίχνευση φορέων απευθείας από το δείγμα

J Antimicrob Chemother. 2019 Feb 1;74(2):357-359. doi: 10.1093/jac/dky429.

Lateral flow immunochromatographic assay for rapid screening of faecal carriage of carbapenemase-producing Enterobacteriaceae

Charlotte Fauconnier [1], Magali Dodemont [2], Angélique Depouhon [1], Ahalieyah Anantharajah [1], Alexia Verroken [1], Hector Rodriguez-Villalobos [1]

Residual rectal swabs (*n*=149), routinely screened for CPE through selective culture and confirmed by PCR

Protocol: 2.5h incubation of the swab in an enrichment medium containing meropenem followed by **O.K.N. *K*-SeT** testing after centrifugation.

Strains: 82 OXA-48, 22 NDM, 5 KPC, 1 IMP, 7 VIM, 3 OXA-23

Detected: 76 OXA-48, 19 NDM, 5 KPC

Sensitivity: 96%

Specificity: 100%

LoD: 10^4-10^5 cfu/ml

Microorganisms. 2021 Apr 27;9(5):942. doi: 10.3390/microorganisms9050942.

Detection of KPC, NDM and VIM-Producing Organisms Directly from Rectal Swabs by a Multiplex Lateral Flow Immunoassay

Alexandra Vasilakopoulou [1], Polyxeni Karakosta [1], Sophia Vourli [1], Eleni Kalogeropoulou [1], Spyros Pournaras [1]

Fecal swabs (*n*=30)

- Culture
- PCR
- **NG-Test® CARBA-5**

Each sample was tested by CARBSA-5 five times:

- Direct testing
- Incubation in TSB for 1h, 2h, 3h, 4h

TSB enriched with 0.25mg/l meropenem

Sensitivity:

80% (direct testing)

88% (1h incubation)

92% (2h incubation)

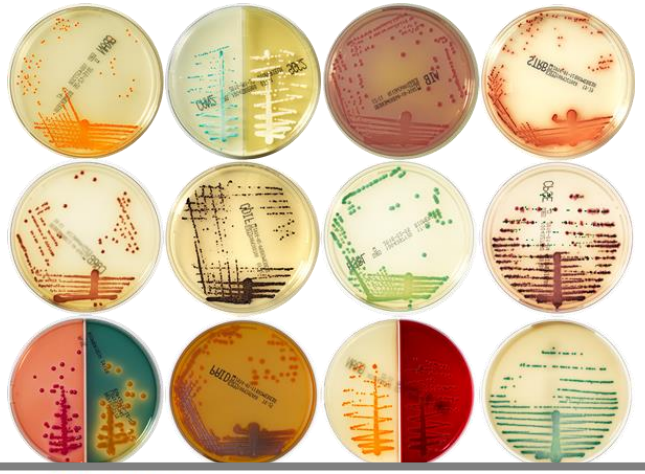
100% (3h incubation)

Specificity: 100%

Concordant results from LFIA and PCR: 11 KPC, 8 VIM, 6 NDM. [In five cases, co-carriage of KPC and VIM]

Χρωμογόνα υλικά

- Purpose: more rapid detection and identification of MDRO
- The target organisms are characterized by specific enzyme systems that metabolize the substrates to release the chromogen.
- The chromogen can then be visually detected by direct observation of a distinct colour change in the medium (coloured colonies).
- Compared with the use of conventional culture media, the use of chromogenic agar often reduces the costs and labor time.
- Their primary use is for screening of patients colonized with various pathogens.
- The sensitivity and specificity depend on the manufacturer and the type of microorganism detected
- Additional confirmation of the resistant bacteria is sometimes needed.

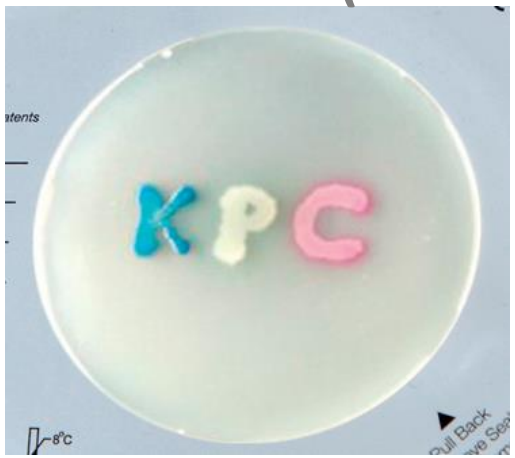


Advantage	
Mass use and the possibility of automatisation Simple to perform Simple and fast interpretation	
Disadvantage	**Comments**
Not completely susceptible and specific Time-consuming Limited spectra or single antibiotic Relatively expensive Screening only or required confirmatory identification No MIC value	Qualitative with no interpretation criteria (S, I, R)

Gajic I et al. Antibiotics (Basel). 2022;11(4):427.

Χρωμογόνα εκλεκτικά υλικά για CRE

CHROMagar KPC, Colorex KPC (CHROMagar)

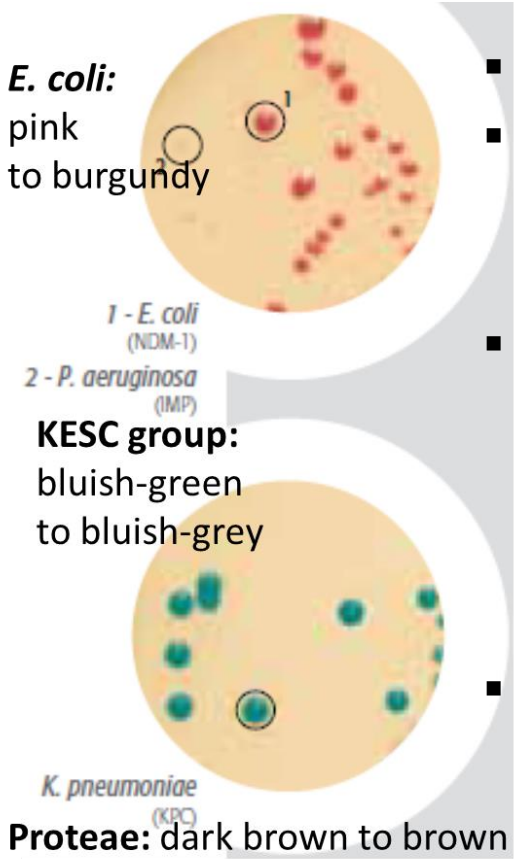


Klebsiella, Enterobacter, Citrobacter CR → Metallic blue
Pseudomonas CR → Cream, translucent
E.coli CR → dark pink to reddish

- Μειονέκτημα: έλλειψη ευαισθησίας
- Δυσκολία ανάπτυξης στελεχών με MIC≤4 μg/ml
- Προβληματική η ανίχνευση στελεχών MBL και OXA-48

Nordmann P et al. J Antimicrob Chemother. 2013; 68(3):487-9.

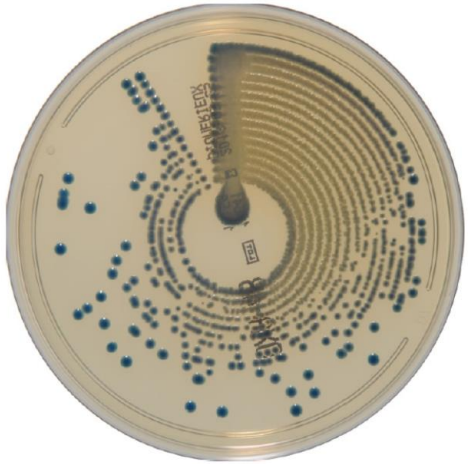
ChromID Carba (bioMérieux)



- SN: 92,4%, SP: 96, 9%
- Ικανότητα ανίχνευσης στελεχών με χαμηλές MIC[1]
- Υψηλότερη ικανότητα ανίχνευσης για KPC-στελέχη vs Brilliance CRE /Colorex KPC (σε υψηλό και σε χαμηλό inoculum)[2]
- Υψηλότερη ικανότητα ανίχνευσης NDM-στελεχών[3]

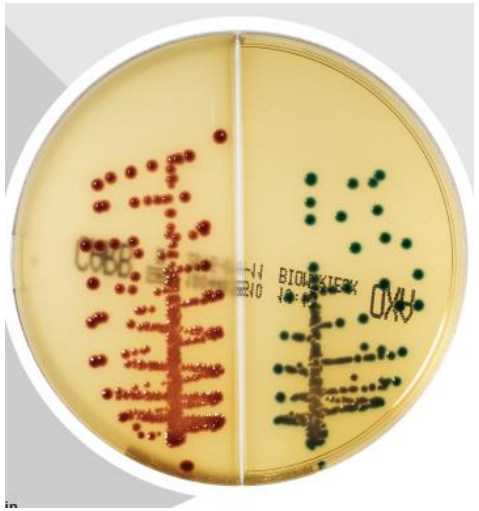
1. Vrioni G, et al. J Clin Microbiol. 2012; 50(6):1841-6.
2. Wilkinson KM, et al. J Clin Microbiol. 2012; 50(9):3102-4.
3. Perry JD, et al. J Antimicrob Chemother. 2011; 66(10):2288-94.

ChromID OXA-48 (bioMérieux)



Incubation : 18 hours
K. pneumoniae OXA-48

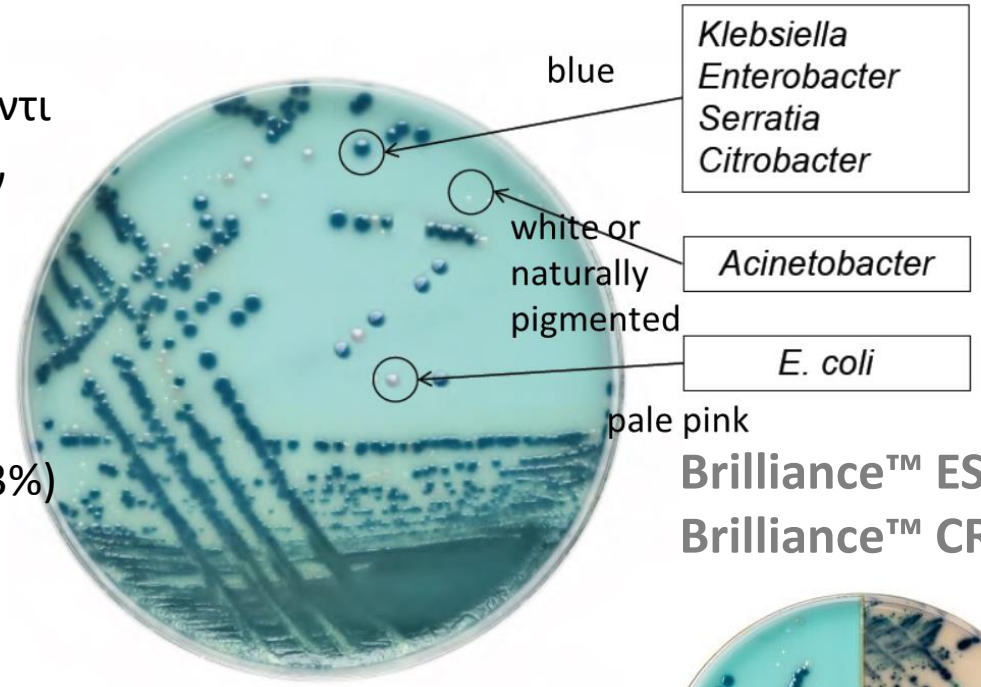
CHROMID® CARBA SMART Agar



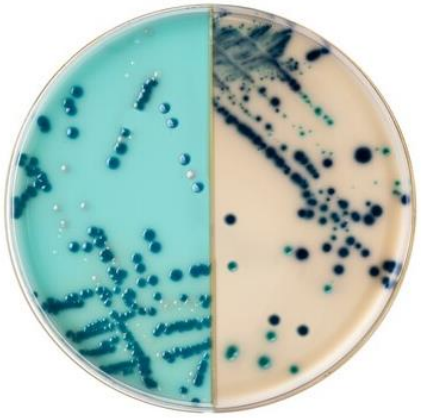
Χρωμογόνα εκλεκτικά υλικά για CRE

Brilliance™ CRE (Oxoid)

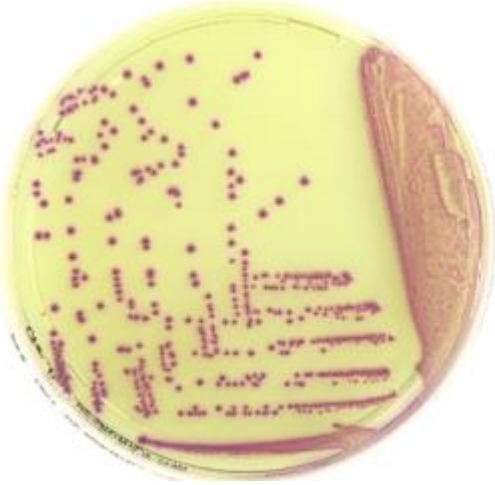
- Χαμηλότερη SN έναντι του ID Carba για την ανίχνευση NDM-στελεχών
- Υπεροχή έναντι του CHROMagar KPC (43%)
- Παρόμοια SP



Brilliance™ ESBL Agar/ Brilliance™ CRE Agar



Liofilchem® Chromatic CRE



Liofilchem® Chromatic OXA-48

OXA-48 positive *Enterobacter cloacae*

Day KM, et al. Diagn Microbiol Infect Dis. 2013; 75(2):187-91.
Girlich D, et al. Diagn Microbiol Infect Dis. 2013;75(2):214-7.

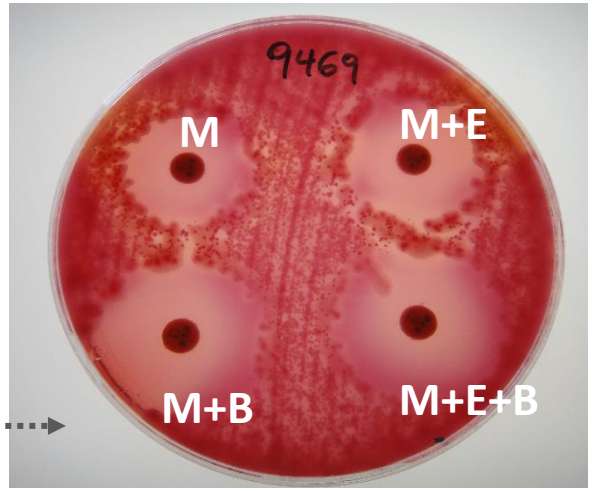
Έλεγχος φορείας για CRE: καλλιεργητικές μέθοδοι

Home-made τρυβλία MacConkey agar:

- Με ενσωματωμένη καρβαπενέμη
  - ικανοποιητική ευαισθησία
- Με δίσκους καρβαπενεμών:
  - SN/SP εξαρτώνται από το όριο
- Με δίσκους + αναστολείς:
  - ανίχνευση + διαφοροποίηση

Χρωμογόνα υλικά

- **chromID CARBA / chromID OXA-48, bioMérieux**
  - Υψηλή ευαισθησία και ειδικότητα
- **Brilliance CRE, Oxoid**
  - Ικανοποιητική ευαισθησία και ειδικότητα
- **CHROMagar KPC/ Colorex KPC, CHROMagar**
  - Ανιχνεύει στελέχη με υψηλού επιπέδου αντοχή

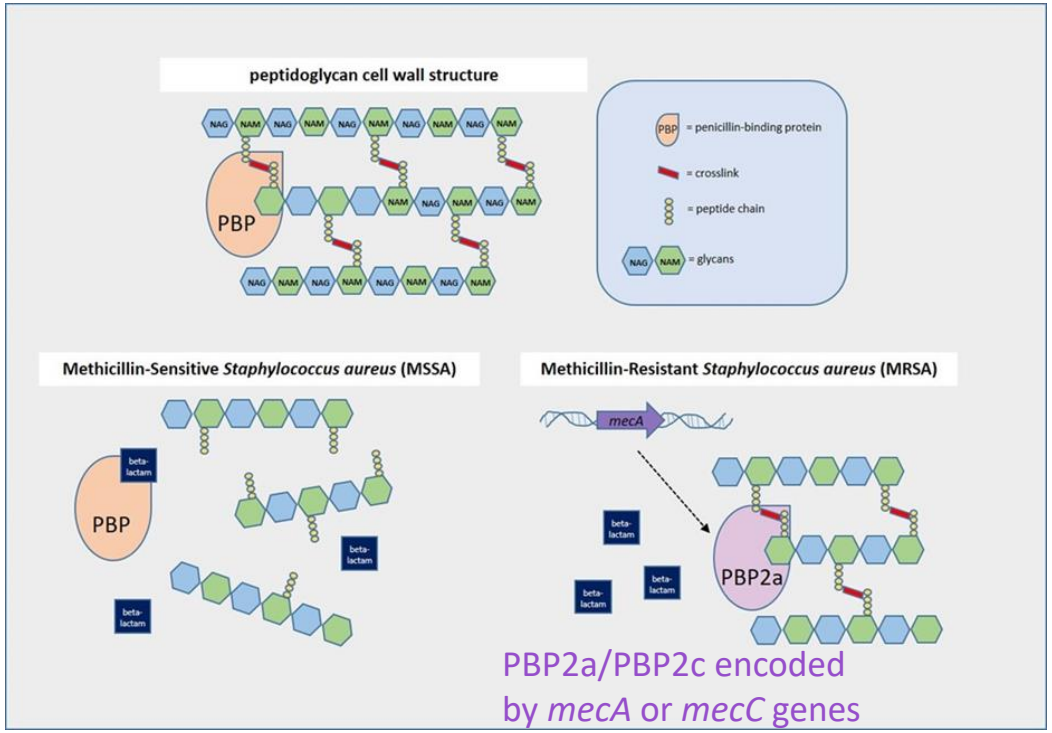


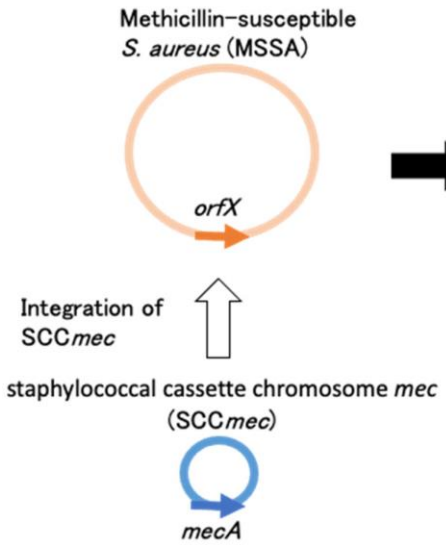
Pournaras S, et al. J Clin Microbiol. 2013; 51(9):2986-90.

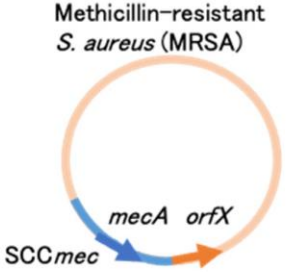
Η επίδοση της κάθε μεθόδου εξαρτάται:

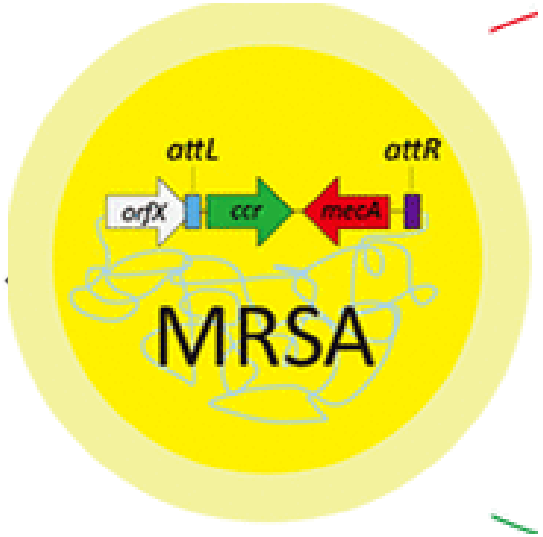
- επίπεδο αντοχής στις καρβαπενέμες
- υδρόλυση άλλων β-λακταμών (φάσμα)
- παρουσία άλλων μηχανισμών αντοχής
- γεωγραφική περιοχή, βακτηριακό είδος, δείγμα, χρόνο επώασης, μέθοδο αναφοράς, ορισμό αληθώς θετικών, …

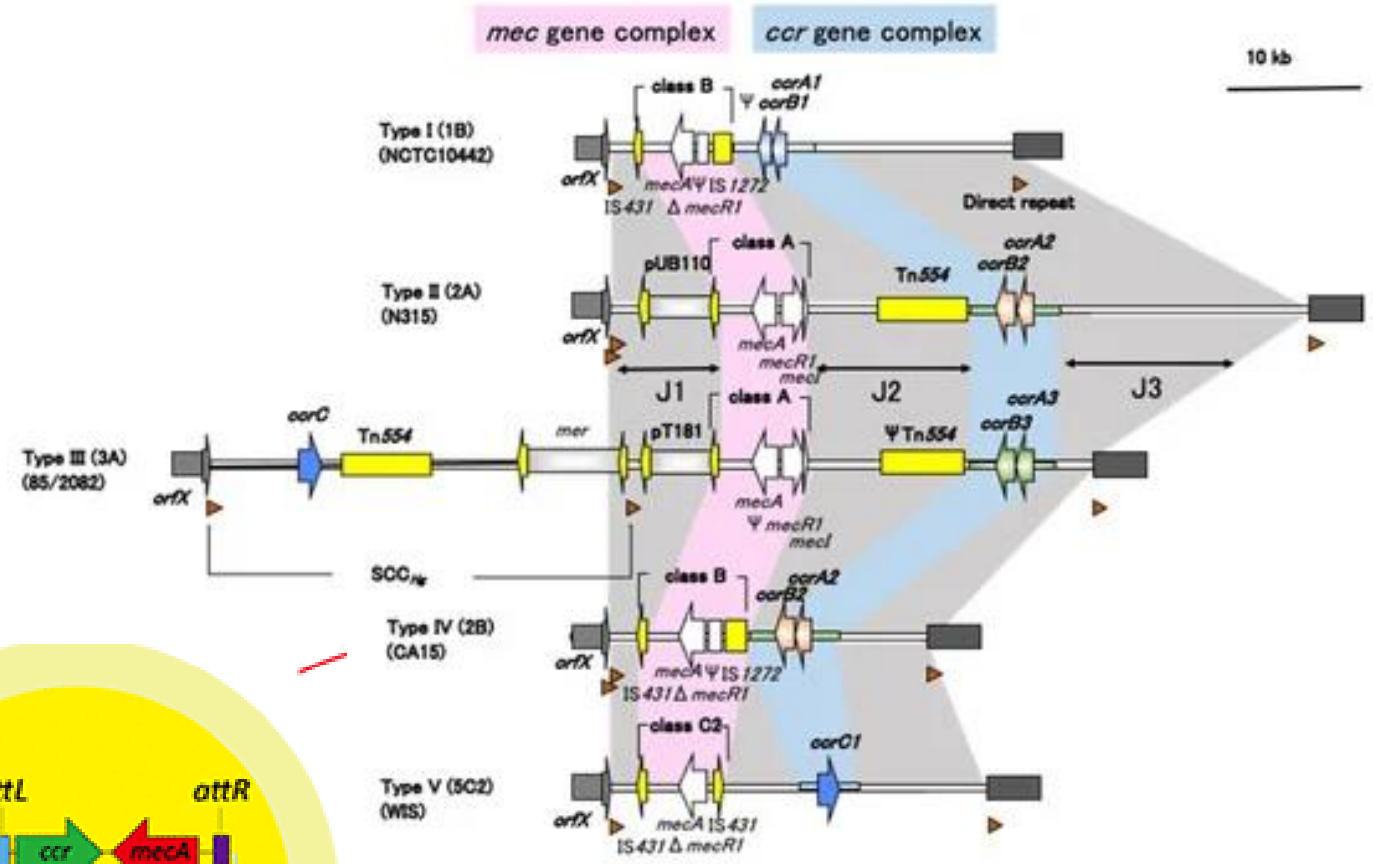
Σύγκριση μελετών-μεθόδων δύσκολη







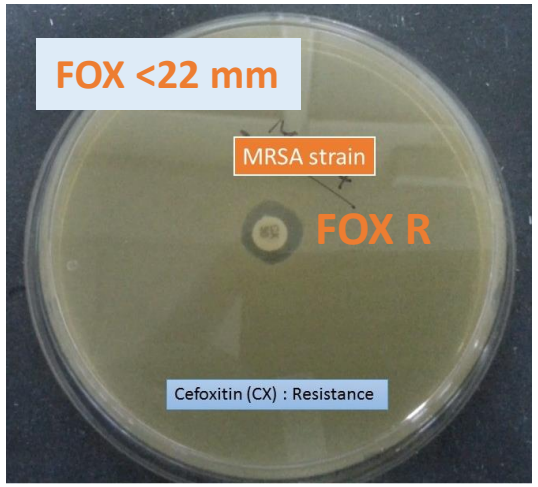




Uehara Y. Current Status of Staphylococcal Cassette Chromosome mec (SCCmec). Antibiotics. 2022; 11(1):86.

Φαινοτυπικές μέθοδοι

Disk diffusion



CEFOXITIN: a very **sensitive and specific marker** of mecA/mecC-mediated methicillin resistance including in heterogeneous expressing strains and **is the agent of choice.**

Broth microdilution

Organism Quantity: **Selected Organism: Staphylococcus aureus**

Comments:	S.aureus - Mupirocin: ECOFF

Identification Information	
Organism Origin	Technologist
Selected Organism	Staphylococcus aureus
	Entered: Oct 7, 2023 17:56 EEST **By:** LabTech
Analysis Messages:	

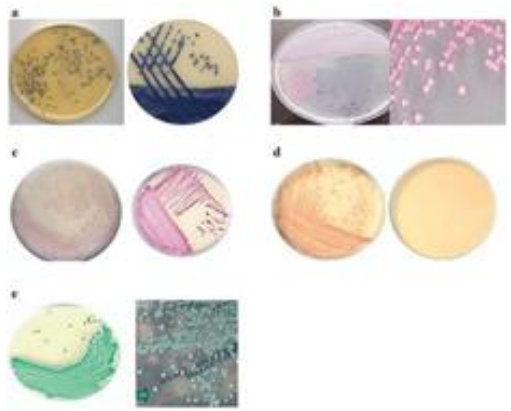
Susceptibility Information	**Card:**	AST-P659	**Lot Number:**	8092252103	**Expires:** Jan 26, 2024 12:00 EET
	Status:	Final	**Analysis Time:**	8.48 hours	**Completed:** Oct 8, 2023 02:22 EEST

Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
Cefoxitin Screen	POS	+	Linezolid	2	S
Benzylpenicillin	>= 0.5	R	Daptomycin	0.25	S
Oxacillin	>= 4	R	Teicoplanin	<= 0.5	S
Ceftaroline			Vancomycin	<= 0.5	S
Pneumonia	0.25	S	Tetracycline	<= 1	S
Other	0.25	S	Tigecycline	<= 0.12	S
Gentamicin	<= 0.5	S	Fusidic Acid	8	R
Levofloxacin	>= 8	R	Mupirocin	<= 1	S
Inducible Clindamycin Resistance	NEG	-	Rifampicin	<= 0.03	S
Erythromycin	0.5	S	Trimethoprim/ Sulfamethoxazole	<= 10	S
Clindamycin	0.25	S			

Detection of PBP2a with latex agglutination kits

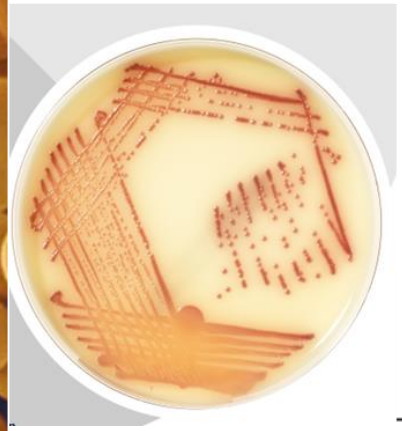
*PBP2c is not detected by the majority of commercial assays

Chromogenic media



Χρωμογόνα εκλεκτικά υλικά για MRSA

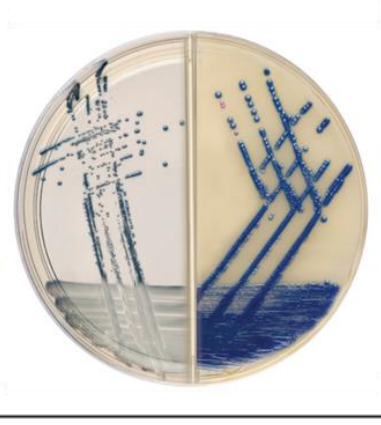
CHROMID® MRSA SMART, bioMerieux



ChromID *S. aureus*/ ChromID MRSA, bioMerieux

Brilliance™ MRSA 2 Agar, Oxoid

Brilliance™ MRSA 2 Agar/ Brilliance™ Staph 24 Agar



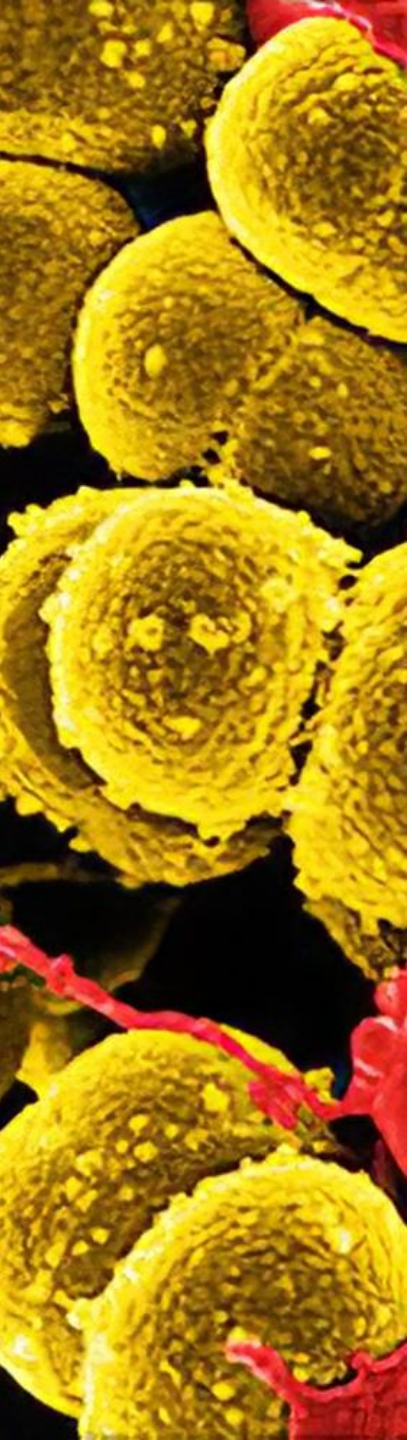
MRSA Select, Bio-Rad

ChromAgar MRSA

Variable	CHROMagar [43]	BBL-CHROMagar [43]	CHROMagar MRSA [35]
Sensitivity (%)	82–93	83–94	96–100
Specificity (%)	97–99	98–99	95–97
Turnaround time (h)	24–48	24–48	24–48
Storage for incubation	2–8 °C; dark	2–8 °C; dark	2–8 °C; dark

Variable	MRSASelect [35]	Brilliance MRSA agar [43]	ChromID [43]
Sensitivity (%)	81–93	90–96	83–94
Specificity (%)	92–97	69–87	90–96
Turnaround time (h)	18–24	18–24	
Storage for incubation	Room temperature	2–10 °C; dark	Room temperature

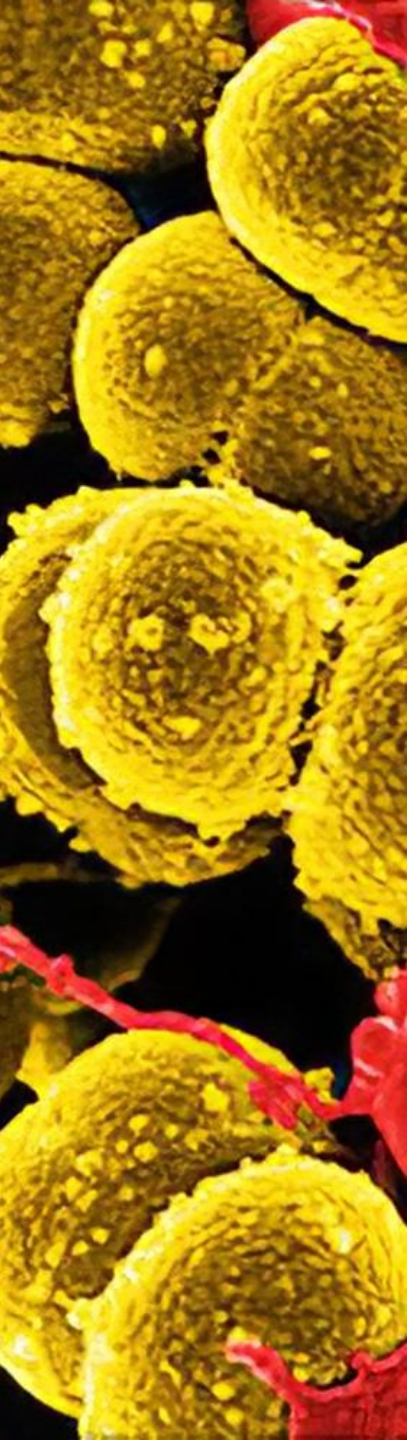
Harbarth S et al. Int J Antimicrob Agents. 2011;37(2):110-7.
Nonhoff C et al. Eur J Clin Microbiol Infect Dis. 2009 Apr;28(4):363-9.
Malhotra-Kumar S et al. J Clin Microbiol. 2010 Apr;48(4):1040-6.



Φαινοτυπικές μέθοδοι για ανίχνευση του MRSA

Phenotypic Method Used	Principle of the Method	On Culture/on Clinical Sample	TAT [1]	Brief Advantages/Disadvantages +/−	No. and Type of *S. aureus* Anlyzed [2]	Major Diagnostic Performance [3]	Reference
Chromogenic media	Selective media, colorimetric colony detection	Nasal swabs, positive blood culture	24 h	+ Easy to perform and interpret, low-cost − No MSSA identification	72 MRSA 28 MSSA	Sensitivity 100% Specificity 78.6%	[28]
					19 MRSA 29 MSSA	Sensitivity 78.9% Specificity 41.3%	[29]
Rapid BMD	Colorimetric assay, MTT dye as oxidation-reactions indicator	Culture	7 h	+ Easy to perform, rapid, low-cost − Larger validations needed	21 MRSA 19 MSSA	Sensitivity 100% Specificity 94.7%	[30]
Disk diffusion on Mueller-Hinton rapid agar MHR-SIR	Disk diffusion with shorter incubation	Positive blood culture	6–8 h	+ Easy to perform, rapid, low-cost − Larger validations needed	23 *S. aureus* tested for several antibiotics	CA 97.8% mEs 1.9% VME 0.3%	[31]
					29 MRSA 50 MSSA	TAT 17h shorter, better therapy de-escalation	[32]
Rapid AST	Disk diffusion with shorter incubation	Positive blood culture	4–6 h	+ Easy to perform, rapid, low-cost − Low growth, diameters margins less demarcated	24 MRSA 313 MSSA	Sensitivity 100% Specificity 100%	[33]
					14 MRSA 183 MSSA	Sensitivity 100% Specificity 99.4% ATU 0.5%	[34]
					9 MRSA 212 MSSA	Sensitivity 100% Specificity 99.1% ATU 0.4% ME 0.5%	[35]

Sanchini A. Diagnostics (Basel). 2022;12(1):208.



Φαινοτυπικές μέθοδοι για ανίχνευση του MRSA

Phenotypic Method Used	Principle of the Method	On Culture/on Clinical Sample	TAT [1]	Brief Advantages/Disadvantages +/−	No. and Type of *S. aureus* Anlyzed [2]	Major Diagnostic Performance [3]	Reference
VITEK 2	Turbidimetric monitoring of bacterial growth	Culture	4–11 h	+ Automated, rapid, standardized interpretation − Fixed range of testable antibiotics, less accurate for linezolid/vancomycin	72 MRSA 28 MSSA	Sensitivity 97.2% Specificity 100%	[28]
					27 MRSA resistant to linezolid	MEs 85.2%	[36]
					28 MRSA with a vancomycin MIC ≥ 2	MEs 46.4%	[37]
BD Phoenix	Turbidimetric and colorimetric growth detection	Culture	6–16 h	+ Automated, rapid, standardized interpretation − Less accurate for SXT	642 *S. aureus* analyzed for SXT resistance	CA 91.9% MEs 7.9% mEs 0.3%	[38]
Copan WASP Colibri	Automated disk diffusion	Culture	16 h	+ Automated, flexible, detect heteroresistance and mixed cultures − Should be compared with standard disk diffusion	107 *S. aureus* tested for several antibiotics	CA 99.9%	[39]
Accelerate PhenoTest™ BC	Single-cell analysis, fluorescent in situ hybridization	Positive blood culture	7 h	+ Automated, monomicrobial call, rapid, identification and AST in the same platform	98 MRSA 86 MSSA	Sensitivity 100% Specificity 98.8% CA 99.5%	[17]
					22 MRSA 2 MSSA	Sensitivity 100% Specificity 100%	[40]
PBP2a latex agglutination assay	Particles with monoclonal antibodies, agglutination reaction	Culture	5 m	+ Rapid, easy to perform and interpret − no PBP2c detection	95 MRSA 10 MSSA	Sensitivity 98.95% Specificity 77.8%	[41]

Sanchini A. Diagnostics (Basel). 2022;12(1):208.

Μοριακές μέθοδοι για ανίχνευση του MRSA απευθείας από το δείγμα: παραδείγματα

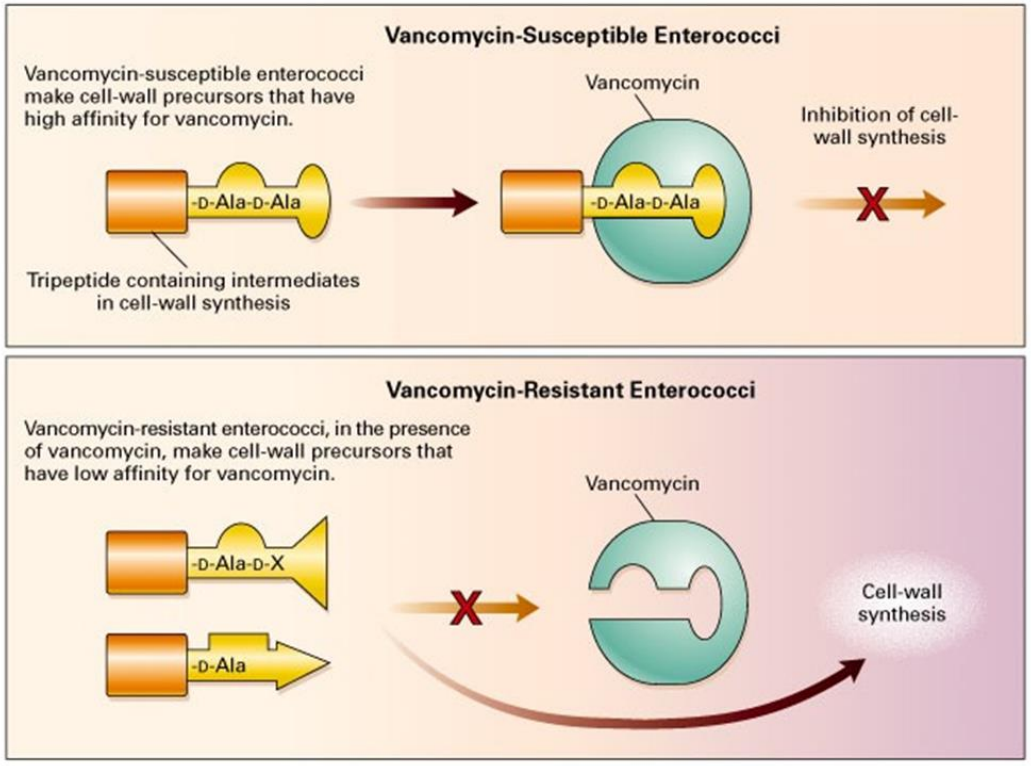
Molecular Method Used	Principle of the Method	On Culture/ on Clinical Sample	TAT [1]
Xpert ® SA Nasal Complete (Cepheid)	Real-time PCR for *mecA/C*, *spa* and SCC*mec-orfX*	Nasal samples	1 h
Xpert ® MRSA/SA BC Assay (Cepheid)	Real-time PCR for *mecA/C*, *spa* and SCC*mec-orfX*	Positive blood cultures	1.7 h
Xpert ® MRSA/SA SSTI (Cepheid)	Real-time PCR for *mecA/C*, *spa* and SCC*mec-orfX*	BAL samples	68 m

Se 86-98%
Sp 90-95%

Molecular Method Used	Principle of the Method	On Culture/ on Clinical Sample	TAT [1]	Brief Advantages/Disadvantages +/−
Hologic Panther Fusion ® MRSA	PCR and Invader chemistries for *mecA/C*, *gap* and SCC*mec-orfX*	Nasal samples	<3 h	+ Can analyze 350 samples in 8 h − Need comparison with a similar method
MRSA/SA ELITe MGB assay (ELITech-Group)	Real time PCR for *mecA/C* and a *S. aureus* specific sequence	Sputum, tracheal aspirate, BAL	<3 h	+ Accurate − Do not target SCC*mec-orfX* junction
Eazyplex ® MRSA	LAMP targeting *S. aureus*, *S. epidermidis*, *mecA/C*	Positive blood cultures	1 h	+ Portable; faster than similar methods − Need optimization for CONS

Sanchini A. Diagnostics (Basel). 2022;12(1):208.

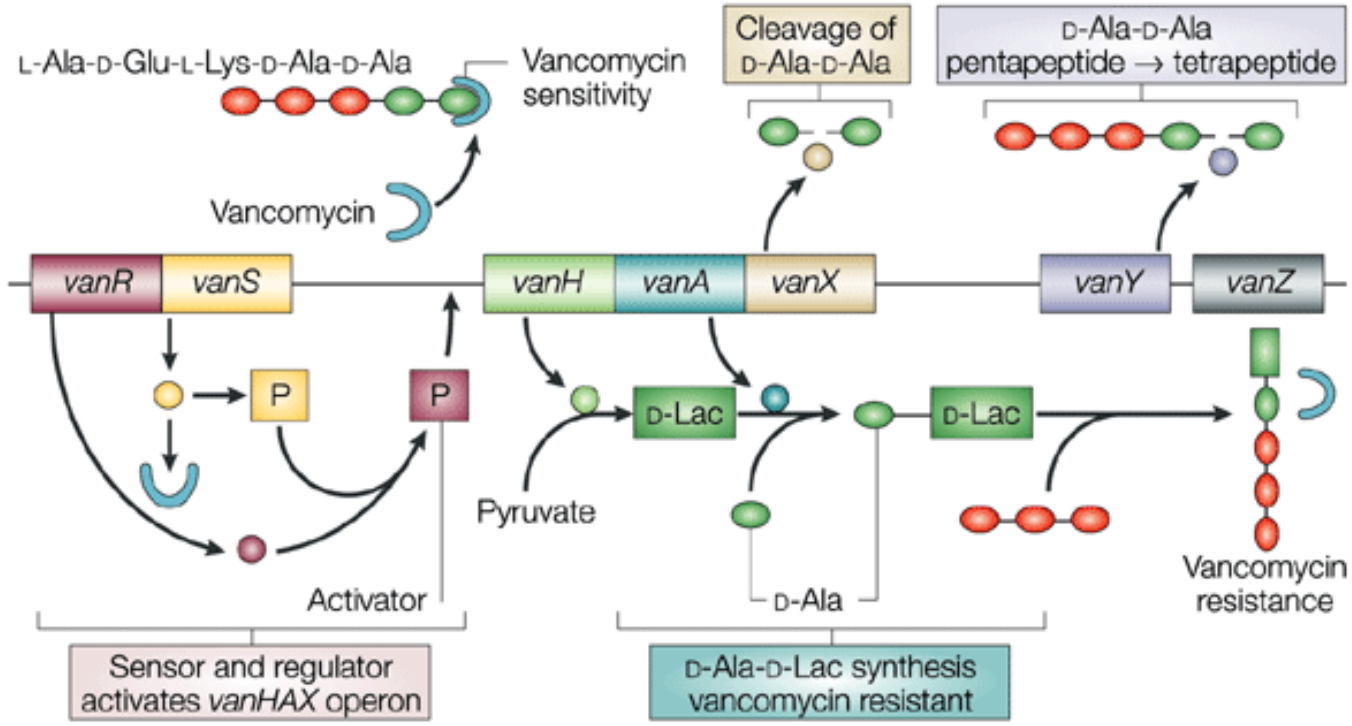
VRE, μηχανισμός αντοχής: τροποποίηση στόχου δράσης



Σύνθεση πεπτιδογλυκάνης που φέρει πλευρικές πενταπεπτιδικές αλυσίδες που καταλήγουν σε

D-ala-D-lactate (VanA, VanB, VanD)

D-ala-D-serine (VanC, VanE, VanG, VanL , VanN)



Nature Reviews | Genetics

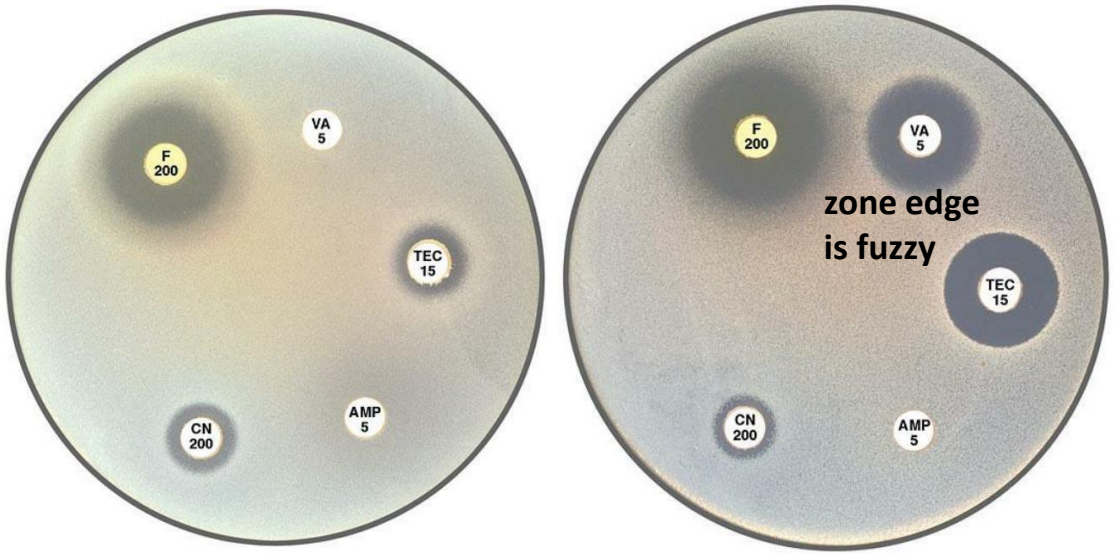
Glycopeptide resistance due to *van*-type gene clusters

	Aquired							Intrinsic
Resistance level	**High**	**Variable**	**Moderate**	**Low**				**Low**
Type	**VanA**	**VanB**	**VanD**	**VanE**	**VanG**	**VanL**	**VanN**	**VanC**
MIC in mg/L:								
Vancomycin	≥16	≥4	≥64	6–32	12–16	8	8	2–32
Teicoplanin	>8	0,5-1	4–64	0,5	0,5			0,5-1
Expression	Inducible	Inducible	Constitutive/ Inducible (*vanD2*)	Inducible/ (Constitutive)	Inducible			Constitutive/ Inducible
van ligase gene	*vanA*	*vanB1-B3*	*vanD1-5*	*vanE*	*vanG1-2*	*vanL*	*vanN*	*vanC1-C3*
Modified target	D-alanine-D-lactate	D-alanine-D-lactate	D-alanine-D-lactate	D-alanine-D-serine	D-alanine-D-serine	D-alanine-D-serine	D-alanine-D-serine?	D-alanine-D-serine
Conjugative transfer	Yes	Yes	No	No	Yes	No	Yes	No
Location	Plasmid/chromosome on transposon(s)	Plasmid/chromosome ± transposon/ICE[a]	Chromosome	Chromosome	Chromosome on possible ICE	Chromosome?	Plasmid	Chromosome
Distribution	*Enterococcus faecium* *Enterococcus faecalis* *Enterococcus avium* *Enterococcus casseliflavus* *Enterococcus durans* *Enterococcus gallinarum* *Enterococcus hirae* *Enterococcus mundtii* *Enterococcus raffinosus* *Staphylococcus aureus* *Bacillus circulans* *Oerskovia turbata* *Arcanobacterium haemolyticum* *Paenibacillus* *Rhodococcus*	*Enterococcus faecium* *Enterococcus faecalis* *Enterococcus casseliflavus* *Enterococcus durans* *Enterococcus gallinarum* *Enterococcus hirae* *Staphylococcus epidermidis* *Streptococcus* *Clostridium* *Ruminococcus* *Eggerthella*	*Enterococcus faecium* *Enterococcus faecalis* *Enterococcus avium* *Enterococcus gallinarum* *Enterococcus raffinosus* Non-enterococcal faecal flora	*Enterococcus faecalis*	*Enterococcus faecalis* Non-enterococcal faecal flora	*Enterococcus faecalis*	*Enterococcus faecium*	*Enterococcus gallinarum* – *vanC1* *Enterococcus casseliflavus* – *vanC2/3*

Hegstad K et al. Clin Microbiol Infect. 2010;16(6):541-54.

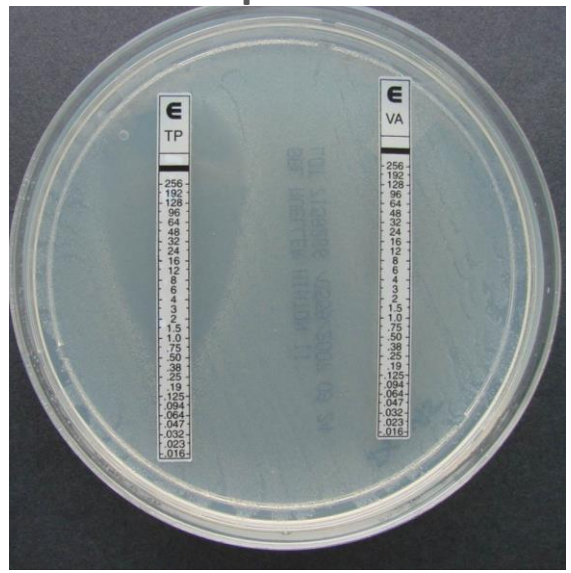
Ανίχνευση VRE: παραδείγματα

Μέθοδος διάχυσης των δίσκων



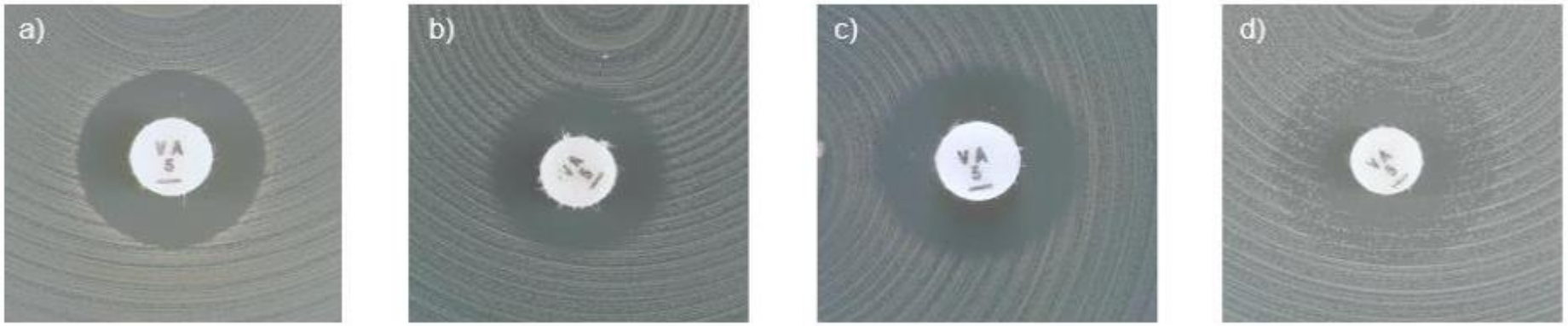
Isolates must not be reported susceptible before 24 h incubation

Ταινίες διαβαθμισμένης συγκέντρωσης αντιβιοτικών



sharp zone edges

Confirmatory testing with PCR or
report resistant even if the zone diameter is ≥ 12 mm



The European Committee on Antimicrobial Susceptibility Testing. Breakpoint tables for interpretation of MICs and zone diameters. Version 13.0, 2023. http://www.eucast.org.

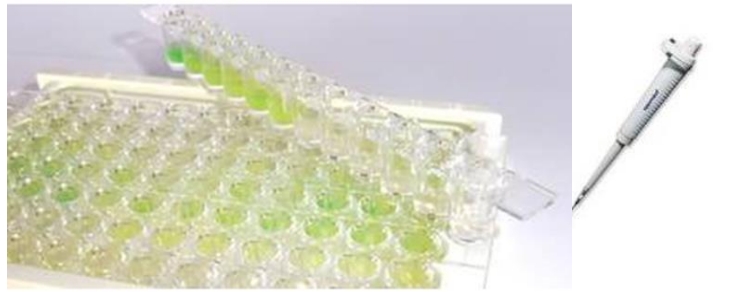
Ανίχνευση VRE: παραδείγματα

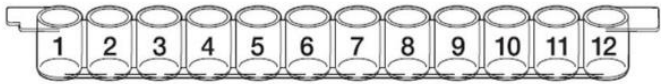
Αυτοματοποιημένα συστήματα

Bionumber: 532047265773771
Organism Quantity:
Selected Organism: Enterococcus faecium

Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
Cefoxitin Screen			Moxifloxacin	(-)	(-)
Benzylpenicillin	(-)	(-)	Inducible Clindamycin Resistance		
Ampicillin	>= 32	R	Erythromycin	(-)	(-)
Oxacillin			Clindamycin	(-)	(-)
Imipenem	>= 16	R	Quinupristin/Dalfopristin	4	R
Gentamicin High Level (synergy)	SYN-S	S	Linezolid	1	S
Streptomycin High Level (synergy)	SYN-R	R	Daptomycin		
Gentamicin			Teicoplanin	>= 32	R
Ciprofloxacin			Vancomycin	>= 32	R
Urine	>= 8	R	Tigecycline	<= 0.12	S
Other	>= 8		Trimethoprim/ Sulfamethoxazole		

Broth microdilution





Μοριακές μέθοδοι απευθείας από το δείγμα

*Van*A or *Van*B resistance in 20 min, from rectal swabs, blood culture or as culture confirmation

VRE **Cepheid Xpert® vanA/vanB**

VanA SN= 87.1%, SP=99.7%, PPV=98.0%, NPV=97.7%

VanB SN=77.6%

The saving of time to results corresponded to 141 saved isolation days and 292 saved transmission risk days.

Holzknecht BJ et al. New Microbes New Infect. 2017;16:54-59.

J Antimicrob Chemother 2021; **76**: 146–151
doi:10.1093/jac/dkaa413 Advance Access publication 9 October 2020

Journal of Antimicrobial Chemotherapy

Development and validation of a lateral flow immunoassay for rapid detection of VanA-producing enterococci

Saoussen Oueslati[1,2]†, Hervé Volland[3]†, Vincent Cattoir[4], Sandrine Bernabeu[1,2], Delphine Girlich[1], Ducan Dulac[3], Marc Plaisance[3], Maxime Laroche[5], Laurent Dortet[1,2,6], Stéphanie Simon[3] and Thierry Naas[1,2,6]*

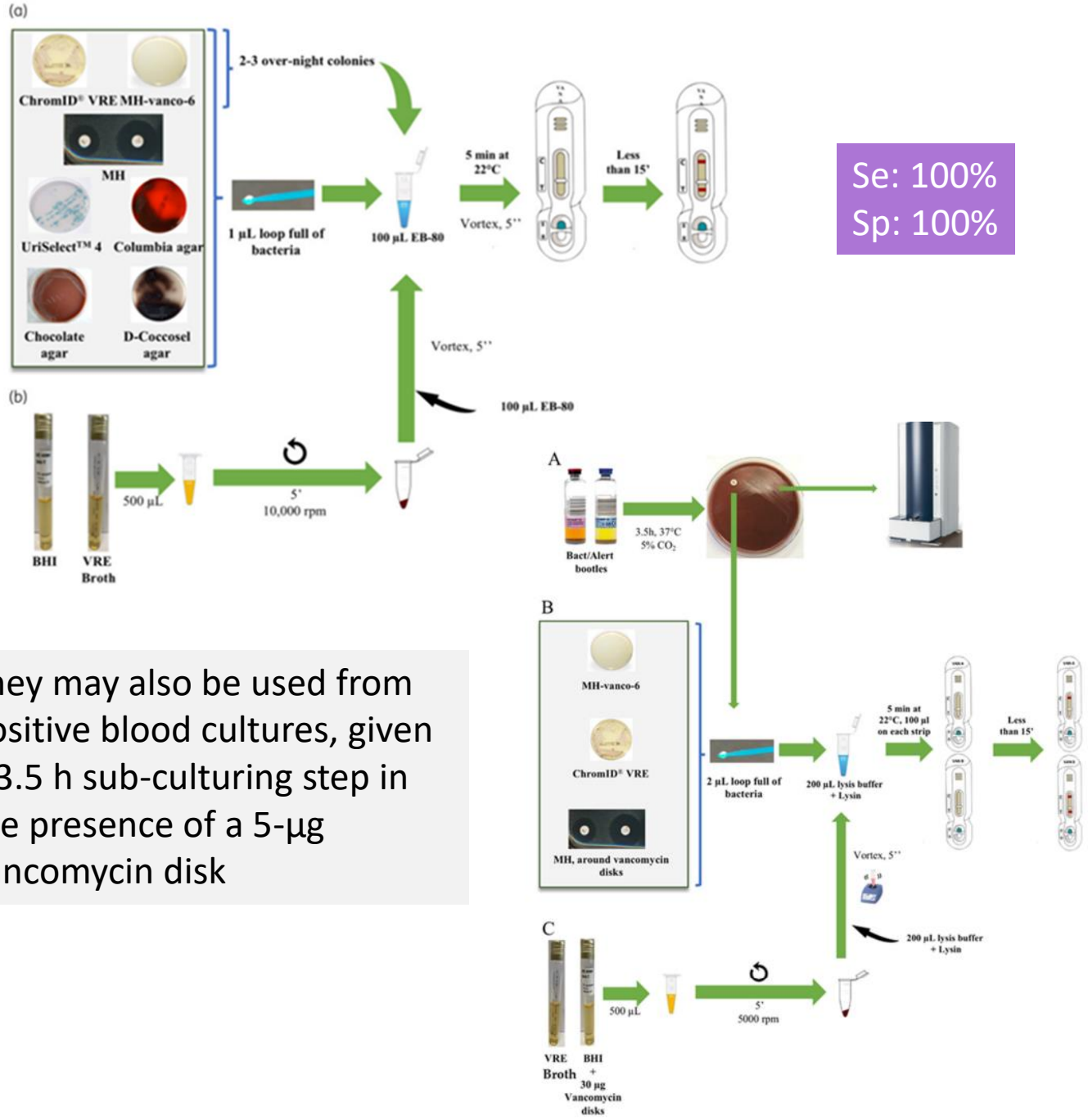
diagnostics

MDPI

Article

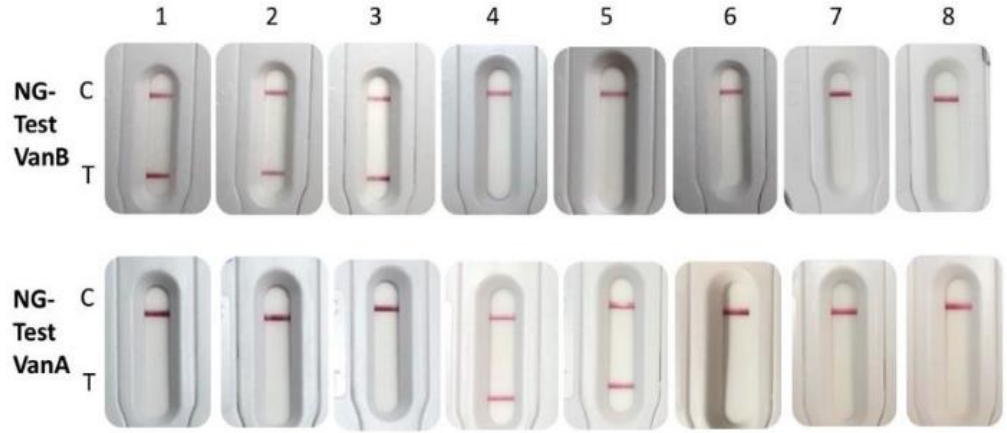
Rapid Detection of VanA/B-Producing Vancomycin-Resistant Enterococci Using Lateral Flow Immunoassay

Saoussen Oueslati [1,2,†], Camille Gonzalez [1,2,†], Hervé Volland [3,*,†], Vincent Cattoir [4], Sandrine Bernabeu [1,2], Delphine Girlich [1,2], Duncan Dulac [3], Marc Plaisance [3], Laure Boutigny [5], Laurent Dortet [1,2], Stéphanie Simon [3] and Thierry Naas [1,*]



Se: 100%
Sp: 100%

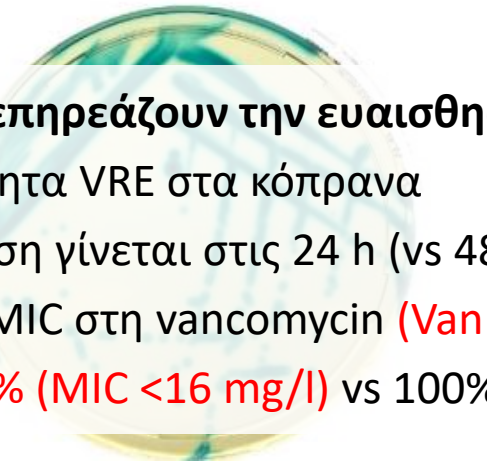
They may also be used from positive blood cultures, given a 3.5 h sub-culturing step in the presence of a 5-µg vancomycin disk



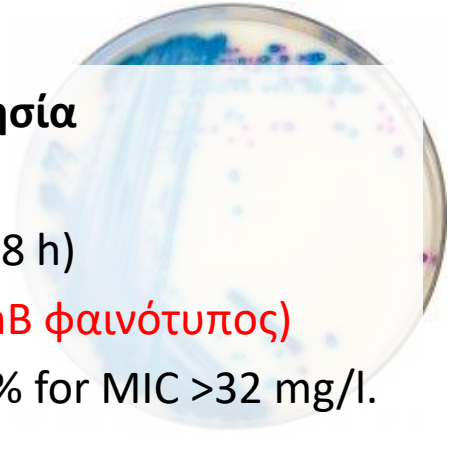
Χρωμογόνα εκλεκτικά υλικά για VRE

Brilliance VRE®, Oxoid

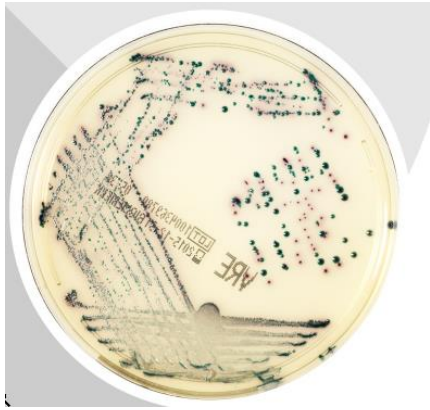
Chromatic VRE, Liofilchem



ChromAgar® VRE



chromID® VRE, bioMerieux



Bile-esculin-azide agar + 6 mg/L vancomycin

Παράγοντες που επηρεάζουν την ευαισθησία

- χαμηλή πυκνότητα VRE στα κόπρανα
- όταν η ανάγνωση γίνεται στις 24 h (vs 48 h)
- χαμηλές τιμές MIC στη vancomycin (VanB φαινότυπος)
  - SN 25-75% (MIC <16 mg/l) vs 100% for MIC >32 mg/l.

TABLE 2 Comparison 396 specimens (combined data)

	Performance (% [95% CI])[b]			
Medium	Sensitivity	Specificity	PPV	NPV
BEAV broth	98.0 (94.7–98.0)	100 (98.9–100)	100 (96.7–100)	99.3 (98.3–99.3)
Enterococcosel (BEAV)	84.8 (80.9–84.8)	100 (98.7–100)	100 (95.3–100)	95.2 (93.9–95.2)
InTray Colorex VRE	91.9 (86.9–94.8)	98.3 (96.6–99.3)	94.8 (89.6–97.9)	97.3 (95.7–98.3)
chromID	94.9 (91.0–95.9)	99.7 (98.3–100)	98.9 (94.8–99.9)	98.3 (97.0–98.7)
VRE*Select*	91.9 (87.8–92.9)	99.7 (98.3–100)	98.9 (94.4–99.9)	97.4 (96.0–97.7)
HardyCHROM VRE	89.9 (85.6–90.9)	99.7 (98.2–100)	98.9 (94.2–99.9)	96.7 (95.4–97.0)
Spectra VRE	93.9 (89.9–94.9)	99.7 (98.3–100)	98.9 (94.7–99.9)	98.0 (96.7–98.3)

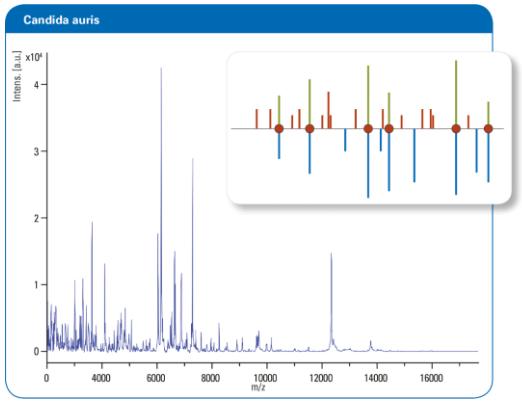
Τα χρωμογόνα υπερέχουν έναντι του BEAV: SN 89.9-93.9% vs 84.8%
Αποτελέσματα διαθέσιμα 24-48 h νωρίτερα

Επιλογή σύμφωνα με:
ευκολία διάκρισης αποικιών, αξιοπιστία, κόστος, ανάγκη επιβεβαιωτικών δοκιμασιών

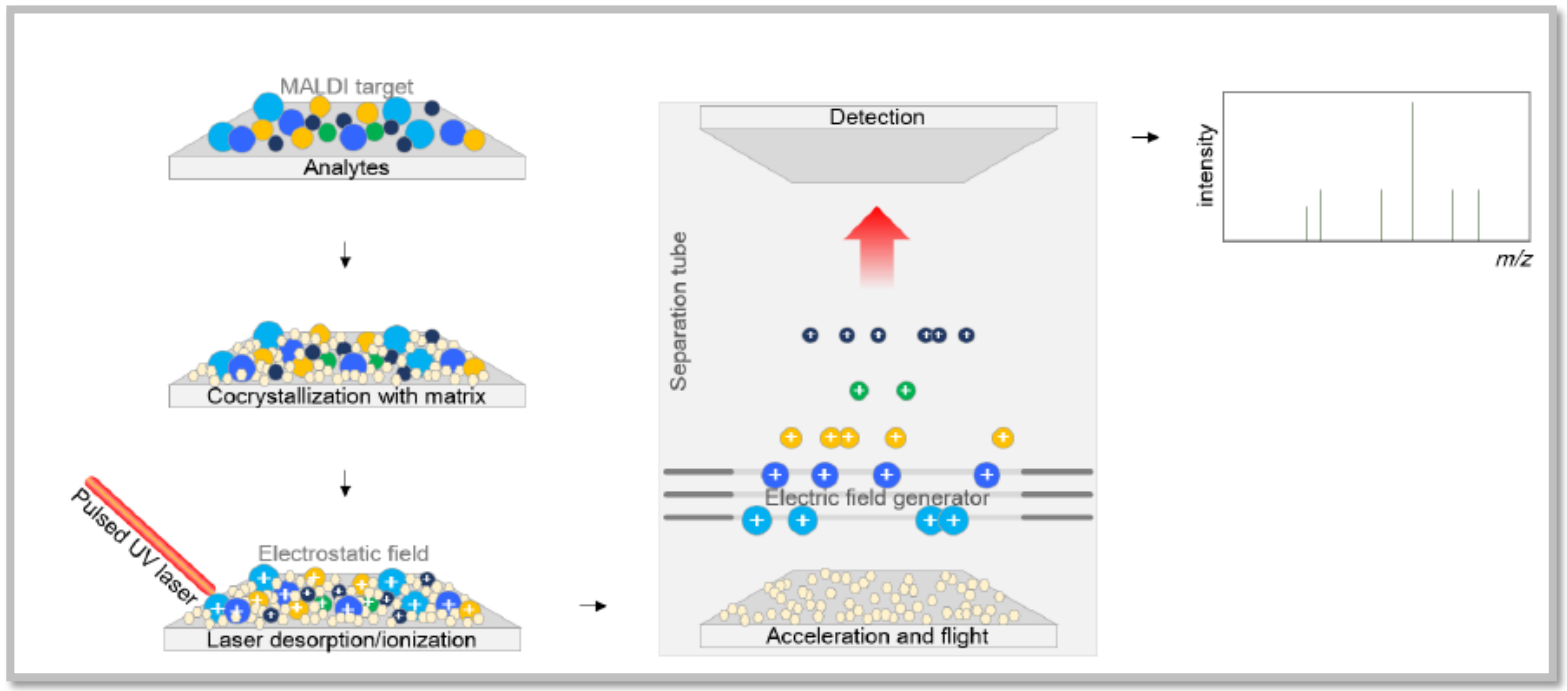
Suwantarat N et al. J Clin Microbiol. 2014;52(11):4039-42.
Wijesuriya TM et al. J Clin Microbiol. 2014 Aug;52(8):2829-33.

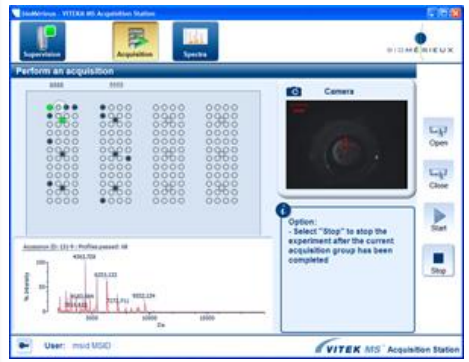
MALDI-TOF Mass Spectrometry και ανίχνευση αντοχής

Matrix-Assisted Laser Desorption Ionization
(MALDI) Time-Of-Flight (TOF)
Mass Spectrometry

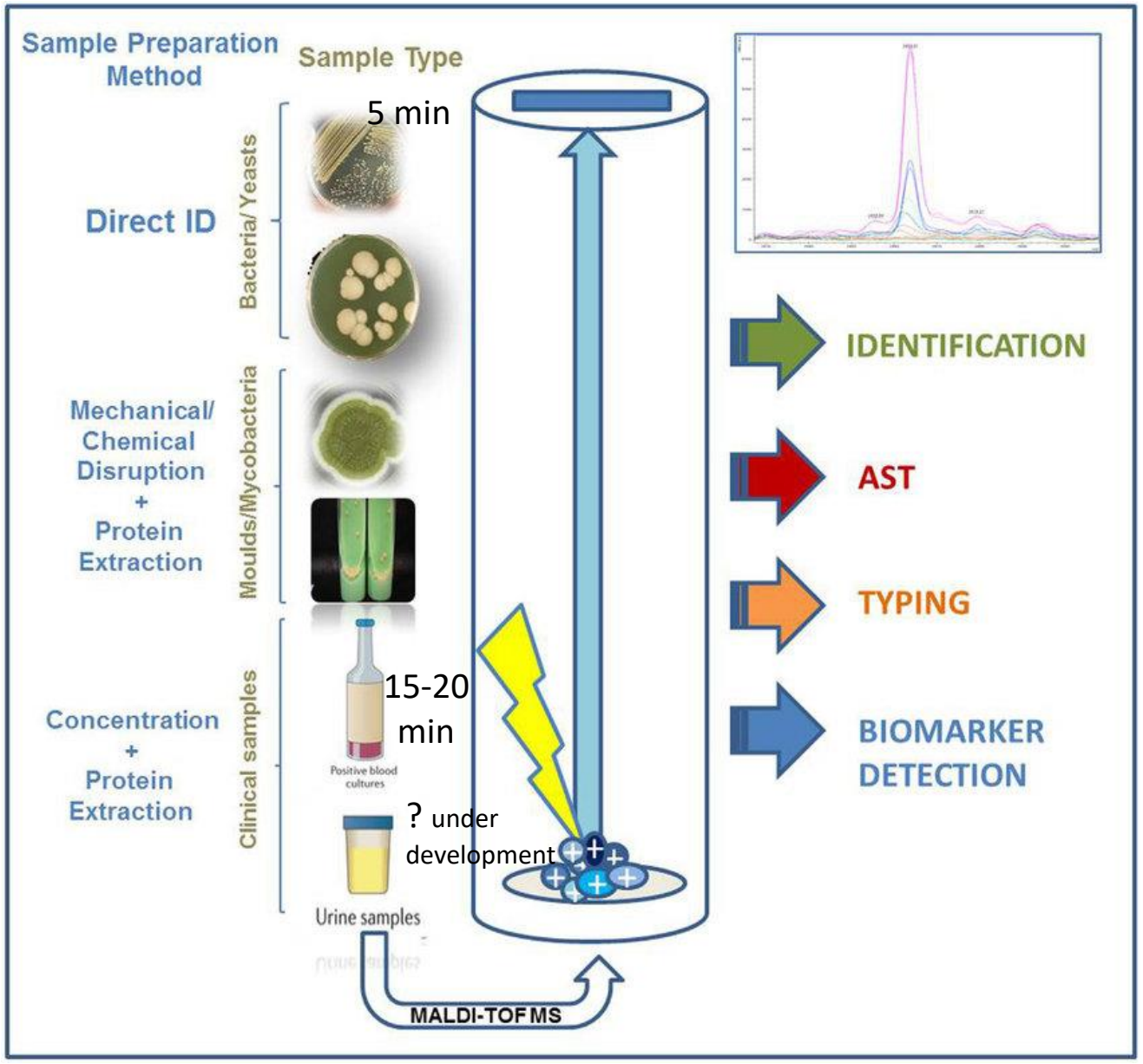


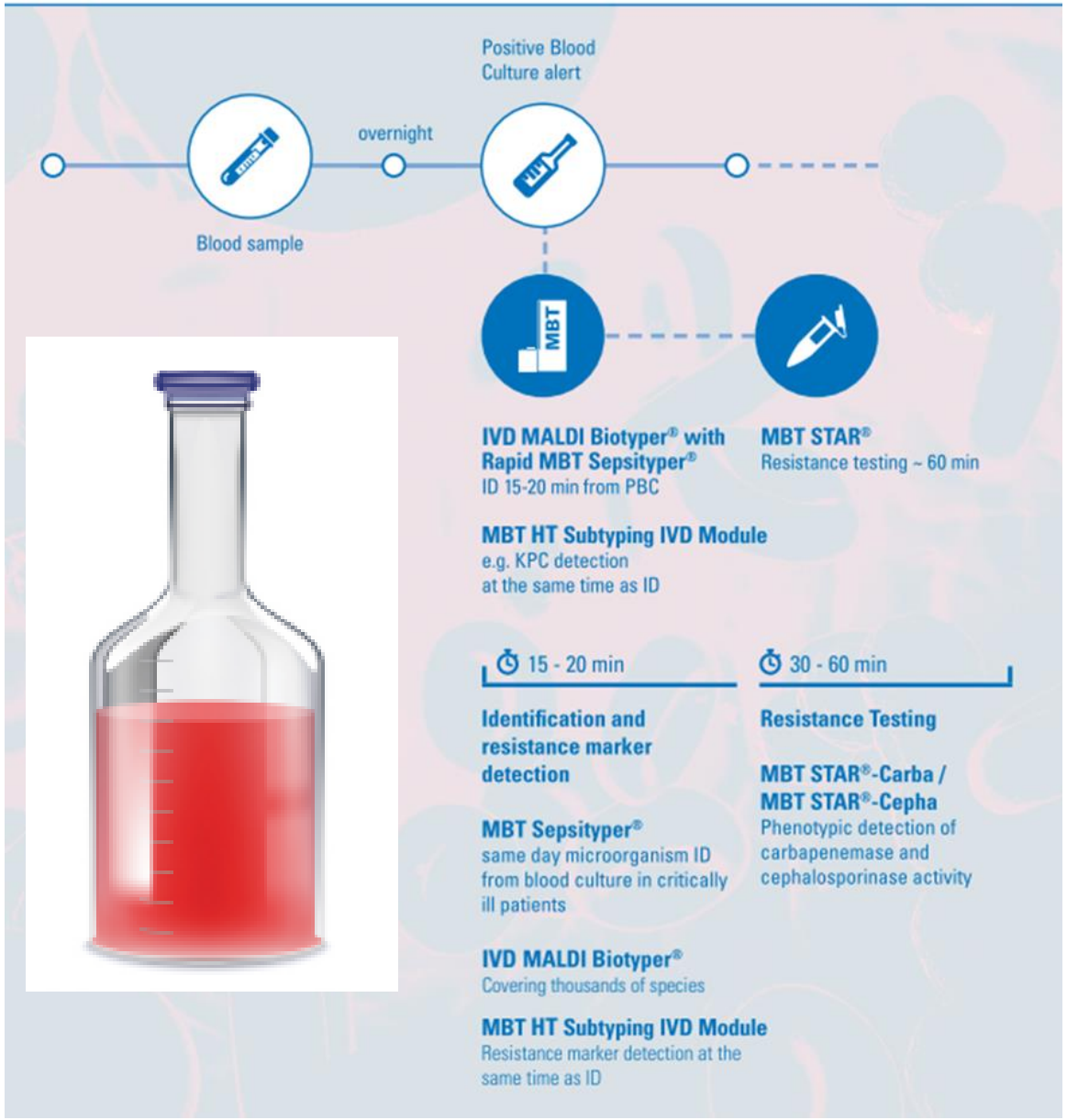
System analysis time to ID result:
95 isolates + 1 QC sample ~5 min





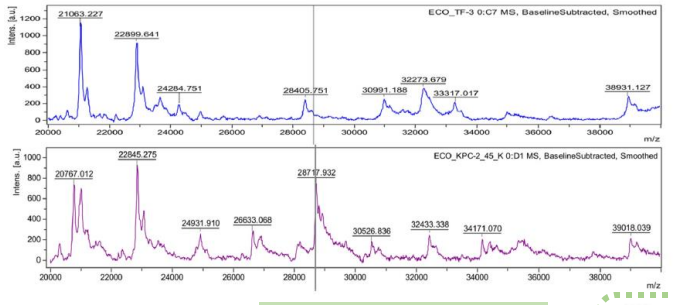
Yoon EJ, Jeong SH. MALDI-TOF Mass Spectrometry Technology as a Tool for the Rapid Diagnosis of Antimicrobial Resistance in Bacteria. Antibiotics (Basel). 2021;10(8):982.


Sample Preparation Method
Sample Type
Direct ID
Bacteria/Yeasts
Mechanical/ Chemical Disruption + Protein Extraction
Moulds/Mycobacteria
Concentration + Protein Extraction
Clinical samples
5 min
15-20 min
Positive blood cultures
? under development
Urine samples
MALDI-TOF MS
IDENTIFICATION
AST
TYPING
BIOMARKER DETECTION

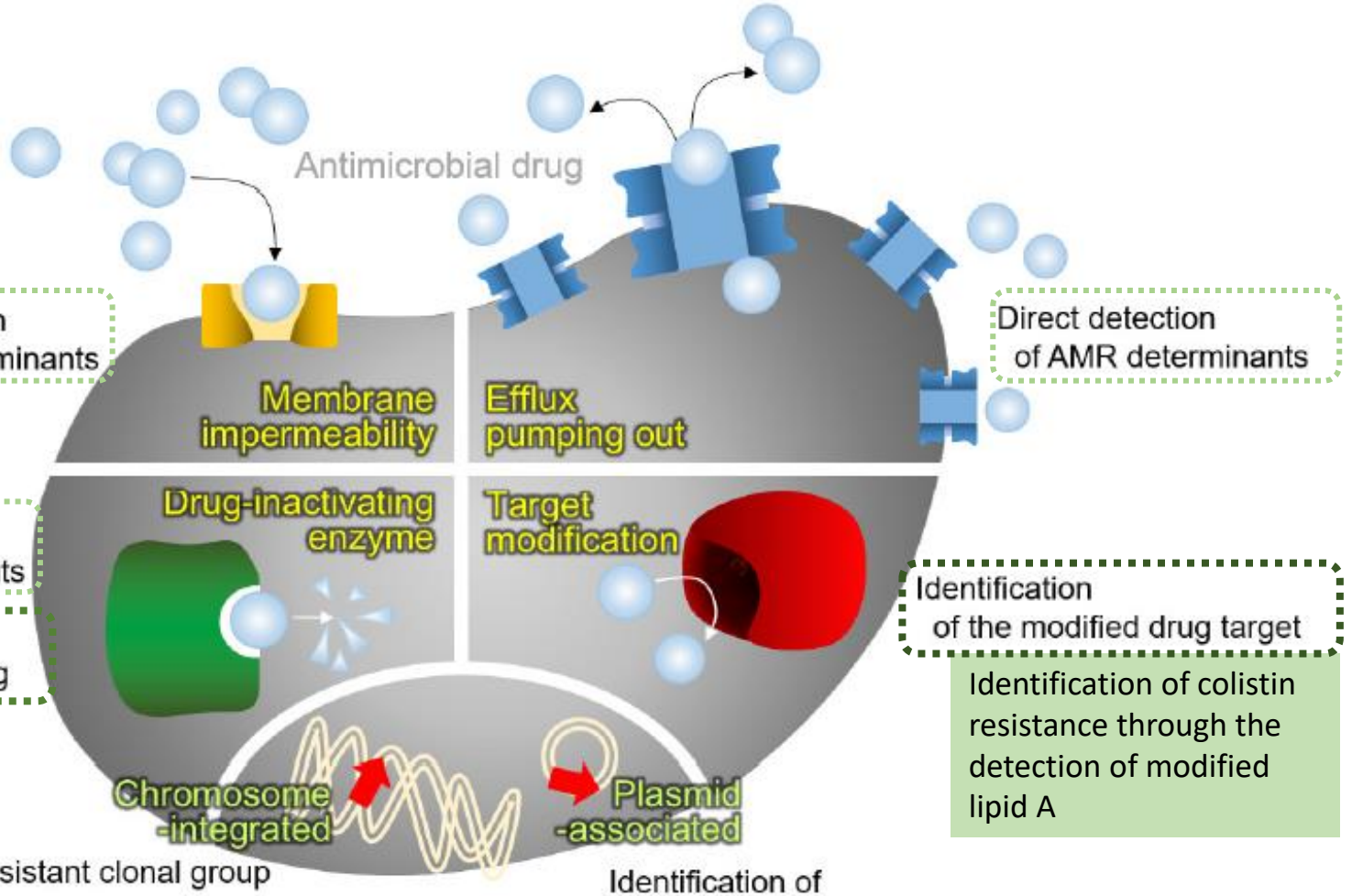

Positive Blood Culture alert
overnight
Blood sample
MBT
IVD MALDI Biotyper® with Rapid MBT Sepsityper®
ID 15-20 min from PBC
MBT STAR®
Resistance testing ~ 60 min
MBT HT Subtyping IVD Module
e.g. KPC detection
at the same time as ID
15 - 20 min
30 - 60 min
Identification and resistance marker detection
Resistance Testing
MBT Sepsityper®
same day microorganism ID from blood culture in critically ill patients
MBT STAR®-Carba / MBT STAR®-Cepha
Phenotypic detection of carbapenemase and cephalosporinase activity
IVD MALDI Biotyper®
Covering thousands of species
MBT HT Subtyping IVD Module
Resistance marker detection at the same time as ID

MALDI-TOF Mass Spectrometry και ανίχνευση αντοχής

Identification of the KPC producer



beta-lactamases
Porin defects



The modified antibiotics change their molecular weights. AMR is identified by detecting the peak shift using the MALDI-TOF MS methodology

MALDI-TOF MS protein fingerprints of well-known AMR clonal groups

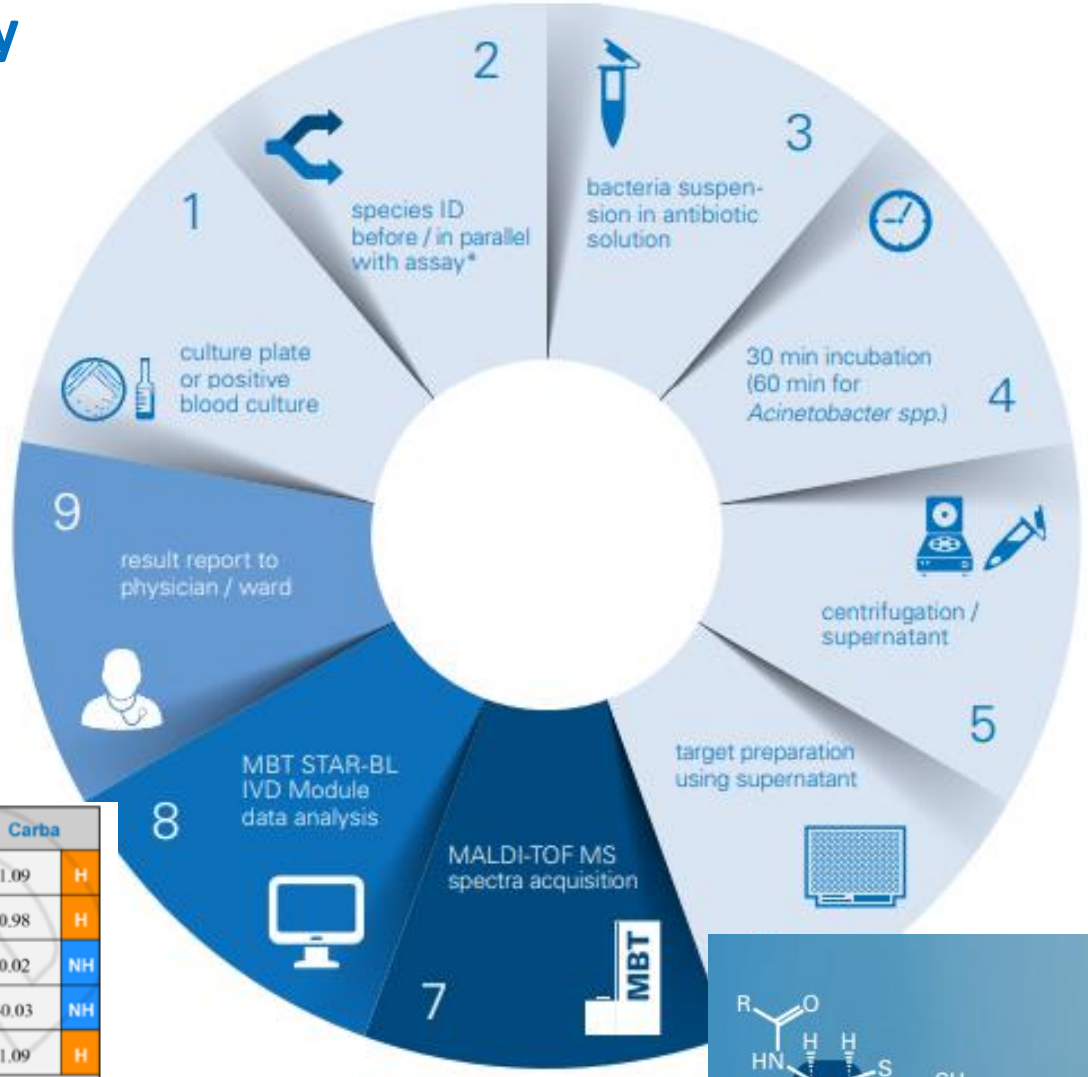
Identification of colistin resistance through the detection of modified lipid A

Yoon EJ, Jeong SH. Antibiotics (Basel). 2021;10(8):982.

MALDI-TOF Mass Spectrometry και ανίχνευση αντοχής

MBT STAR®-Carba IVD Assay

Sensitivity 93.9%
specificity, 100%



Sample	Species	Control ID	Carba	
Sample 1	Klebsiella pneumoniae	confirmed	1.09	H
Sample 2	Klebsiella pneumoniae	confirmed	0.98	H
Sample 3	Escherichia coli	confirmed	0.02	NH
neg.control		not performed	-0.03	NH
pos.control		not performed	1.09	H
Δ controls			1.47	

H	Hydrolyzed[1]
NH	Non-hydrolyzed[2]

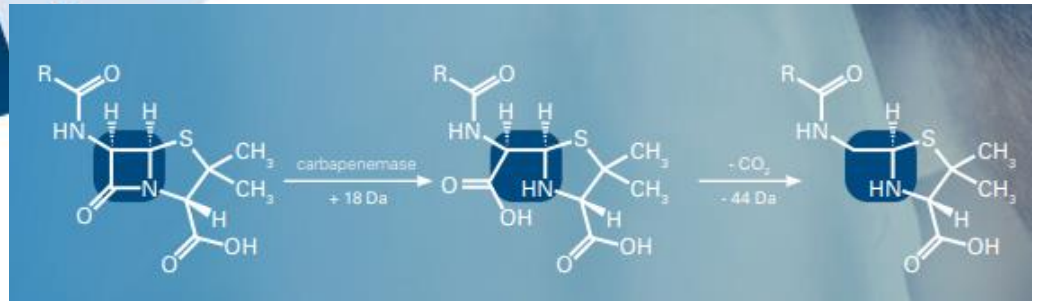
Se: 100%, Sp: 100%

Del Corpo O et al. Clin Microbiol Infect. 2023 Sep 16:S1198-743X(23)00425-1.

Bacteria with active carbapenemase will inactivate the carbapenem antibiotic by hydrolysation of the ß-lactam ring, **which is associated with a detectable mass shift.**

In assays with bacteria without active carbapenemase, only peaks corresponding to the intact antibiotic will be present in the mass spectrum.

In assays with bacteria with active carbapenemase, peaks of the intact antibiotic will decrease.



MALDI-TOF Mass Spectrometry και ανίχνευση αντοχής

MBT STAR®-Cepha IVD Assay

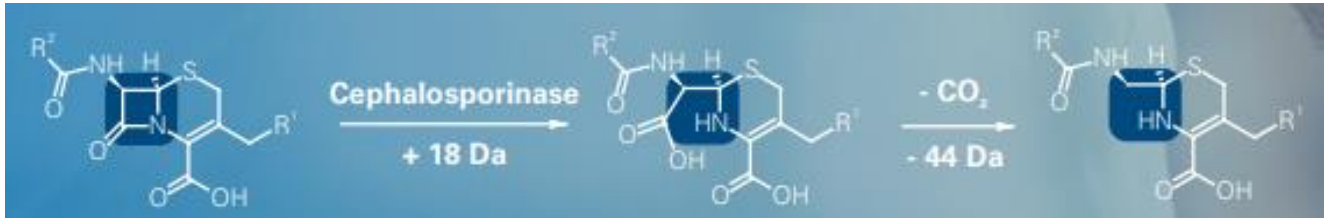
1. Positive blood culture[$] or culture plate
2. Optional species ID before / in parallel (control ID) with assay*
3. Bacteria suspension in antibiotic solution
4. 30 min incubation
5. MALDI target plate preparation
6. MALDI-TOF MS spectra acquisition and automated data analysis by MBT STAR-BL IVD Module

1 hour

Se: 94%
Sp: 97%

Del Corpo O et al. Clin Microbiol Infect. 2023 Sep 16:S1198-743X(23)00425-1.

Hydrolysis of β-lactam ring leads to mass shifts that can easily be detected by MALDI-TOF mass spectrometry



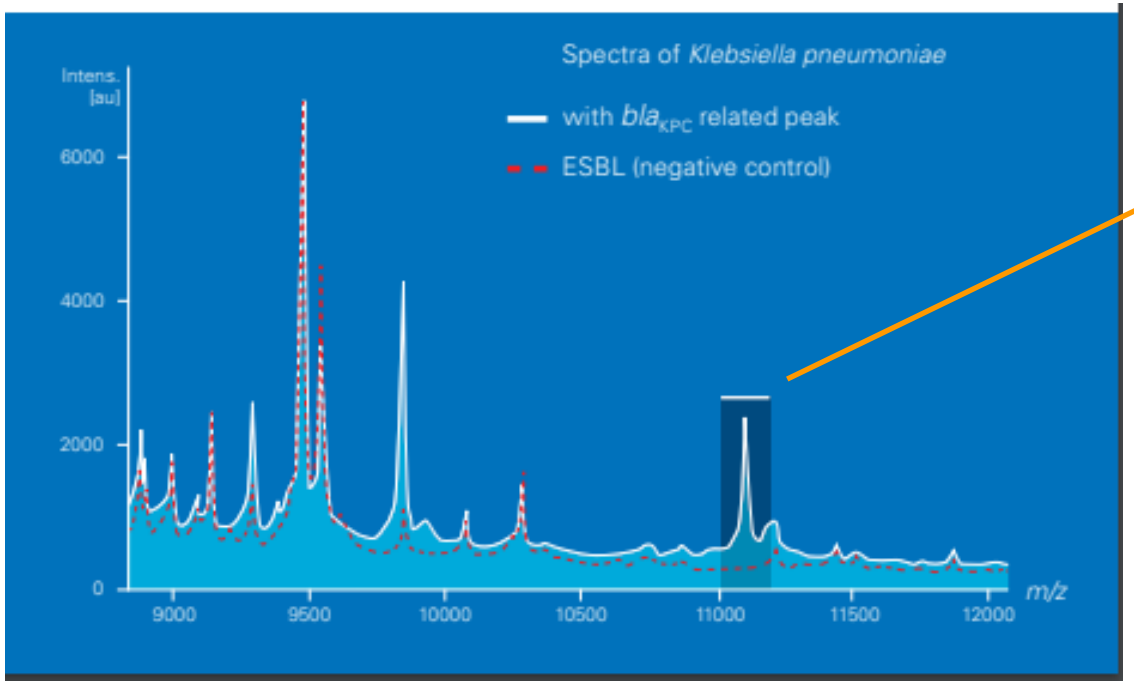
Sample	Species	Control ID	Cepha	
Sample 1	Escherichia coli	confirmed	1.28	H
Sample 2	Escherichia coli	confirmed	1.14	H
Sample 3	Klebsiella variicola	confirmed	-0.55	NH
neg.control		not performed	-0.10	NH
pos.control		not performed	1.04	H
Δcontrols			1.12	

H	Hydrolyzed[1]
NH	Non-hydrolyzed[2]

MALDI-TOF Mass Spectrometry και ανίχνευση αντοχής

MBT Subtyping IVD Module

Quick detection of *bla*$_{KPC}$ expressing *K. pneumoniae* and *E. coli*



*A peak in MALDI-TOF mass spectra of KPC-producing *K. pneumoniae*, related to the plasmid carrying *bla*$_{KPC}$ (pKpQIL). This peak at 11,109 m/z is clearly detectable in MALDI-TOF mass spectra.

Prerequisite for the automated detection process is the successful ID.

The MBT HT Subtyping IVD Module then looks for the *bla*$_{KPC}$ related peak in the sample spectrum and, if present, the software will report this sample as a KPC positive one.

KPC detection of *K. pneumoniae* and *E. coli* **includes only strains** with a *bla*$_{KPC}$ pKpQIL plasmid.

If the gene expression rate is low, there will be no characteristic peak and no KPC subtyping alert.

Cultivation media and conditions might suppress or induce a signal at m/z 11,109 which is not related to a KPC resistance. Therefore, Columbia Agar with 5% sheep blood agar must be used for cultivation of *K. pneumoniae* and *E. coli*.

Lau AF et al. J Clin Microbiol. 2014;52(8):2804-12.
Youn JH et al. J Clin Microbiol. 2016;54(1):35-42.

Applications of MALDI-TOF MS for specific AMR detection

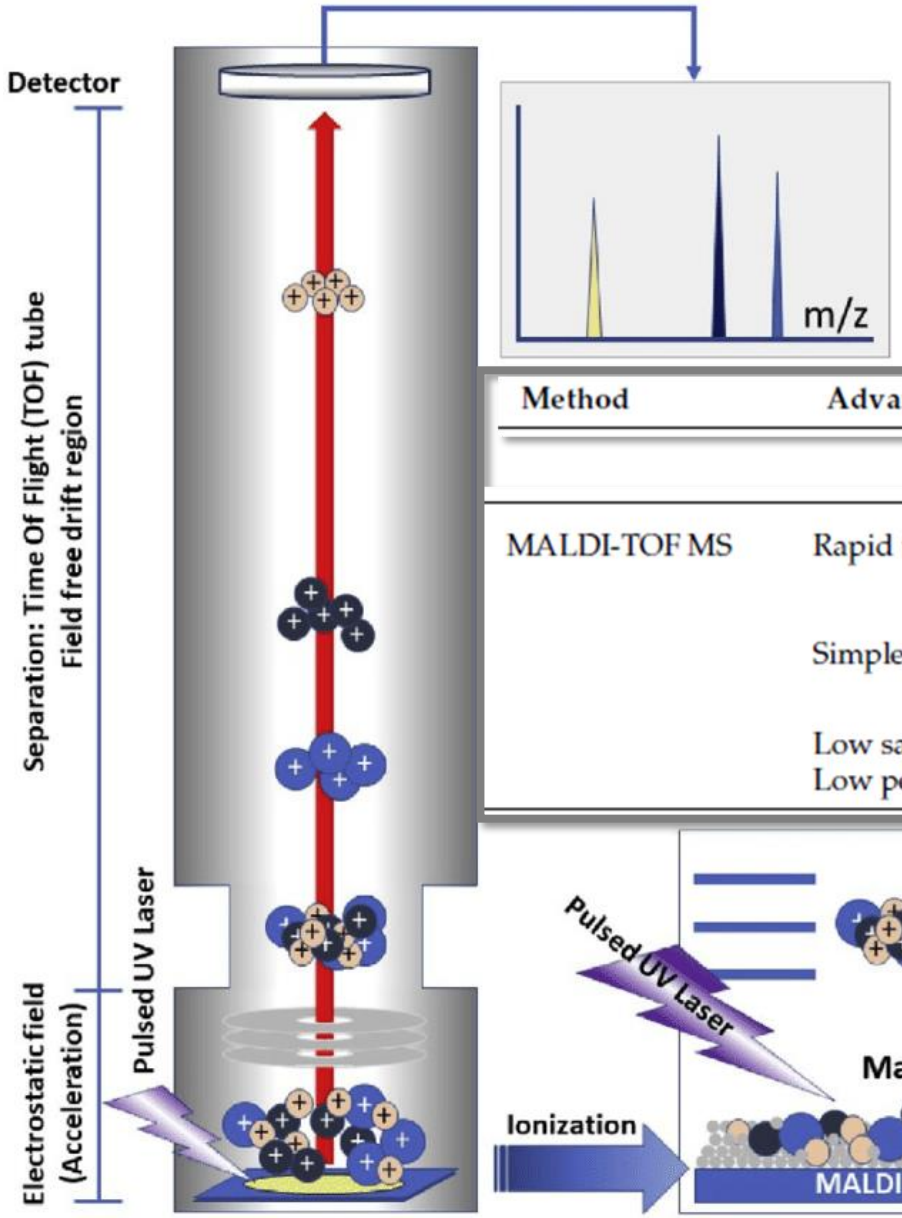
Organism	Antibiotic	Year (Reference)
E. coli	Polymyxins	2018 [122]
E. coli	Colistin	2019 [123]
E. coli *Klebsiella pneumoniae*	Beta-lactams (ESBL-producing isolates)	2019 [124]
Staphylococcus aureus *S. intermedius* *S. pseudintermedius*	Novobiocin Polymyxin B Acriflavine	2019 [125]
S. aureus	Methicillin	2019 [126]
Candida auris	Echinocandins	2019 [127]
K. pneumoniae *Bacteroides fragilis* *S. aureus*	Carbapenems (carbapenemase-producing isolates) Methicillin	2019 [128]
Enterobacteriaceae	Carbapenems (carbapenemase-producing isolates)	2019 [129]
Enterobacteriaceae	Carbapenem	2019 [130]
Pseudomonas aeruginosa	Beta-lactams (MBL)	2019 [131]
Enterococcus faecium	Vancomycin	2019 [132]
K. pneumoniae	Carbapenems (carbapenemase-producing isolates)	2019 [133]
Acinetobacter baumannii	Colistin	2020 [134]
E. coli *K. pneumoniae*	Cefotaxime Meropenem, Ciprofloxacin	2020 [135]
S. aureus *Enterococcus* species *E. coli* *K. pneumoniae*	Oxacillin (methicillin) Vancomycin Ceftriaxone Meropenem	2020 [136]
Enterobacterales	Imipenem/Relebactam	2020 [137]
S. aureus	Methicillin	2020 [138]

Kaprou GD et al. Antibiotics (Basel). 2021;10(2):209.

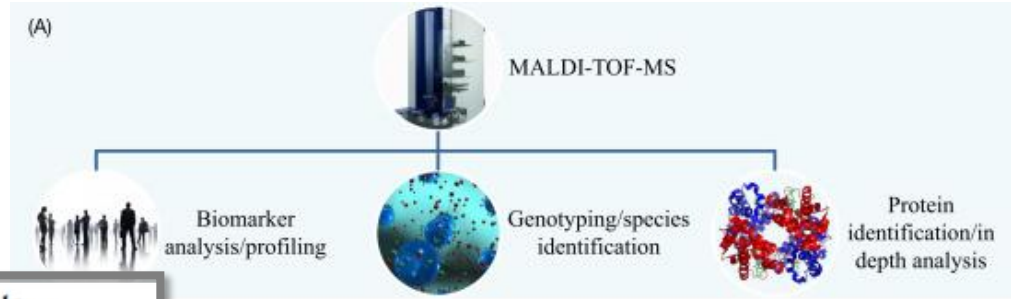
MALDI-TOF MS approaches for AMR detection in *S. aureus*

MALDI-TOF System Used	Principle of the Method	On Culture/ on Clinical Sample	TAT [1]	Brief Advantages/ Disadvantages +/−	No. and Type of *S. aureus* Analyzed [2]	Major Diagnostic Performance [3]	Reference
MALDI Biotyper® CA System (Bruker Daltonics)	21 peaks to discriminate MRSA/MSSA	Culture	Few m	+ Use a combination of peaks − Low specificity	181 *S. aureus*	Sensitivity 87.6% Specificity 71.4%	[64]
MALDI Biotyper® CA System (Bruker Daltonics)	Peptide PSM-*mec* and δ-toxin peaks for MRSA identification	Culture	Few m	+ Sensitive for SCC*mec* type II, III and VIII − Not adapted for other SCC*mec* types	35 MRSA	Sensitivity 40%	[65]
MALDI Biotyper® CA System (Bruker Daltonics)	Peptide PSM-*mec* peak for MRSA identification	Culture	Few m	+ Good specificity − SCC*mec* types of isolates unknown	241 MRSA 106 MSSA	Sensitivity 60.2% Specificity 100%	[66]
MALDI Biotyper® CA System (Bruker Daltonics)	m/z 4594 peak for MRSA identification	Culture	Few m	+ Potential MRSA biomarker peak − To be tested in an independent set of data	36 MRSA 31 MSSA	Sensitivity 83.3% Specificity 96.8%	[67]
VITEK MS (BioMérieux)	support vector machine algorithm to identify 38 peaks to discriminate MRSA/MSSA	Culture	Few m	+ Use a combination of peaks − MRSA/MSSA classification model needs optimization	194 MRSA 258 MSSA	Sensitivity 84.0% Specificity 88.0%	[68]
MALDI Biotyper® CA System (Bruker Daltonics)	DOT-MGA	Positive blood cultures	6 h	+ Rapid; tested with cefoxitin − Could be optimized for additional antibiotics	30 MRSA 14 MSSA	Sensitivity 100% Specificity 100%	[69]
VITEK MS (BioMérieux)	DOT-MGA	Culture	5 h	+ Tested with oxacillin − Could be optimized for additional antibiotics	20 MRSA 20 MSSA	Sensitivity 100% Specificity 100%	[70]

Sanchini A. Diagnostics (Basel). 2022;12(1):208.



Method	Advantage	Disadvantage
MALDI-TOF MS	Rapid turnaround time	High cost of the MALDI-TOF MS
	Simple to perform	Need further optimisation for each species and antibiotic combination
	Low sample volume requirements Low per-sample costs	No MIC value

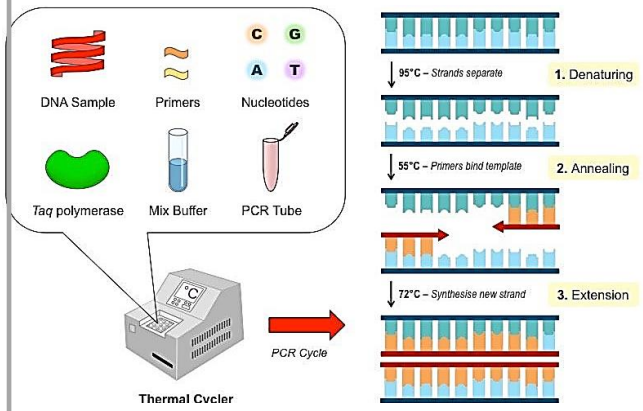


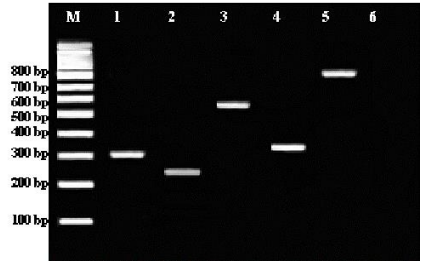
Gajic I et al. Antibiotics (Basel). 2022;11(4):427.

Μοριακές μέθοδοι: από την PCR στο mNGS

Gene(s) amplification + amplicons detection

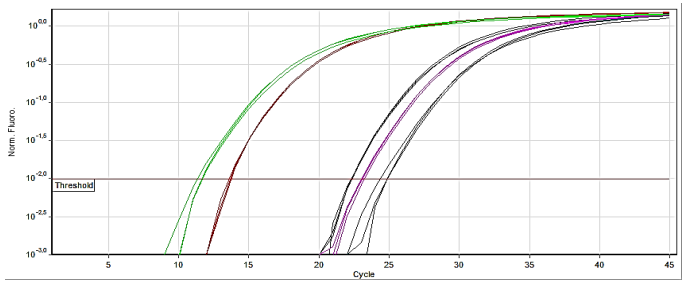
Single / Multiplex Endpoint PCR





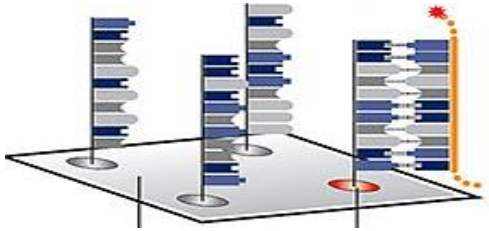
Διαδικασία εργώδης
Κίνδυνος επιμολύνσεων

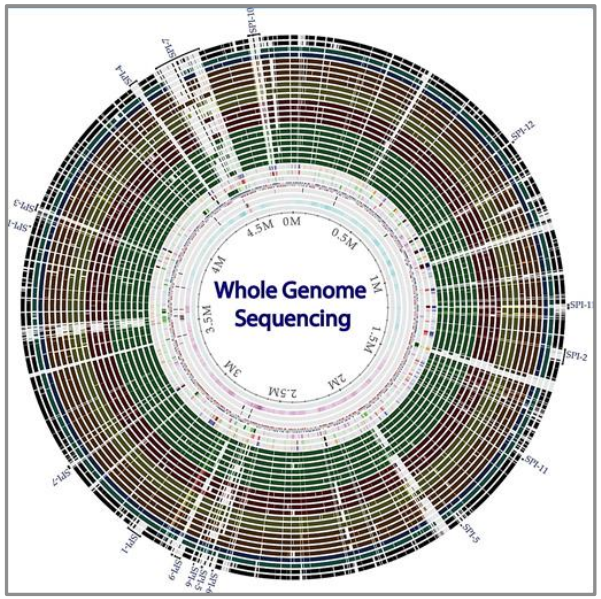
Single / Multiplex Real time PCR

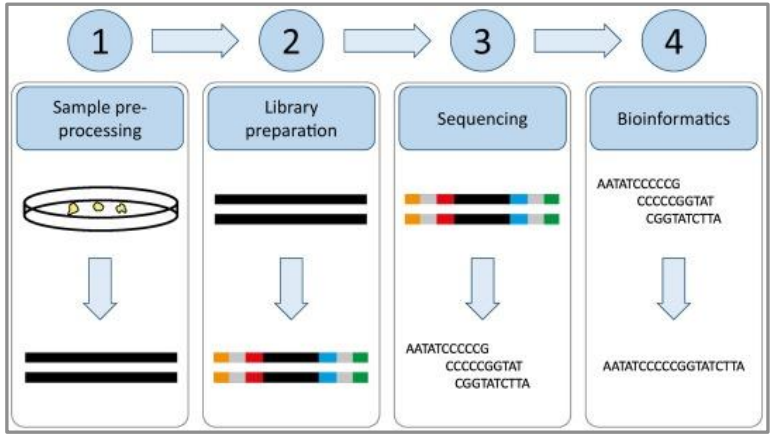


Multiplexing and miniaturization
of the hybridization step

PCR / hybridization σε microarray

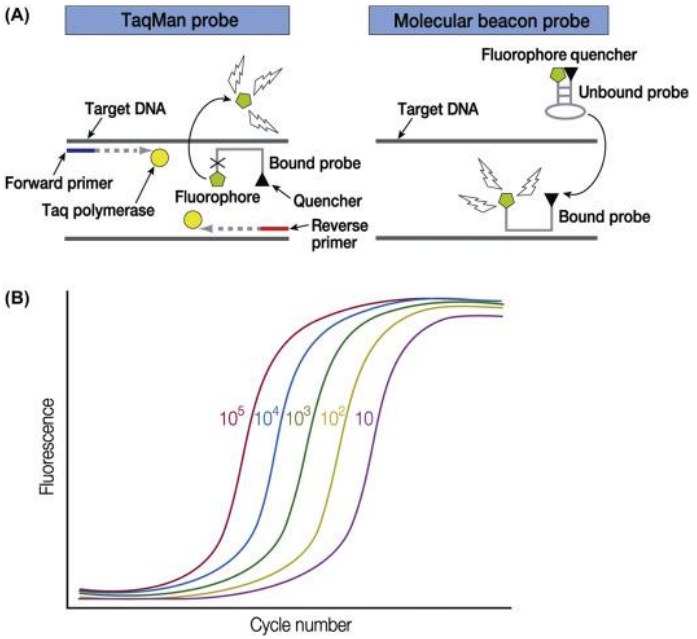




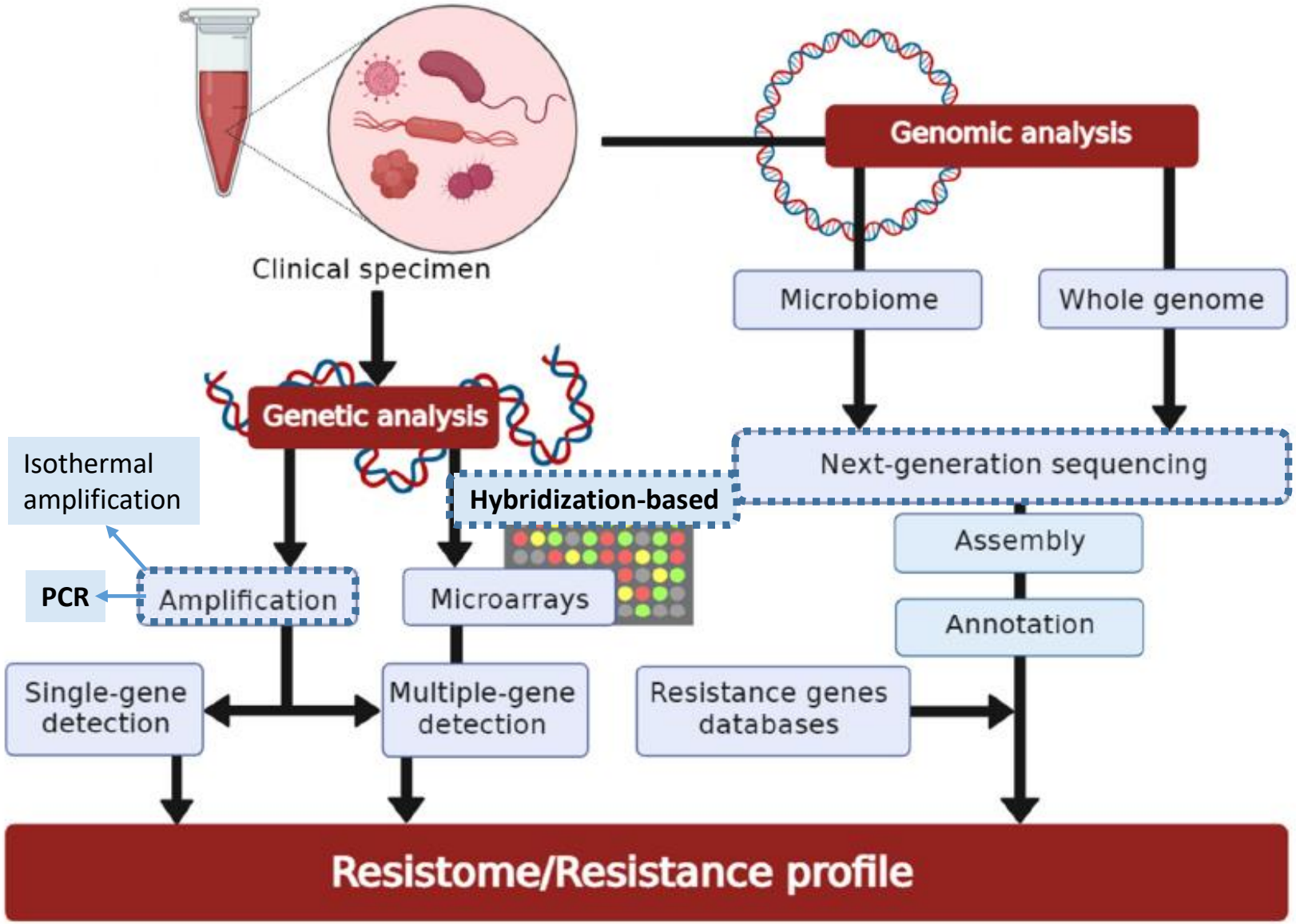


The basic workflow of molecular-based techniques for AMR detection

Real- time PCR (qPCR)



- measurement of data in real-time
- greater sensitivity
- reduced risk of contamination
- greater amenity to multiplexing
- many systems are partially or even completely automated



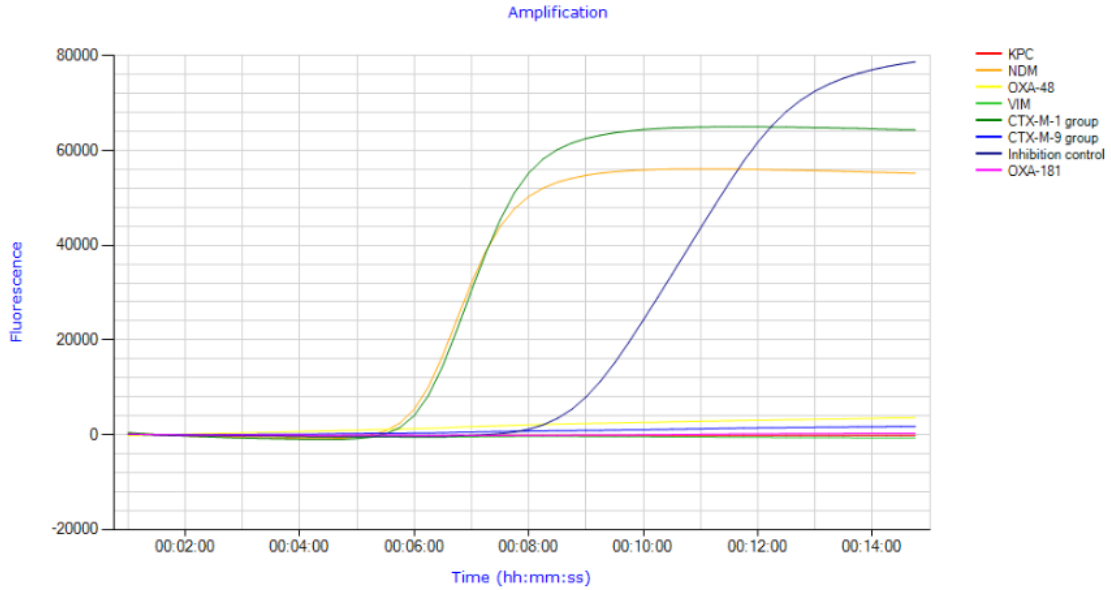
Gajic I et al. Antibiotics (Basel). 2022;11(4):427.

Ισοθερμικές μοριακές μέθοδοι και ανίχνευση αντοχής: παράδειγμα

Loop-mediated isothermal amplification technology and a real-time PCR platform

No DNA/RNA extraction necessary

eazyplex®, Amplex



TAT= 20-30 min

Sample: swab, culture

eazyplex® SuperBug CRE

KPC, NDM, OXA-48, OXA-181 and VIM

ESBL genes: CTX-M-1 and CTX-M-9 group

TAT= 15-20 min

Direct screening from rectal swab and urine

Confirmation from positive BC and agar plate

eazyplex SuperBug Acineto

OXA-51, OXA-23-,-40- and -58-like and NDM

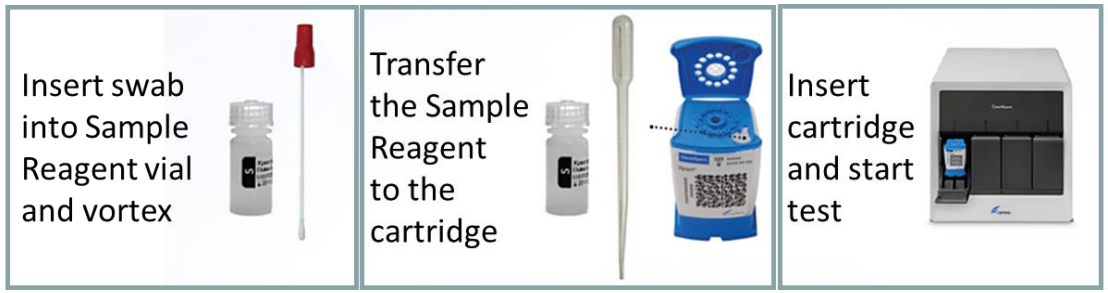
in 15 minutes

	SuperBug complete A	SuperBug complete B	SuperBug complete C
NDM	X	X	X
VIM	X	X	X
KPC	X	X	X
OXA-48	X	X	X
OXA-23	X	X	
OXA-40	X	X	
OXA-58	X		
OXA-181		X	X
IMP			X

Μοριακές μέθοδοι και ανίχνευση αντοχής: παραδείγματα

Xpert® Carba-R, Cepheid

TAT: 48-minutes



Targeted genes	Δείγμα
KPC, NDM, VIM, IMP, OXA-48 (covering OXA-181 & OXA-232)	Ορθικός στυλεός Αποικίες

[1]Overall percentage agreement with WGS: 92.8%

[2]Metanalysis of 17 studies involving 15,972 samples

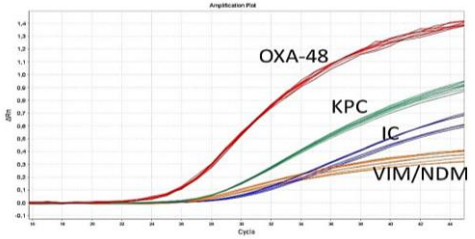
Pooled Se= 95%, Sp= 99%

In high-risk populations: Se= 99%, Sp= 98%

1. Khoo BY et al.J Clin Microbiol. 2023;61(9):e0031623.
2. Bai Y et al. J Mol Diagn. 2021;23(11):1534-1544.

Check-Direct CPE® assay, (Checks points)

TAT: 2 h
(+DNA extraction)



Targeted genes	Specimen	Technology/ instrumentation
KPC, VIM, NDM, OXA-48	Rectal swab Strains	Two-step ligation-mediated multiplex real-time PCR amplification – micro array hybridization / non-dedicated platform

867 samples from 627 patients (Reference method: culture + PCR)

CPO assay Se= 95.7%, SP= 96.5%, PPV= 60.8% and NPV= 99.8%

Xpert assay

Se= 97.9%, Sp= 99.8%, PPV= 95.8%, and NPV= 99.9%

The CPO assay: useful when handling many specimens, as tests are conducted in batches.

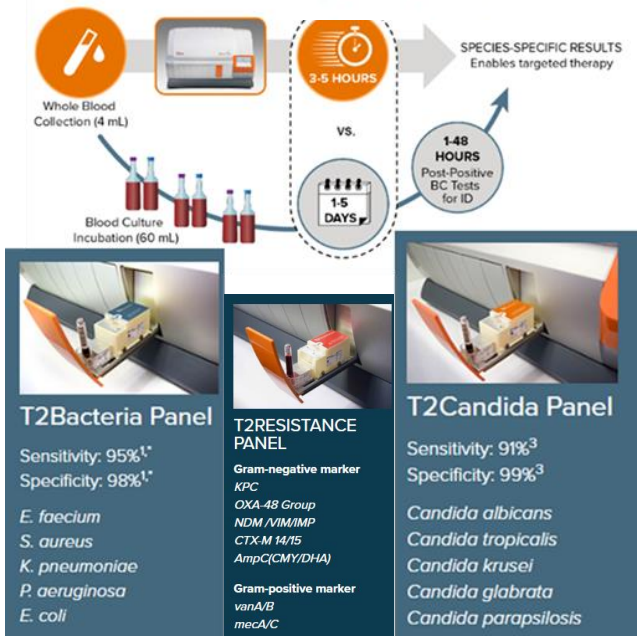
Positive cases showing high Ct values should be confirmed by another assay to rule out false positivity.

Yoo IY et al. Diagn Microbiol Infect Dis. 2022;103(3):115716.

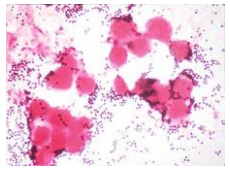
Συμβατική vs. ταχεία διάγνωση

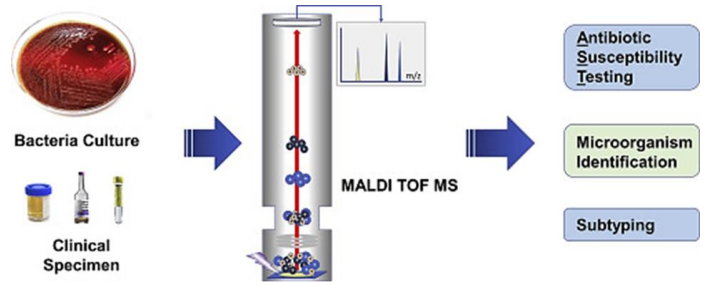
Εμπειρική αγωγή

Ολικό αίμα

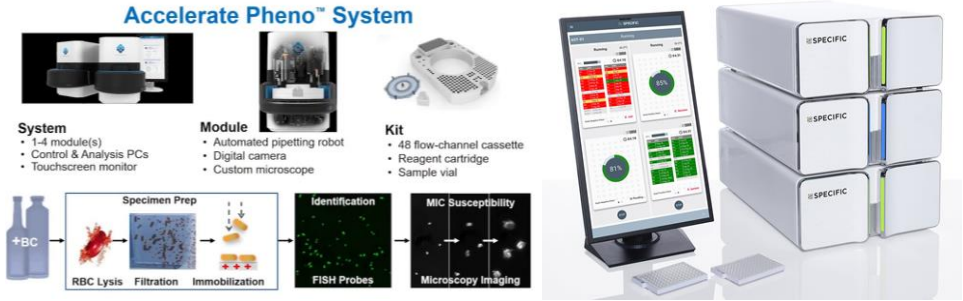


Χρώση Gram



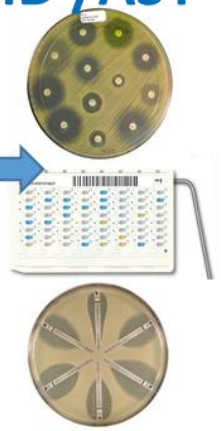


MALDI Sepsityper
VITEK MS blood culture kit



Ροή εργασίας συμβατικών μεθόδων (~48-168 h)

Short subculture ⟹ ID /AST



Ροή εργασίας μοριακών μεθόδων

Διάγνωση Στοχευμένη αγωγή

Direct MALDI-TOF MS identification from positive blood cultures

ADVANTAGES	LIMITATIONS
Very rapid identification Easy Low additional cost	Identification difficulties with some species Confirmation might be needed Mixed cultures

MALDI-TOF MS identification from positive blood cultures using short sub-culture on solid medium

ADVANTAGES	LIMITATIONS
Rapid identification Very easy Easy to integrate in lab workflow Confirmation usually not needed	Slow-growing organisms Mixed cultures

Molecular methods for identification from positive blood cultures

ADVANTAGES	LIMITATIONS
Rapid identification Easy	High cost Confirmation needed Limited pathogen panels

Reduced diagnostic accuracy for polymicrobial cultures

Sensitivity is influenced by:

- the concentration of pathogen-derived nucleic acids
- the presence of PCR inhibitors
- the sample volume

DNA-based identification from whole blood

Ολικό αίμα

ADVANTAGES	LIMITATIONS
Time advantage compared to culture Advantage in pathogen detection under antibiotics	Limited number of pathogens in panel assays Relatively low sensitivity (only 1-5 ml blood sampled) Resistance detection ≠ susceptibility testing Clinical relevance of DNAemia ? High workload Highly experienced staff required High cost Analytical cut-offs set by some manufacturers Does not substitute culture-based testing

Lamy B et al. Clin Microbiol Infect. 2020;26(2):142-150.

JAMA Network Open
American Medical Association

Prevalence of Antibiotic-Resistant Pathogens in Culture-Proven Sepsis and Outcomes Associated With Inadequate and Broad-Spectrum Empiric Antibiotic Use

N= 17 430 adults with culture-positive sepsis
admitted to 104 US hospitals
67% received empiric broad-spectrum antibiotics

Is there risk associated with the receipt of empiric broad-spectrum antibiotics?

Resistant GP isolated in 13.6% of patients
Resistant GN in 13.2%
Both undertreatment (failure to cover organisms)
and overtreatment (resistant organisms targeted but not isolated)
were associated with higher mortality after detailed risk adjustment.

Table 2.

Outcomes Associated With Inadequate and Unnecessarily Broad Empiric Antibiotic Therapy[a]

Outcome	Inadequate vs adequate empiric therapy						Unnecessarily broad vs not unnecessarily broad empiric therapy[b]					
	No./total No. (%)		Unadjusted OR (95% CI)	*P* value	Adjusted OR (95% CI)	*P* value	No./total No. (%)		Unadjusted OR (95% CI)	*P* value	Adjusted OR (95% CI)	*P* value
	Inadequate	Adequate empiric therapy					Unnecessarily broad	Not unnecessarily broad				
In-hospital death	488/2785 (17.5)	2011/12 388 (16.3)	1.10 (0.98-1.22)	.09	1.19 (1.03-1.37)	.02	1575/8405 (18.7)	436/3993 (10.9)	1.88 (1.68-2.11)	<.001	1.22 (1.06-1.40)	.007
Hospital-onset acute kidney injury	486/2785 (17.5)	2196/12 398 (17.7)	0.98 (0.88-1.09)	.74	1.02 (0.90-1.16)	.72	1641/8405 (19.5)	555/3993 (13.9)	1.50 (1.35-1.67)	<.001	1.12 (1.00-1.26)	.05
Clostridioides difficile	207/2785 (7.4)	498/12 398 (4.0)	1.92 (1.63-2.27)	<.001	1.19 (0.98-1.45)	.09	367/8405 (4.4)	131/3993 (3.3)	1.34 (1.10-1.65)	.004	1.26 (1.01-1.57)	.04

These findings underscore the need for better tests to rapidly identify patients with resistant pathogens

Rhee C et al. JAMA Netw Open. 2020;3(4):e202899.

FilmArray BCID2: 43 Targets, TAT 1 h

GRAM-NEGATIVE BACTERIA
Acinetobacter baumannii complex
Bacteroides fragilis
Enterobacterales
- *Enterobacter cloacae* complex
- *Escherichia coli*
- *Klebsiella aerogenes*
- *Klebsiella oxytoca*
- *Klebsiella pneumoniae* group
- *Proteus* spp.
- *Salmonella* spp.
- *Serratia marcescens*

Haemophilus influenzae
Neisseria meningitidis
Pseudomonas aeruginosa
Stenotrophomonas maltophilia

GRAM-POSITIVE BACTERIA
- *Enterococcus faecalis*
- *Enterococcus faecium*
- *Listeria monocytogenes*
- *Staphylococcus* spp.

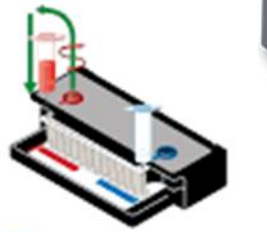
Staphylococcus aureus
Staphylococcus epidermidis
Staphylococcus lugdunensis
- *Streptococcus* spp.

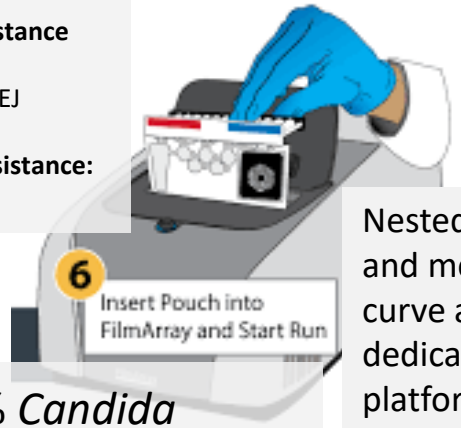
Streptococcus agalactiae
Streptococcus pneumonia
Streptococcus pyogenes

YEAST:
- *Candida albicans*
- *Candida auris*
- *Candida glabrata*
- *Candida krusei*
- *Candida parapsilosis*
- *Candida tropicalis*
- *Cryptococcus (C. neoformans/C. gattii)*

AMR GENES
Carbapenemases
- IMP
- KPC
- OXA-48-like
- NDM
- VIM

Colistin Resistance: *mcr-1*
ESBL: CTX-M
Methicillin Resistance
mecA/C
mecA/C and MREJ (MRSA)
Vancomycin Resistance:
vanA/B





Nested-PCR and melting curve analysis dedicated platform

Se: 98.1% GN, 97.3% GP, 99.2% *Candida*

Sp: 99.9% GN, 99.8% GP, 99.9% *Candida*

Se/Sp για AMR γονίδια: 98.4-100/98.3-100%

Salimnia H et al. J Clin Microbiol 2016.

ePlex® BCID Panels

***Se 97-99%**
Sp 96-99%

*Huang TD et al.
J Clin Microbiol. 2019;57(2).

Gram-positive Organisms

21 παθογόνα
6 γονίδια αντοχής
Gram-Negative Organisms

20 παθογόνα
4 γονίδια αντοχής

15 παθογόνα
Fungal Organisms

VERIGENE® Bloodstream Infection Testing Panels

Gram-Positive Blood Culture Test (BC-GP)

Species
Staphylococcus aureus
Staphylococcus epidermidis
Staphylococcus lugdunensis
Streptococcus agalactiae
Streptococcus pneumoniae
Streptococcus pyogenes
Enterococcus faecalis
Enterococcus faecium

Group
Streptococcus anginosus

Genus
Staphylococcus spp.
Streptococcus spp.
Micrococcus spp.+
Listeria spp.

Resistance
mecA (methicillin)
vanA (vancomycin)
vanB (vancomycin)

Gram-Negative Blood Culture Test (BC-GN)

Species
*Escherichia coli**
Klebsiella pneumoniae
Klebsiella oxytoca
Pseudomonas aeruginosa
Serratia marcescens++

Genus
Acinetobacter spp.
Citrobacter spp.
Enterobacter spp.
Proteus spp.

Resistance
CTX-M (ESBL)
IMP (carbapenemase)
KPC (carbapenemase)
NDM (carbapenemase)
OXA (carbapenemase)
VIM (carbapenemase)

Micro-array hybridization dedicated platform

TAT 2-2.5 h

Συνδρομική διάγνωση και ανίχνευση γονιδίων αντοχής: Blood Culture Panels (positive BC bottle)

Parameter	FilmArray BCID	Verigene Gram-positive blood culture	Verigene Gram-negative blood culture
Total no. of targets	27	15	14
Ability to detect presence of resistance gene			
mecA	✓	✓	
vanA	✓	✓	
vanB	✓	✓	
bla_{KPC}	✓		✓
bla_{NDM}	✓		✓
bla_{OXA}	✓		✓
bla_{VIM}	✓		✓
bla_{IMP}	✓		✓
bla_{CTX-M}	✓		✓
mcr-1	✓		
Time to result (h)	~1	~2.5	~2

Se 93.9%

Se: 90.9

NPA >99.9%

Sp> 98 %

Se: 94.9%

PPA 100%

PPA 96.2%

PPA 94.3%

PPA 100%

PPA 100%

PPA 98.9%

ePlex BCID, GenMark

Resistance Genes

CTX-M
KPC
NDM
VIM
IMP
OXA

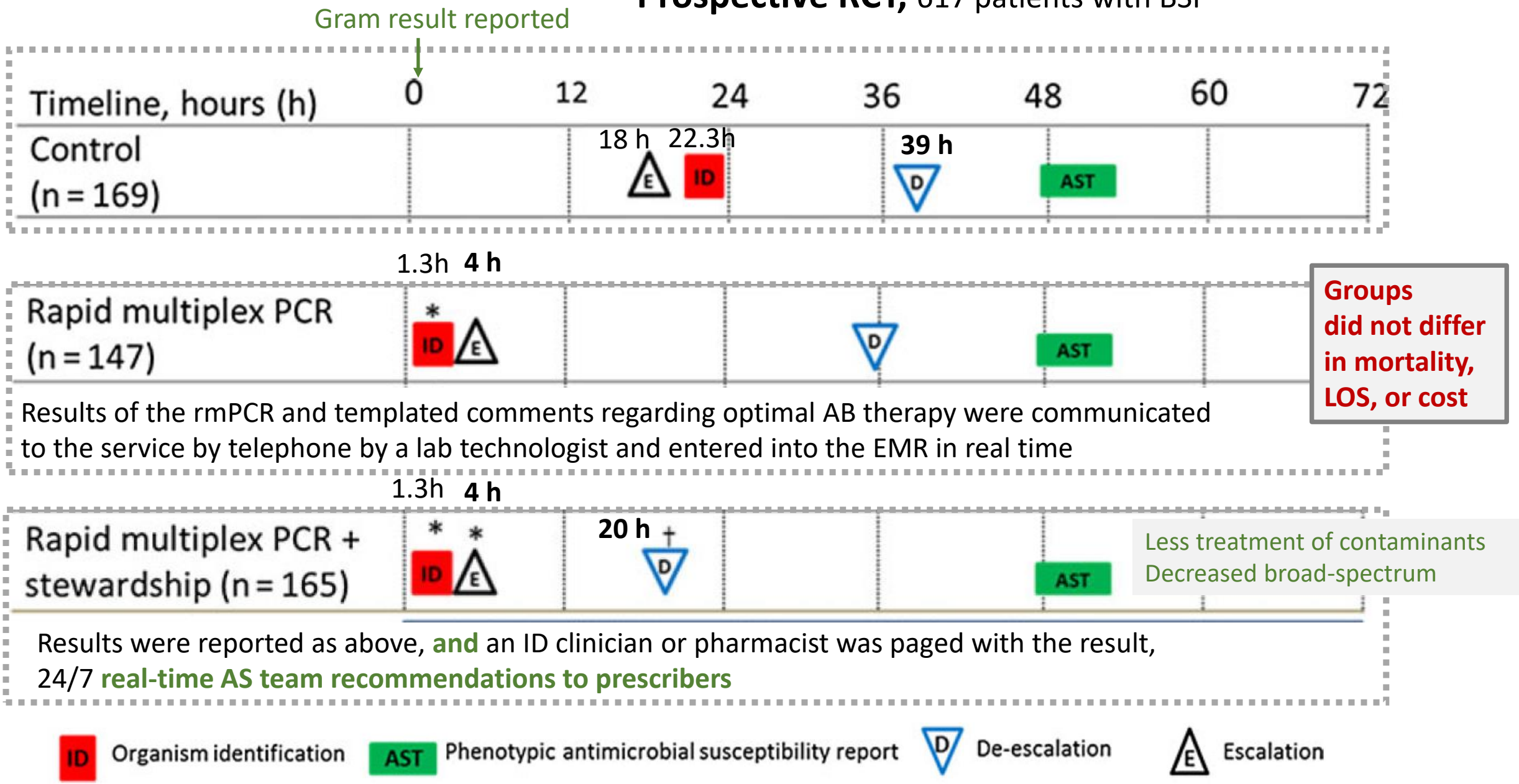
Resistance Genes

mecA
mecC
vanA
vanB

Multiplexed NAAT and a electrochemical detection technology with a dedicated platform

Peri AM et al. BMC Infect Dis. 2022;22(1):794.
Ramanan P et al. Clin Microbiol Rev. 2017;31(1) (με επικαιροποίηση).
Salimnia H et al. J Clin Microbiol. 2016;54(3):687-98.
Ledeboer NA et al. J Clin Microbiol. 2015;53(8):2460-72.

Prospective RCT, 617 patients with BSI



Results of the rmPCR and templated comments regarding optimal AB therapy were communicated to the service by telephone by a lab technologist and entered into the EMR in real time

Groups did not differ in mortality, LOS, or cost

Less treatment of contaminants
Decreased broad-spectrum

Results were reported as above, **and** an ID clinician or pharmacist was paged with the result, 24/7 **real-time AS team recommendations to prescribers**

ID Organism identification
AST Phenotypic antimicrobial susceptibility report
D De-escalation
E Escalation

Banerjee R et al. Clin Infect Dis. 2015;61(7):1071-80.

Clinical Infectious Diseases

MAJOR ARTICLE

2022;75(12):2066-2075.

Impact of a Rapid Molecular Test for *Klebsiella pneumoniae* Carbapenemase and Ceftazidime-Avibactam Use on Outcomes After Bacteremia Caused by Carbapenem-Resistant Enterobacterales

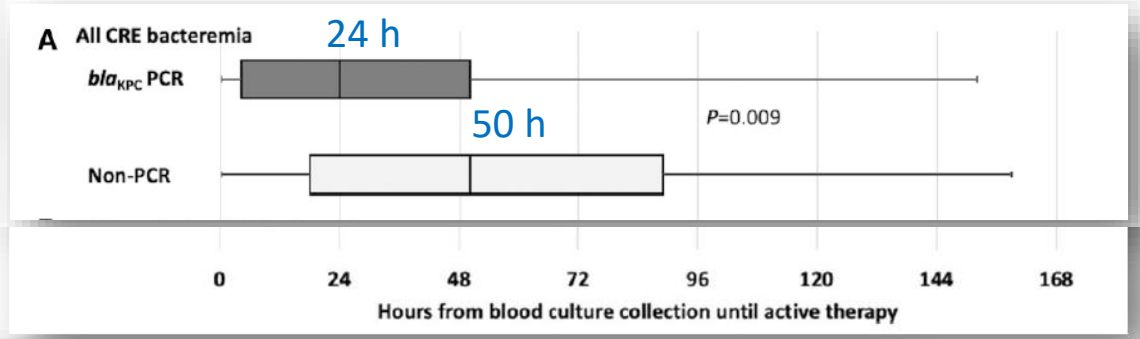
Michael J. Satlin,[1,2] Liang Chen,[3,4] Angela Gomez-Simmonds,[5] Jamie Marino,[2] Gregory Weston,[6] Tanaya Bhowmick,[7] Susan K. Seo,[8] Steven J. Sperber,[9,10] Angela C. Kim,[11] Brandon Eilertson,[12] Sierra Derti,[1] Stephen G. Jenkins,[1,2] Michael H. Levi,[13] Melvin P. Weinstein,[7,14] Yi-Wei Tang,[15] Tao Hong,[16] Stefan Juretschko,[17] Katherine L. Hoffman,[18] Thomas J. Walsh,[1] Lars F. Westblade,[1,2] Anne-Catrin Uhlemann,[5] and Barry N. Kreiswirth[3,4]

N= 137 patients with CRE bacteremia

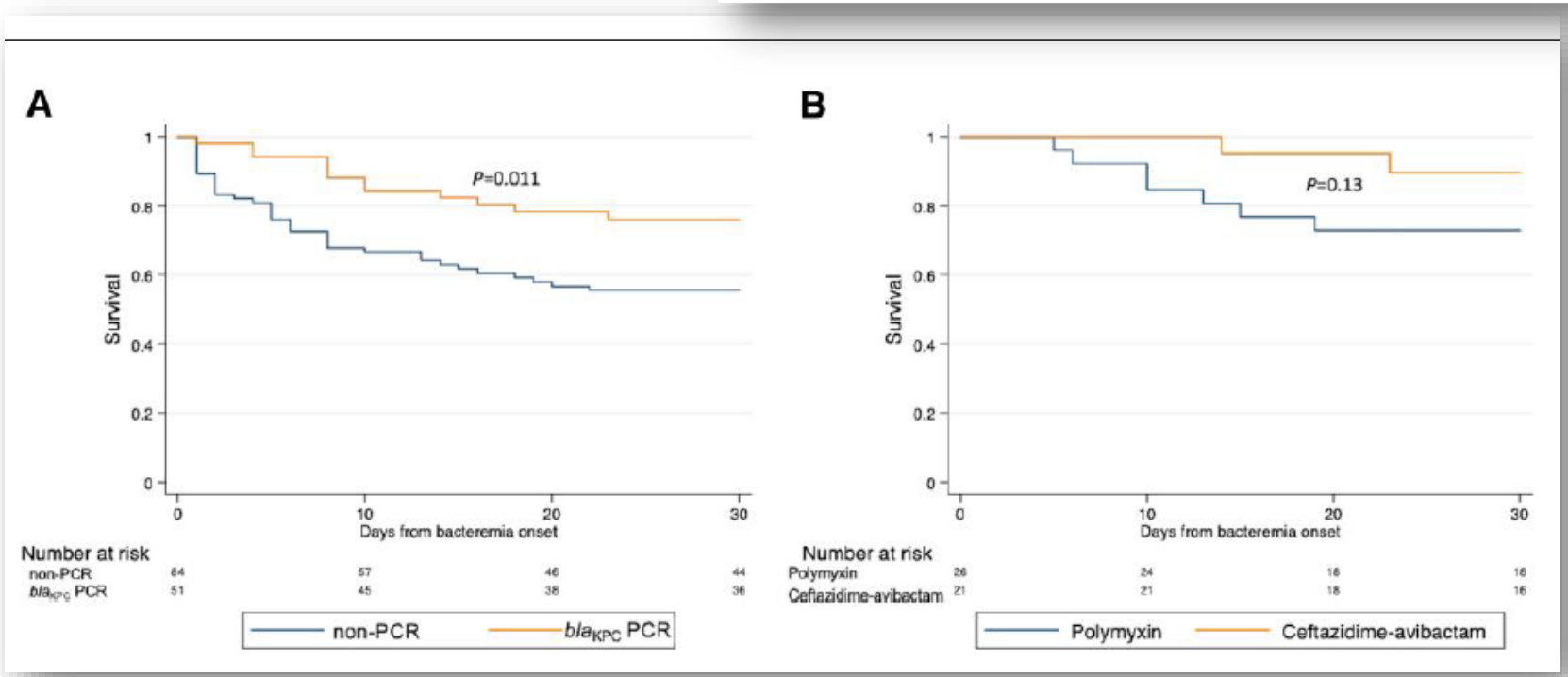
[77% CP-CRE (65% KPC)]

2016-2018, 8 New York and New Jersey medical centers

3/8 study hospitals used the FilmArray BCID



30-day mortality 24% vs 47%; P=.007



30-day mortality 10% with caz-avi monotherapy vs. 31% with polymyxin monotherapy (P=.08)

antibiotics

MDPI

Article

Impact of an Antimicrobial Stewardship Program Intervention Associated with the Rapid Identification of Microorganisms by MALDI-TOF and Detection of Resistance Genes in ICU Patients with Gram-Negative Bacteremia

216 episodes of GN bacteremia, ICU

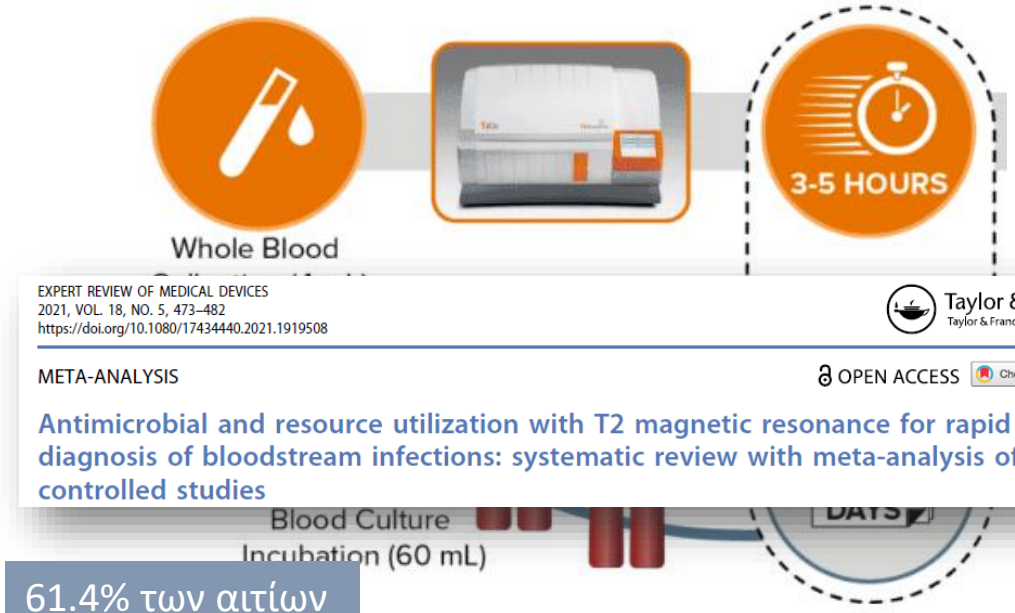
MALDI-TOF και ανίχνευση των γονιδίων AMR απευθείας από τη φιάλη της θετικής αιμοκ/ας

Table 4. Antimicrobial consumption in DOT per 1000 days present and collection (21 days).

Antimicrobial Consumption and Cost	Pre-Intervention	Intervention	*p*-Value
Consumption (DOT/1000 days present, median, IQR)			
All antimicrobials	N = 114 1.381 (1.103–2.251)	N = 102 1.262 (1.063–1.662)	0.032 [a]
Antimicrobial for gram-negative bacteria	N = 114 1.281 (1.004–1.775)	N = 102 1.172 (1.006–1.427)	0.067 [a]
Antimicrobial for gram-positive bacteria	N = 52 475 (238–761)	N = 43 270 (139–467)	0.004 [a]
Carbapenems	N = 76 836 (504–1056)	N = 72 543 (301–991)	0.040 [a]
Colistin/Polymyxin B	N = 45 722 (390–932)	N = 40 881 (462–1001)	0.299 [a]
Ceftazidime/avibactam	N = 3 931 (725–1022)	N = 8 911 (823–940)	0.865 [a]

Καμιά επίδραση στη θνητότητα 30-ημερών
Σημαντικά μικρότερη
η συνολική διάρκεια νοσηλείας (44 vs. 39 ημέρες, p = 0.005)
και ο χρόνος νοσηλείας στη ΜΕΘ (17 vs. 13 ημέρες, p = 0.033)

Campos AF et al. Antibiotics (Basel). 2022;11(9):1226.



EXPERT REVIEW OF MEDICAL DEVICES
2021, VOL. 18, NO. 5, 473–482
https://doi.org/10.1080/17434440.2021.1919508
Taylor & Francis
Taylor & Francis Group

META-ANALYSIS

OPEN ACCESS Check for updates

Antimicrobial and resource utilization with T2 magnetic resonance for rapid diagnosis of bloodstream infections: systematic review with meta-analysis of controlled studies

61.4% των αιτίων μικροβιαιμίας

T2BACTERIA PANEL

Sensitivity: 90%[7]

Specificity: 98%[7]

E. faecium
S. aureus
K. pneumoniae
P. aeruginosa
E. coli

T2RESISTANCE PANEL

Gram-negative marker
KPC
OXA-48 Group
NDM /VIM/IMP
CTX-M 14/15
AmpC(CMY/DHA)

Gram-positive marker
vanA/B
mecA/C

T2CANDIDA PANEL

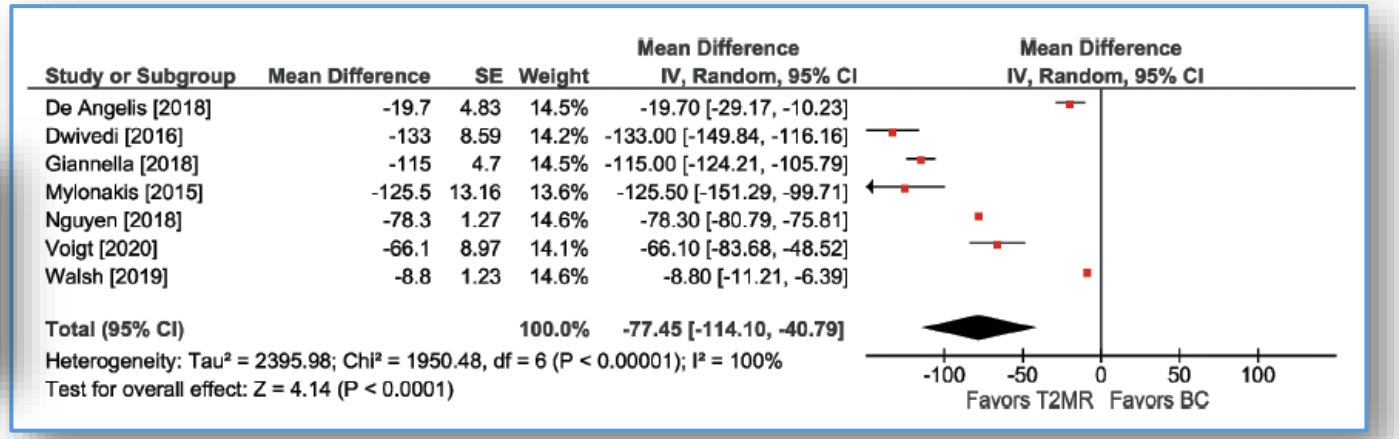
Sensitivity: 91%[5]

Specificity: 99%[5]

Candida albicans
Candida tropicalis
Candida krusei
Candida glabrata
Candida parapsilosis

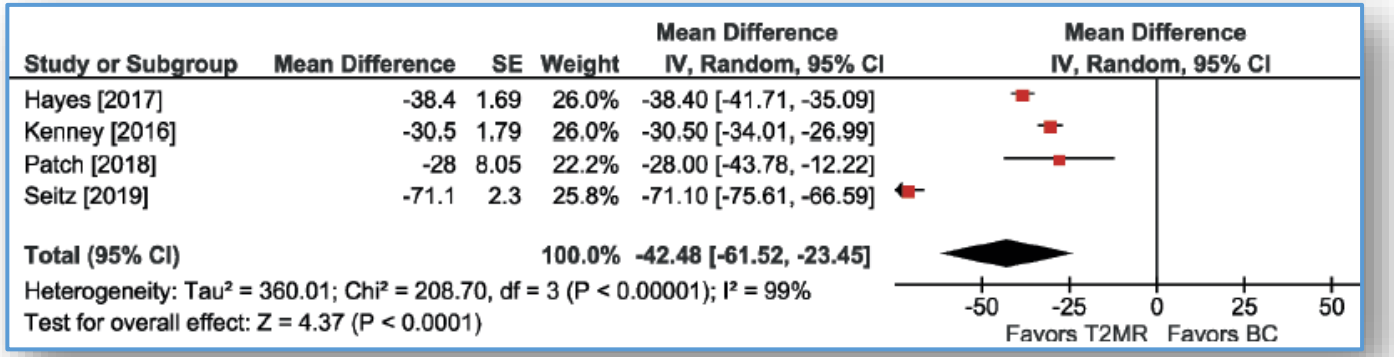
1-3 CFU/mL LoD

Hours to species identification with T2MR vs. BC



Pooled mean difference = –77 hours (p <0.001)

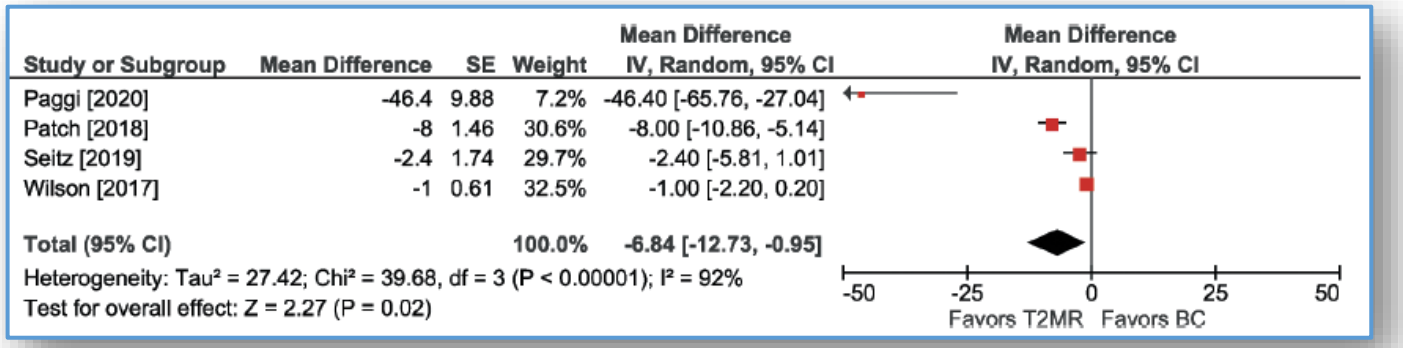
Hours to targeted therapy among T2MR positive cases vs. BC



Pooled mean difference = –42 hours (p <0.001)

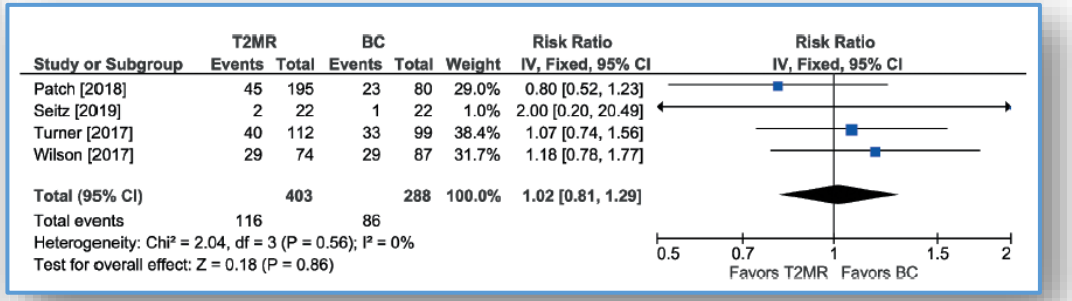
Giannella M et al. Expert Rev Med Devices. 2021;18(5):473-482.

Hours to empirical therapy de-escalation among T2MR negative cases vs. BC



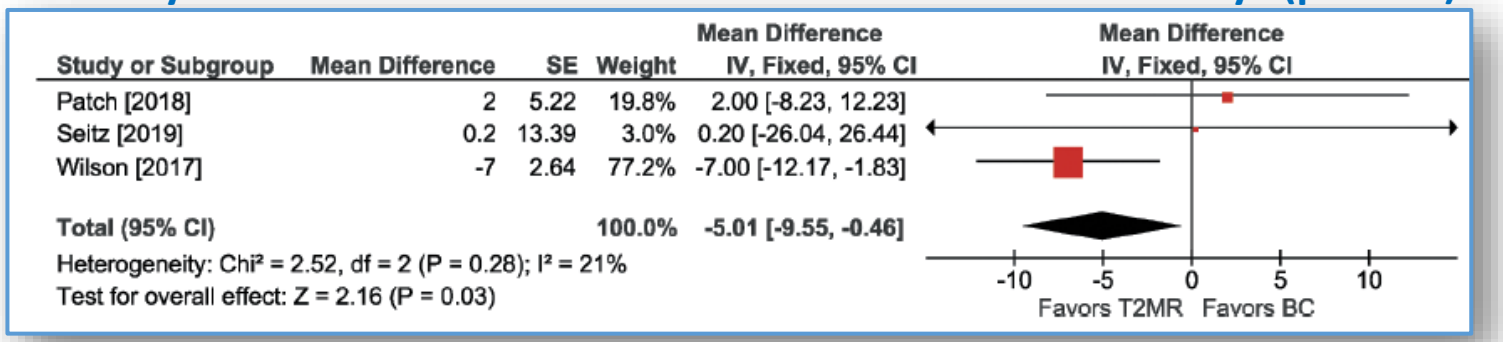
Pooled mean difference = −7 hours (p = 0.02).

Mortality with T2MR vs. BC

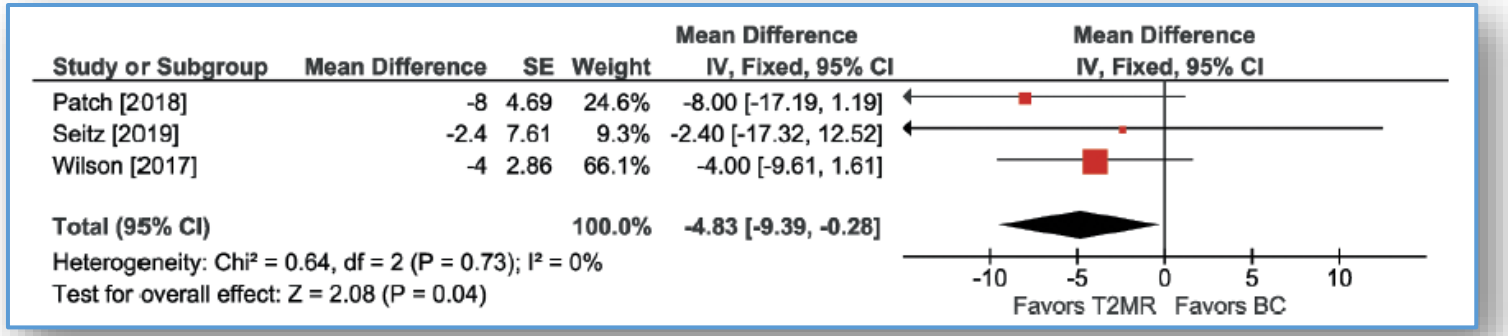


28.9% vs. 29.9%, RR = 1.02, p = 0.86

ICU stay with T2MR vs. BC. Pooled mean difference = −5.0 days (p =0.03)



Hospital stay with T2MR vs. BC. Pooled mean difference = −4.8 days (p =0.04)



Considering hospital costs for sepsis patients range from 2,000 USD to 5,000 USD per day depending on sepsis severity, implementation of T2MR could theoretically reduce hospital costs by 10,000 USD to 25,000 USD per patient tested

Giannella M et al. Expert Rev Med Devices. 2021;18(5):473-482.

Μοριακή ανίχνευση αντοχής: προβληματισμοί

Detection of particular resistance mechanisms vs. phenotypic AST

Universal phenotypic AST

Growth-based assays

- → Universally applicable
- → Mechanism-independent
- → Exact phenotypic categorisation
- → Therapeutic relevance

- → Time for microbial growth
- → Expression-dependent

Παρουσία ή απουσία γενετικού μηχανισμού αντοχής

Μοριακή ανίχνευση αντοχής

Detection of selected resistance mechanisms

- → Very rapid
- → Confirmation of resistance mechanism

- → Negativity does not necessarily mean susceptibility
- → Positivity does not necessarily confer phenotypic resistance
- → Limited to some antibiotics

Idelevich EA, Becker K. Clin Microbiol Infect. 2019;25(11):1347-1355. Με τροποποίηση

- Πόσα και ποια γονίδια περιλαμβάνονται στα panel
- Επιλογή γονιδίων σε σχέση με την τοπική επιδημιολογία τη δεδομένη χρονική στιγμή
- Μη αναγνώριση κάποιων variants ή αναγνώριση variants με διαφορετικό υδρολυτικό προφίλ
- Μη ανίχνευση νέων αναδυόμενων γονιδίων αντοχής
- **Σύνθετοι μηχανισμοί αντοχής**
- **Πολυμικροβιακά δείγματα και γονίδια αντοχής**

Είναι ασφαλής η αποκλιμάκωση;

AMERICAN SOCIETY FOR MICROBIOLOGY | Antimicrobial Agents and Chemotherapy®

CLINICAL THERAPEUTICS

An Antibiotic Stewardship Program Blueprint for Optimizing Verigene BC-GN within an Institution: a Tale of Two Cities

Δεν υπάρχει σαφής κατεύθυνση για τις περιπτώσεις που δεν ανιχνεύονται καθοριστές αντοχής

1046 GN bloodstream isolates

TABLE 2 Verigene BC-GN analytic results by bug-drug combination[a]

Institution and target organism	*n*	No. (%) of	No. of isolates	P (%)	PPV (%)	NPV (%)
Detroit Medical Center						
E. coli	3			9	97	98
K. pneumoniae	1			9	97	94
	1			00	100	99
K. oxytoca	2			00	100	95
Proteus spp.	5			00	100	94
Enterobacter spp.	6			00	100	97
Citrobacter spp.	1					100
Acinetobacter spp.	3			3	80	93
Pseudomonas spp.	5					88

AMERICAN SOCIETY FOR MICROBIOLOGY | Journal of Clinical Microbiology®

LETTER TO THE EDITOR

2020;58(4):e02098-19.

The Clinical Impact of a Negative Molecular β-Lactamase Gene Test for *Enterobacteriaceae*: Let's Not Let Perfect Be the Enemy of Really Good

Jason M. Pogue,[a] Emily L. Heil[b]

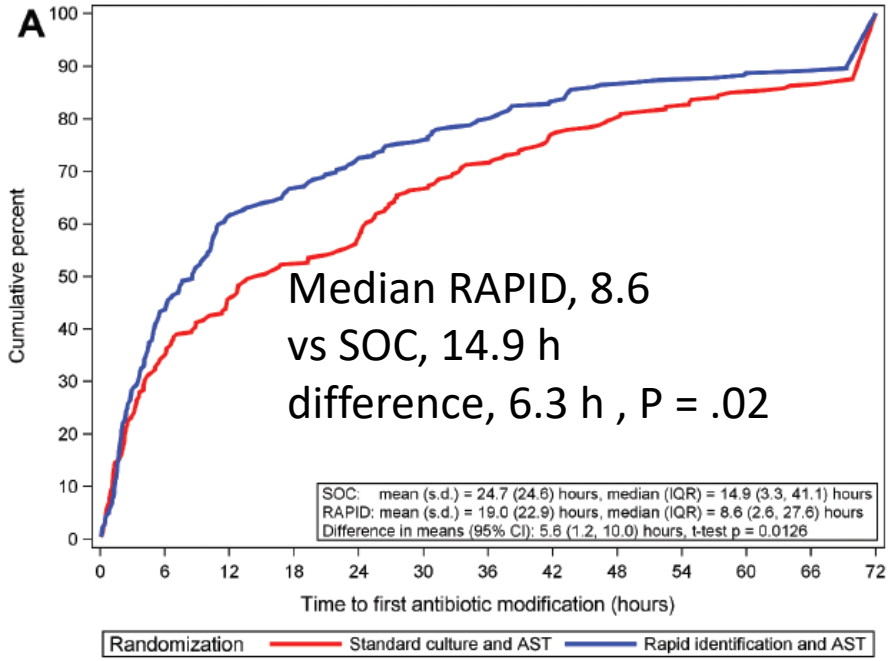
Με εξαίρεση την *P. aeruginosa*, η απουσία καθοριστών αντοχής **μπορούσε να προβλέψει την ευαισθησία στα αντιβιοτικά στόχους**

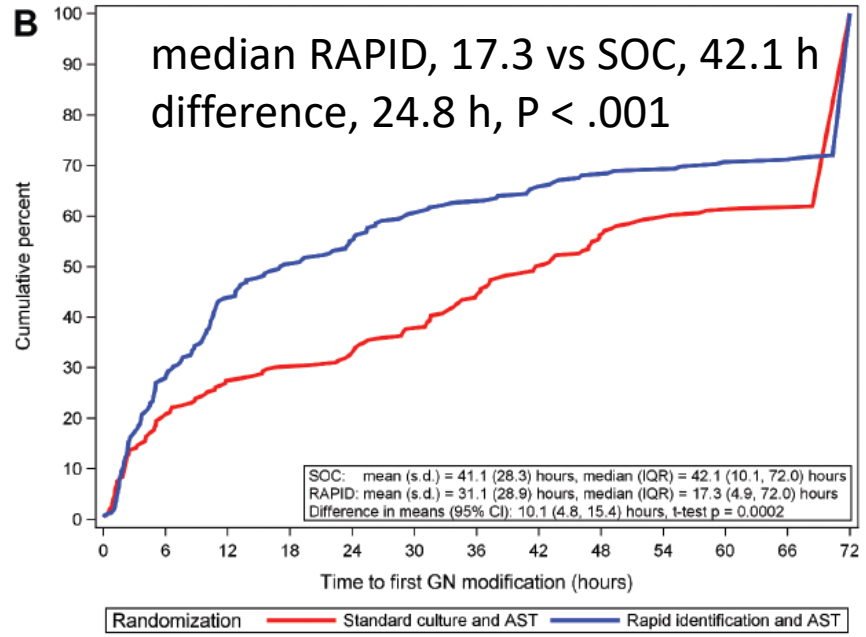
Pogue JM et al. Antimicrob Agents Chemother. 2018;62(5):e02538-17.

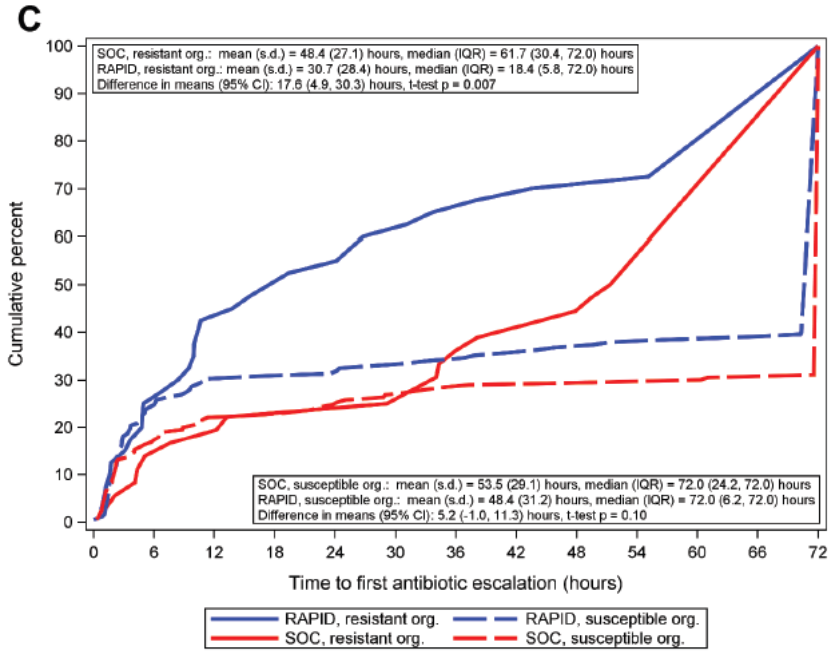
ID and phenotypic AST using the Accelerate Pheno System (RAPID)

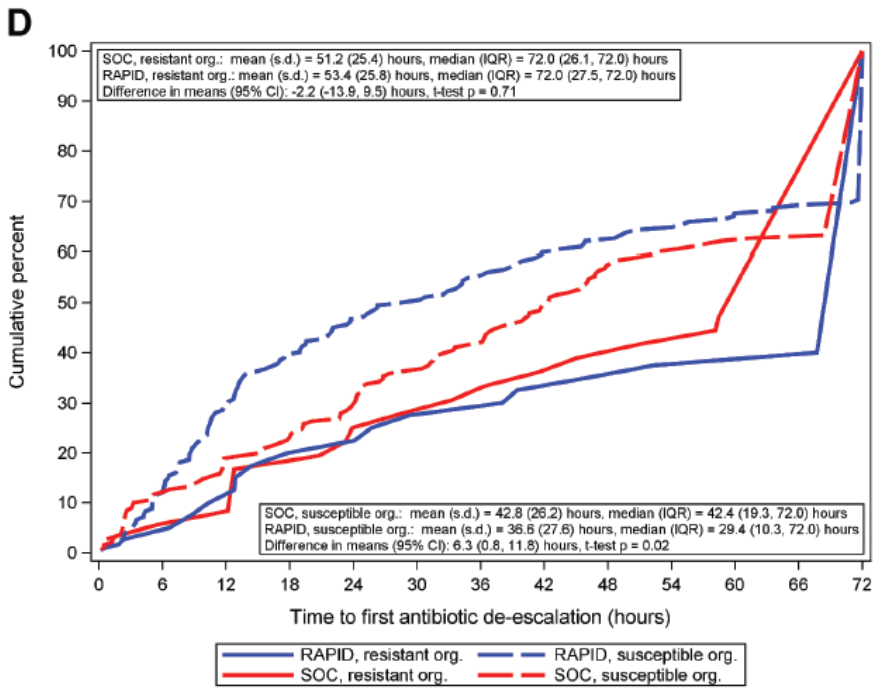
RCT
Patients (N= 448)
with positive BC with GNB
RANDOMIZED
SOC testing with AS review
or RAPID with AS

Patients with MDRO, escalation
Median RAPID, 18.4 vs SOC, 61.7 h
(difference, 43.3 h; P = .01)
Patients with S organisms, de-escalation
median RAPID, 29.4 vs SOC, 42.4 h
(difference, 13 h, P = .02)



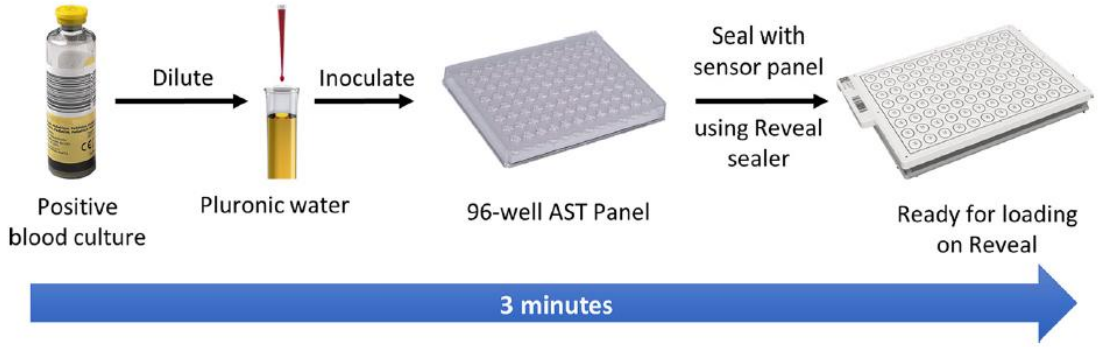






Banerjee R et al. Clin Infect Dis. 2021;73(1):e39-e46.

Rapid AST

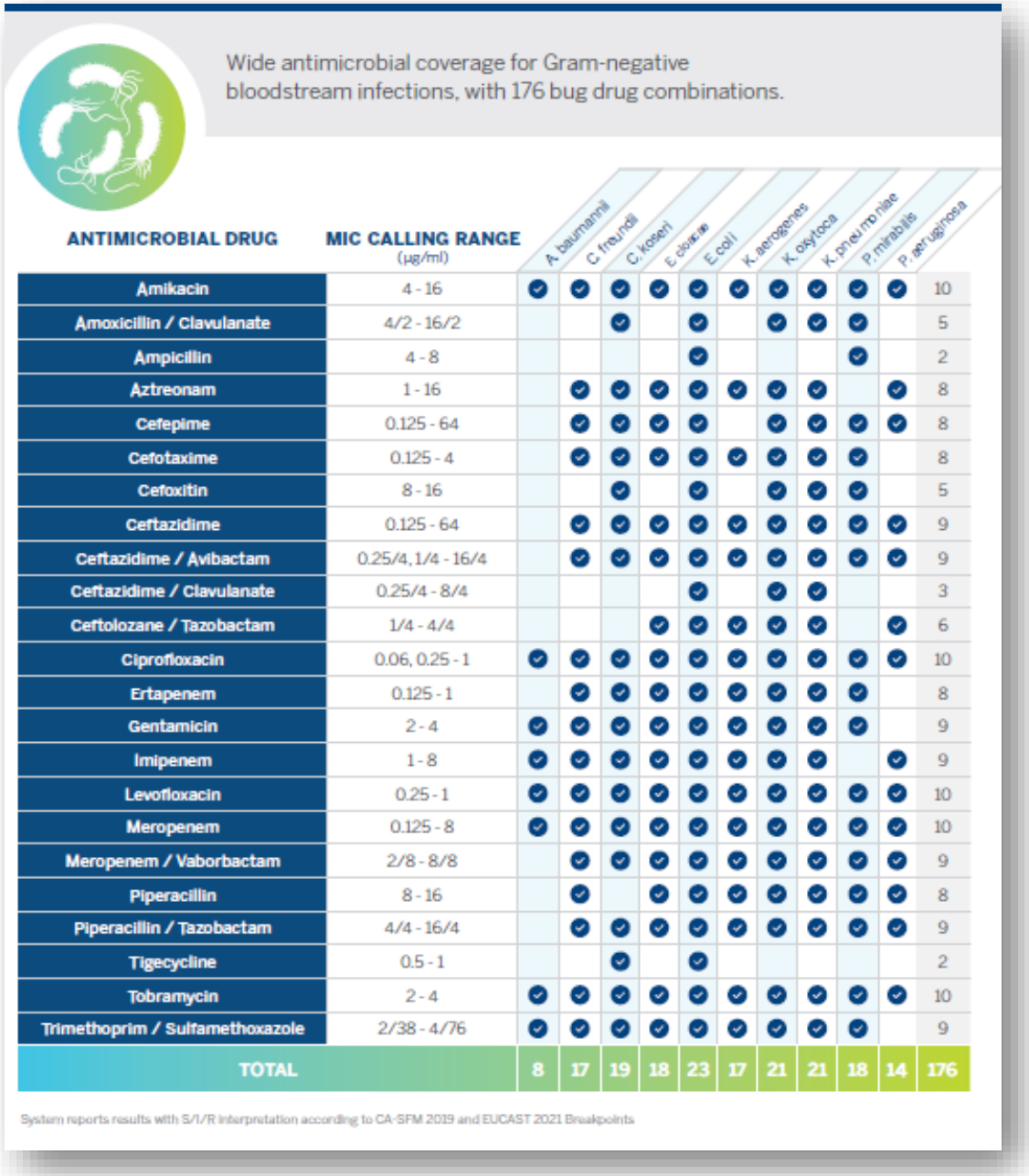


RAPID AST SYSTEM

5.5 hours

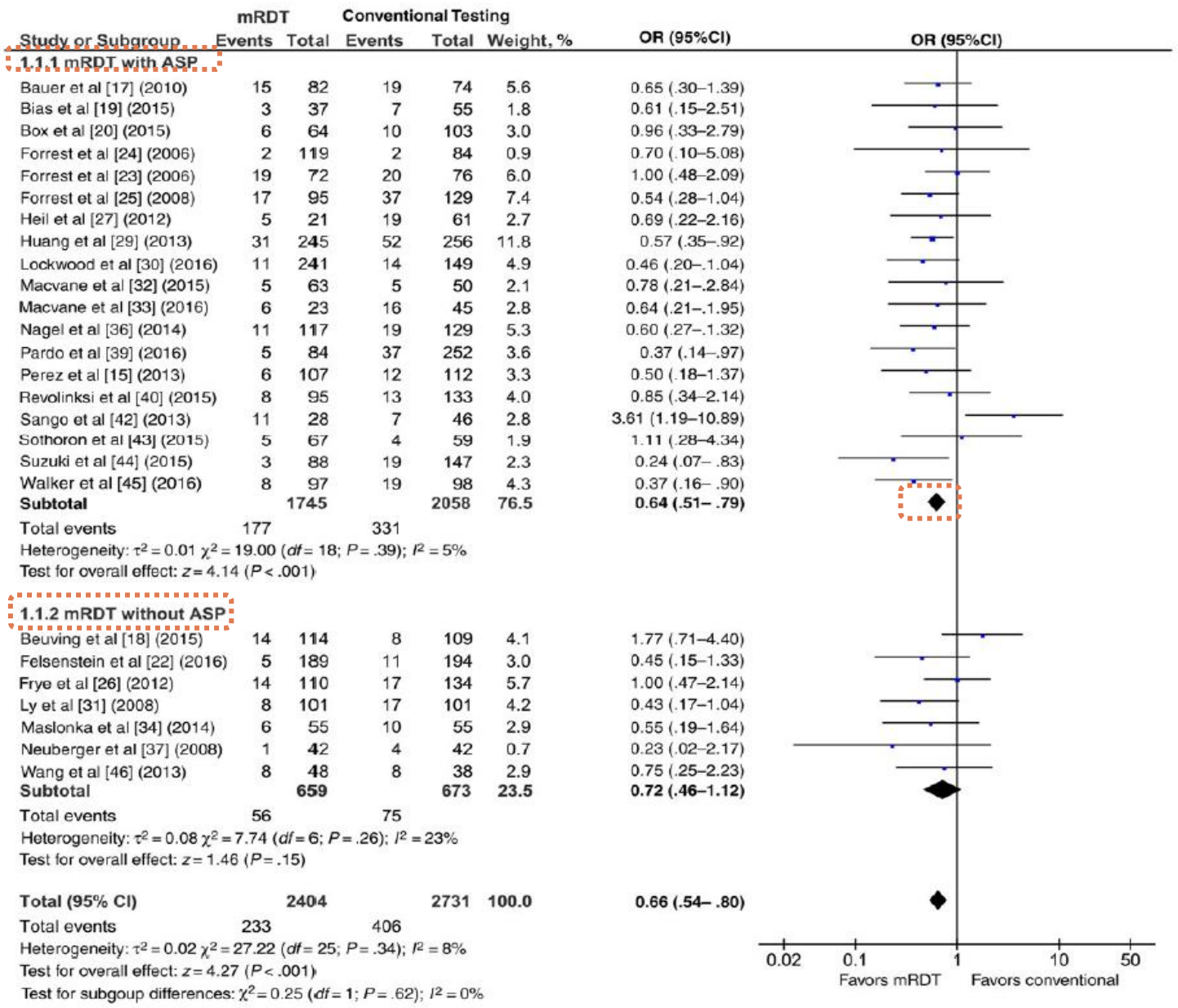
TABLE 1 Overall performance of the Reveal AST system

Parameter or detail	Performance of Reveal AST against: Sensititre	Vitek 2
Parameter, % (no. positive/total no.)		
EA[c]	98.0 (2,129/2,173)	97.0 (1,482/1,528)
CA[c]	96.3 (2,174/2,258)	96.2 (1,554/1,615)
mE	3.5 (78/2,258)	3.3 (54/1,615)
ME	0.3 (5/1,889)	0.3 (4/1,342)
VME	1.3 (4/313)	1.3 (3/232)



Tibbetts R et al. J Clin Microbiol. 2022;60(6):e0009822.

Mortality outcomes with molecular rapid diagnostic testing (mRDT) versus conventional testing in bloodstream infection



mRDT και ASP

31 μελέτες, 5920 BSI pts

Mortality risk decreased significantly with mRDT in the presence of ASP

Number needed to treat: 20 patients with BSI to prevent 1 death within 30 days

Time to effective therapy decreased by a weighted mean difference of −5.03 hours

Length of stay decreased by −2.48 days

Timbrook TT et al. Clin Infect Dis. 2017;64(1):15-23

AMERICAN SOCIETY FOR MICROBIOLOGY | Clinical Microbiology Reviews®

2018;31(3):e00095-17.

REVIEW

The Cost-Effectiveness of Rapid Diagnostic Testing for the Diagnosis of Bloodstream Infections with or without Antimicrobial Stewardship

Elina Eleftheria Pliakos,[a] Nikolaos Andreatos,[a] Fadi Shehadeh,[a] Panayiotis D. Ziakas,[a] Eleftherios Mylonakis[a]

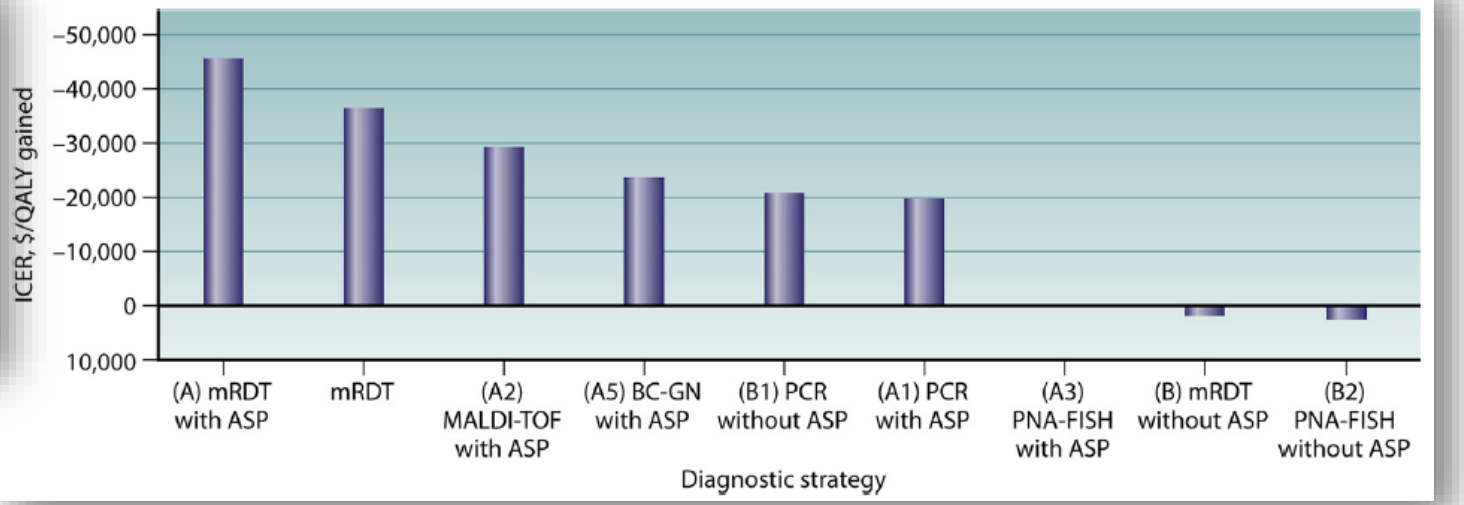
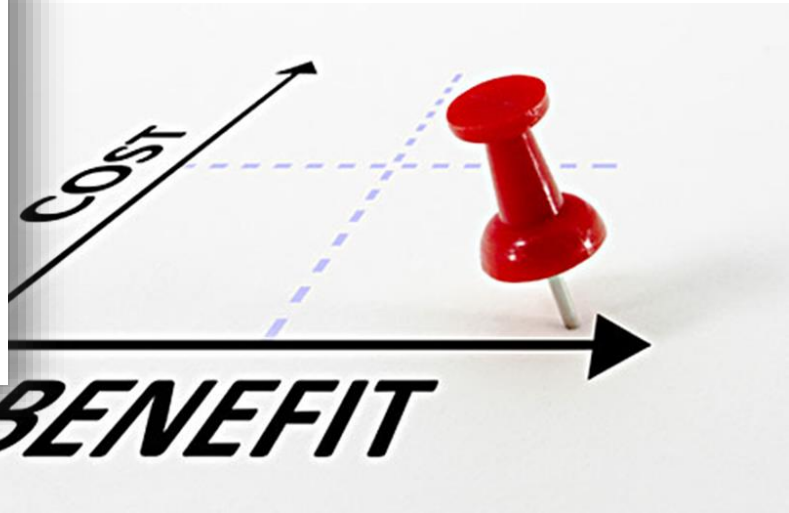


TABLE 3 Base-case analysis results for competing strategies

Strategy	Base-case estimate				
		Effect		ICER	
	Cost ($)	Probability of survival	QALY value	$/death averted	$/QALY gained
mRDT (with and without ASP)	36,301.50	0.89	11.9883	−490,763	−36,434
mRDT with ASP (A)	31,274.24	0.89	11.9883	−616,445	−45,764
mRDT without ASP (B)	57,220.14	0.90	12.1230	25,762	1,913
PCR with ASP (A1)	47,917.58	0.88	11.8536	−267,148	−19,833
MALDI-TOF analysis with ASP (A2)	28,394.21	0.92	12.3924	−393,397	−29,205
PNA-FISH with ASP (A3)	53,226.09	0.85	11.4495	0	0
BC-GP with ASP (A4)	24,904.91	0.84	11.3148	Dominated	Dominated
BC-GN with ASP (A5)	33,691.47	0.92	12.3924	−317,722	−23,587
PCR without ASP (B1)	47,430.21	0.88	11.8536	−283,394	−21,039
PNA-FISH without ASP (B2)	58,284.16	0.92	12.3924	33,602	2,495
Conventional laboratory methods with ASP (C)	41,723.98	0.84	11.3148	Dominated	Dominated
Conventional laboratory methods without ASP (D)	55,932.02	0.85	11.4495	Baseline	Baseline



Ταχεία μοριακή διάγνωση και diagnostic stewardship

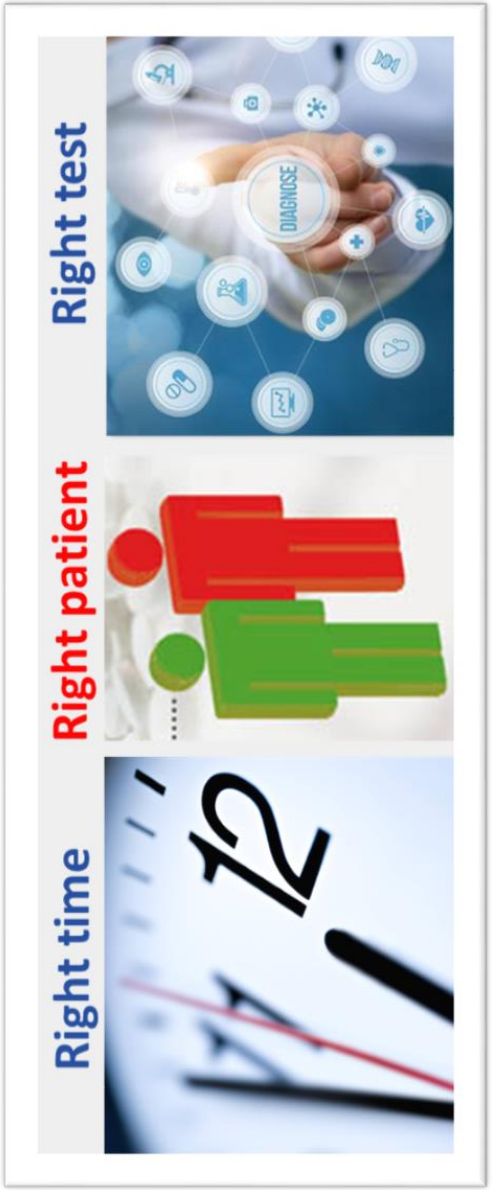


TABLE 1 Key diagnostic stewardship considerations for implementation of rapid infectious disease diagnostics

Goal	Key question	Key considerations and potential strategies
Right test	Is the test appropriate for the clinical setting?	Sensitivity and specificity Predictive values Testing volumes Diagnostic yield Laboratory feasibility Cost Clinical impact
Right patient	Will the clinical care of the patient be affected by the test result?	Laboratory test utilization committee Automatic laboratory reflex CPOE decision support Appropriate use criteria Indication selection Prior authorization Benchmarking Specimen rejection
Right time	Will the result be available in time to optimally affect care? **Λειτουργεία 24/7?**	Time to specimen receipt Centralized vs point-of-care testing On-demand vs batched testing Specimen preparation time Run time Result reporting time

Τρόπος παρουσίασης αποτελεσμάτων

Messacar K et al. J Clin Microbiol, 2017.

Μοριακή ανίχνευση: αναφορά αποτελέσματος

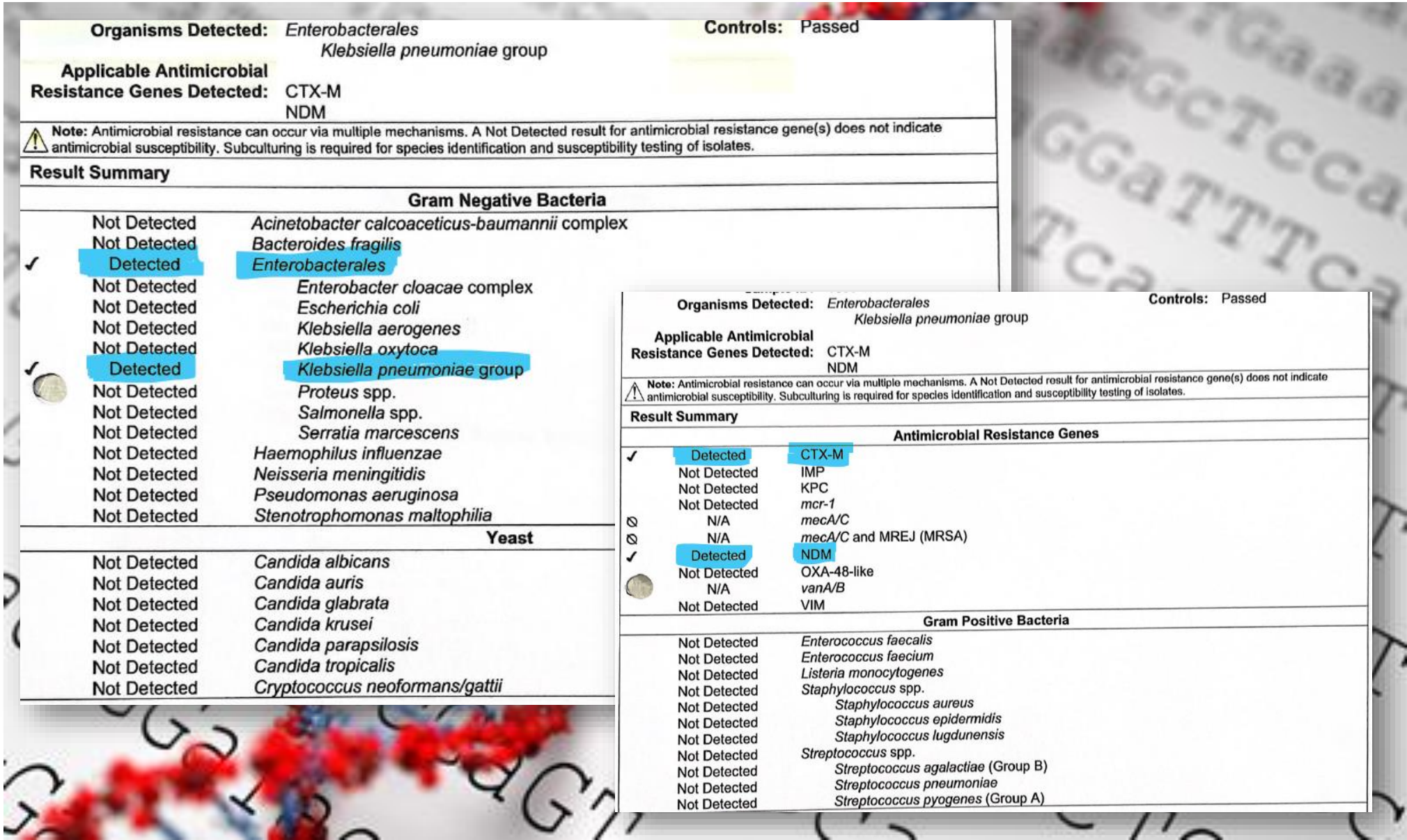
Reporting

"detected" or "not detected" for a specific molecular target

+

interpretative comments with therapeutic guidance

Simner PJ et al. Clin Infect Dis. 2023;76(9):1550-1558.



Organisms Detected: *Enterobacterales*
Klebsiella pneumoniae group

Controls: Passed

Applicable Antimicrobial Resistance Genes Detected: CTX-M
NDM

Note: Antimicrobial resistance can occur via multiple mechanisms. A Not Detected result for antimicrobial resistance gene(s) does not indicate antimicrobial susceptibility. Subculturing is required for species identification and susceptibility testing of isolates.

Result Summary

Gram Negative Bacteria

Not Detected	*Acinetobacter calcoaceticus-baumannii* complex
Not Detected	*Bacteroides fragilis*
✓ Detected	*Enterobacterales*
Not Detected	*Enterobacter cloacae* complex
Not Detected	*Escherichia coli*
Not Detected	*Klebsiella aerogenes*
Not Detected	*Klebsiella oxytoca*
✓ Detected	*Klebsiella pneumoniae* group
Not Detected	*Proteus* spp.
Not Detected	*Salmonella* spp.
Not Detected	*Serratia marcescens*
Not Detected	*Haemophilus influenzae*
Not Detected	*Neisseria meningitidis*
Not Detected	*Pseudomonas aeruginosa*
Not Detected	*Stenotrophomonas maltophilia*

Yeast

Not Detected	*Candida albicans*
Not Detected	*Candida auris*
Not Detected	*Candida glabrata*
Not Detected	*Candida krusei*
Not Detected	*Candida parapsilosis*
Not Detected	*Candida tropicalis*
Not Detected	*Cryptococcus neoformans/gattii*

Organisms Detected: *Enterobacterales*
Klebsiella pneumoniae group

Controls: Passed

Applicable Antimicrobial Resistance Genes Detected: CTX-M
NDM

Note: Antimicrobial resistance can occur via multiple mechanisms. A Not Detected result for antimicrobial resistance gene(s) does not indicate antimicrobial susceptibility. Subculturing is required for species identification and susceptibility testing of isolates.

Result Summary

Antimicrobial Resistance Genes

✓ Detected	CTX-M
Not Detected	IMP
Not Detected	KPC
Not Detected	*mcr-1*
⦸ N/A	*mecA/C*
⦸ N/A	*mecA/C* and MREJ (MRSA)
✓ Detected	NDM
Not Detected	OXA-48-like
N/A	*vanA/B*
Not Detected	VIM

Gram Positive Bacteria

Not Detected	*Enterococcus faecalis*
Not Detected	*Enterococcus faecium*
Not Detected	*Listeria monocytogenes*
Not Detected	*Staphylococcus* spp.
Not Detected	*Staphylococcus aureus*
Not Detected	*Staphylococcus epidermidis*
Not Detected	*Staphylococcus lugdunensis*
Not Detected	*Streptococcus* spp.
Not Detected	*Streptococcus agalactiae* (Group B)
Not Detected	*Streptococcus pneumoniae*
Not Detected	*Streptococcus pyogenes* (Group A)

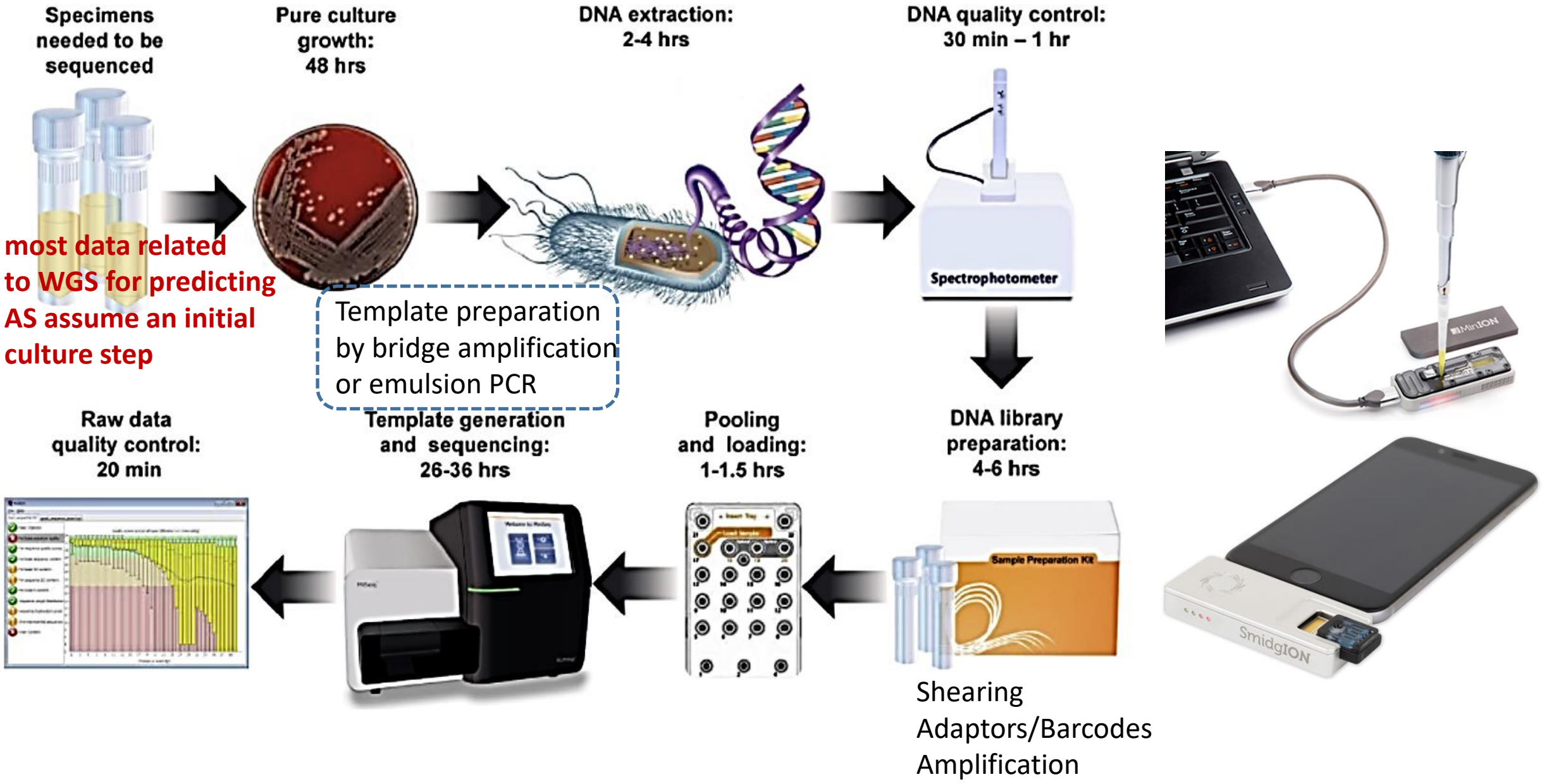
Μοριακή ανίχνευση αντοχής: σχόλια για την αναφορά των αποτελεσμάτων

Table 3. Reporting comments for molecular blood culture diagnostics. Adapted from Banerjee *et al.*[29]

Staphylococcus aureus, *mecA* detected	Probable methicillin-resistant *Staphylococcus aureus* (MRSA); further testing in progress. MRSA is predictably resistant to beta-lactam antibiotics (except ceftaroline). Patient requires contact precautions if hospitalized.
Staphylococcus aureus, *mecA* not detected	Methicillin (oxacillin)-susceptible *Staphylococcus aureus*. Preferred therapy is an anti-staphylococcal β-lactam antibiotic, unless clinically contraindicated.
Staphylococcus, coagulase-negative, *mecA* detected	Methicillin (oxacillin)-resistant coagulase-negative *Staphylococcus*. Possible blood culture contaminant (unless isolated from more than one blood culture draw or clinical case suggests pathogenicity). No antibiotic treatment is indicated for blood culture contaminants.
Enterobacter cloacae complex	This organism may contain an inducible β-lactamase. Penicillin or second- or third-generation cephalosporin monotherapy may result in emergence of high-level resistance.
Escherichia coli, $bla_{CTX\text{-}M}$ detected	Extended-spectrum β-lactamase-producer. Carbapenems are drugs of choice for ESBL-producers.
E. coli, bla_{KPC} detected	Carbapenemase producer. Patient requires contact precautions if hospitalized. This organism is resistant to carbapenems and other β-lactam antibiotics. Consult infectious diseases.

Banerjee R, Patel R. JAC Antimicrob Resist. 2023;5(1):dlad018.

WGS: τα βήματα της διαδικασίας



most data related to WGS for predicting AS assume an initial culture step

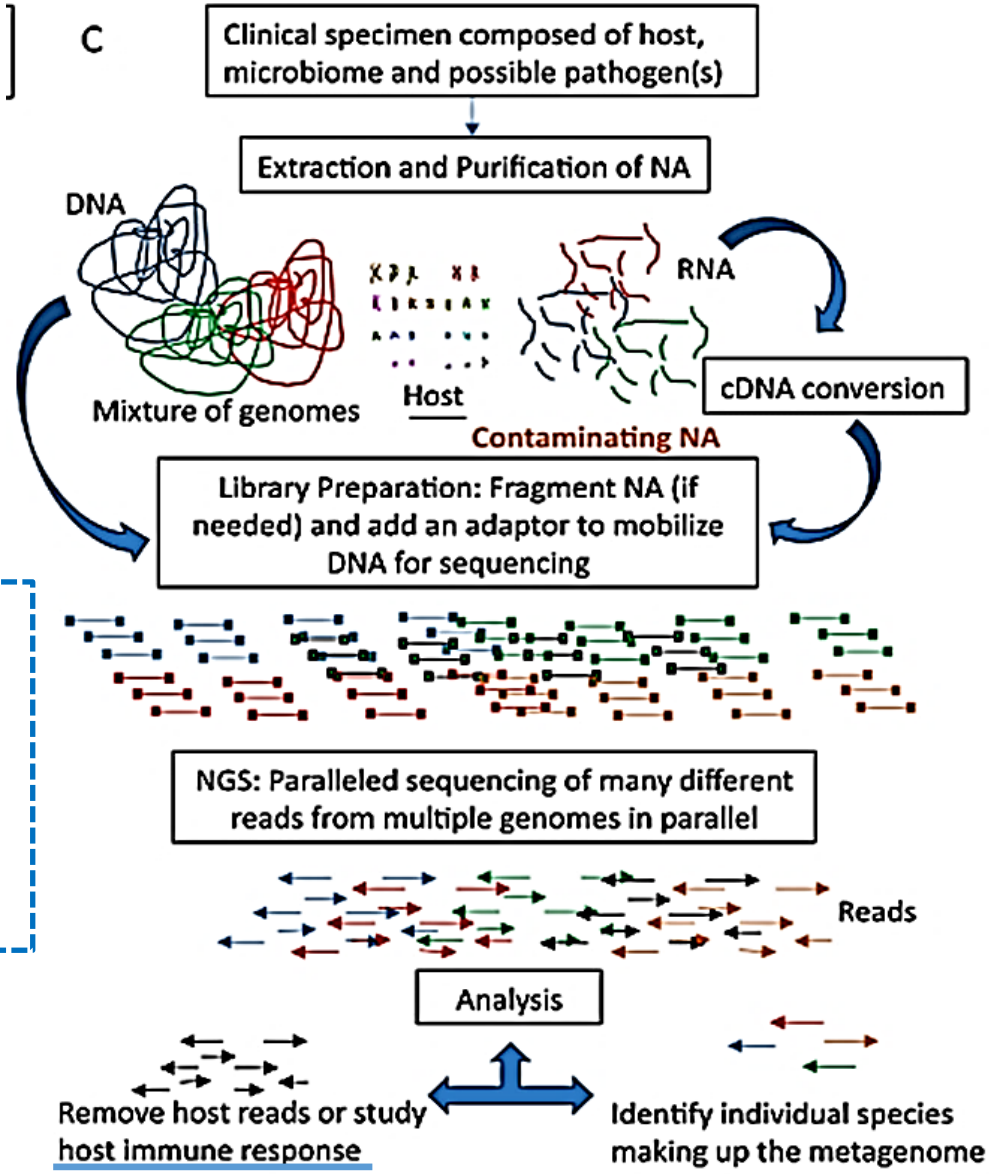
Template preparation by bridge amplification or emulsion PCR

Shearing
Adaptors/Barcodes
Amplification

Besser J et al. Clin Microbiol Infect. 2018;24(4):335-341.

Metagenomic NGS (agnostic NGS): το επόμενο βήμα

hypothesis-free,
culture-independent,
pathogen detection



evaluate the immunologic
response associated
with the presence and type of infection
e.g. biomarkers
provide insight into the pathogenesis
of the microorganisms detected

Ερμηνεία αποτελεσμάτων

Simner PJ et al. Clin Infect Dis. 2018;66(5):778-788.

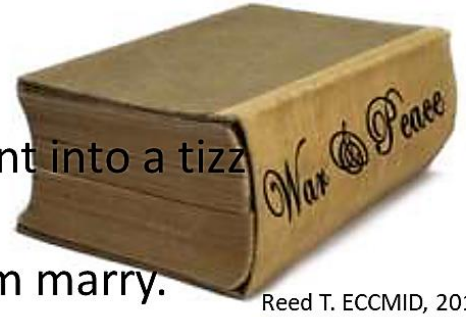
NAAT versus Genomic data

WGS:
“one test fits all”
approach

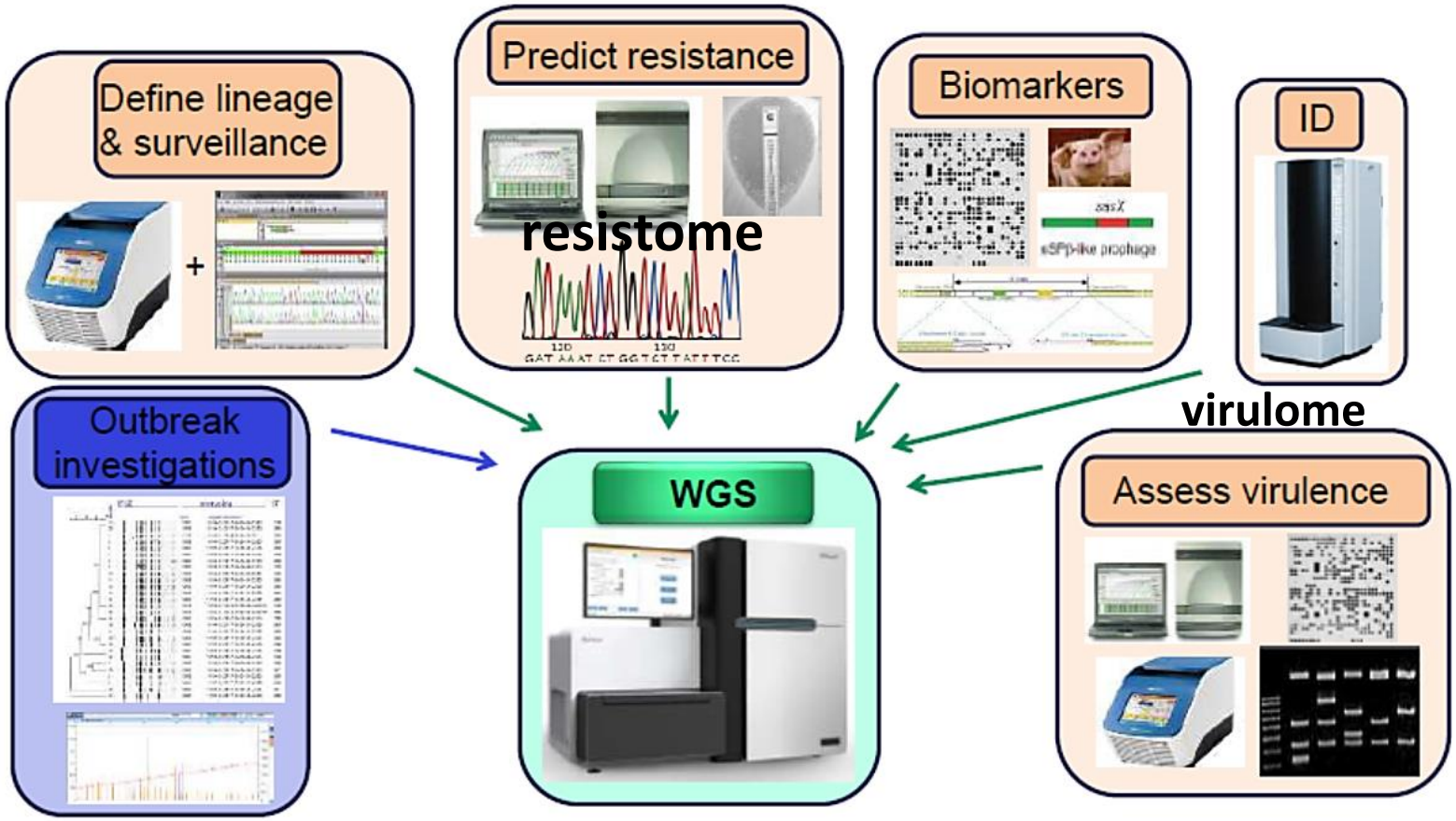
Tweet versus…

Leo Tolstoy, War and Peace
Napoleon invades Russia.
Russian aristocratic families sent into a tizz
War ensues. French retreat.
Russians celebrate.Lots of them marry.

Tome



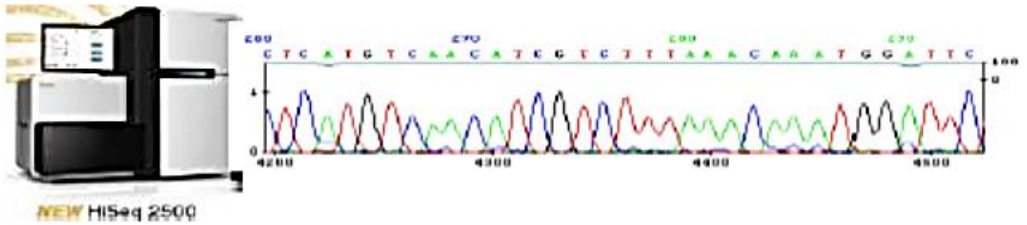
Reed T. ECCMID, 2016.



Woodford N. ECCMID, 2016.

	Phenotypic AST	WGS-based AST
Measures susceptibility	✓	X
Resistance mechanisms	✓ (limited)	✓✓✓
ECOFF (WT vs. non-WT)	✓	✓
Clinical resistance (S vs. R)	✓	? (must be inferred)
Additional data	X	✓✓✓
Suitable speed	✓(most) X (e.g. TB)	X (most) ✓(e.g. TB)
Cost	✓	X

Woodford N. ECCMID, 2016.



M. tuberculosis: the speed of WGS results offers advantage over traditional AST

- >95% of pathogen ID and AST in present CM labs is based on around 20 bacterial species and a limited number of AB
- may not be necessary to cover all possibilities to provide useful data rapidly, but rather we might focus on a limited number of agents for each pathogen initially and let more detailed data become available later.

Ellington MJ et al. Clin Microbiol Infect. 2017;23(1):2-22.

frontiers | Frontiers in Microbiology
https://www.frontiersin.org/journals/microbiology
ORIGINAL RESEARCH
published: 10 June 2022
doi: 10.3389/fmicb.2022.804627

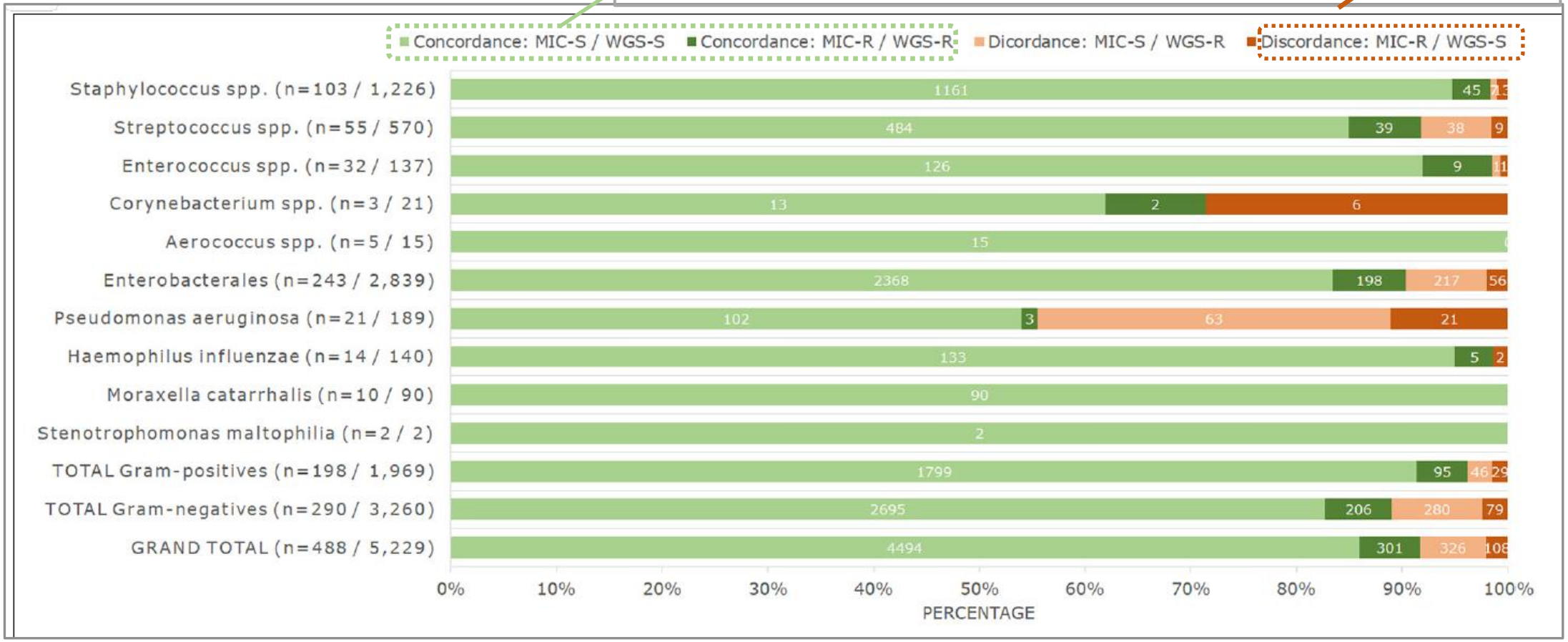
Rebelo AR et al. 2022;13:804627.

One Day in Denmark: Comparison of Phenotypic and Genotypic Antimicrobial Susceptibility Testing in Bacterial Isolates From Clinical Settings

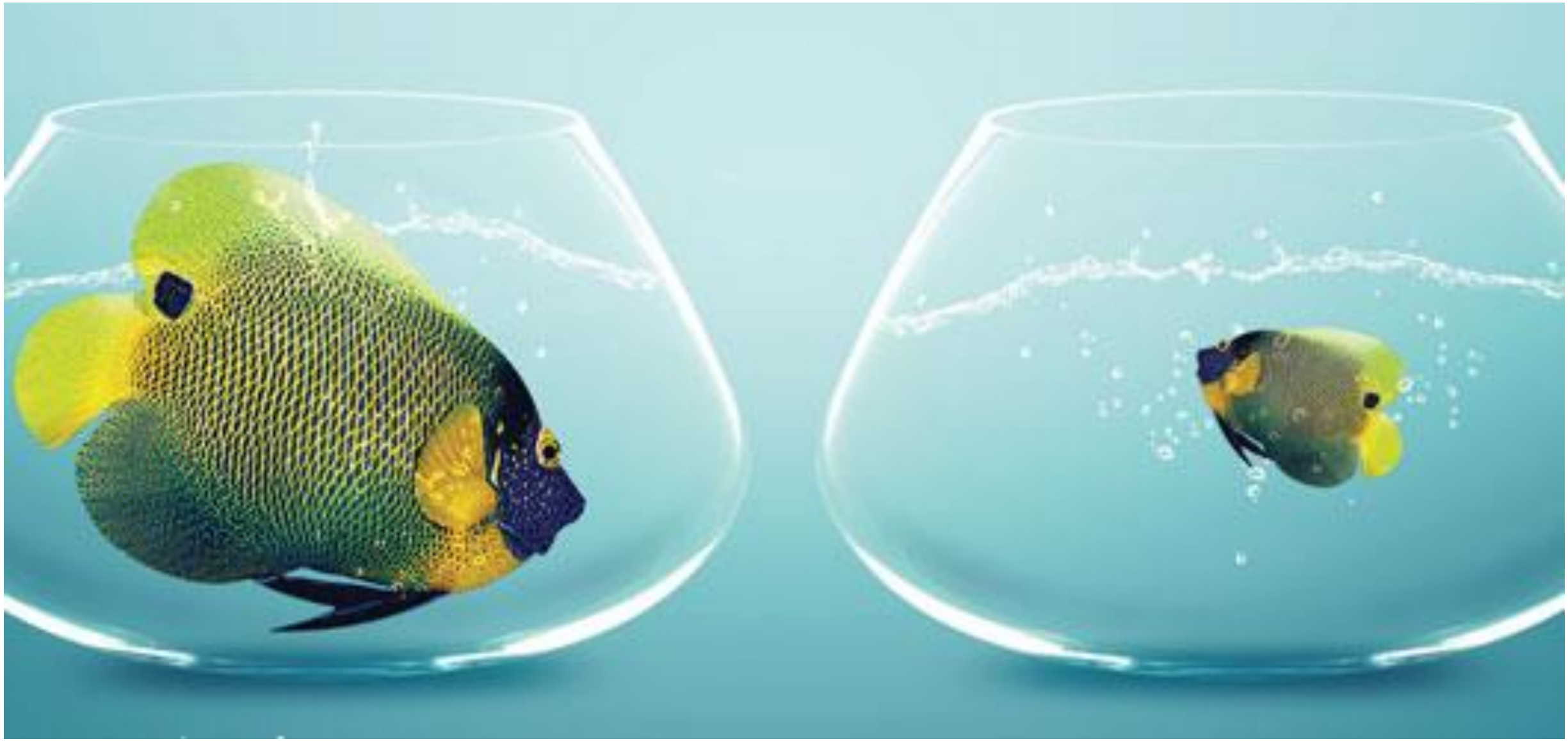
concordance of 91.7%

cases of phenotypically resistant isolates without any known genetic resistance mechanism: 2.1% of all combinations analyzed

Percentage and number of genotype–phenotype concordances and discordances observed for all bacteria analyzed in this study, when comparing MIC and WGS results.



One size does not fit all



stewardship

Noun: the activity or job of **protecting** and being **responsible** for something

World Antimicrobial Awareness Week becomes World AMR Awareness Week

WORLD AMR AWARENESS WEEK
18-24 NOVEMBER

HANDLE ANTIMICROBIALS WITH CARE

Go blue!

Join us in raising awareness of one of the biggest global public health threats: antimicrobial resistance

Every one, everywhere, at all ages is affected

Be an AMR Awareness Champion and Go Blue for AMR!

World Health Organization
REGIONAL OFFICE FOR THE Eastern Mediterranean

PREVENTING ANTIMICROBIAL RESISTANCE TOGETHER

HANDLE ANTIMICROBIALS WITH CARE

Antibiotics
Antivirals
Antifungals
Antiparasitics