



EUCAST

European Committee
on Antimicrobial
Susceptibility Testing

Streptococcus pneumoniae

Oxacillin 1 μg as screen for
beta-lactam resistance

Version 13.0
January 2026

Streptococcus pneumoniae

MIC and zone diameter correlates

- The following histograms present inhibition zone diameter distributions from EUCAST antimicrobial susceptibility testing. In most, the different colours of the bars indicate different MIC values. In some, the colours of the bars indicate a resistance gene or a resistance mechanism.
- The distributions include data for wild-type isolates and for isolates with acquired resistance mechanisms. A large number of isolates with MIC values close to the edge of the wild-type distribution and/or close to EUCAST clinical breakpoints were intentionally included. These distributions can not be used to infer resistance rates or the performance of the tests with routine isolates.
- For some agents, isolates were tested on more than one occasion, including parallel tests with disks and media from several manufacturers. When this is the case, data are presented as both the “number of isolates tested” and the “total number of MIC-zone diameter correlates”, including replicate tests and parallel tests with disks and media from different sources.

Streptococcus pneumoniae

Materials and methods

- Antimicrobial susceptibility testing was performed on clinical isolates of *Streptococcus pneumoniae*, including isolates with known resistance mechanisms. Disk diffusion was performed on MH-F media according to EUCAST methodology and MIC determination was performed with the ISO broth microdilution method using MH-F broth or gradient tests.
- The following graphs present inhibition zone distributions for oxacillin 1 µg with MIC values for beta-lactam agents as coloured bars.
- The distributions of MIC vs. zone diameter in this presentation are mostly the result of a collaboration between EUCAST, JMI Laboratories (USA) and Laboratory Specialists Inc. (USA).
- This presentation is based on EUCAST Clinical Breakpoint Tables v. 16.0.

Changes from previous version (12.0)

Changes
<ul style="list-style-type: none">• Flow chart updated.• MIC and zone diameter breakpoints changed for oxacillin zone vs. ampicillin iv and amoxicillin iv in endocarditis and meningitis.

Streptococcus pneumoniae

Screen for beta-lactam resistance

- The oxacillin 1 µg disk screening test or benzylpenicillin MIC test shall be used to exclude beta-lactam resistance mechanisms.
- The screening breakpoint for oxacillin 1 µg is S ≥20 mm and for benzylpenicillin MIC S ≤0.06 mg/L.
- When the screen is negative, all beta-lactam agents for which clinical breakpoints are available, including those with a “Note”, can be reported susceptible without further testing, except for cefaclor, which if reported, should be reported as “susceptible, increased exposure” (I).
- When the screen is positive, see flow chart for interpretation.

Streptococcus pneumoniae

Screen for beta-lactam resistance

***Streptococcus pneumoniae*: Flow chart based on screen tests for beta-lactam resistance mechanisms**

Following the flow chart avoids delays in reporting benzylpenicillin susceptibility in *S. pneumoniae*.
Include both the oxacillin (1 µg) and the benzylpenicillin (1 unit) disks already from the beginning.
Read and interpret the benzylpenicillin disk **only** for isolates with oxacillin zones <20 mm.

**Oxacillin 1 µg zone diameter ≥20 mm
(or benzylpenicillin MIC ≤0.06 mg/L)**

Mechanism: excludes all beta-lactam resistance mechanisms

Report susceptible (**S**) to beta-lactam agents for which clinical breakpoints are available, including those with "Note".

Exception: Cefaclor is reported "susceptible, increased exposure" (**I**).

No further testing required.

**Oxacillin 1 µg zone diameter <20 mm
(or benzylpenicillin MIC >0.06 mg/L)**

Mechanism: beta-lactam resistance detected

Report resistant (**R**) to benzylpenicillin, ampicillin iv and amoxicillin iv in endocarditis and meningitis and to phenoxymethylpenicillin (all indications).

For benzylpenicillin in indications other than endocarditis and meningitis,

read and interpret the benzylpenicillin disk:

If zone ≥14 mm, report benzylpenicillin "susceptible, increased exposure" (**I**),

If zone <14 mm, report benzylpenicillin resistant (**R**).

For other beta-lactam agents, see below.

Oxacillin 1 µg zone diameter 9-19 mm

Report susceptible (**S**) without further testing to: ampicillin and amoxicillin (indications other than endocarditis and meningitis) and piperacillin (without and with beta-lactamase inhibitor), cefepime, cefotaxime, ceftaroline, ceftobiprole, ceftriaxone, imipenem and meropenem.

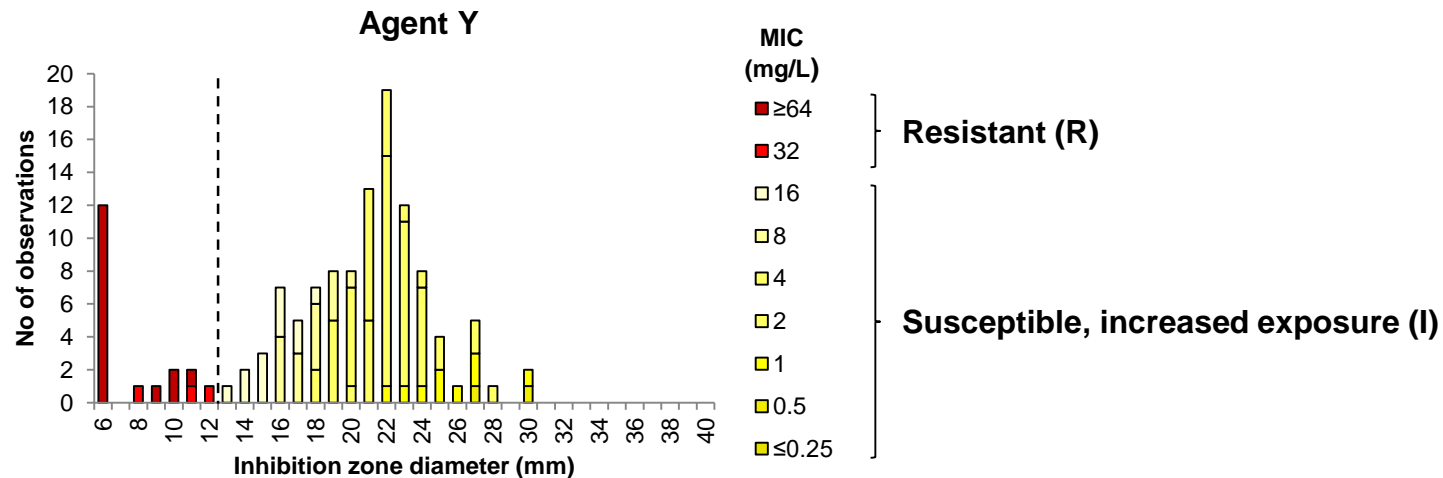
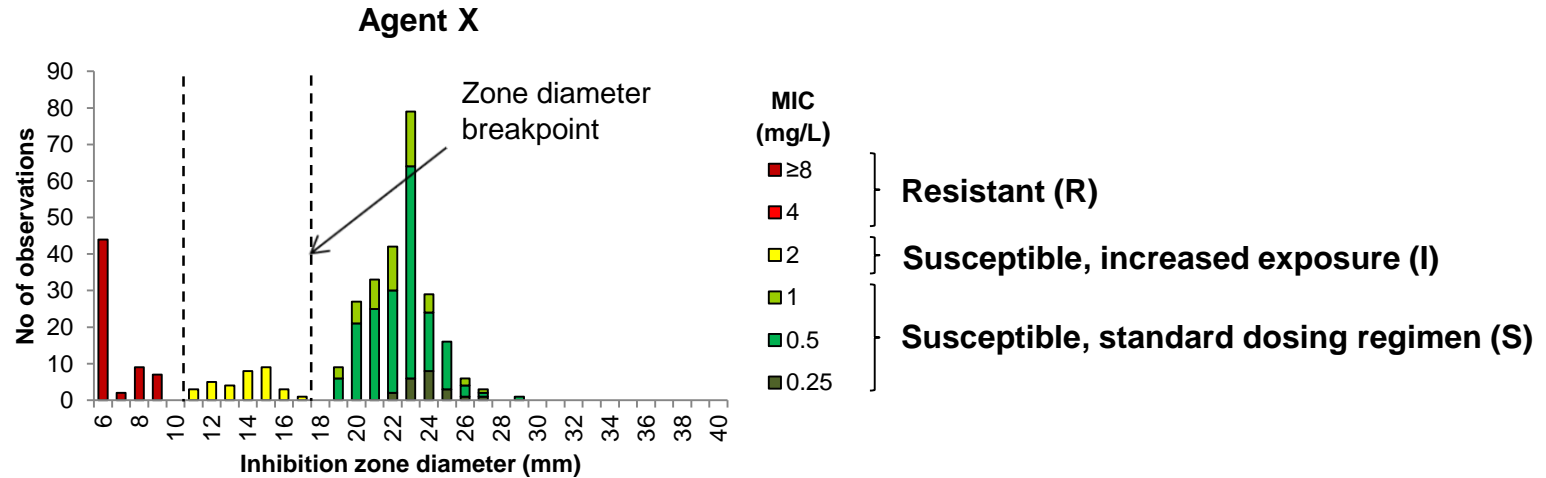
For beta-lactam agents not listed, perform susceptibility test and interpret according to breakpoints.

Oxacillin 1 µg zone diameter <9 mm

For beta-lactam agents other than benzylpenicillin, perform susceptibility testing and interpret according to breakpoints.

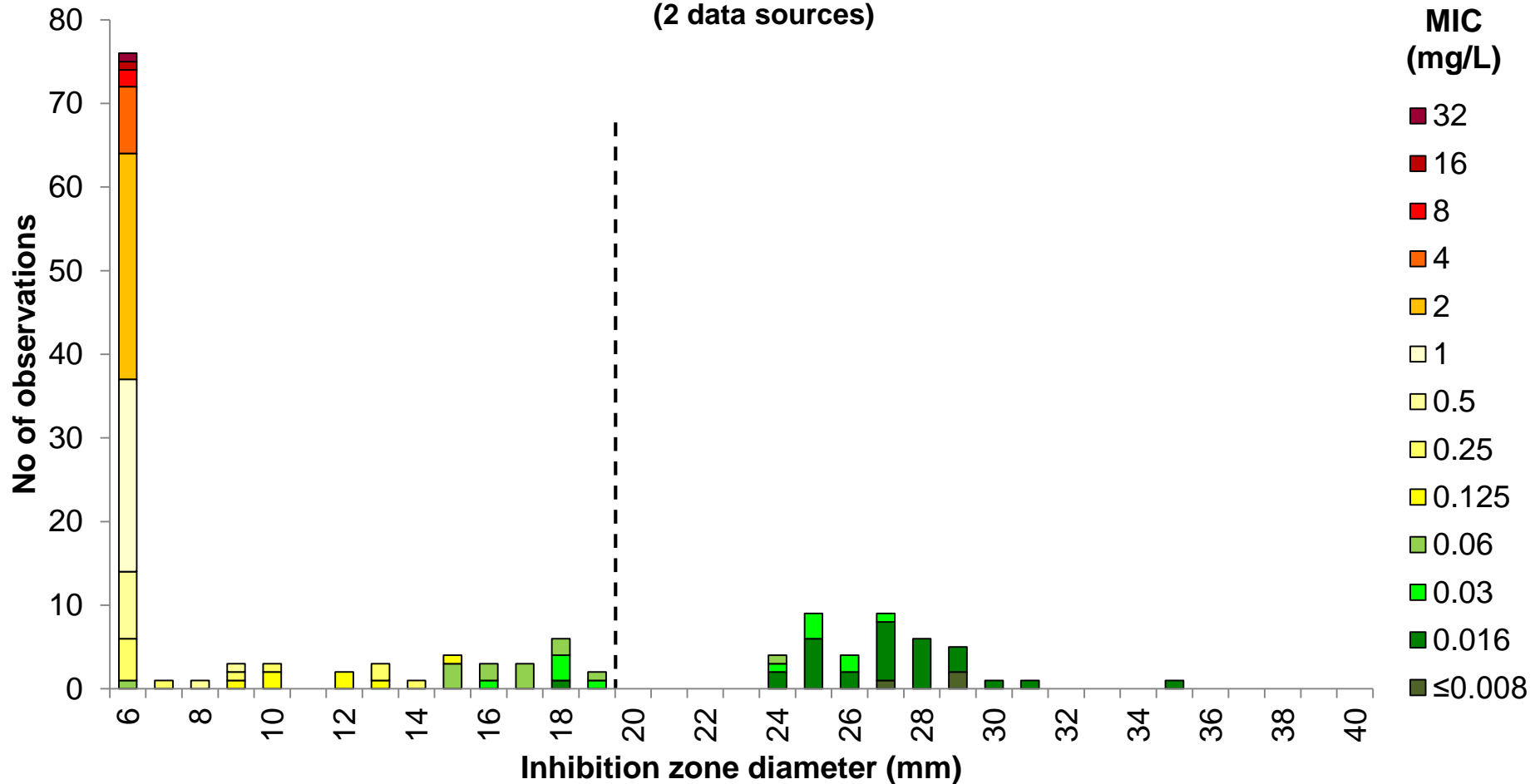
Explanation of graphs:

- These graphs show zone diameter distributions with MIC values or resistance mechanisms as coloured bars. Colours are related to current EUCAST MIC breakpoints.



Oxacillin 1 µg vs. Benzylpenicillin MIC *S. pneumoniae*, 148 isolates

(2 data sources)



Breakpoints (non-endocarditis, non-meningitis)

Benzylpenicillin MIC

S \leq 0.06, R>1 mg/L

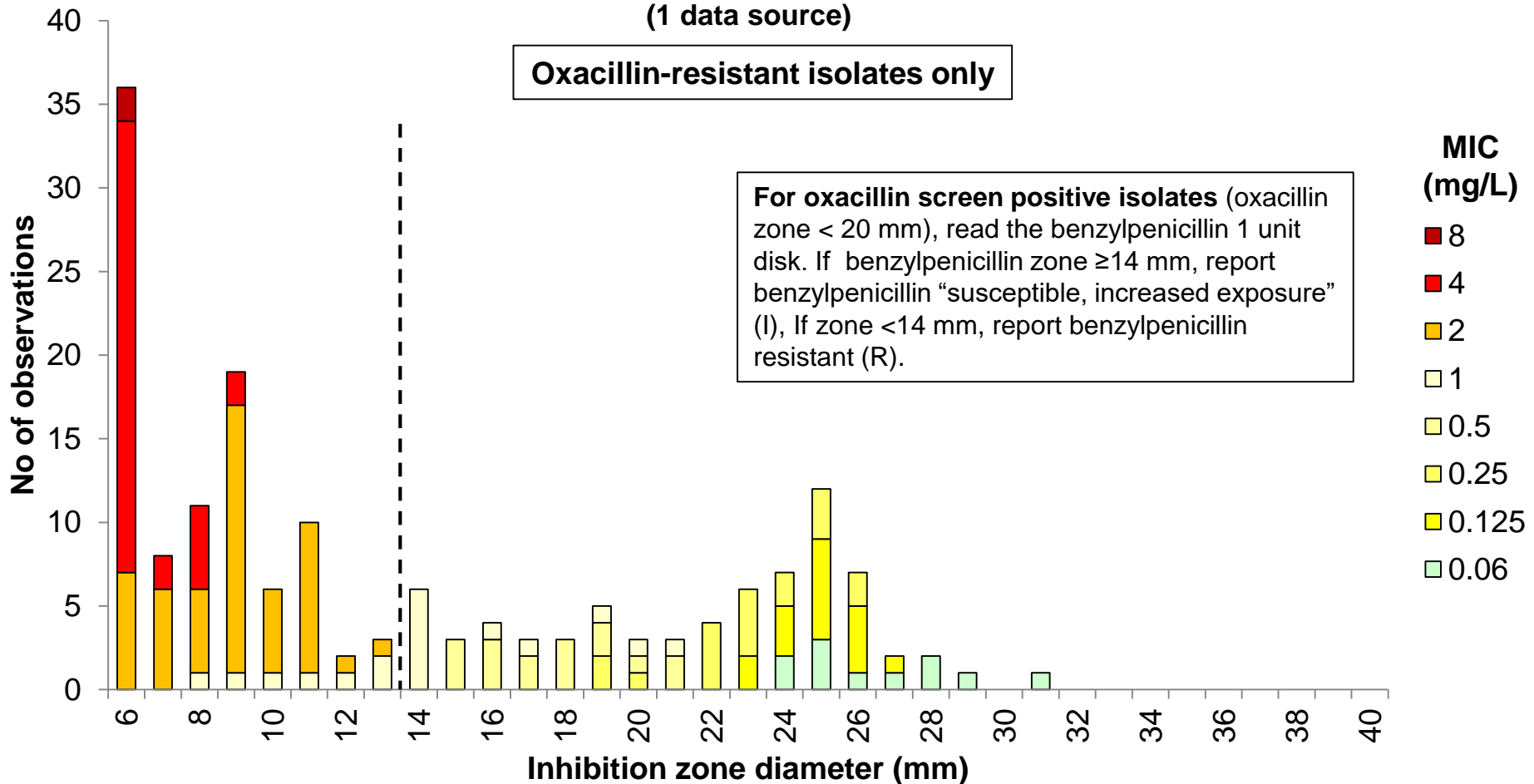
Oxacillin zone diameter (screen)

S \geq 20 mm

Benzylpenicillin 1 unit vs. MIC

S. pneumoniae, 84 isolates (167 correlates)

(1 data source)



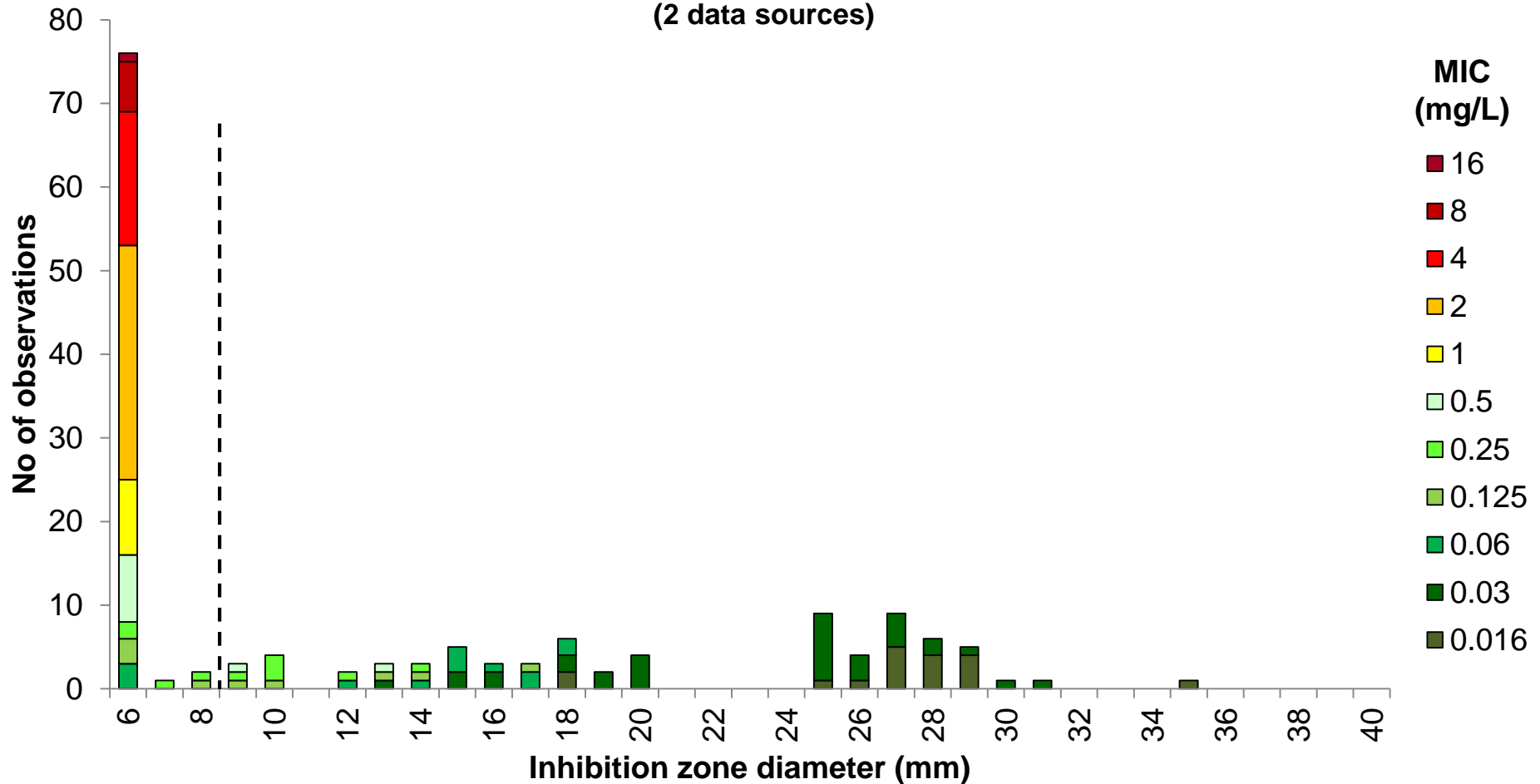
Breakpoints (non-endocarditis, non-meningitis)

MIC $S \leq 0.06$, $R > 1$ mg/L

Zone diameter $R < 14$ mm

Oxacillin 1 µg vs. Ampicillin MIC *S. pneumoniae*, 153 isolates

(2 data sources)



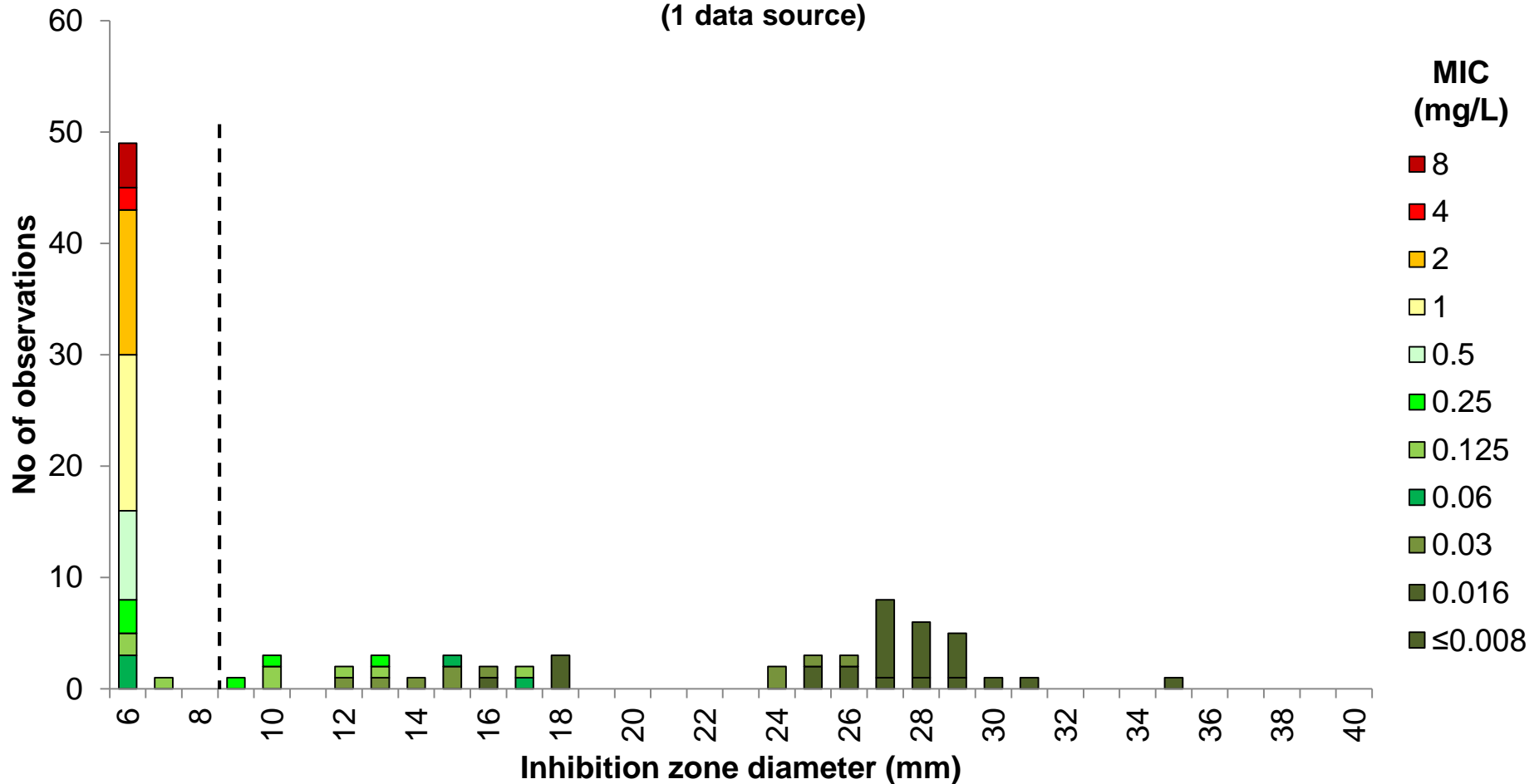
Breakpoints (non-endocarditis, non-meningitis)

Ampicillin MIC $S \leq 0.5$, $R > 1$ mg/L

Oxacillin zone diameter (screen) $S \geq 9$ mm

Oxacillin 1 µg vs. Amoxicillin MIC *S. pneumoniae*, 100 isolates

(1 data source)



Breakpoints (oral)

Amoxicillin MIC

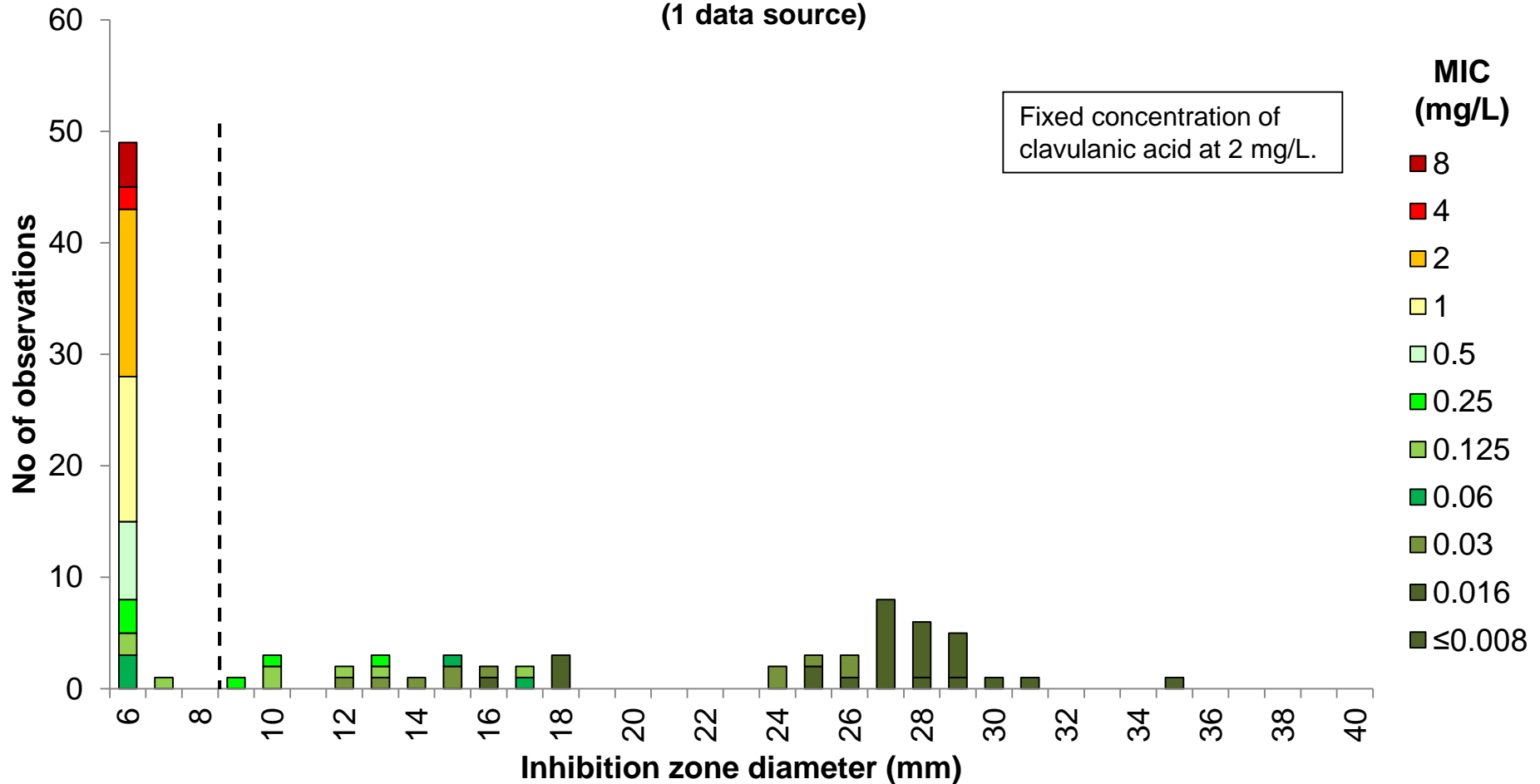
$S \leq 0.5$, $R > 1$ mg/L

Oxacillin zone diameter (screen)

$S \geq 9$ mm

Oxacillin 1 μg vs. Amoxicillin-clavulanic acid MIC *S. pneumoniae*, 100 isolates

(1 data source)



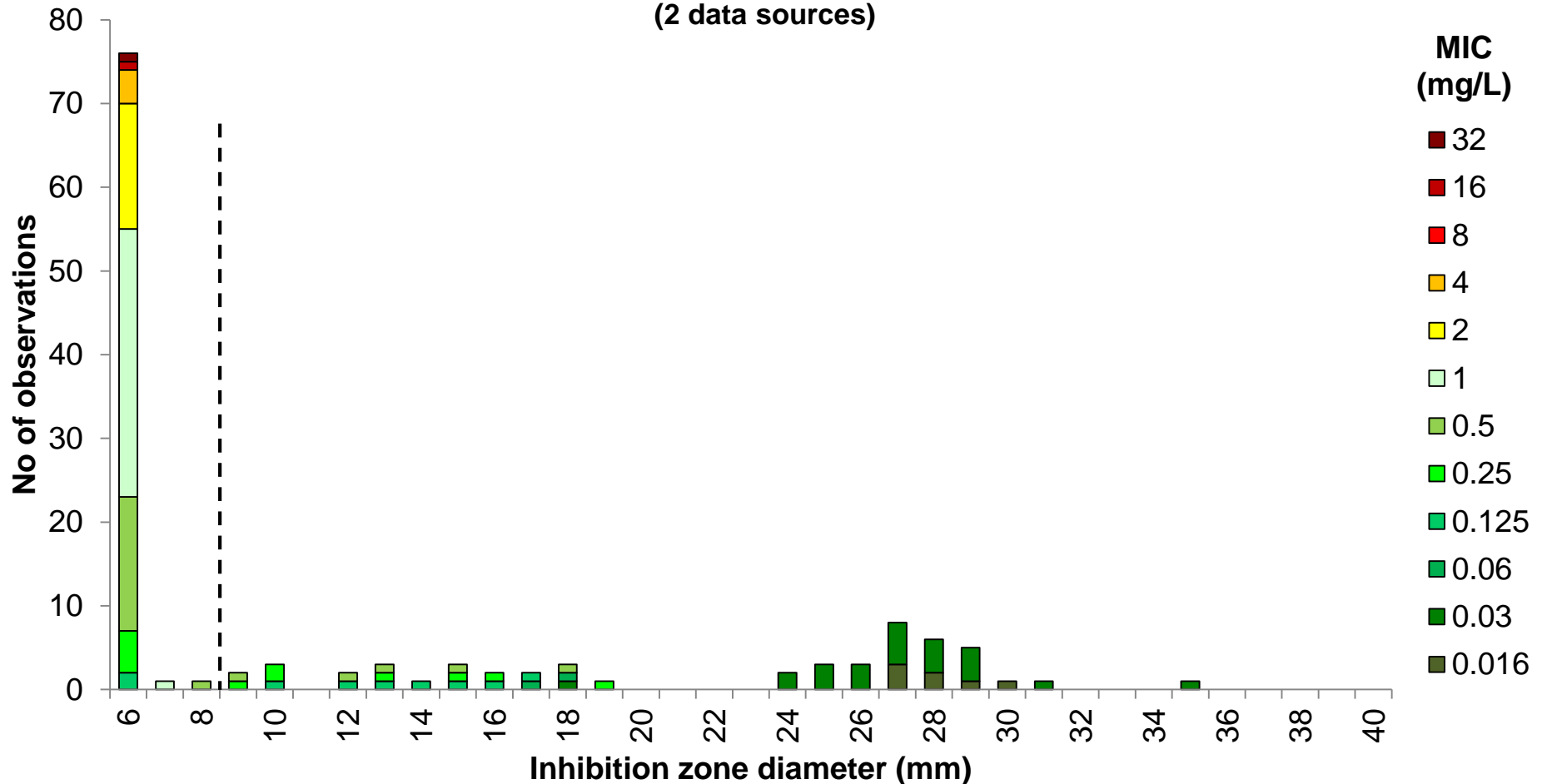
Breakpoints (oral)

Amoxicillin-clavulanic acid MIC $S \leq 0.5$, $R > 1$ mg/L

Oxacillin zone diameter (screen) $S \geq 9$ mm

Oxacillin 1 µg vs. Cefepime MIC *S. pneumoniae*, 130 isolates

(2 data sources)



Breakpoints

Cefepime MIC

S ≤ 1, R > 2 mg/L

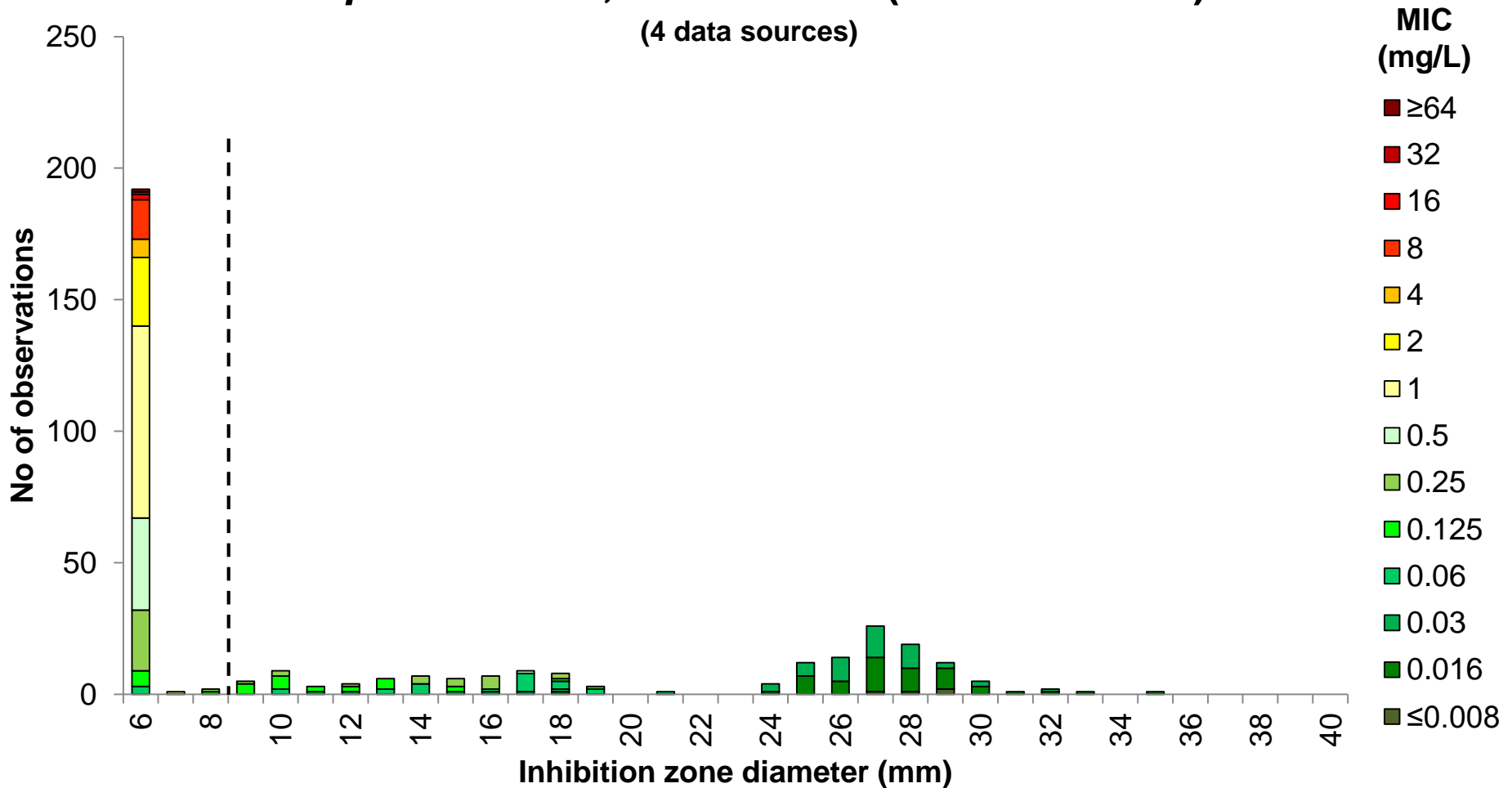
Oxacillin zone diameter (screen)

S ≥ 9 mm

Oxacillin 1 μ g vs. Cefotaxime MIC

S. pneumoniae, 151 isolates (360 correlates)

(4 data sources)

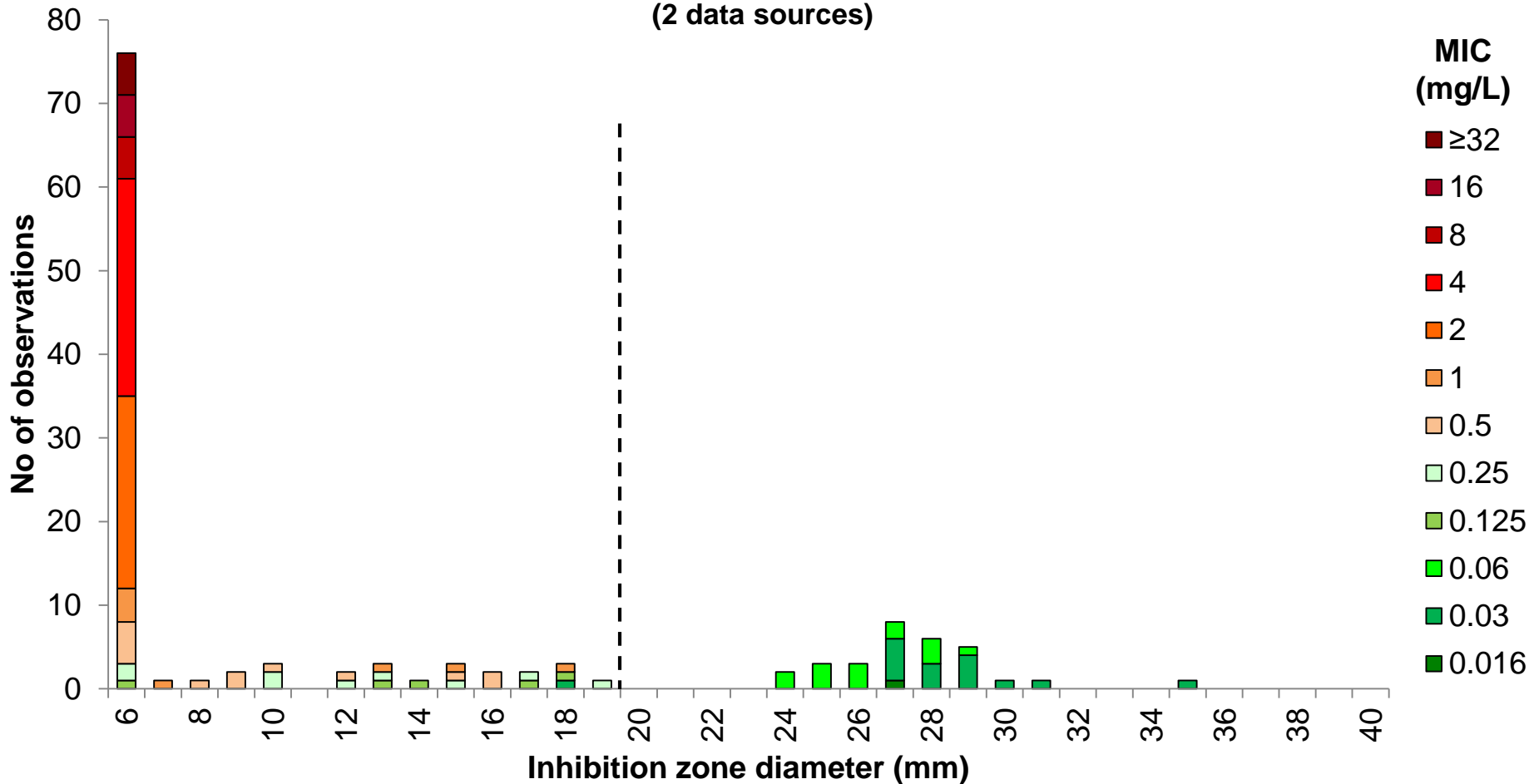


Breakpoints (non-endocarditis, non-meningitis)

Cefotaxime MIC	$S \leq 0.5$, $R > 2$ mg/L
Oxacillin zone diameter (screen)	$S \geq 9$ mm

Oxacillin 1 µg vs. Cefpodoxime MIC *S. pneumoniae*, 130 isolates

(2 data sources)



Breakpoints

Cefpodoxime MIC

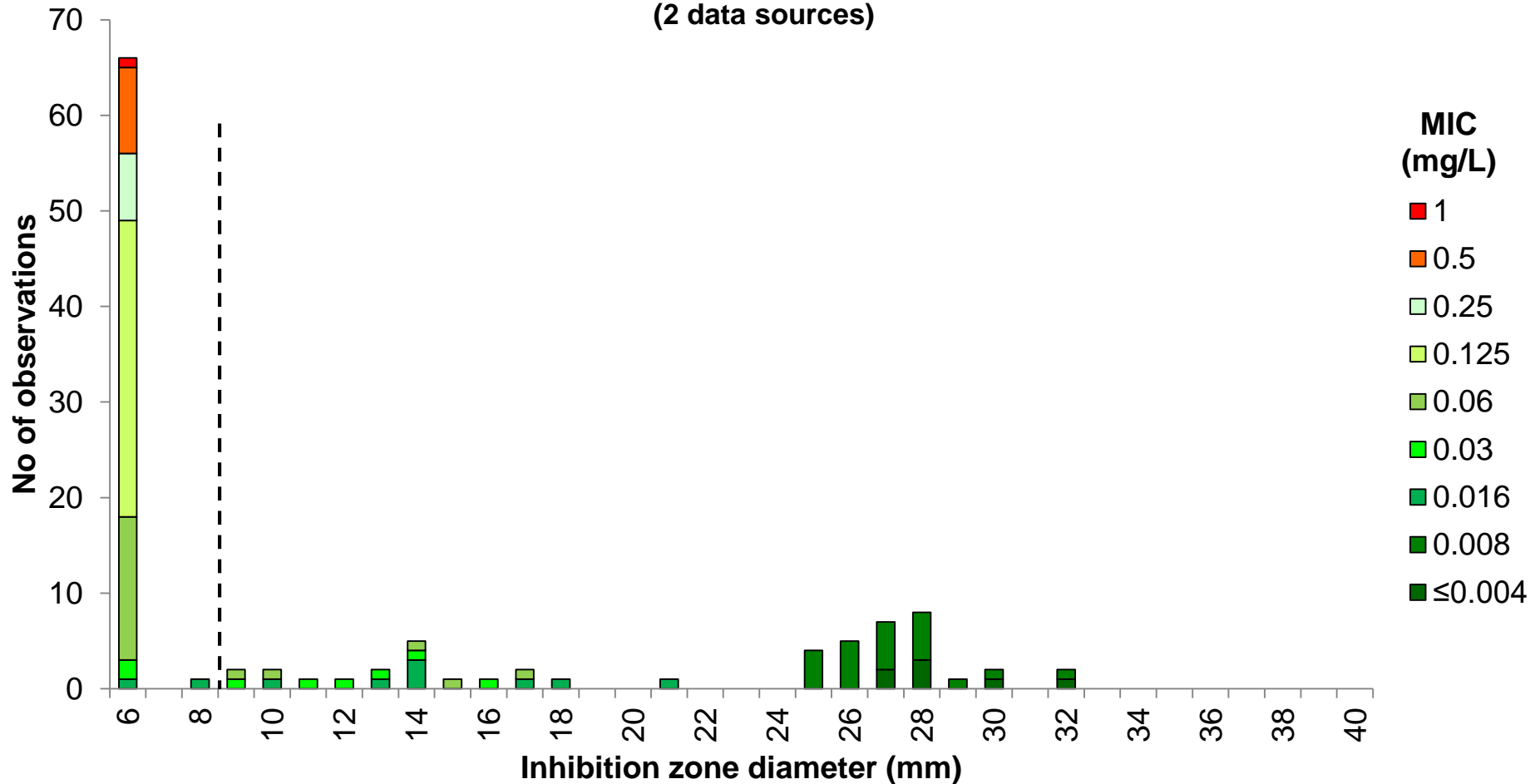
S ≤ 0.25, R > 0.25 mg/L

Oxacillin zone diameter (screen)

S ≥ 20 mm

Oxacillin 1 µg vs. Ceftaroline MIC *S. pneumoniae*, 115 isolates

(2 data sources)



Breakpoints

Ceftaroline MIC

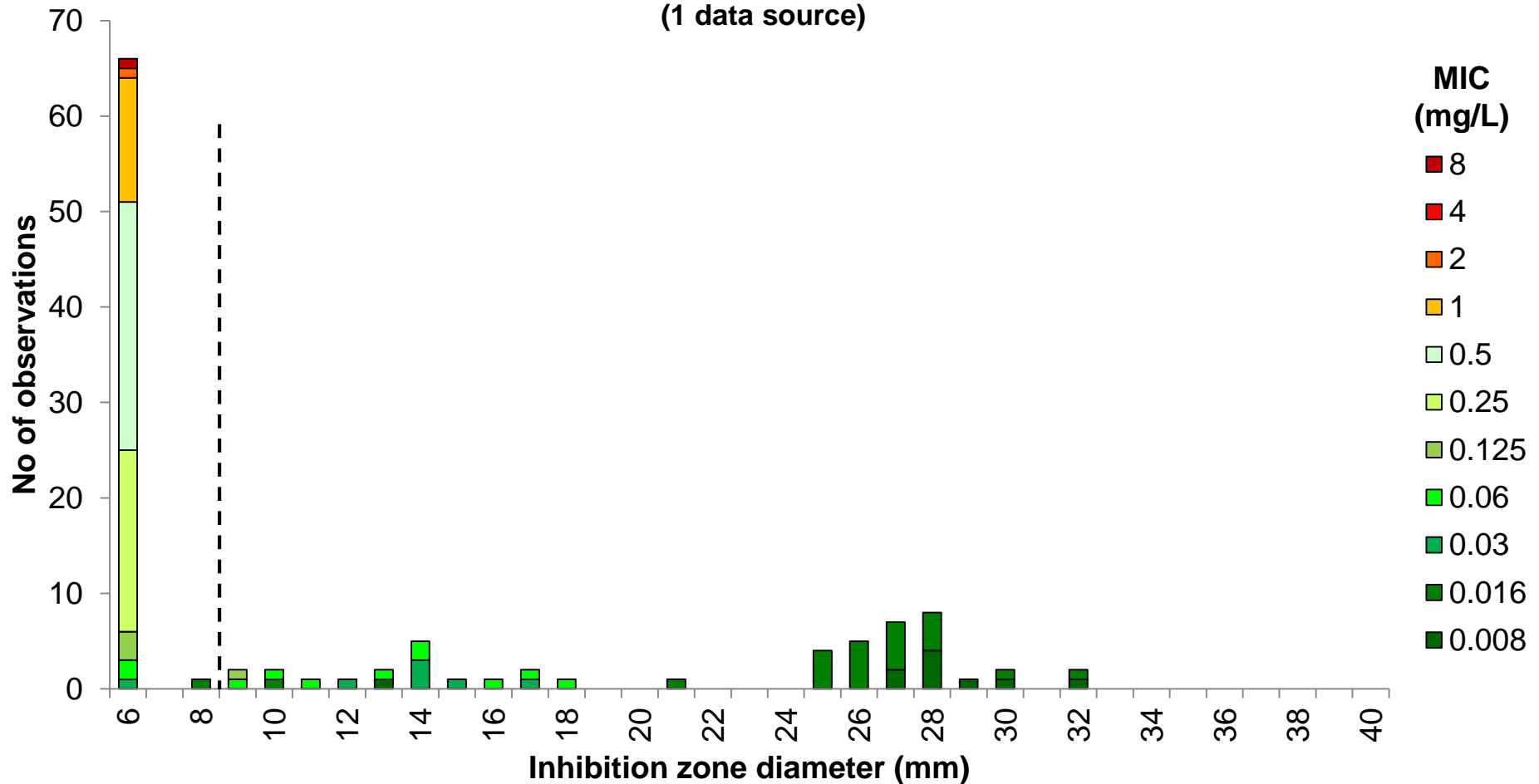
S ≤ 0.25, R > 0.25 mg/L

Oxacillin zone diameter (screen)

S ≥ 9 mm

Oxacillin 1 µg vs. Ceftobiprole MIC *S. pneumoniae*, 115 isolates

(1 data source)



Breakpoints

Ceftobiprole MIC

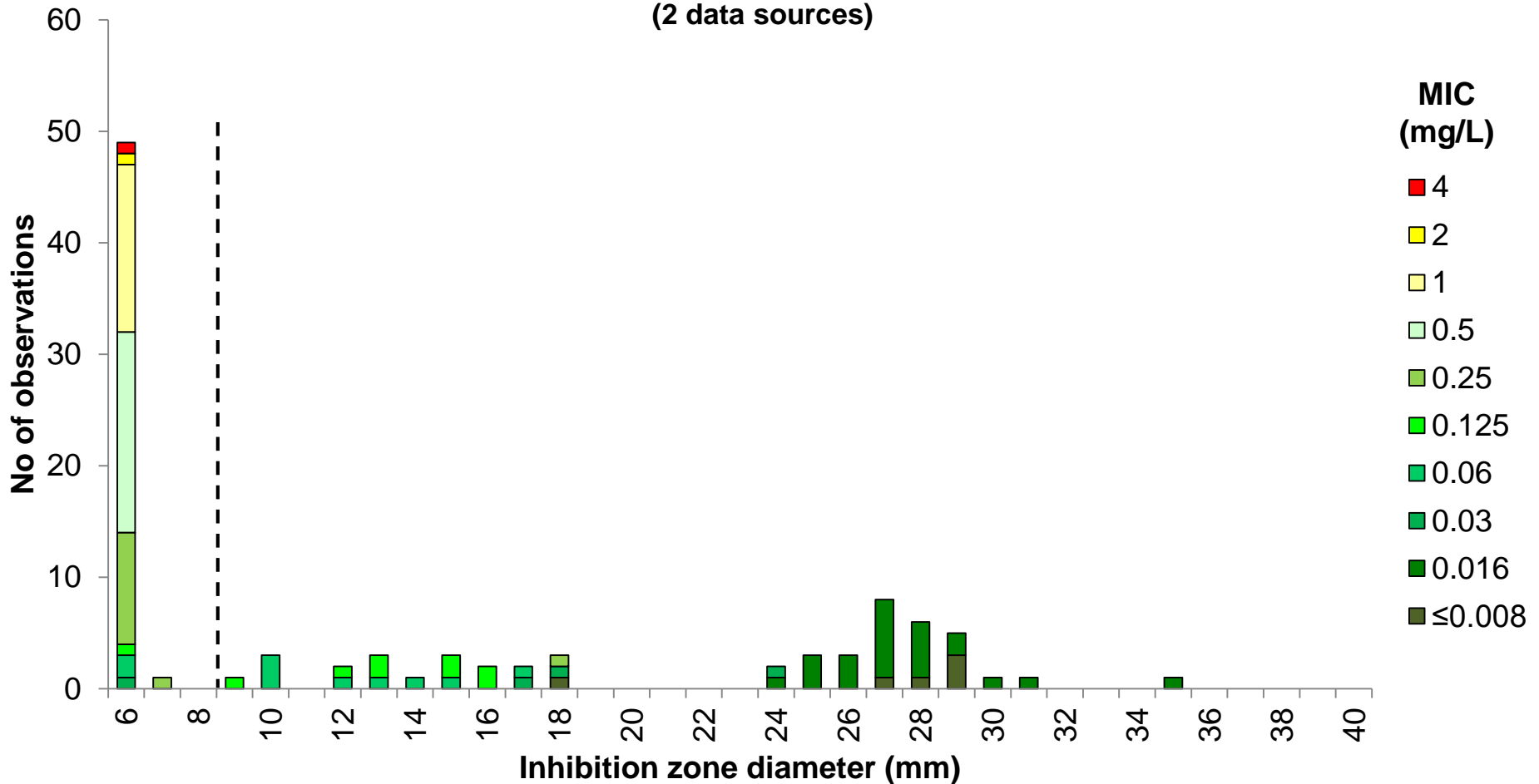
$S \leq 0.5$, $R > 0.5$ mg/L

Oxacillin zone diameter (screen)

$S \geq 9$ mm

Oxacillin 1 μg vs. Ceftriaxone MIC *S. pneumoniae*, 100 isolates

(2 data sources)



Breakpoints (non-endocarditis, non-meningitis)

Ceftriaxone MIC

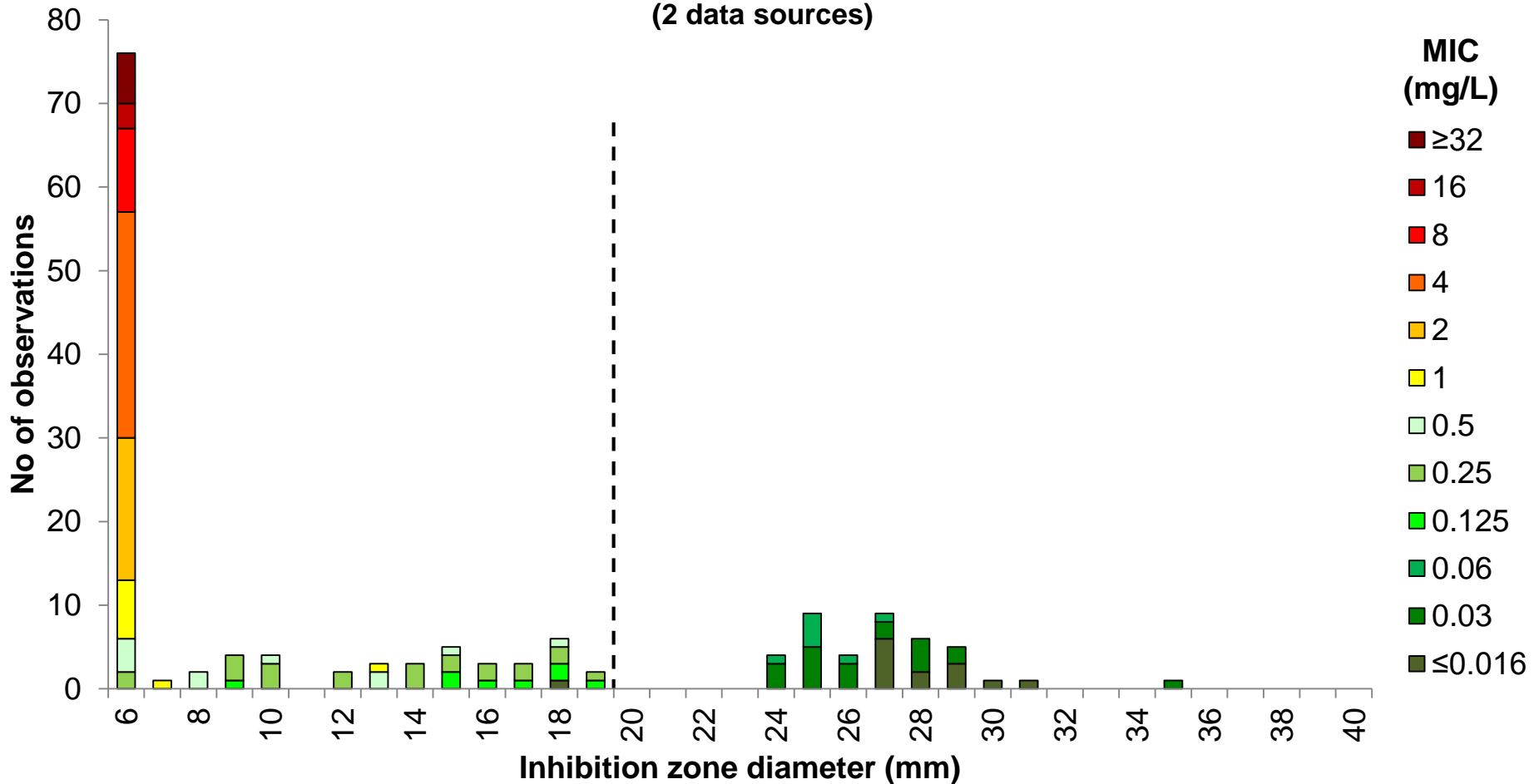
$S \leq 0.5$, $R > 2$ mg/L

Oxacillin zone diameter (screen)

$S \geq 9$ mm

Oxacillin 1 µg vs. Cefuroxime MIC *S. pneumoniae*, 154 isolates

(2 data sources)



Breakpoints (iv)

Cefuroxime MIC

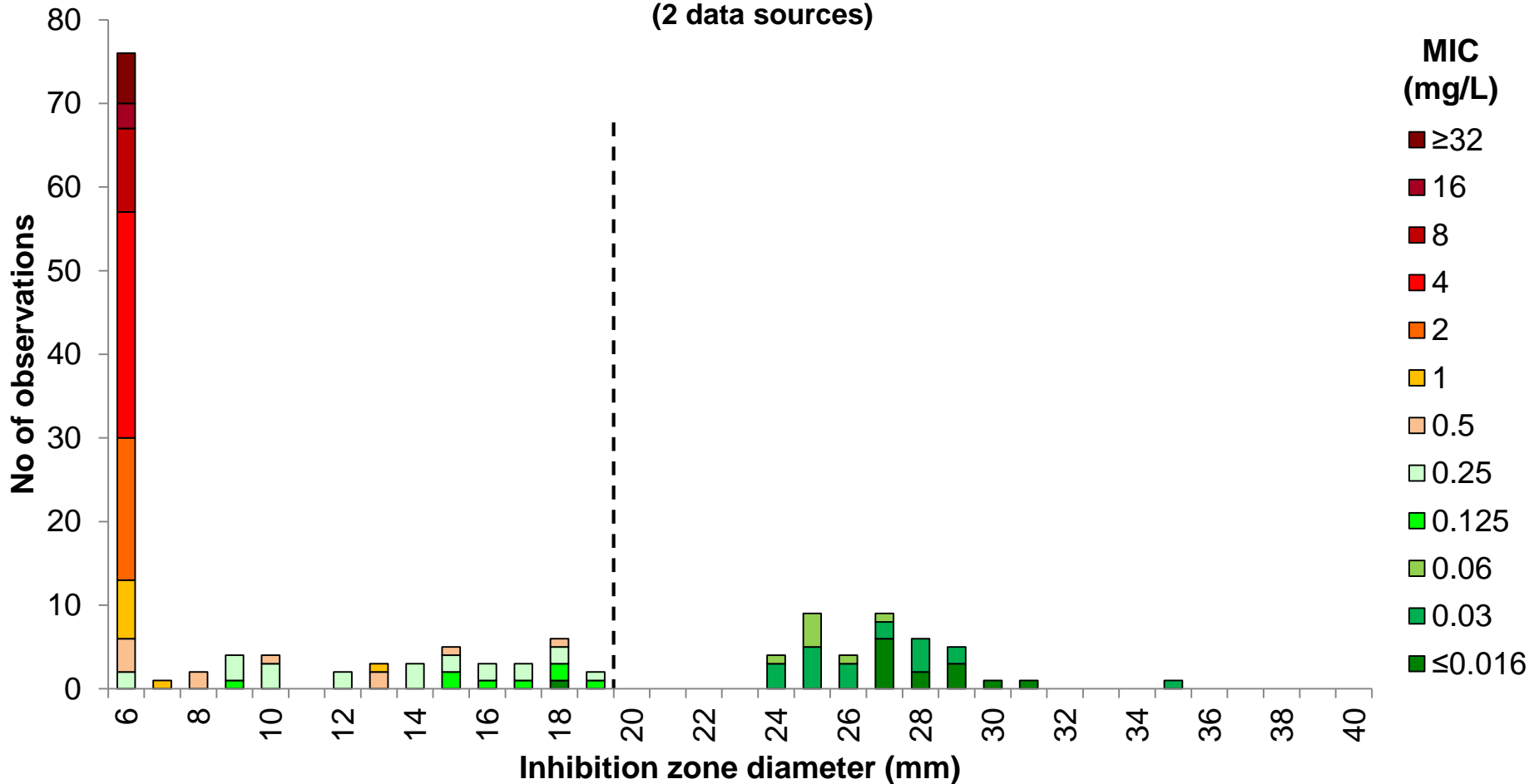
S ≤ 0.5, R > 1 mg/L

Oxacillin zone diameter (screen)

S ≥ 20 mm

Oxacillin 1 µg vs. Cefuroxime MIC *S. pneumoniae*, 154 isolates

(2 data sources)



Breakpoints (oral)

Cefuroxime MIC

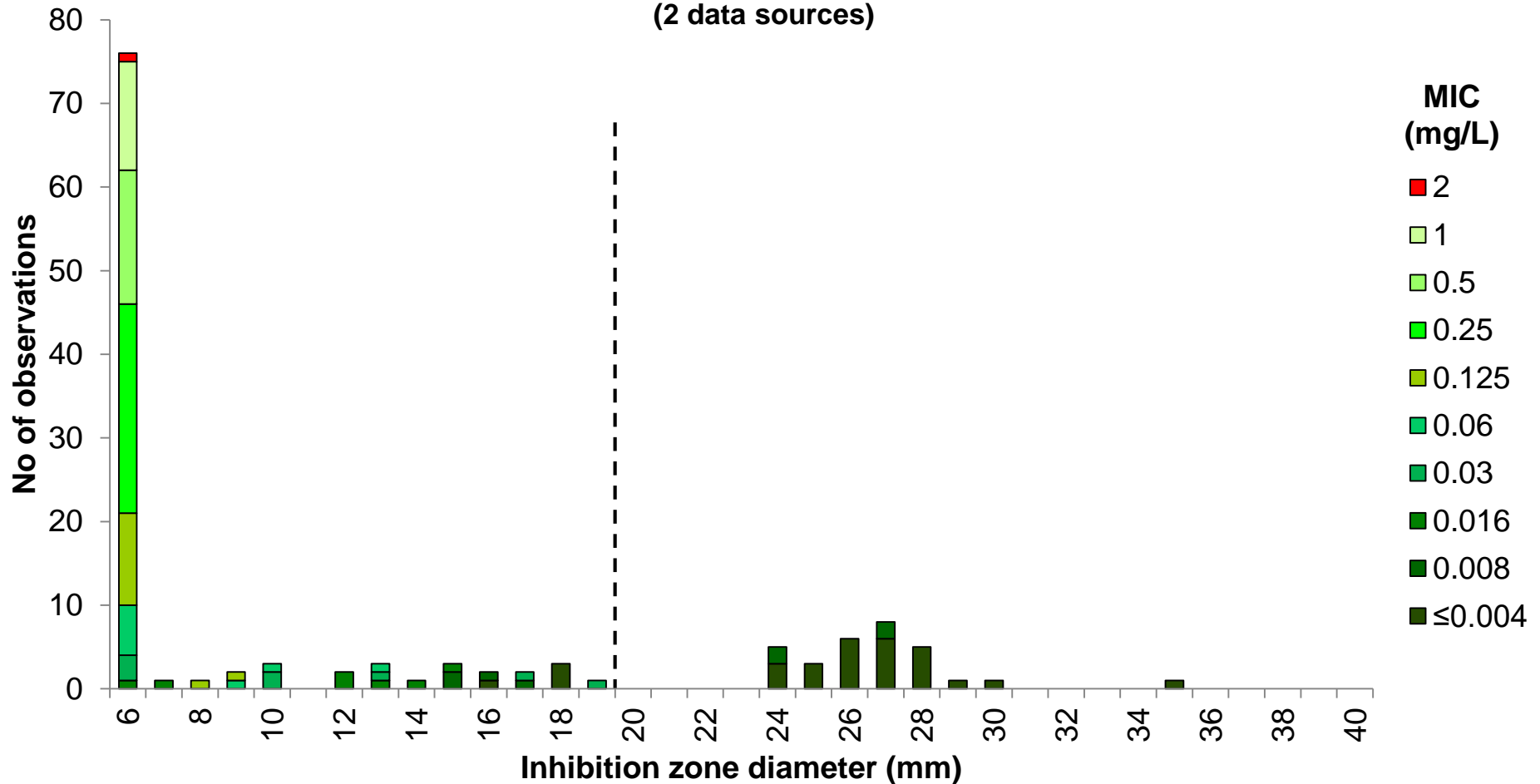
S ≤ 0.25, R > 0.25 mg/L

Oxacillin zone diameter (screen)

S ≥ 20 mm

Oxacillin 1 µg vs. Doripenem MIC *S. pneumoniae*, 130 isolates

(2 data sources)



Breakpoints

Doripenem MIC

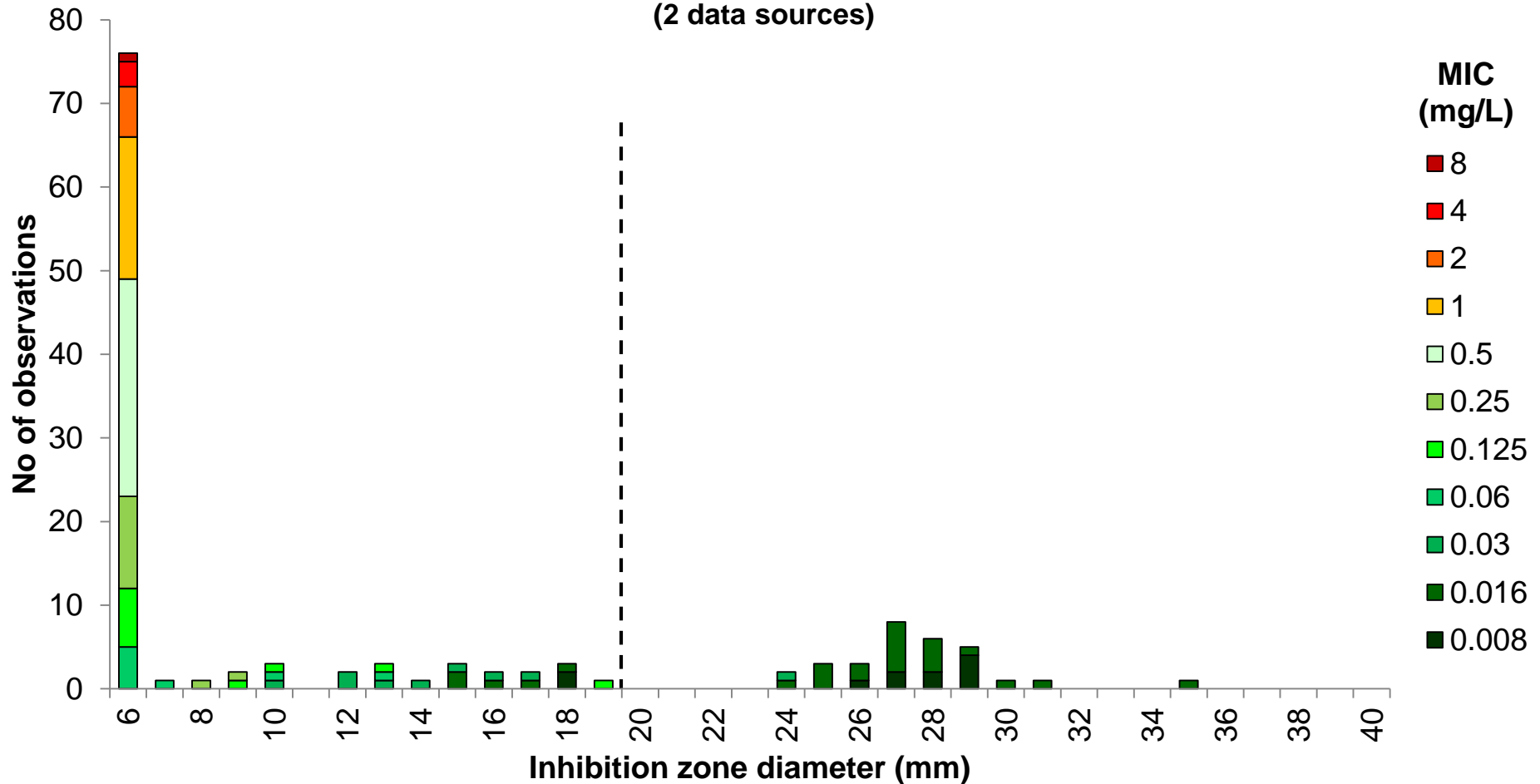
S ≤ 1, R > 1 mg/L

Oxacillin zone diameter (screen)

S ≥ 20 mm

Oxacillin 1 µg vs. Ertapenem MIC *S. pneumoniae*, 130 isolates

(2 data sources)



Breakpoints

Ertapenem MIC

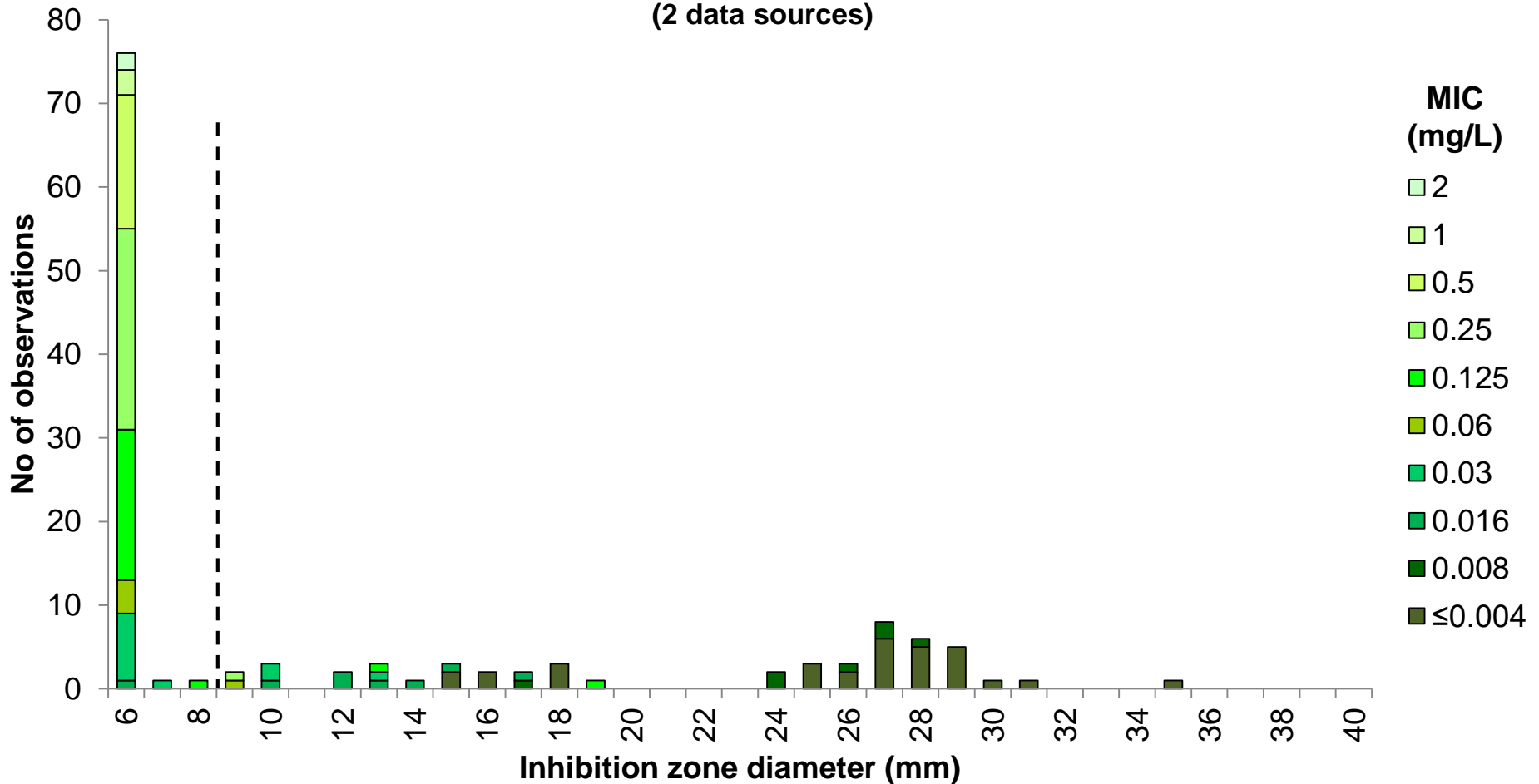
$S \leq 0.5$, $R > 0.5$ mg/L

Oxacillin zone diameter (screen)

$S \geq 20$ mm

Oxacillin 1 µg vs. Imipenem MIC *S. pneumoniae*, 130 isolates

(2 data sources)



Breakpoints

Imipenem MIC

S ≤ 2, R > 2 mg/L

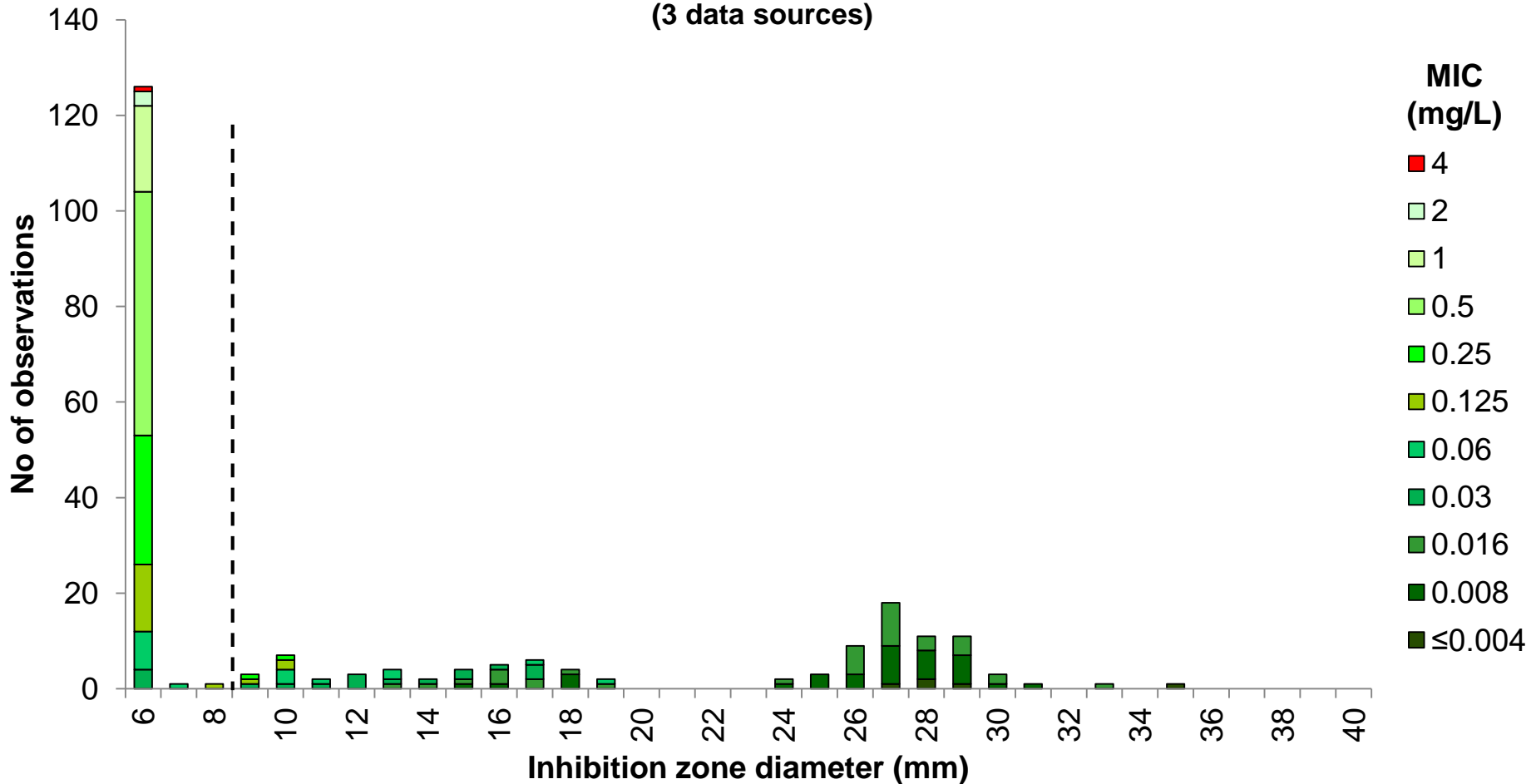
Oxacillin zone diameter (screen)

S ≥ 9 mm

Oxacillin 1 µg vs. Meropenem MIC

S. pneumoniae, 130 isolates (230 correlates)

(3 data sources)



Breakpoints (non-meningitis)

Meropenem MIC

S ≤ 2, R > 2 mg/L

Oxacillin zone diameter (screen)

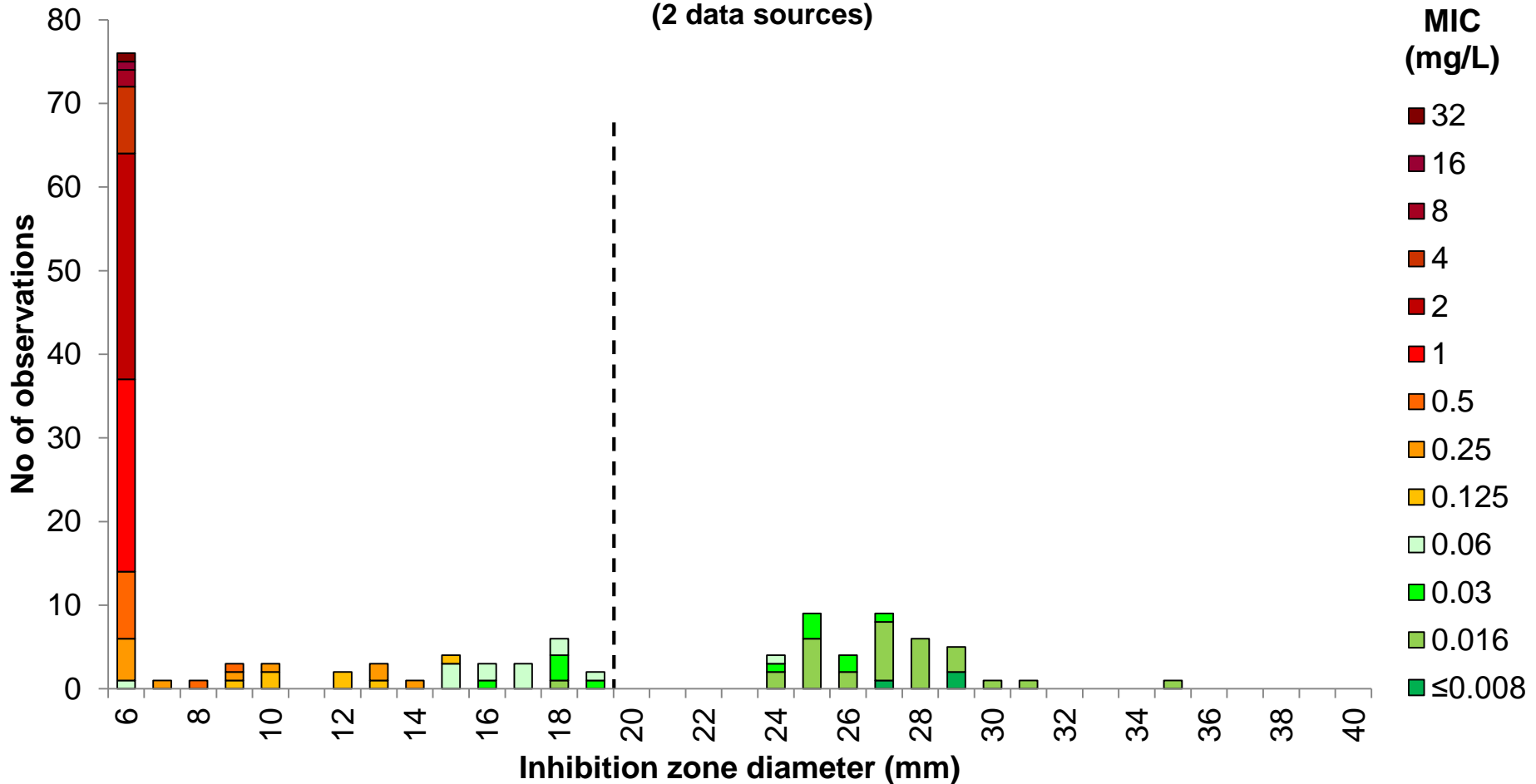
S ≥ 9 mm

Streptococcus pneumoniae

Distributions with separate
breakpoints for endocarditis and
meningitis

Oxacillin 1 µg vs. Benzylpenicillin MIC *S. pneumoniae*, 148 isolates

(2 data sources)



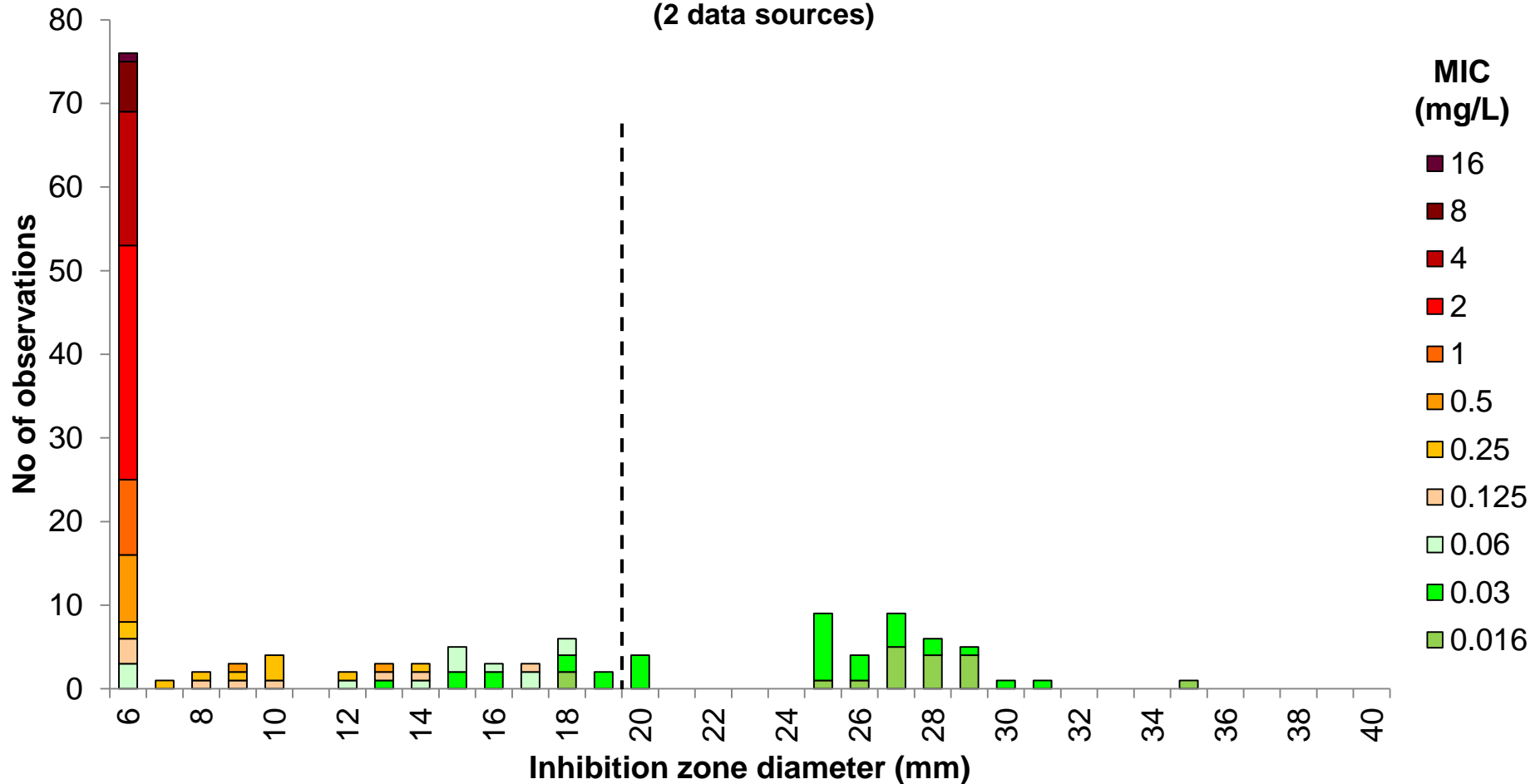
Breakpoints (endocarditis and meningitis)

Benzylpenicillin MIC $S \leq 0.06$, $R > 0.06$ mg/L

Oxacillin zone diameter (screen) $S \geq 20$ mm

Oxacillin 1 µg vs. Ampicillin MIC *S. pneumoniae*, 153 isolates

(2 data sources)



Breakpoints (iv, endocarditis and meningitis)

Ampicillin MIC

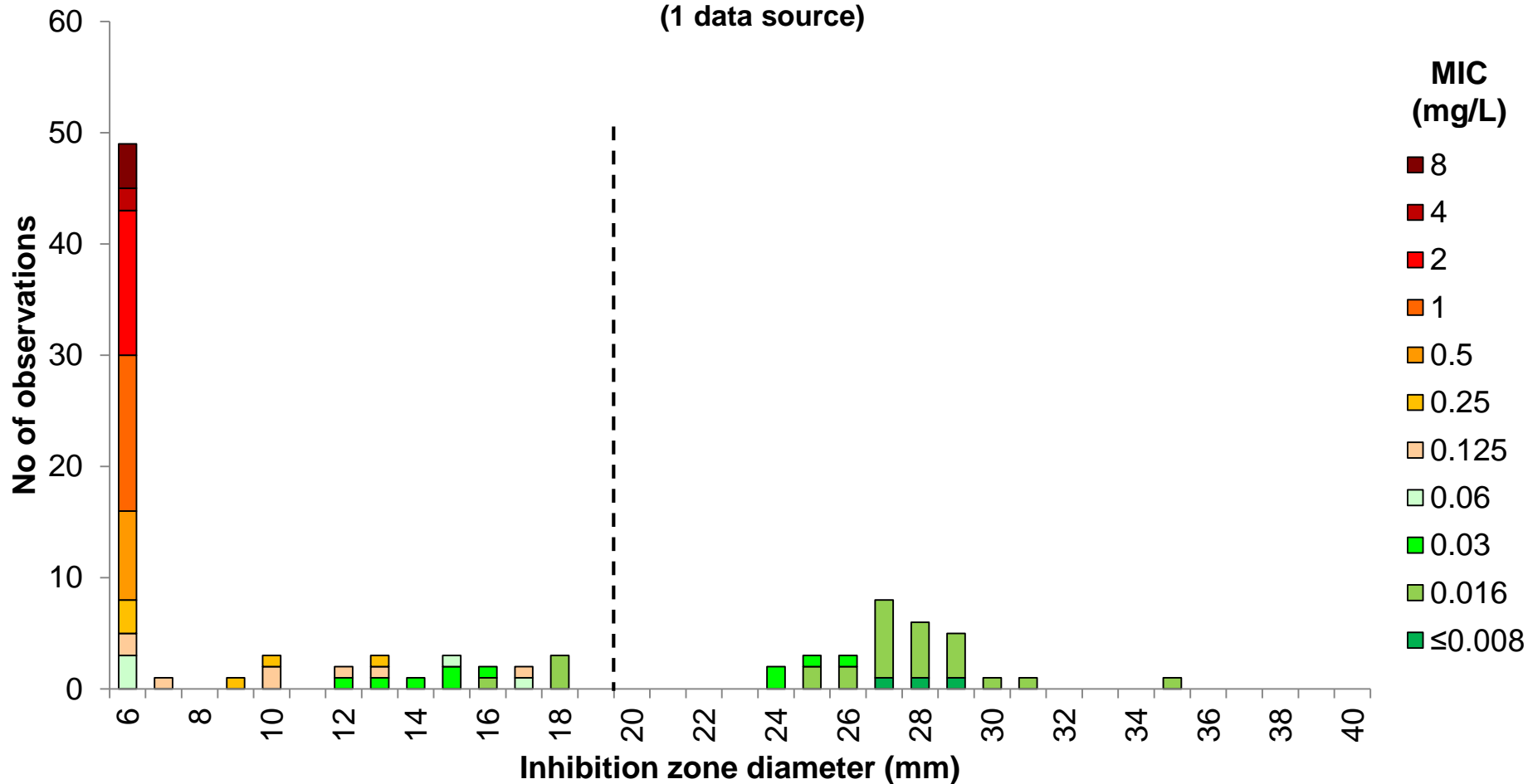
$S \leq 0.06$, $R > 0.06$ mg/L

Oxacillin zone diameter (screen)

$S \geq 20$ mm

Oxacillin 1 µg vs. Amoxicillin MIC *S. pneumoniae*, 100 isolates

(1 data source)



Breakpoints (iv, endocarditis and meningitis)

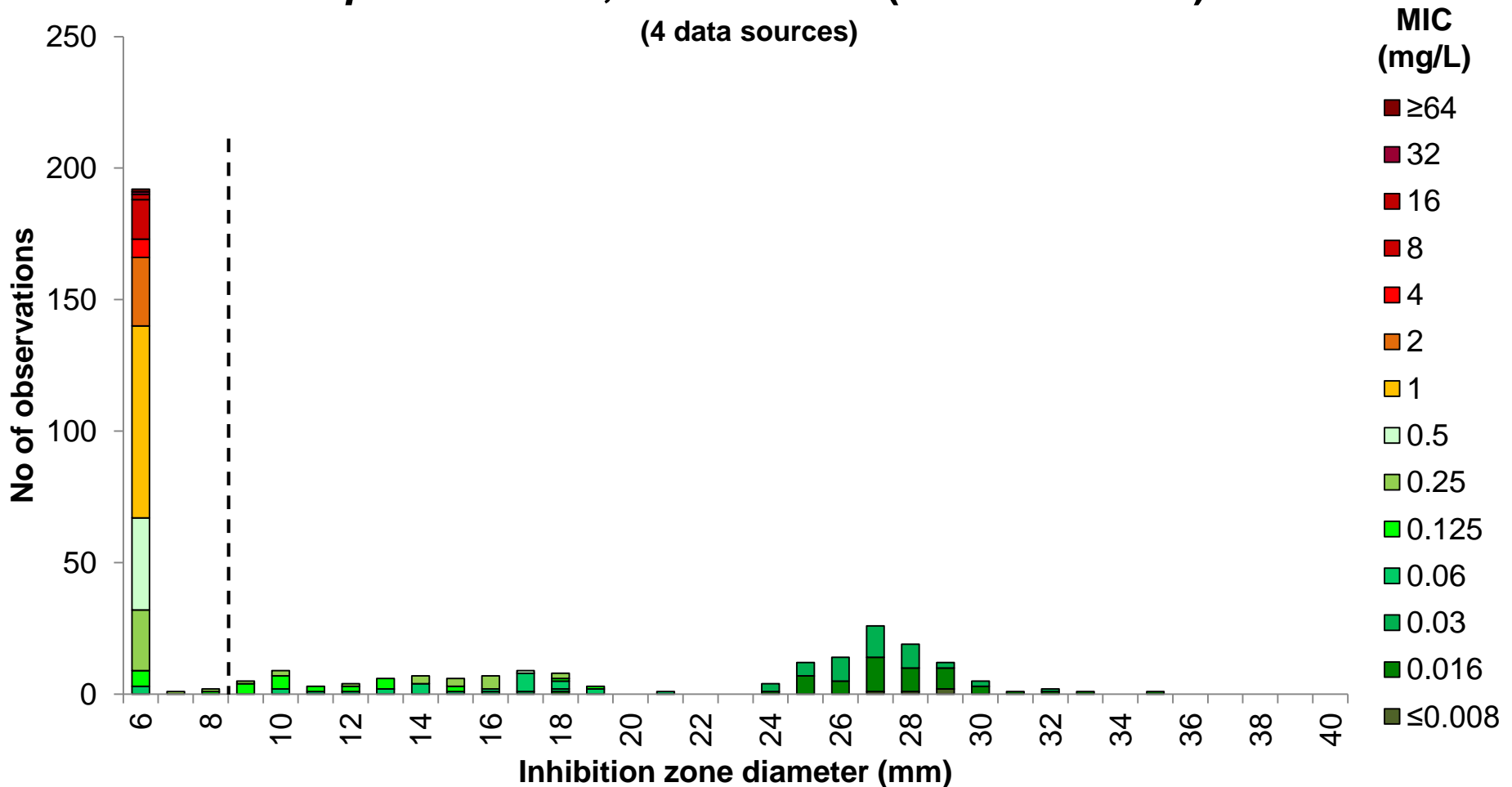
Amoxicillin MIC $S \leq 0.06$, $R > 0.06$ mg/L

Oxacillin zone diameter (screen) $S \geq 20$ mm

Oxacillin 1 µg vs. Cefotaxime MIC

S. pneumoniae, 151 isolates (360 correlates)

(4 data sources)



Breakpoints (endocarditis and meningitis)

Cefotaxime MIC

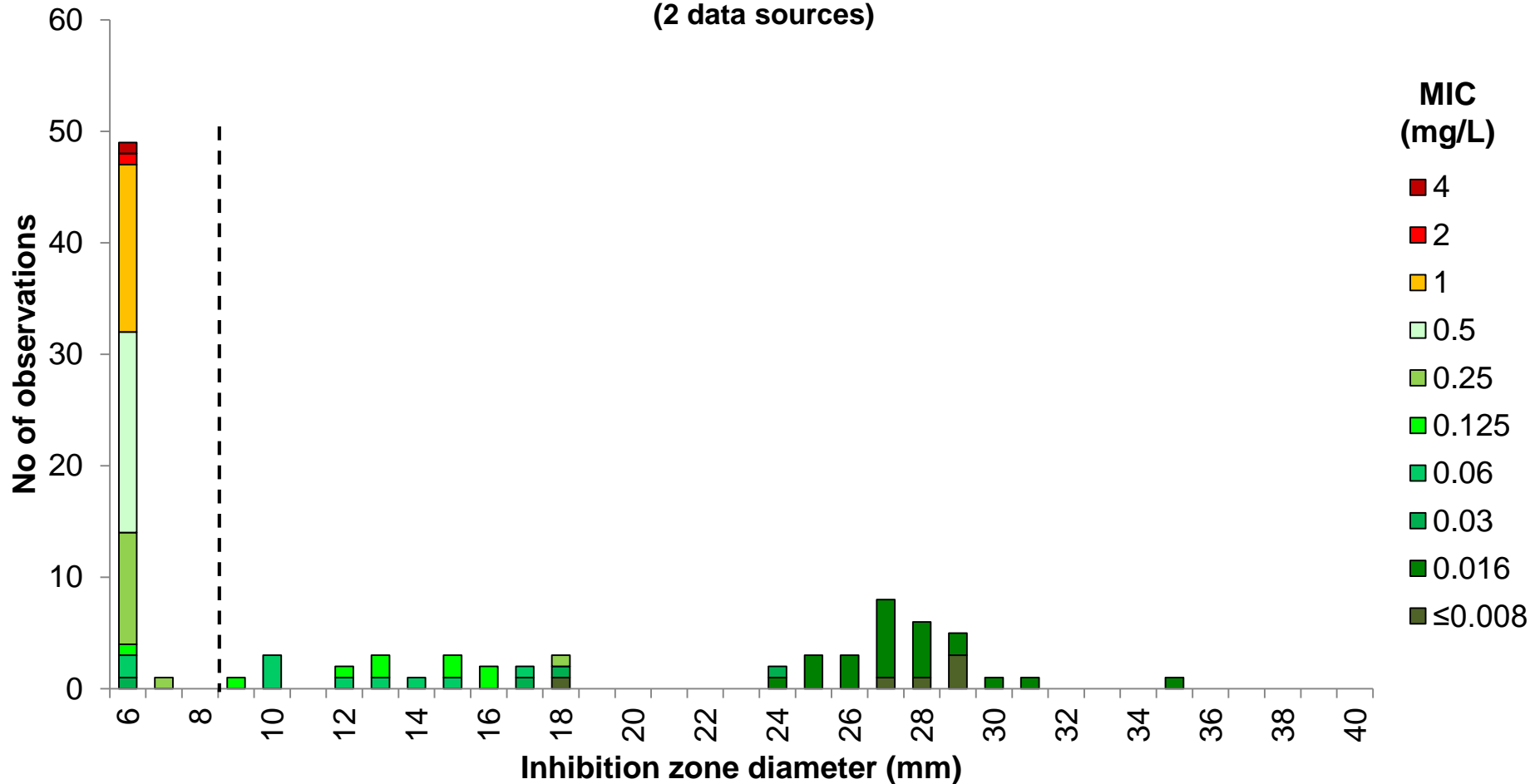
S \leq 0.5, R $>$ 0.5 mg/L

Oxacillin zone diameter (screen)

S \geq 9 mm

Oxacillin 1 µg vs. Ceftriaxone MIC *S. pneumoniae*, 100 isolates

(2 data sources)



Breakpoints (endocarditis and meningitis)

Ceftriaxone MIC

S ≤ 0.5, R > 0.5 mg/L

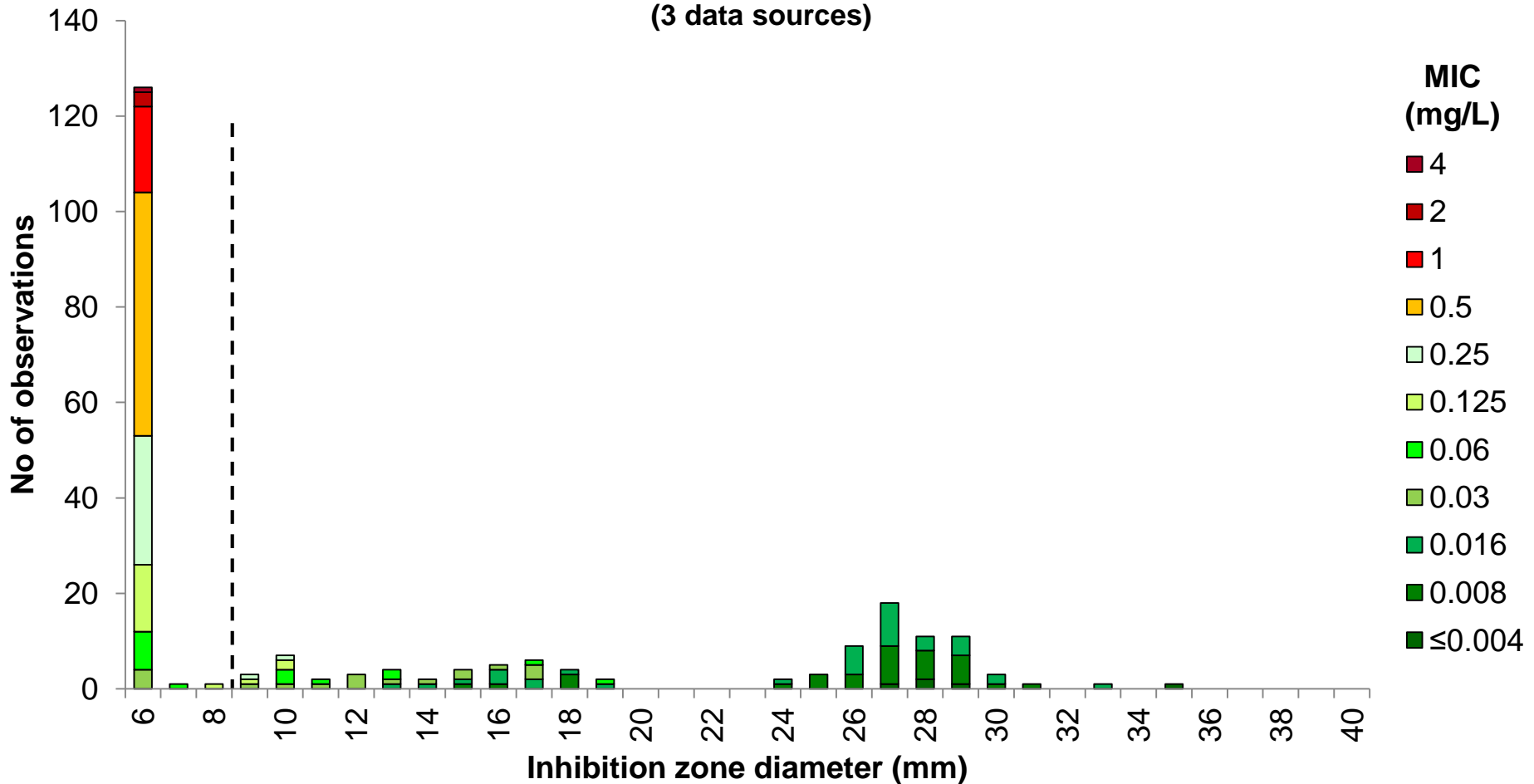
Oxacillin zone diameter (screen)

S ≥ 9 mm

Oxacillin 1 µg vs. Meropenem MIC

S. pneumoniae, 130 isolates (230 correlates)

(3 data sources)



Breakpoints (meningitis)

Meropenem MIC

S ≤ 0.25, R > 0.25 mg/L

Oxacillin zone diameter (screen)

S ≥ 9 mm



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