Annex to: EFSA's BIOHAZ Panel Scientific opinion "Public health aspects of *Vibrio* spp. related to the consumption of seafood in the EU". doi:10.2903/j.efsa.2024.8896



# Annex E – Antimicrobial resistances of the relevant *Vibrio* spp. from clinical and seafood associated isolates from Europe as reported in official reports, reviews and primary research papers

**Table E.1:** Antimicrobial resistances of *Vibrio parahaemolyticus, Vibrio vulnificus* and *Vibrio cholerae* non-O1/non-O139 reported in official reports, reviews and primary research papers[a]. Data are from Europe for clinical isolates (gastrointestinal infections) and seafood associated isolates.

| Sample source | Seafood | Country / region | Period of isolation | AMR profile (phenotypic) Number of tested isolates (% of resistant or intermediate) | Criteria used for R/S | AMR genes Number of tested isolates (% harbouring AMR genes) | Source |
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| ***V. parahaemolyticus*** | | | | | | | |
| Retail | Bivalve molluscs imported from other European countries | Poland | 2009-2012 | N=64<br>Resistant:<br>• Ampicillin (87.5)<br>• Streptomycin (70.3)<br>• Gentamicin (10.9)<br>• Ciprofloxacin (1.6) | CLSI (2010) | No data | Lopatek et al. (2015) |
| Retail | Shellfish, fish imported from other European countries | Poland | 2009-2015 | N=104<br>Resistant:<br>• Ampicillin (75)<br>• Streptomycin (68)<br>• Gentamicin (12.5)<br>• Ciprofloxacin (2) | CLSI (2010).<br><br>For STR as described by Baker-Austin et al. (2008) | No data | Lopatek et al. (2018) |
| Retail | Clams, mussels, oysters, scallops imported from other European countries | Poland | 2009-2018 | N=242<br>Resistant:<br>• Ampicillin (77.3)<br>• Streptomycin (64)<br>• Gentamicin (12.8)<br>• Ciprofloxacin (1.7)<br>• Tetracycline (0.8) | CLSI (2010)<br><br>For STR as described by Baker-Austin et al. (2008) | No data | Lopatek et al. (2022) |
| Retail | Mussels, oysters, snails from Black Sea (30 isolates); | Bulgaria | 2021-2022 | N=44<br>Resistant:<br>• Cefepime (16)<br>• Ampicillin (9) | CLSI (2016) | No data | Stratev et al. (2023) |

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| | fish, shrimps imported (14 isolates) | | | • Ceftazidime (5)<br>Intermediate:<br>• Ampicillin (25)<br>• Cefepime (16)<br>• Ceftazidime (2) | | | |
| Retail | Prawns imported (South-East Asia, Latin America, Madagascar) | UK | 2018-2019 | No data | Not applicable | N=83<br>• Aminoglycosides (38): *aac*(6)-IIa, *aadA5*, *aadA1/24*, *ant*(2)-Ia, *aph*(3)-Ia, *aph*(6)-Id<br>• ß-Lactams (100): $bla_{CARB47/48}$, $bla_{CMY-4}$, $bla_{CARB-2}$, $bla_{CTX-M-15}$, $bla_{OXA-10}$, $bla_{TEM-1B/116}$, $bla_{VEB-1/2/5}$<br>• Tetracyclines (28): *tet*59, *tetA, tetB, tetC, tetG*<br>• Quinolones (24); *qnrC*, *qnrS5*, *qnrVC1/6*, *qnrVC4/5/7*, *gyrA*.S83I, *parC*.S85F, *parC*.S85Y<br>• Folate pathway inhibitors: Sulfonamides (28): *sul1*, *sul2;*<br>Trimethoprim (10): *dfrA14*, *dfrA17*, *dfrA23*, *dfrA31*;<br>• Phenicols (14): *cmlA1*, *floR*<br>• Macrolides (4): *ereA*, *mphA*<br>• Rifamycins (10) (ARR2/3) | Janecko et al. (2021) |
| Primary production | Marine environment, production sites for bivalves | Italy | 2009-2011 | N=87<br>Resistant:<br>• Ampicillin (100)<br>• Amoxicillin (100)<br>• Cefalexin (68)<br>• Streptomycin (32)<br>• Cefotaxime (24)<br>• Erythromycin (21)<br>• Colistin (14)<br>• Polymyxin B (1)<br>• Ciprofloxacin (6)<br>• Kanamycin (3)<br>• Neomycin (3)<br>Intermediate:<br>• Polymyxin B (90)<br>• Kanamycin (90)<br>• Neomycin (97)<br>• Colistin (78) | CLSI (no year specified) | N=87<br>• ß-Lactam PCR negative for: $bla_{TEM}$, $bla_{PSE-1}$, $bla_{CARB-4}$, $bla_{OXA-30}$ | Ottaviani et al. (2013) |

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|---|---|---|---|---|---|---|---|
| Retail | Retail seafood from bivalves, fish, clamps, cephalopods | Italy | 2015-2019 | N=43<br>Resistant:<br>• Ampicillin (69.7)<br>• Cephalotin (20.9)<br>• Streptomycin (18.6)<br>• Tetracycline (14.0)<br>• Gentamicin (4.7)<br>• Kanamycin (4.7)<br>• Colistin (4.7)<br>• Amoxicillin/ sulfametoxazole (4.7)<br>Intermediate:<br>• Colistin (20.9)<br>• Streptomycin (20.9)<br>• Cephalotin (20.9)<br>• Cefotaxime (18.6)<br>• Ceftazidime (18.6)<br>• Kanamycin (18.6)<br>• Tetracycline (9.3)<br>• Amoxicillin/ sulfametoxazole (4.7) | CLSI (2021) | No data | Castello et al. (2022) |
| Primary production | Shellfish from production sites for bivalves | Italy | 2021-2022 | N=17<br>Resistant:<br>• Ampicillin (76.5)<br>• Cefazolin (94.1)<br>• Sulfisoxazole (70.6)<br>• Piperacillin (35.3)<br>Intermediate:<br>• Piperacillin (11.8)<br>• Amoxicillin/clavulanic acid (5.9)<br>• Cefoxitin (5.9)<br>• Tetracycline (5.9)<br>• Streptomycin (5.9) | CLSI (2016) | No data | Mancini et al. (2023) |
| Clinical (106 patient isolates; 102 GS[b] | | France | 2017-2020 | N=106<br>Resistant:<br>• Polymyxin B (73)<br>• Colistin (70)<br>• Ampicillin (42)<br>• Sulfonamides (31)<br>• Streptomycin (23)<br>• Tetracycline (1)<br>Intermediate:<br>• Streptomycin (19)<br>• Ciprofloxacin (4)<br>• Erythromycin (2) | The most recent EUCAST breakpoints for Enterobacterales for each year[c] | No data | CNR du Vibrions et du Cholera, reports from 2017, 2018, 2019, and 2020 |

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|---|---|---|---|---|---|---|---|
| Retail | Retail prawns, imported from outside the EU (Southeast Asia, South America) | Germany | 2015 - 2018 | N=124<br>Resistant:<br>• Ampicillin (30)<br>• Tetracycline (30)<br>• Sulfamethoxazole (21)<br>• Cefotaxime (11)<br>• Cefepime (6)<br>• Ceftazidime (4)<br>• Cefoxitin (2)<br>Intermediate:<br>• Ampicillin (50)<br>• Gentamicin (2)<br>• Chloramphenicol (1)<br>• Tetracycline (1)<br>• Cefoxitin (1) | CLSI (2016) | N=15<br>• ESBL-producing isolates: *bla*$_{CARB}$ (10), *bla*$_{CTX-M-15}$ (3), *bla*$_{CMY}$ (3), *bla*$_{VEB}$ (3), *bla*$_{NDM}$ (1) | Personal communication (Hammerl, 2024) |
| Retail | Shrimps imported mostly from outside Europe | France | 2012 - 2016 | N=304<br>Non-wildtype (resistant)<br>• Tetracycline (14.5)<br>• Trimethoprim/ sulfamethoxazole (3.6%)<br>• Chloramphenicol (2.0)<br>• Streptomycin (2.0)<br>• Temocillin (2.0)<br>• Cephalothin (1.6)<br>• Amoxicillin/clavulanic acid (1.3)<br>• Nalidixic acid (1.0)<br>• Cefotaxime (0.6)<br>• Cefoxitin (0.3)<br>• Ceftazidime (0.3)<br>• Ciprofloxacin (0.3)<br>• Azithromycin (0.3) | Disc diffusion for determination of epidemiological cut-off values for *V. parahaemolyticus* (calculated in the study) | N=7 (multi drug resistant isolates)<br>• Aminoglycosides (86*): aph(3")-Ib, aph(6)-Id, aadA2*<br>• Tetracyclines (86): *tetA, tet(59)*<br>• *Sulfonamides (86): sul1, sul2*<br>• Phenicols (71): *floR*<br>. ß-Lactams (71): *bla*$_{OXA-SHE}$, *bla*$_{CARB-31}$, *bla*$_{CARB-41}$, *bla*$_{CARB-26}$, *bla*$_{NDM-1}$<br>• Quinolones (14): *qnrA5* | Bourdonnais et al. (2024) |
| ***V. vulnificus*** | | | | | | | |
| Primary production/Sea water | Bivalves (20 isolates)<br>sea water (19 isolates)<br>aquatic animal (1 isolate) | Italy | 2015-2016 | N=40<br>Resistant:<br>• Cefazolin (5)<br>Intermediate:<br>• Amikacin (30)<br>• Tetracycline (5)<br>• Ciprofloxacin (5)<br>• Ceftazidime (5) | CLSI (2006) | No data | Serratore et al. (2017) |
| Retail | Bivalves, fish, clamps, cephalopods | Italy | 2015-2019 | N=5<br>Resistant:<br>• Streptomycin (100) | CLSI (2021) | No data | Castello et al. (2022) |

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| | | | | • Cefazolin (20)<br>Intermediate:<br>• Ciprofloxacin (20) | | | |
| ***V. cholerae non-O1/non-O139*** | | | | | | | |
| Retail | Italian seafood, imported seafood | Italy | 2003-2014 | N=25<br>Resistant:<br>• Colistin (100)<br>• Ampicillin (24)<br>• Nalidixic Acid (12)<br>• Gentamicin (8)<br>• Tetracycline (8)<br>• Trimethoprim/ sulfamethoxazole (8)<br>• Amoxicillin/clavulanic acid (4)<br>• Chloramphenicol (4)<br>• Meropenem (4)<br>• Streptomycin (4)<br>• Kanamycin (4)<br>Intermediate:<br>• Erythromycin (92)<br>• Streptomycin (64)<br>• Ampicillin (48)<br>• Amoxicillin/clavulanic acid (36)<br>• Gentamicin (20)<br>• Meropenem (16)<br>• Kanamycin (12)<br>• Cefotaxime (8)<br>• Tetracycline (4) | CLSI (2010) | No data | Ottaviani et al. (2018) |
| Retail | Imported prawns (5 isolates) | UK | 2018-2019 | No data | Not applicable | N=5<br>• Aminoglycosides (80): *ant*(2)-Ia, *aph*(3)-Ia, *aph* (3)-Ib/*strA*, *aph*(6)-Id<br>• Phenicols (80): *catB9, floR*<br>• Quinolones (80): *qnrVC4/5/7*, *gyrA*.S83I, *parC*.S85L<br>• Tetracyclines (40): *tetA, tetB*<br>• ß-Lactams (20): $bla_{VEB-1/2/5}$<br>• Macrolides (20): *ereA*<br>• Sulfonamides (20): *sul2* | Janecko et al. (2021) |

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|---|---|---|---|---|---|---|---|
| Retail | Bivalves, fish, clamps, cephalopods | Italy | 2015-2019 | N=12<br>Resistant:<br>• Ampicillin (75)<br>• Trimethoprim/ sulfamethoxazole (42)<br>• Ceftriaxone (17)<br>• Ceftazidime (17)<br>Intermediate:<br>• Cephalothin (50)<br>• Ceftazidime (17)<br>• Streptomycin (17) | CLSI (2021) | No data | Castello et al. (2022) |
| Retail | Shrimps North Sea and imported worldwide | Germany | 2014-2019 | N=63<br>Resistant and intermediate:<br>• Colistin (87)<br>• Imipenem (78)<br>• Ampicillin (11)<br>• Trimethoprim (6)<br>• Nalidixic acid (5)<br>• Ciprofloxacin (2)<br>• Cefoxitin (2) | CLSI (2018) | N=63<br>• Colistin *almG* (100)<br>• Quinolones *qnrVC* (86)<br>• Beta-lactams: Ampicillin $bla_{CARB}$ (8); Imipenem $bla_{varG}$ (49)<br>• Chloramphenicol *catB9* (13)<br>• Trimethoprim *dfrA31* (5) | Zhang et al. (2023) |
| Clinical | NA | Italy | 2003-2014 | N=9 (with 7 related to seafood consumption)<br>Resistant:<br>• Colistin (100)<br>• Ampicillin (22)<br>• Nalidixic Acid (22)<br>• Amoxicillin/clavulanic acid (11)<br>• Streptomycin (11)<br>• Kanamycin (11)<br>Intermediate:<br>• Erythromycin (88)<br>• Gentamicin (44)<br>• Ampicillin (33)<br>• Amoxicillin/clavulanic acid (22)<br>• Cefotaxime (22)<br>• Meropenem (22)<br>• Streptomycin (22)<br>• Ciprofloxacin (11)<br>• Kanamycin (12)<br>• Tetracycline (11)<br>• Trimethoprim/ sulfamethoxazole (11) | CLSI (2010) | No data | Ottaviani et al. (2018) |

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| Clinical (72 patient isolates;56 GS[b]) | France | 2017-2020 | N=72<br>Resistant:<br>• Colistin (92)<br>• Polymyxin B (89)<br>• Sulfonamides (39)<br>• Nalidixic Acid (19)<br>• Trimethoprim/ sulfamethoxazole (15)<br>• Tetracycline (11)<br>• Erythromycin (8)<br>• Ciprofloxacin (8)<br>• Streptomycin (7)<br>• Azithromycin (4)<br>• Ampicillin (4)<br>• Nitrofuran (1.4)<br>Intermediate<br>• Ciprofloxacin (7)<br>• Streptomycin (4)<br>• Azithromycin (1.4)<br>• Erythromycin (1.4)<br>• Nalidixic Acid (1.4) | The most recent EUCAST breakpoints for Enterobacteriaceae for each year[c] | No data | CNR du Vibrions et du Cholera, reports from 2017, 2018, 2019, and 2020 |

Note: CLSI (2006). Method for antimicrobial dilution and disk susceptibility testing of infrequently isolated or fastidious bacteria. Approved standard M45A 1st ed. Clinical and Laboratory Standards Institute, Wayne, PA, USA; CLSI (2010). Methods for antimicrobial dilution and disk susceptibility testing of infrequently isolated or fastidious bacteria; approved guideline, 2nd ed, M45-A2. Clinical and Laboratory Standards Institute, Wayne, PA, USA; CLSI (2016). Methods for antimicrobial dilution and disk susceptibility testing of infrequently isolated or fastidious bacteria; approved guideline, M45 3rd ed. Clinical and Laboratory Standards Institute, Wayne, PA, USA; CLSI (2018). Methods for dilution antimicrobial susceptibility tests for bacteria that grow aerobically, 11th ed.; Clinical and Laboratory Standards Institute, Wayne, PA, USA; CLSI (2021). Performance standards for antimicrobial susceptibility: Supplement M100, 31st ed. Clinical and Laboratory Standards Institute: Wayne, PA, USA.

[a]Only detected AMR are reported.

[b]GS Gastrointestinal infections.

[c]as communicated by the CNR du Vibrions et du Cholera, Institut Pasteur[1].

[1] https://www.pasteur.fr/fr/sante-publique/cnr/les-cnr/vibrions-cholera/missions#:~:text=Cette%20maladie%20pouvant%20justifier%20une,infections%20suppuratives%20et%20de%20septic%C3%A9mies. As communicated to the WG experts, for their report of 2020, the interpretation into categories S (Sensitive), I (Intermediate) and R (Resistant) for disc diffusion, MIC strips and Microdilution was made in accordance with the 2020 edition of EUCAST for Enterobacteriaceae.

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