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Activity of Ceftaroline and Comparator Agents Tested Against Organisms Responsible for Community-acquired Respiratory Tract Infections in Europe (2009)

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Abstract

Objective: To evaluate the activity of ceftaroline (CPT) and comparators against isolates from patients with community-acquired respiratory tract infections (CARTI) in European (EU) medical centres. CPT, the active component of the prodrug CPT fosamil, exhibits broad-spectrum activity against Gram-positive organisms, including resistant (R) subsets of methicillin-R *S. aureus* (MRSA) and penicillin (PEN)-R *S. pneumoniae* (SPN).

Methods: 1085 consecutive, non-duplicate isolates from CARTI (n=942) and blood cultures (n=143, including; SPN and *H. influenzae* [HI]) were collected in 2009 from 25 hospitals located in 13 EU countries. Isolates included: SPN (n=581; 16.4% PEN-R [MIC, ≥2 mg/L]), HI (n=292; 16.1% β-lactamase [BL] producers), *M. catarrhalis* (MCAT; n=134) and *S. aureus* (n=78 [44.9% MRSA]). All isolates were susceptibility (S) tested using reference CLSI broth microdilution methods against CPT and comparators for CARTI treatment.

Results: CPT inhibited all SPN, MCAT and HI isolates at 0.25, 0.25 and 0.03 mg/L, respectively (Table). CPT was the most active β-lactam tested against SPN ($MIC_{50/90}$, ≤0.008/0.12 mg/L), exhibiting 8-, 16- and 64-fold lower MICs than ceftriaxone (CRO; $MIC_{50/90}$, ≤0.25/1 mg/L), amoxicillin/clavulanate (A/C; $MIC_{50/90}$, ≤1/2 mg/L) and cefuroxime ($MIC_{50/90}$, ≤1/8 mg/L), respectively. Against PEN-R SPN (n=95), CPT ($MIC_{50/90}$, 0.25/0.25 mg/L) was at least 4- and 8-fold more potent than CRO ($MIC_{50/90}$, 1/2 mg/L) and A/C ($MIC_{50/90}$, 2/8 mg/L), respectively. CPT was very active against HI (MIC_{90}, 0.015 mg/L), regardless of BL production. BL-producing HI isolates showed CPT MIC values slightly higher ($MIC_{50/90}$, 0.015/0.03 mg/L) than those of non-BL-producers ($MIC_{50/90}$, ≤0.008/0.015 mg/L). CPT was very active against MCAT isolates ($MIC_{50/90}$, 0.03/0.12 mg/L), most (>90%) BL-positive. All methicillin-S *S. aureus* (MSSA) were inhibited by CPT at ≤0.5 mg/L and the highest CPT MIC among MRSA was only 2 mg/L ($MIC_{50/90}$, 1/2 mg/L). Against MSSA, CPT ($MIC_{50/90}$, 0.25/0.5 mg/L) was 8- to 16-fold more potent than CRO ($MIC_{50/90}$, 4/8 mg/L) and cefepime (CPM; $MIC_{50/90}$, 2/4 mg/L), respectively.

Conclusion: CPT was the most active β-lactam agent tested and demonstrated good coverage against contemporary (2009) CARTI organisms recovered from EU hospitals. CPT showed excellent *in vitro* activity against all PEN-R SPN, BL-producing HI and MCAT, MSSA and MRSA isolates tested.

Organism (no. tested)	Cumulative % inhibited at ceftaroline MIC (mg/L) of:								
	≤0.008	0.015	0.03	0.06	0.12	0.25	0.5	1	2
S. pneumoniae (581)	60.9	72.5	77.6	81.1	95.3	100.0	-	-	-
Penicillin-S (412)[a]	84.9	97.6	99.5	99.8	100.0	-	-	-	-
Penicillin-I (74)[a]	5.4	25.7	77.0	98.6	100.0	-	-	-	-
Penicillin-R (95)[a]	0.0	0.0	0.0	3.2	72.6	100.0	-	-	-
H. influenzae (292)	67.1	94.5	100.0	-	-	-	-	-	-
BL-negative (245)	74.3	97.6	100.0	-	-	-	-	-	-
BL-positive (47)	29.8	78.7	100.0	-	-	-	-	-	-
M. catarrhalis (134)	8.2	15.7	53.0	85.0	99.2	100.0	-	-	-
S. aureus (78)	0.0	0.0	0.0	0.0	0.0	50.0	64.1	87.2	100.0
MSSA (43)	0.0	0.0	0.0	0.0	0.0	88.4	100.0	-	-
MRSA (35)	0.0	0.0	0.0	0.0	0.0	2.9	20.0	71.4	100.0

[a]Criteria for S/I/R were according to CLSI oral penicillin V breakpoints (MIC, ≤0.06/0.12-1/≥2 mg/L). I = intermediate; R = resistant; S = susceptible

Introduction

Respiratory tract infections (RTIs) are very common in communities and healthcare facilities, with mortality rates as high as 76% reported under some circumstances. Inadequate (insufficient level of agent at the site of infection), inappropriate (pathogen resistant to agent) or delayed antimicrobial therapy is associated with increased morbidity and mortality, as well as increased length of hospital stay and costs.

Streptococcus pneumoniae, Haemophilus influenzae and *Staphylococcus aureus* are among the dominant pathogens causing RTIs in community and healthcare settings. The emergence of multidrug-resistant (MDR) organisms among these bacterial species, such as MDR *S. pneumoniae* (MDRSP) and methicillin-resistant *S. aureus* (MRSA) are limiting the use of currently available β-lactams and agents from other antimicrobial classes.

Ceftaroline fosamil is the prodrug form of ceftaroline, a novel, broad-spectrum cephalosporin with *in vitro* activity against pathogens causing community-acquired pneumonia (CAP), including MDRSP and MRSA. In two phase 3 trials, ceftaroline was shown to be non-inferior to ceftriaxone for the treatment of patients with CAP requiring hospitalization. Ceftaroline fosamil has been approved by the United States Food and Drug Administration for acute bacterial skin and soft tissue infections and CAP.

In this study, we evaluated ceftaroline and comparator antimicrobial agents against 1085 isolates from bacterial species associated with community-acquired RTIs collected in European hospitals during 2009 as part of the Assessing Worldwide Antimicrobial Resistance Evaluation (AWARE) programme, a global ceftaroline surveillance study.

Materials and methods

Organism collection: A total of 942 isolates recovered from RTIs and 143 blood culture isolates (*S. pneumoniae* and *H. influenzae*) were tested. These isolates were collected from patients in 25 medical centres located in 13 countries in 2009, including 11 European countries (Belgium, France, Germany, Ireland, Italy, Poland, Portugal, Spain, Sweden, Switzerland, UK), Israel and Turkey. Isolates included *S. pneumoniae* (n=581), *H. influenzae* (n=292), *Moraxella catarrhalis* (n=134) and *S. aureus* (n=78).

Susceptibility testing: Isolates were susceptibility tested against ceftaroline and comparator agents by reference broth microdilution methods as described by Clinical and Laboratory Standards Institute (CLSI) M07-A8 (2009). CLSI interpretations were based on M100-S21 and M45-A breakpoints. European Committee on Antimicrobial Susceptibility Testing (EUCAST) breakpoints (2011) were also applied. *S. pneumoniae* isolates were tested in Mueller-Hinton broth supplemented with 3–5% lysed horse blood, and *H. influenzae* isolates were tested in Haemophilus Test Media, while *S. aureus* and *M. catarrhalis* isolates were tested in cation-adjusted Mueller-Hinton broth.

Concurrent testing of quality control (QC) strains assured proper test conditions were applied. These QC strains included *S. aureus* ATCC 29213, *S. pneumoniae* ATCC 49619, and *H. influenzae* ATCC 49247 and 49766. All QC results were within published ranges.

Table 1. *Summary of ceftaroline activity tested against contemporary (2009) European organisms associated with RTIs*

Organism/region (no. tested)	No. of organisms (cumulative %) inhibited at ceftaroline MIC (mg/L) of:									
	≤0.008	0.015	0.03	0.06	0.12	0.25	0.5	1	2	≥4
S. pneumoniae (581)	354 (60.9)	67 (72.5)	30 (77.6)	20 (81.1)	83 (95.4)	27 (100.0)	-	-	-	-
Penicillin-susceptible (412)[a]	350 (84.9)	52 (97.6)	8 (99.5)	1 (99.8)	1 (100.0)	-	-	-	-	-
Penicillin-intermediate (74)[a]	4 (5.4)	15 (25.7)	22 (55.4)	16 (77.0)	16 (98.6)	1 (100.0)	-	-	-	-
Penicillin-resistant (95)[a]	0 (0.0)	0 (0.0)	0 (0.0)	3 (3.2)	66 (72.6)	26 (100.0)	-	-	-	-
H. influenzae (292)	196 (67.1)	80 (94.5)	16 (100.0)	-	-	-	-	-	-	-
β-lactamase-negative (245)	182 (74.3)	57 (97.6)	6 (100.0)	-	-	-	-	-	-	-
β-lactamase-positive (47)	14 (29.8)	23 (78.7)	10 (100.0)	-	-	-	-	-	-	-
M. catarrhalis (134)	11 (8.2)	10 (15.7)	50 (53.0)	43 (85.1)	19 (99.3)	1 (100.0)	-	-	-	-
S. aureus (78)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	39 (50.0)	11 (64.1)	18 (87.2)	10 (100.0)	-
Oxacillin-susceptible (43)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	38 (88.4)	5 (100.0)	-	-	-
Oxacillin-resistant (35)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.9)	6 (20.0)	18 (71.4)	10 (100.0)	-

[a]Criteria for S/I/R were according to CLSI oral penicillin V breakpoints (MIC, ≤0.06/0.12-1/≥2 mg/L).

Table 2. *Activity of ceftaroline and comparator antimicrobial agents when tested against contemporary (2009) European organisms associated with RTIs*

Antimicrobial agent	MIC_{50} (mg/L)	MIC_{90} (mg/L)	Range	CLSI[a] %S / %R	EUCAST[a] %S / %R
S. pneumoniae (n=581)					
Ceftaroline	≤0.008	0.12	≤0.008 – 0.25	- / -	- / -
Penicillin[b]	≤0.03	2	≤0.03 – >4	95.7 / 0.3	- / -
Penicillin[c]	≤0.03	2	≤0.03 – >4	70.9 / 16.4	70.9 / 4.3
Amoxicillin/clavulanate	≤1	2	≤1 – 16	93.6 / 2.9	70.9 / 14.4
Ceftriaxone	≤0.25	1	≤0.25 – 4	92.3 / 0.5	81.8 / 0.5
Cefuroxime	≤2	8	≤2 – >8	75.4 / 21.6	75.4 / 24.6
Erythromycin	≤0.25	>2	≤0.25 – >2	73.7 / 25.6	73.7 / 25.6
Azithromycin	≤0.5	>4	≤0.5 – >4	71.1 / 28.7	71.1 / 28.9
Clindamycin	≤0.25	>2	≤0.25 – >2	80.7 / 18.4	81.6 / 18.4
Levofloxacin	1	1	≤0.5 – >4	99.1 / 0.3	99.1 / 0.9
Trimethoprim/sulfamethoxazole	≤0.5	>2	≤0.5 – >2	76.7 / 14.7	83.1 / 14.7
Penicillin-susceptible *S. pneumoniae* (n=412)					
Ceftaroline	≤0.008	0.015	≤0.008 – 0.12	- / -	- / -
Penicillin[b]	≤0.03	≤0.03	≤0.03 – 0.06	100.0 / 0.0	- / -
Penicillin[c]	≤0.03	≤0.03	≤0.03 – 0.06	100.0 / 0.0	100.0 / 0.0
Amoxicillin/clavulanate	≤1	≤1	≤1 – 2	100.0 / 0.0	100.0 / 0.0
Ceftriaxone	≤0.25	≤0.25	≤0.25 – 0.5	100.0 / 0.0	100.0 / 0.0
Cefuroxime	≤2	≤2	≤2 – 4	97.2 / 0.7	97.2 / 2.8
Erythromycin	≤0.25	≤0.25	≤0.25 – >2	93.7 / 6.1	93.7 / 6.1
Azithromycin	≤0.5	≤0.5	≤0.5 – >4	92.3 / 7.3	92.3 / 7.7
Clindamycin	≤0.25	≤0.25	≤0.25 – >2	95.6 / 4.1	95.9 / 4.1
Levofloxacin	1	1	≤0.5 – 4	99.8 / 0.0	99.8 / 0.2
Trimethoprim/sulfamethoxazole	≤0.5	≤0.5	≤0.5 – >2	91.0 / 3.4	94.9 / 3.4
Penicillin-intermediate *S. pneumoniae* (n=74)					
Ceftaroline	0.03	0.12	≤0.008 – 0.25	- / -	- / -
Penicillin[b]	0.25	1	0.12 – 1	100.0 / 0.0	- / -
Penicillin[c]	0.25	1	0.12 – 1	0.0 / 0.0	0.0 / 0.0
Amoxicillin/clavulanate	≤1	2	≤1 – 4	98.6 / 0.0	0.0 / 5.4
Ceftriaxone	≤0.25	1	≤0.25 – 2	94.6 / 0.0	83.8 / 0.0
Cefuroxime	≤2	4	≤2 – >8	69.4 / 19.4	69.4 / 30.6
Erythromycin	>2	>2	≤0.25 – >2	29.7 / 66.2	29.7 / 66.2
Azithromycin	>4	>4	≤0.5 – >4	34.4 / 65.6	34.4 / 65.6
Clindamycin	2	>2	≤0.25 – >2	47.3 / 52.7	47.3 / 52.7
Levofloxacin	1	1	≤0.5 – >4	97.3 / 2.7	97.3 / 2.7
Trimethoprim/sulfamethoxazole	≤0.5	>2	≤0.5 – >2	70.3 / 25.7	74.3 / 25.7
Penicillin-resistant *S. pneumoniae* (n=95)					
Ceftaroline	0.12	0.25	0.06 – 0.25	- / -	- / -
Penicillin[b]	2	4	2 – >4	73.7 / 2.1	- / -
Penicillin[c]	2	4	2 – >4	0.0 / 100.0	0.0 / 26.3
Amoxicillin/clavulanate	2	8	≤1 – 16	62.1 / 17.9	0.0 / 84.2
Ceftriaxone	1	2	≤0.25 – 4	56.8 / 3.2	1.1 / 3.2
Cefuroxime	8	8	4 – >8	0.0 / 100.0	0.0 / 100.0
Erythromycin	>2	>2	≤0.25 – >2	21.1 / 78.9	21.1 / 78.9
Azithromycin	>4	>4	≤0.5 – >4	21.8 / 78.2	21.8 / 78.2
Clindamycin	>2	>2	≤0.25 – >2	42.1 / 53.7	46.3 / 53.7
Levofloxacin	1	1	≤0.5 – 4	97.9 / 0.0	97.9 / 2.1
Trimethoprim/sulfamethoxazole	>2	>2	≤0.5 – >2	20.0 / 54.7	38.9 / 54.7
H. influenzae (n=292)					
Ceftaroline	≤0.008	0.015	≤0.008 – 0.03	- / -	- / -
Ampicillin	≤1	>16	≤1 – >16	83.9 / 16.1	83.9 / 16.1
Amoxicillin/clavulanate	≤1	≤1	≤1 – 4	100.0 / 0.0	91.1 / 8.9
Ceftriaxone	≤0.25	≤0.25	≤0.25 – 1	100.0 / -	99.7 / 0.3
Cefuroxime	≤2	≤2	≤2 – 8	99.7 / 0.0	82.9 / 5.8
Azithromycin	1	2	≤0.5 – >4	99.2 / -	11.4 / 0.8
Levofloxacin	≤0.5	≤0.5	≤0.5	100.0 / -	100.0 / 0.0
Trimethoprim/sulfamethoxazole	≤0.5	>2	≤0.5 – >2	74.7 / 19.5	74.7 / 22.6
β-lactamase-positive *H. influenzae* (n=47)					
Ceftaroline	0.015	0.03	≤0.008 – 0.03	- / -	- / -
Ampicillin	>16	>16	2 – >16	0.0 / 100.0	0.0 / 100.0
Amoxicillin/clavulanate	≤1	2	≤1 – 4	100.0 / 0.0	83.0 / 17.0
Ceftriaxone	≤0.25	≤0.25	≤0.25	100.0 / -	100.0 / 0.0
Cefuroxime	≤2	2	≤2 – 2	100.0 / 0.0	78.7 / 0.0
Azithromycin	1	2	≤0.5 – >4	94.7 / -	2.6 / 5.3
Levofloxacin	≤0.5	≤0.5	≤0.5	100.0 / -	100.0 / 0.0
Trimethoprim/sulfamethoxazole	≤0.5	>2	≤0.5 – >2	72.3 / 23.4	72.3 / 23.4

Table 2. *(Cont)*

Antimicrobial agent	MIC_{50} (mg/L)	MIC_{90} (mg/L)	Range	CLSI[a] %S / %R	EUCAST[a] %S / %R
β-lactamase-negative *H. influenzae* (n=245)					
Ceftaroline	≤0.008	0.015	≤0.008 – 0.03	- / -	- / -
Amoxicillin/clavulanate	≤1	≤1	≤1 – 4	100.0 / 0.0	92.7 / 7.3
Ceftriaxone	≤0.25	≤0.25	≤0.25 – 1	100.0 / -	99.6 / 0.4
Cefuroxime	≤2	≤2	≤2 – 8	99.6 / 0.0	83.7 / 6.9
Azithromycin	1	2	≤0.5 – 4	100.0 / -	13.1 / 0.0
Levofloxacin	≤0.5	≤0.5	≤0.5	100.0 / -	100.0 / 0.0
Trimethoprim/sulfamethoxazole	≤0.5	>2	≤0.5 – >2	75.1 / 18.8	75.1 / 22.4
M. catarrhalis (n=134)					
Ceftaroline	0.03	0.12	≤0.008 – 0.25	- / -	- / -
Penicillin	4	>4	≤0.03 – >4	- / -	- / -
Amoxicillin/clavulanate	≤1	≤1	≤1	100.0 / -	100.0 / 0.0
Ceftriaxone	≤0.25	0.5	≤0.25 – 1	100.0 / -	100.0 / 0.0
Cefuroxime	≤1	2	≤1 – 4	100.0 / -	88.1 / 1.5
Erythromycin	0.12	0.25	≤0.06 – 0.5	100.0 / -	95.5 / 0.0
Levofloxacin	≤0.5	≤0.5	≤0.5 – 1	100.0 / -	100.0 / 0.0
Trimethoprim/sulfamethoxazole	≤0.5	≤0.5	≤0.5 – >2	91.0 / 0.0	91.0 / 2.2
S. aureus (n=78)					
Ceftaroline	0.25	2	0.25 – 2	- / -	- / -
Oxacillin	1	>2	≤0.25 – >2	55.1 / 44.9	55.1 / 44.9
Ceftriaxone	8	>32	2 – >32	55.1 / 44.9	55.1 / 44.9
Cefepime	4	>16	2 – >16	55.1 / 44.9	55.1 / 44.9
Imipenem	≤0.12	>8	≤0.12 – >8	55.1 / 44.9	55.1 / 44.9
Erythromycin	>2	>2	≤0.25 – >2	47.4 / 51.3	48.7 / 51.3
Clindamycin	≤0.25	>2	≤0.25 – >2	79.5 / 20.5	79.5 / 20.5
Levofloxacin	≤0.5	>4	≤0.5 – >4	53.8 / 44.9	53.8 / 44.9
Trimethoprim/sulfamethoxazole	≤0.5	≤0.5	≤0.5 – >2	92.3 / 7.7	92.3 / 7.7
Linezolid	1	2	1 – 2	100.0 / 0.0	100.0 / 0.0
Vancomycin	1	1	0.5 – 2	100.0 / 0.0	100.0 / 0.0
MSSA (n=43)					
Ceftaroline	0.25	0.5	0.25 – 0.5	- / -	- / -
Ceftriaxone	4	8	2 – 8	100.0 / 0.0	100.0 / 0.0
Cefepime	2	4	2 – 8	100.0 / 0.0	100.0 / 0.0
Imipenem	≤0.12	≤0.12	≤0.12	100.0 / 0.0	100.0 / 0.0
Erythromycin	0.5	>2	≤0.25 – >2	81.4 / 18.6	81.4 / 18.6
Clindamycin	≤0.25	≤0.25	≤0.25	100.0 / 0.0	100.0 / 0.0
Levofloxacin	≤0.5	≤0.5	≤0.5 – >4	95.3 / 2.3	95.3 / 2.3
Trimethoprim/sulfamethoxazole	≤0.5	≤0.5	≤0.5	100.0 / 0.0	100.0 / 0.0
Linezolid	2	2	1 – 2	100.0 / 0.0	100.0 / 0.0
Vancomycin	1	1	0.5 – 2	100.0 / 0.0	100.0 / 0.0
MRSA (n=35)					
Ceftaroline	1	2	0.25 – 2	- / -	- / -
Ceftriaxone	>32	>32	8 – >32	0.0 / 100.0	0.0 / 100.0
Cefepime	>16	>16	4 – >16	0.0 / 100.0	0.0 / 100.0
Imipenem	>8	>8	≤0.12 – >8	0.0 / 100.0	0.0 / 100.0
Erythromycin	>2	>2	≤0.25 – >2	5.7 / 91.4	8.6 / 91.4
Clindamycin	≤0.25	>2	≤0.25 – >2	54.3 / 45.7	54.3 / 45.7
Levofloxacin	>4	>4	≤0.5 – >4	2.9 / 97.1	2.9 / 97.1
Trimethoprim/sulfamethoxazole	≤0.5	>2	≤0.5 – >2	82.9 / 17.1	82.9 / 17.1
Linezolid	1	2	1 – 2	100.0 / 0.0	100.0 / 0.0
Vancomycin	1	1	0.5 – 2	100.0 / 0.0	100.0 / 0.0

R=resistant; S=susceptible. [a]Criteria as published by the CLSI [2010] and EUCAST [2010]. [b]Criteria as published by the CLSI [2010] for 'Penicillin parenteral (non-meningitis)'. [c]Criteria as published by the CLSI [2010] for 'Penicillin (oral penicillin V)'.

Results

- Ceftaroline was highly potent against *S. pneumoniae*, inhibiting all strains at ≤0.25 mg/L (Table 1). Additionally, compared with other β-lactams, ceftaroline was the most potent against *S. pneumoniae* (MIC_{90}, 0.12 mg/L; Table 2).
- The MIC range of ceftaroline was slightly lower against penicillin-susceptible *S. pneumoniae* (≤0.008–0.12 mg/L) than against penicillin-resistant strains (0.06–0.25 mg/L; Tables 1 and 2).
- The activity of ceftaroline against penicillin-resistant *S. pneumoniae* (MIC_{50}, 0.12 mg/L and MIC_{90}, 0.25 mg/L) was 8- and 16-fold greater than the activities of ceftriaxone (MIC_{50}, 1 mg/L and MIC_{90}, 2 mg/L) and amoxicillin/clavulanic acid (MIC_{50}, 2 mg/L and MIC_{90}, 8 mg/L), respectively (Table 2).
- Overall, ceftaroline was highly potent against *H. influenzae* (MIC_{50}, ≤0.008 mg/L and MIC_{90}, 0.015 mg/L; Table 2), with all strains inhibited at ≤0.03 mg/L of ceftaroline, regardless of β-lactamase production (Table 1).
- β-lactamase-producing *H. influenzae* strains (n=47) exhibited ceftaroline MIC values slightly higher (MIC_{50}, 0.015 mg/L and MIC_{90}, 0.03 mg/L) than those of non-β-lactamase-producing, ampicillin-susceptible strains (n=245; MIC_{50}, ≤0.008 mg/L and MIC_{90}, 0.015 mg/L (Table 2), although both were highly susceptible.
- The vast majority of *M. catarrhalis* strains exhibited elevated penicillin MIC values (β-lactamase-positive; data not shown). The highest ceftaroline MIC value for these organisms was 0.25 mg/L (Table 1).
- Ceftaroline was the most potent β-lactam agent tested against *M. catarrhalis* (MIC_{90}, 0.12 mg/L); it was 4- to 16-fold more active than ceftriaxone (MIC_{90}, 0.5 mg/L) or cefuroxime (MIC_{90}, 2 mg/L; Table 2).
- Ceftaroline was generally highly potent against *S. aureus* (MIC_{50}, 0.25 mg/L and MIC_{90}, 2 mg/L; Table 2). The highest ceftaroline MIC value among methicillin-susceptible *S. aureus* (MSSA) strains was 0.5 mg/L (five isolates); 88.4% of MSSA strains were inhibited at a ceftaroline MIC of ≤0.25 mg/L (Table 1).
- Against MRSA strains, ceftaroline MIC values ranged from 0.25 to 2 mg/L (MIC_{50}, 1 mg/L and MIC_{90}, 2 mg/L; Table 2).

Conclusions

- Ceftaroline showed *in vitro* activity against pneumococci, including *S. pneumoniae* highly resistant to penicillin (MIC, ≥4 mg/L), and Gram-negative pathogens (*H. influenzae* and *M. catarrhalis*) associated with community-acquired RTIs.
- Although ceftaroline MIC values were higher (approximately 4-fold) among MRSA compared with MSSA, its activity against MRSA was higher than that of other tested cephalosporins.
- These *in vitro* results demonstrate that ceftaroline could be a valuable option for the treatment of bacterial species frequently associated with contemporary RTIs in Europe. The clinical effectiveness of ceftaroline against MRSA and *M. catarrhalis* in CAP has not been established and ceftaroline is not intended for use in this setting.

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