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Activity of Aztreonam-Avibactam and Comparators against Difficult-To-Treat Resistant (DTR) Enterobacterales from European Medical Centres Stratified by Infection Type and Country (2021–2025)

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Abstract

Background: Difficult-to-treat resistant (DTR) isolates, defined as bacterial isolates expressing nonsusceptibility to all first-line agents, is a major problem worldwide. We evaluated the activity of aztreonam-avibactam and comparators against DTR Enterobacterales from European medical centres. Methods: 30,345 Enterobacterales isolates were consecutively collected from 41 European medical centres in 19 countries in 2021–2025. Isolates were susceptibility tested by broth microdilution and MIC interpreted according to EUCAST breakpoints. The collection included 1113 DTR isolates, defined as a carbapenem-resistant isolate (MIC ≥4 mg/L for meropenem and/or imipenem) not susceptible to fluoroquinolones. All DTR isolates were screened for β-lactamase genes by whole genome sequencing. Results were stratified by infection type and country. Results: Aztreonam-avibactam was active against 99.6% of DTR (MIC50/90, 0.25/0.5 mg/L), and exhibited consistent activity against DTR isolates from all infection types. Cefiderocol was active against 78.8% of DTR isolates; ceftazidime-avibactam, meropenem-vaborbactam, imipenem-relebactam, and the aminoglycosides exhibited limited activity against these organisms. The frequency of DTR was higher among isolates from pneumonia (6.6%) compared to other infection types (2.3–3.4%) and varied from 0.0% (Switzerland) to 19.7% (Poland) among countries. DTR susceptibility to aztreonam-avibactam ranged from 94.4% (France) to 100.0% (14 countries). Aztreonam-avibactam retained potent activity against DTR isolates nonsusceptible to ceftazidime-avibactam (99.2% susceptible), meropenem-vaborbactam (99.6% susceptible), and/or cefiderocol (97.8% susceptible). The most common carbapenemase identified among DTR isolates was NDM (41.2% of DTR), followed by OXA-48–like (38.2%), and KPC (34.3%). Moreover, 99.6% of metallo-β-lactamase (MBL) producers were susceptible to aztreonam-avibactam and 68.2% were susceptible to cefiderocol. Conclusions: Aztreonam-avibactam retained potent activity against DTR Enterobacterales from European medical centres and its activity was not adversely affected by clinically relevant carbapenemases or resistance to agents currently used to treat multidrug-resistant Enterobacterales. The activities of other β-lactamase inhibitor combinations and cefiderocol were compromised by the increased occurrence of MBL producers.

Introduction

Difficult-to-treat resistance (DTR) indicates nonsusceptibility to all first-line, high-efficacy, low-toxicity agents. DTR Enterobacterales are characterized by nonsusceptibility to fluoroquinolones and all β-lactams, excluding cefiderocol and the newer β-lactam-β-lactamase inhibitor combinations that are stable to hydrolyses by KPC and other serine carbapenemases, such as ceftazidime-avibactam, meropenem-vaborbactam, and imipenem-relebactam [1]. The 30-day mortality risk is substantially higher among patients with DTR Gram-negative infections compared to patients with infections caused by non-DTR organisms; the main reason for increased mortality is delay in the introduction of effective antimicrobial therapy [2–4].

Since 2014, several antimicrobial agents active against DTR Enterobacterales have been approved by the European Medicines Agency and implemented into clinical practice in many European countries [5, 6]. However, resistance to these newer agents is elevated in some geographic regions due to the growing occurrence of infections caused by metallo-β-lactamase (MBL)–producing Enterobacterales [7, 8]. The

major challenge with infections caused by MBL-producing Enterobacterales is the limited availability of effective antibiotics for treatment [9, 10]. In addition to resistance to the newer β-lactamase inhibitor combinations such as ceftazidime-avibactam, meropenem-vaborbactam, and imipenem-relebactam, these organisms are frequently resistant to multiple non-β-lactam agents as well, resulting in very limited therapeutic options [11].

Aztreonam-avibactam was first approved by the European Medicines Agency in April 2024 to treat adults with complicated intra-abdominal infection and urinary tract infection, hospital-acquired pneumonia, including ventilator-associated pneumonia, and infections caused by aerobic Gram-negative where treatment options are limited. (https://www.ema.europa.eu/en/news/new-antibiotic-fight-infections-caused-multidrug-resistant-bacteria; accessed on 28 July 2026). Aztreonam-avibactam received United States (US) Food and Drug Administration (FDA) approval in February 2025 for patients 18 years and older who have limited or no alternative options for the treatment of complicated urinary tract infections caused by Enterobacterales (https://www.accessdata.fda.gov/drugsatfda_docs/label/2025/217906Orig1s000lbl.pdf).

Aztreonam is stable to hydrolysis by MBLs and avibactam provides protection against serine β-lactamases, including the ESBLs, chromosomal derepressed AmpC, and *Klebsiella pneumoniae* carbapenemases (KPC). Thus, aztreonam-avibactam has demonstrated potent *in vitro* activity against carbapenem-resistant Enterobacterales (CRE) producing clinically relevant carbapenemases [12, 13]. In the present study, we evaluated the activity of aztreonam-avibactam and comparators against DTR Enterobacterales from European medical centres.

Methods

A total of 30,345 Enterobacterales isolates were collected from 41 medical centres located in 19 countries in the European and Mediterranean region. Bacterial isolates were collected between January 2021 and December 2025 via a network of medical centres participating in the SENTRY Antimicrobial Surveillance Program and sent to Element Iowa City (JMI Laboratories; North Liberty, Iowa, USA) [14, 15]. Participating centres were requested to consecutively collect bacterial isolates from individual patients (one isolate per infection episode). Only isolates established to be the cause of infection were included in the programme. The number of isolates by type of infection as well as the period of the year that the isolates were collected varied slightly by year and by geography. The collection included isolates from patients with bloodstream infection (BSI; *n* = 9199), intra-abdominal infection (IAI; *n* = 2601), pneumonia (*n* = 6777), skin and soft tissue infection (SSTI; *n* = 2127), and urinary tract infection (UTI; *n* = 9641). Results were stratified by infection type and by country. The number of participant medical centres per country varied from one (Belgium, Czechia, Greece, Ireland, Poland, Portugal, Slovakia, and Switzerland) to six (Germany).

Susceptibility testing was performed by the broth microdilution method described by CLSI standards [16]. Cefiderocol was tested on iron depleted media only against DTR isolates only. All tests were conducted in a central laboratory (Element Iowa City [JMI Laboratories]). EUCAST breakpoint criteria was applied for aztreonam-avibactam (susceptible at ≤ 4 mg/L and resistant at > 4 mg/L) and comparator agents when

available [17]. Enterobacterales isolates with imipenem or meropenem MIC ≥ 4 mg/L were categorized as CRE. Imipenem criterion was not employed to indole-positive Proteeae or *Proteus mirabilis* because these organisms show intrinsically elevated imipenem MIC values. DTR was defined as a CRE isolate not susceptible to fluoroquinolones (levofloxacin and/or ciprofloxacin) according to EUCAST criteria [17, 1]. All DTR isolates were screened for β-lactamase–encoding genes by applying genome sequencing and *in silico* screening, as previously described [18].

Results

Aztreonam-avibactam was highly active against Enterobacterales ($MIC_{50/90}$, ≤ 0.03/0.12 mg/L; 99.9% susceptible) and exhibited consistent activity against isolates from all infection types (Table 1). Only 18 isolates (0.06%) were resistant to aztreonam-avibactam according to EUCAST breakpoint criteria: 12 with an aztreonam-avibactam MIC of 8 mg/L (which is intermediate per CLSI and US FDA criteria), four with an aztreonam-avibactam MIC of 16 mg/L, and two with an aztreonam-avibactam MIC of > 16 mg/L. The aztreonam-avibactam–resistant isolates were *Escherichia coli* (9 isolates), *Enterobacter cloacae* species complex (3), *Klebsiella pneumoniae* (3), *K. aerogenes* (2), and *Providencia stuartii* (1). These isolates were collected from seven countries.

Table 1
Antimicrobial susceptibility of Enterobacterales from European medical centres stratified by infection type (2021–2025)

Antimicrobial agent	% Susceptible per EUCAST criteria (no. of isolates: all/DTR)					
	BSI (9199/311)	IAI (2601/65)	Pneumonia (6777/445)	SSTI (2127/72)	UTI (9641/220)	All (30,345/1113)
All isolates						
ATM-AVI	99.9	99.9	99.9	99.9	> 99.9	99.9
CAZ-AVI	98.2	98.7	96.9	98.6	98.6	98.1
MEM-VAB	97.8	98.6	95.9	98.2	98.6	97.7
IMI-REL	96.7	97.1	94.7	96.7	96.8	96.3
TOL-TAZ	92.1	91.0	87.0	90.0	94.0	91.3
PIP-TAZ	83.7	82.5	77.2	82.2	86.5	82.9
Meropenem	96.3	97.3	93.1	96.5	97.6	96.1
Ceftriaxone	76.0	77.6	73.8	73.7	77.3	75.9
Cefepime	79.3	82.9	80.3	81.1	80.2	80.2
Levofloxacin	77.1	82.1	82.1	77.0	77.0	78.6
Gentamicin	87.8	91.9	89.6	88.7	89.2	89.1
Amikacin	96.3	98.2	94.5	96.6	97.4	96.4
Colistin	85.5	86.2	76.1	70.7	85.7	82.5
DTR isolates						
ATM-AVI	99.7	100.0	99.6	100.0	99.5	99.6
Cefiderocol	72.7	77.6	79.5	79.4	85.3	78.8
CAZ-AVI	54.3	55.4	57.8	68.1	47.7	55.3
MEM-VAB	39.5	44.6	39.8	47.2	41.8	40.9
IMI-REL	37.6	41.5	43.3	56.5	37.0	41.1
Gentamicin	38.7	44.6	42.1	33.3	42.7	40.9
Amikacin	40.2	60.0	37.5	44.4	46.4	41.8

Abbreviations: DTR, difficult-to-treat resistant; BSI, bloodstream infection; IAI, intra-abdominal infection; SSTI, skin and soft tissue infection; UTI, urinary tract infection; ATM-AVI, aztreonam-avibactam; CAZ-AVI, ceftazidime-avibactam; MEM-VAB, meropenem-vaborbactam; IMI-REL, imipenem-relebactam; TOL-TAZ, ceftolozane-tazobactam; PIP-TAZ, piperacillin-tazobactam.

Antimicrobial agent	% Susceptible per EUCAST criteria (no. of isolates: all/DTR)					
	BSI (9199/311)	IAI (2601/65)	Pneumonia (6777/445)	SSTI (2127/72)	UTI (9641/220)	All (30,345/1113)
Colistin	72.3	82.8	63.8	69.4	66.8	68.3

Abbreviations: DTR, difficult-to-treat resistant; BSI, bloodstream infection; IAI, intra-abdominal infection; SSTI, skin and soft tissue infection; UTI, urinary tract infection; ATM-AVI, aztreonam-avibactam; CAZ-AVI, ceftazidime-avibactam; MEM-VAB, meropenem-vaborbactam; IMI-REL, imipenem-relebactam; TOL-TAZ, ceftolozane-tazobactam; PIP-TAZ, piperacillin-tazobactam.

Ceftazidime-avibactam ($MIC_{50/90}$, 0.12/0.5 mg/L; 98.1% susceptible), meropenem-vaborbactam ($MIC_{50/90}$, 0.03/0.06 mg/L; 97.7% susceptible), imipenem-relebactam ($MIC_{50/90}$, 0.12/1 mg/L; 96.3% susceptible), and meropenem ($MIC_{50/90}$, 0.03/0.06 mg/L; 96.1% susceptible) were also very active against Enterobacterales, with susceptibility rates ranging from 96.1% (meropenem) to 98.1% (ceftazidime-avibactam; Table 1). Notably, susceptibility rates for these agents were lower among isolates from patients with pneumonia (93.1% to 96.9%) compared to other infection types (Table 1). Susceptibility rates for ceftolozane-tazobactam, piperacillin-tazobactam, and amikacin were also lower among isolates from patients with pneumonia when compared to other infection types (Table 1).

The frequency of DTR isolates varied among infection types, with the highest occurrence among isolates from pneumonia (6.6%), followed by BSI and SSTI (3.4% for both), IAI (2.5%), and UTI (2.3%). Aztreonam-avibactam exhibited consistent activity against DTR isolates from all infection types: all (100.0%) DTR isolates from IAI and SSTI and 99.5% to 99.7% of DTR isolates from BSI, pneumonia, and UTI (99.6% overall; Table 1). In contrast, the activities of the comparator agents varied markedly among infection types. Cefiderocol activity varied from 72.7% against DTR isolates from BSI to 85.3% against DTR isolates from UTI (78.6% overall) and ceftazidime-avibactam activity ranged from 47.7% against DTR isolates from UTI to 68.1% against DTR isolates from SSTI (55.3% overall; Table 1).

Moreover, the frequency of DTR isolates varied markedly among countries, from < 1.0% in Switzerland (0.0%), Sweden (0.1%), Slovenia (0.2%), Ireland (0.3%), United Kingdom (0.4%), Belgium (0.7%), France (0.6%), and Germany (0.5%) to as high as 17.0% in Greece, 19.5% in Turkey, and 19.7% in Poland (3.7% overall; Table 2). Remarkably, Greece, Italy, Poland, and Turkey combined contributed 77.3% (860/1131) of DTR isolates.

Table 2
Frequency and antimicrobial susceptibility of difficult-to-treat resistant (DTR) organisms stratified by country

Country	No. of	No. of	% of DTR	% of MBL	% of DTR susceptible (EUCAST) to:			
(no. of centres)	organisms	DTR		producers[a]	ATM-AVI	Cefiderocol	CAZ-AVI	MEM-VAB
Belgium (1)	913	6	0.7	33.3	100.0	75.0	66.7	66.7
Czech Republic (1)	596	7	1.2	42.9	100.0	80.0	57.1	57.1
France (4)	3208	18	0.7	83.3	94.4	66.7	16.7	27.8
Germany (6)	4708	23	0.5	47.8	95.7	68.8	56.5	56.5
Greece (1)	1010	172	17.0	48.8	98.8	75.8	50.6	52.9
Hungary (3)	1105	24	2.2	66.7	100.0	79.2	20.8	12.5
Ireland (1)	914	3	0.3	66.7	100.0	100.0	33.3	33.3
Israel (2)	1361	21	1.5	42.9	100.0	76.9	52.4	61.9
Italy (4)	3521	147	4.2	27.9	100.0	79.1	70.7	71.4
Poland (1)	760	150	19.7	69.3	100.0	73.6	30.0	18.7
Portugal (1)	1005	15	1.5	0.0	100.0	100.0	100.0	100.0
Romania (2)	404	34	8.4	64.7	100.0	95.8	35.3	32.4
Slovakia (1)	429	50	11.7	18.0	100.0	100.0	82.0	66.0
Slovenia (2)	1156	2	0.2	100.0	100.0	100.0	0.0	0.0
Spain (3)	2965	40	1.3	27.5	100.0	100.0	72.5	82.5
Sweden (2)	1009	1	0.1	100.0	100.0	100.0	0.0	0.0
Switzerland (1)	1001	0	0.0					
Turkey (2)	2008	391	19.5	40.4	100.0	75.5	60.4	23.0
United Kingdom (3)	2274	9	0.4	44.4	100.0	85.7	66.7	66.7
Total (41)	**30,385**	**1131**	**3.7**	**44.4**	**99.6**	**78.8**	**55.3**	**40.9**

[a] % of MBL producers among difficult-to-treat resistant organisms.

Abbreviations: DTR, difficult-to-treat resistant; MBL, metallo-β-lactamase; ATM-AVI, aztreonam-avibactam; CAZ-AVI, ceftazidime-avibactam; MEM-VAB, meropenem-vaborbactam.

Aztreonam-avibactam was active against 99.6% ($MIC_{50/90}$, 0.25/0.5 mg/L) of DTR isolates overall (1109/1113), including 100.0% of DTR isolates from countries other than France (94.4%), Germany (95.7%), and Greece (98.8%; Table 2). Cefiderocol was the second most active agent against DTR isolates ($MIC_{50/90}$, 1/4 mg/L; 78.8% susceptible). Susceptibility rates for cefiderocol were ≤ 80.0% in 10 countries and 100.0% in six countries (Table 2). Ceftazidime-avibactam ($MIC_{50/90}$, 4/>32 mg/L; 55.3% susceptible), meropenem-vaborbactam ($MIC_{50/90}$, 16/>32 mg/L; 40.9% susceptible), and imipenem-relebactam ($MIC_{50/90}$, 4/>16 mg/L; 41.1% susceptible) exhibited limited activity against DTR isolates (Tables 2 and 3).

Table 3
Antimicrobial susceptibility of selected resistant subsets

Antimicrobial agent	**% Susceptible per EUCAST criteria (no. of isolates)**				
	DTR (1,113)	**MBL producers (494)[a]**	**CAZ-AVI-NS (497)[a]**	**MEM-VAB-NS (658)[a]**	**Cefiderocol-NS (180)[a]**
ATM-AVI	99.6	99.6	99.2	99.7	97.8
Cefiderocol	78.8	68.2	67.7	71.4	0.0
CAZ-AVI	55.3	1.2	0.0	31.3	11.1
MEM-VAB	40.9	8.5	9.1	0.0	7.2
IMI-REL	41.1	2.2	2.7	12.5	9.2
Gentamicin	40.9	33.7	33.7	33.1	24.4
Amikacin	41.8	32.8	32.6	29.0	25.0
Colistin	68.3	69.2	69.8	64.3	57.2

[a] Includes only DTR isolates. Abbreviations: DTR, difficult-to-treat resistant; MBL, metallo-β-lactamase; CAZ-AVI, ceftazidime-avibactam; NS, nonsusceptible; MEM-VAB, meropenem-vaborbactam; IMI-REL, imipenem-relebactam.

Abbreviations: DTR, difficult-to-treat resistant; MBL, metallo-β-lactamase; CBase, carbapenemase.

A carbapenemase gene was identified in 1060 (95.2%) DTR isolates (Fig. 1). The most common carbapenemase identified among DTR isolates was NDM (*n* = 459; 41.2% of DTR), followed by OXA-48–like (*n* = 425; 38.2%), and KPC (*n* = 382; 34.3%; Fig. 1). Notably, 494 (44.4%) DTR isolates included an MBL: NDM-1 (321 isolates), NDM-5 (125), NDM-6 (5), NDM-7 (3), NDM-9 (2), NDM-19 (1), NDM-71 (1), VIM-1 (29), VIM-4 (4), IMP-1 (1), IMP-4 (1), and NDM-1 plus VIM-1 (1) were identified. Moreover, 242 (21.7%) DTR isolates had 2 carbapenemase genes (Fig. 1).

The frequency of MBL producers among DTR isolates ranged from 0.0% to 100.0% among the countries surveyed in this investigation (Table 2). Among countries with at least 10 DTR isolates, the frequency of MBL producers ranged from 0.0% in Portugal and 18.0% in Slovakia to as high as 69.3% in Poland and

83.3% in France (Table 2). Aztreonam-avibactam showed almost complete activity against MBL producers ($MIC_{50/90}$, 0.25/0.5 mg/L; 99.6% susceptible). Other compounds with some activity against MBL-producing DTR isolates were cefiderocol ($MIC_{50/90}$, 2/8 mg/L; 68.2% susceptible), colistin ($MIC_{50/90}$, 0.25/>8 mg/L; 69.2% susceptible), gentamicin ($MIC_{50/90}$, > 16/>16 mg/L; 33.7% susceptible), and amikacin ($MIC_{50/90}$, 16/>32 mg/L; 32.8% susceptible; Table 3).

Remarkably, aztreonam-avibactam retained activity against > 99% of isolates not susceptible to ceftazidime-avibactam and/or meropenem-vaborbactam and 97.8% of DTR isolates not susceptible to cefiderocol (Table 3), with $MIC_{50/90}$ values of 0.25/0.5 mg/L for all 3 groups. In contrast, cefiderocol was active against 67.7% of ceftazidime-nonsusceptible and 71.4% of meropenem-vaborbactam–nonsusceptible DTR isolates. Cross resistance between ceftazidime-avibactam, meropenem-vaborbactam, and imipenem-relebactam was very high among DTR isolates (Table 3).

Discussion

DTR Enterobacterales pose a major risk to patients and healthcare systems in European countries and have been increasing in prevalence and burden in the past 20 years [19, 4]. The mechanisms of resistance in DTR Enterobacterales mainly rely on the production of carbapenemases associated with various resistance mechanisms to non–β-lactam agents [20]. The armamentarium against DTR Enterobacterales has grown, with most newer agents being active against ESBL and KPC producers. However, there is a desperate need of agents active against MBL producers [20].

In the present investigation, we evaluated > 30,000 Enterobacterales from 19 countries in Europe and the Mediterranean region, including 1113 DTR isolates. While the activities of ceftazidime-avibactam, meropenem-vaborbactam, imipenem-relebactam, and even cefiderocol was compromised against DTR Enterobacterales, aztreonam-avibactam retained potent activity against these organisms, and its activity was not adversely affected by MBL production or resistance to agents currently used to treat CRE and multidrug-resistant Enterobacterales.

Although aztreonam-avibactam was equally active against isolates from all infection sites, the activity of the comparator agents, including other β-lactam-β-lactamase inhibitor combinations, were lower against isolates from pneumonia compared to other infection sites. Lower antimicrobial susceptibility among bacterial isolates causing pneumonia has been previously reported and could be related to various factors, such as previous antibiotic exposure, length of hospitalisation before acquiring the infection, and underlying disease [21, 22].

The most striking finding of this investigation was the dominance of MBLs, mainly NDM, as the most common carbapenemase type among DTR Enterobacterales in most European countries surveyed. An MBL was observed in > 40% of DTR Enterobacterales in 13 of 18 countries that reported DTR isolates. These results corroborate those of other investigators and surveillance programs in Europe by showing an increasing occurrence of NDM-producing Enterobacterales in various European countries [11, 23–27]. In 2023, Emeraud et al. reported the emergence and rapid dissemination of NDM-producing *K. pneumoniae*

ST147 in France [23]. Sandfort et al. detected a substantial increase in NDM-1–producing *K. pneumoniae* in Germany associated with Ukraine war and observed both national and international transmissions of these organisms [24]. Tsilipounidaki documented a diversity of bacterial clones and plasmids of NDM-1 producing *E. coli* in Greece [25]. In summary, there has been plenty of evidence that the increasing frequency of DTR Enterobacterales is related to MBL production in Europe.

This study has two limitations. First, the criteria for categorising a bacterial isolate as probable cause of infection were based on local algorithms and these criteria may vary among participating medical centres. Second, the number of medical centres in some countries were very limited, especially in countries from Eastern Europe, and not all medical centres participated in the program during the entire 5-year period of the investigation. If a participating centre exits the program, another centre from the same country is recruited, with the goal of maintaining a robust and as broadly representative sample as possible [14, 15].

In conclusion, aztreonam-avibactam retained potent activity against DTR and MBL-producing Enterobacterales from European medical centres. In contrast, the activities of other β-lactamase inhibitor combinations and cefiderocol were compromised by the increased occurrence of MBL producers in many European countries. The results of this investigation underline the continuous evolution of the epidemiology of antimicrobial resistance in Enterobacterales causing infections in European medical centres and highlight the importance of comprehensive surveillance programmes.

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Declarations

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Not applicable.

Consent to participate

Not applicable.

Consent for publication

The content has been read and approved by all co-authors and the manuscript has not been submitted elsewhere. All authors agree to transfer the copyright, following the policies of the journal at the time of acceptance/publication.

Transparency Statement

Element Iowa City (JMI Laboratories) was contracted to perform services in 2025 for AbbVie, Inc., AdjuTec Pharma, Affinity Biosensors, AimMax Therapeutics, Amazon.com Services LLC, AN2 Therapeutics, Inc., Andira Pharmaceuticals, Astellas Pharma, Inc., AstraZeneca, Basilea Pharmaceutica AG, Beckman Counter, Inc., bioMérieux, BioVersys AG, Blacksmith Medicines, Center for Discovery and Innovation, Cepheid, Chemia Biosciences Inc, Crestone, Inc., CytoSpar, LLC, Elion Therapeutics, Ellison Institute, Fedora Pharmaceuticals, FlightPath Biosciences, GARDP Foundation, Genentech, GenSci, GlaxoSmithKline plc, Gradientech, Hartford Hospital, Harvard University, ICON Laboratory Services, Inc., Innoviva Specialty Therapeutics,Inc., Institute for Clinical Pharmacodynamics, Iterum Therapeutics plc, Kaizen Biosciences, Kissaki Biosciences, LabConnect, LLC, Locus Biosciences, Inc., Meitheal Pharmaceuticals, Inc, Macro Biologics, Melinta Therapeutics, Merck & Co., MicrobiotiX, MicuRx Pharmaceutical Inc., Mundipharma International Ltd., National Institutes of Health, NovoBiotic Pharmaceuticals, LLC, Omnix Medical Ltd., Paratek Pharmaceuticals, Pattern Bioscience, Inc, Pfizer, Inc, Polaroid Therapeutics AG, PolyPid Ltd, PPD Global Central Labs, LLC, Pulmocide Ltd, Qiagen Sciences LLC, Qpex Biopharma, Inc, Revagenix, Inc, Roche Holding AG, Sandoz AG, Scynexis, Inc., SeLux Diagnostics, Shionogi & Co., Ltd., Specific Diagnostics, Spero Therapeutics, ThermoFisher Scientific, U.S. Food and Drug Administration, UT Southwestern Medical Center, Wockhardt Bio AG, and Zoetis, Inc.

Potential Conflicts of Interest

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Author Contribution

HSS: Conceptualization, Writing – Original Draft, Writing – Review & Edit, Visualization, Funding Acquisition REM: Conceptualization, Formal Analysis, Validation, Data Curation, Resources, Supervision, Writing – Review & Edit.KP: Investigation, Funding Acquisition, Review & Edit.GS: Investigation, Funding Acquisition, Review & Edit.KMP: Methodology, Formal Analysis, Data Curation, Software, Validation, Supervision MC: Conceptualization, Validation, Resources, Writing – Review & Edit, Supervision, Funding AcquisitionAll authors reviewed and approved the manuscript.

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Figures

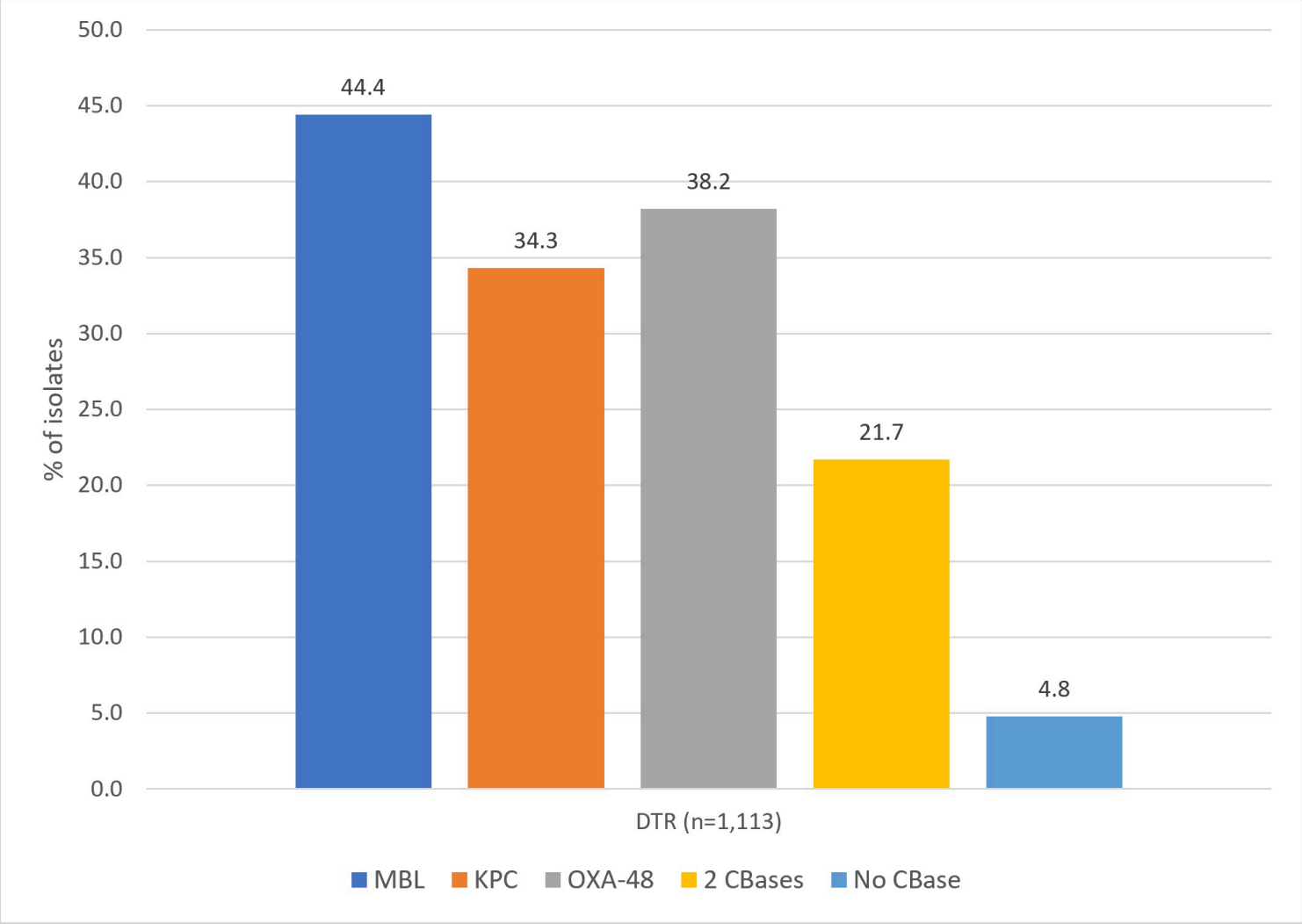


Figure 1

Distribution of carbapenemase (CBase) types among DTR isolates