Review

The Emergence of the Genus *Comamonas* as Important Opportunistic Pathogens

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Abstract: *Comamonas* spp. are non-fermenting Gram-negative bacilli. They were first discovered in 1894, and since then, twenty-four species have been characterized. The natural habitat of these bacteria is soil, wastewater/sludge, fresh water such as ponds and rivers, and the animal intestinal microbiome. They were also isolated from industrial settings, such as activated sludge and polluted soil, and from the hospital environment and clinical samples, such as urine, pus, blood, feces, and kidney. *Comamonas* spp. are associated with environmental bioremediation and are considered an important environmental bacterium rather than a human pathogen. However, in the 1980s, they became a concern when several human infections associated with these species were reported. Here, the *Comamonas* genus was examined in terms of its members, identification techniques, and pathogenicity. Seventy-seven infection cases associated with these microorganisms that have been discussed in the literature were identified and investigated in this project. All relevant information regarding year of infection, country of origin, patient information such as age, sex, underlying medical conditions if any, type of infection caused by the *Comamonas* species, antibiotic susceptibility testing, treatment, and outcomes for the patient were extracted from case reports. The findings suggest that even though *Comamonas* spp. are thought of as being of low virulence, they have caused harmful health conditions in many healthy individuals and even death in patients with underlying conditions. Antimicrobial treatment of infections associated with these species, in general, was not very difficult; however, it can become an issue in the future because some strains are already resistant to different classes of antibiotics. Therefore, these pathogens should be considered of such importance that they should be included in the hospital screening programs.

Keywords: *Comamonas*; nosocomial infection; environmental bacteria

1. Introduction

The growing range of severe infections caused by little-known non-fermenting Gram-negative rods is developing into a major cause of concern. These pathogens are opportunistic, infecting patients undertaking medical treatments in hospital and immunocompromised individuals outside of clinical locations. Bacterial species, including *Ralstonia* spp., *Ochrobactrum* spp., *Pseudomonas aeruginosa*, *Sphingomonas paucimobilis*, and *Brevundimonas* spp., all belong to this group [1–6]. Other emerging Gram-negative, non-fermenting rod bacteria that can cause potentially severe infections are members of the β-proteobacterial genus *Comamonas* [7].

*Comamonas* spp. have been isolated from a broad variety of environments, including water, aircraft water, soil, plants, and animals [8–12]. Several *Comamonas* spp. have been investigated for their potential to degrade xenobiotic pollutants and for heavy metal detoxification under a variety of environmental conditions [13–19]. *Comamonas* spp. are thought to be of low virulence. They have, however, caused infections, including serious infection such as septicemia or endocarditis, in immunocompetent hosts [20–22].
Analysis of the scientific/medical literature showed wide-ranging types of infections resulting from *Comamonas* spp. These were resistant to numerous different antibiotics. The data uncovered that this genus is a more commonplace pathogen than hitherto believed, with numerous infections/conditions caused by *Comamonas* spp. being severe and incapacitating. The purpose of this study was to give a general summation of infections caused by *Comamonas* spp., any underlying disorders/illnesses in patients that predispose them to infections with these bacteria and the antibiotic therapies that can be used for the management of these infections to aid medical professionals.

2. Genus *Comamonas*

Previously designated as *Pseudomonas* rRNA homology group III, the family Comamonadaceae now includes the genera *Comamonas*, *Delftia* and *Acidovorax*. The genus *Comamonas*, assigned to the Comamonadaceae lineage in the β-Proteobacteria, was originally proposed by Davis and Park [23] and the name validly published with the revival of the genus and the type species *Comamonas terrigena* by De Vos et al. [24]. In 1987, two *Pseudomonas* species, *Pseudomonas acidovorans* and *Pseudomonas testosterone*, were transferred to the genus *Comamonas* as *Comamonas acidovorans* and *Comamonas testosteroni*, respectively [24]. Based on a detailed 16S rRNA gene sequence-based phylogenetic study of the Comamonadaceae *C. acidovorans* was transferred as a type species to the novel genus *Delftia* as *Delftia acidovorans* [25]. Since then, the *Comamonas* genus has expanded to 24 species (see Table 1). The phylogenetic relationship between all *Comamonas* spp. described to date is presented in Figure 1.

![Figure 1. Phylogenetic tree of the genus *Comamonas* (accession numbers are given alongside species name) with the closely related genus *Delftia*. The tree was built with 16S rDNA genes (partial sequences of ~1400 bp) using neighbor-joining with the Tajima-Nei method utilizing the MEGA 11 software package. Bootstrap values are represented by numbers at nodes. These are based on 1000 resamplings. Bar, 0.0050 substitutions per site [26,27]. It should be remembered that these analyses are based upon 16S rDNA and, as such, are suggestive only.](image-url)
| Species               | Origin/Isolation Site                          | Genome Sequences                          | Reference                        |
|-----------------------|-----------------------------------------------|--------------------------------------------|----------------------------------|
| Comamonas aquatica    | China/Freshwater River                        | Strain: CJG, Size: 3.76 Mb, Ref Genome: GCA_000935165.2 (6 genomes) | Wauters et al., 2000 [28]        |
| Comamonas aquatilis   | Germany/Garden Pond                           | No Genome                                  | Kampfer et al., 2018 [29]        |
| Comamonas badia       | Japan/Activated sludge                        | Strain: IAM 14839, Size: 3.68 Mb, Ref Genome: GCA_000484635.1 | Tago and Yokota, 2004 [30]       |
| Comamonas composti    | Taiwan/food waste compost                     | Strain: YY287T, Size: 4.63 Mb, Ref Genome: GCA_000429845.1 | (Young et al., 2008) [31]        |
| Comamonas denitrificans | Sweden/Activated sludge                      | Strain: 123T, Size: 3 Mb, Ref Genome: GCA_017368815.1 | Gumaelius et al., 2001 [32]      |
| Comamonas fluminis    | China/River water                             | Strain: CJ34T, Size: 4.86 Mb, Ref Genome: NZ_CP066783.1 | Park et al., 2022 [33]          |
| Comamonas granuli     | Korea/Granules used in wastewater treatment plant | Strain: NBRC 101663T, Size: 3.51 Mb, Ref Genome: GCA_003604195.1 | Kim et al., 2008 [34]          |
| Comamonas guangdongensis | China/Subterranean Forest sediment           | No Genome                                  | Zhang et al., 2013 [35]         |
| Comamonas humi        | Japan/Soil                                    | No Genome                                  | Hatayama, 2014 [36]             |
| Comamonas jiangduensis | China/Agricultural soil                       | Strain: YW1T, Size: 2.76 Mb, Ref Genome: GCA_902829245.1 | Sun et al., 2013 [37]          |
| Comamonas kerstersii  | Dialysis effluent of a patient                | Strain: 8943, Size: 3.55 Mb, Ref Genome: GCA_002056725.1 | Wauters et al., 2003 [28]      |
| Comamonas koreensis   | Korea/Wetland                                 | Strain: YH12T, T50-37, Size: 5.3 Mb, Ref Genome: GCA_014076495.1 | Chang et al., 2002 [38]         |
| Comamonas nitrativorans | Uruguay/Denitrifying reactor                 | Strain: 23310T, Size: 3.36 Mb, Ref Genome: SAMN02746010 | Etchebehere, 2001 [39]         |
| Comamonas odontotermis | Taiwan/Termite Odontotermes formosanus gut    | Strain: Dant 3-8T, Size: 4.42 Mb, Ref Genome: GCA_02080045 (For WLL) | (Chou et al., 2007) [40]      |
| Comamonas phosphati   | China/Phosphate rock powder—from phosphate mine | Strain: WYH 22-41T, Size: 4.1 Mb, Ref Genome: GCA_014637085.1 | Fuhong et al., 2016 [41]        |
| Comamonas piscis      | Korea/Korean rockfish intestine               | Strain: CN1T, Size: 5.2 Mb, Ref Genome: GCA_014109725.1 | Kang et al., 2016 [42]          |
| Comamonas sediminis   | USA/Lagoon sediments                          | Strain: SJ1, Size: 4.42 Mb, Ref Genome: JAFB/FN01000000 (for 4487) | Subhash et al., 2016 [43]       |
| Comamonas serinivorans | China/Wheat straw compost                     | Strain: SP-35T, Size: 4.52 Mb, Ref Genome: GCA_002158865.1 | Daochen et al., 2014 [44]       |
Table 1. Cont.

| Species                | Origin/Isolation Site                          | Genome Sequences                  | Reference                                |
|------------------------|------------------------------------------------|------------------------------------|------------------------------------------|
| Comamonas suwonensis   | Republic of Korea/Stream water                  | Strain: EJ-4, Size: 4.72 Mb        | Park et al. 2021 [45]                    |
|                        |                                                 | Ref Genome: GCA_012844455.2        |                                          |
| Comamonas terrae       | Thailand / Agricultural soil                    | Strain: A3-3T, Size: 4.7Mb.        | Chipirom et al., 2012 [46]               |
|                        |                                                 | Ref Genome: GCA_001544075.1        |                                          |
| Comamonas terrigena    | Boston/Hay infusion made from fresh water       | Strain: NCIB 8193, Size: 4.7 Mb    | De Vos et al., 1985 [24]                 |
|                        |                                                 | Ref Genome: AP019749.1             |                                          |
| Comamonas testosteroni | Organic compounds                               | Strain: KS 0043, Size: 5.41 Mb    | Tamaoka et al., 1987 [47]                |
|                        |                                                 | Ref Genome: GCA_000241525.2 (21 Genomes) |                                    |
| Comamonas thiooxydans  | Sulphur spring                                  | Strain: S23T, Size: 5.27 Mb       | Pandey et al., 2009 [48]                 |
|                        |                                                 | Ref Genome: GCA_000964545.1        |                                          |
| Comamonas zonglianii   | China/Phenol contaminated soil                  | No Genome                         | Xin-Yan et al., 2011 [49]               |

3. Identification of Comamonas spp.

The *Comamonas* species are Gram-negative and comprised of straight or slightly curved rods or spirilla. They are usually 0.5 to 2 by 1 to 6 µm. They are generally motile by means of polar or bipolar tufts of 1–5 flagella (excepting *C. koreensis*). They are aerobic and chemoorganotrophic (De Vos et al., 2015) [50]. Some of the species are non-pigmented, some appear to be cream or yellow-white in color, and some can produce a brown halo around them (Willems and De Vos, 2006) [51], but they do not produce fluorescent pigments. Colonies appear pink-pigmented with a slimy and convex surface on blood agar. No hemolysis was observed on blood and chocolate agar. They are aerobic, oxidase and catalase-positive, non-spore formers, glucose non-fermenters, and chemoorganotrophic. Good growth was observed on media that contained peptone, organic acids, and amino acids (Public Health England, 2015) [52].

4. Comamonas spp. Virulence

*Comamonas* spp. are believed to be of low virulence. A study of the pangenome of 34 *Comamonas* genomes, however, showed that they have a diverse array of virulence factors, including polysaccharide biosynthesis for adherence and anti-phagocytosis, a motility system and metabolic enzymes for adaptation in vivo. All sequenced, clinically-isolated *Comamonas* strains and a number of environmental *Comamonas* spp. contain hemolysin genes. These analyses indicated that virulence might be species-specific as certain virulence factors are conserved in pathogenic-like strains [53].

5. Comamonas spp. Outbreaks

The overall knowledge gained from research into the scientific and medical literature can be seen in Tables 2–4. These tables show the year when the infection happened (if not available, the year of publication was used), country where the infection happened, patient information (age, sex, any reported underlying medical conditions), type of infection caused by the *Comamonas* infection, antimicrobial testing (susceptibility and resistance), treatment (focusing on the antibiotic therapies used) and patient outcome.

Tables 2–4 illustrate 77 instances of infection caused by *Comamonas* spp. that were found in literature sources. It was found that only five *Comamonas* species (out of 24 species so far identified) have caused infections in humans. Most of these infections were caused by *Comamonas testosteroni* (50 instances—65.3%), other infections were due to *Comamonas kerstersii* (23 instances—29.8%), *Comamonas aquatica* (1 instance—1.3%), *Comamonas thiooxy-
dans (1 instance—1.3%), and Comamonas terrigena (1 instance—1.3%). In 47 instances (61%) out of 76, the patients had underlying conditions. Twenty different types of infection were caused by the different Comamonas species. These included pneumonia, polymicrobial bacteremia, bacteremia/septic shock, purulent meningitis, and sepsis.

Most patients had one underlying condition, seven had patients with two underlying conditions (for example, obesity and diabetes). The most abundant of these underlying conditions were diabetes (in 8 patients—10.3%), various types of cancer (in 5 patients—6.5%) and alcoholism (in 4 patients—5.2%). Other major underlying conditions included obesity (in 3 patients—3.9%), hypertension (in 4 patients—10.9%), and renal failure (in 3 patients—3.9%). A full list of underlying conditions can be seen in Tables 2-4. A total of 70 patients (92.1%) were treated successfully and recovered fully, and 6 patients (7.8%) died. All patients who died due to Comamonas spp. infection suffered from one or more underlying conditions. These cases are discussed in more detail below. Surprisingly, to date, no pseudo-outbreaks have been found associated with Comamonas spp.

Most of the reported infections caused by Comamonas spp. appear to be community-acquired [22].

Death Associated with Comamonas spp. Infection

Six instances of death associated with Comamonas spp. infection have been reported. All six cases were linked to C. testosterone (Table 2). The first two instances were reported by Barbaro et al. [54]. In one of these instances, a mother who was an intravenous drug abuser gave birth to a premature baby, and this newborn baby died of sepsis caused by C. testosterone infection 24 h after he was born. The second instance was very similar as it was also associated with sepsis due to C. testosterone infection in a premature baby who was stillborn by an intravenous drug abuser mother. The third instance of death was reported in 2008 by Jin et al. [55]. In this case, a 54-year-old homeless man alcoholic was hit by a car, he received multiple fractures of the facial bones and was hospitalized. He was diagnosed with multiple cerebral and cerebellar infarcts, which resulted in changed mental status. He died 15 days after the injury. An autopsy revealed diffuse purulent meningitis due to C. testosterone infection. In the fourth instance reported by Swain and Rout, a 50-year-old woman who suffered from diabetes and had a chronic renal disease was hospitalized for bacteremia and septic shock [56]. She was treated with piperacillin-tazobactam antibiotics until C. testosterone was identified. The microorganism was found to be resistant to piperacillin-tazobactam, so treatment was then changed to cefoperazone-sulbactam. However, despite this, the woman died due to septic shock. The fifth instance of death associated with Comamonas spp. was reported in 2017 by Yasayancan and Koseoglu [57]. A 68-year-old man with lung cancer and adrenal metastasis was diagnosed with polymicrobial bacteremia due to C. testosterone, Staphylococcus haemolyticus, and Acinetobacter baumannii infection. The patient died on the 16th day, despite suitable treatments against these pathogens. The last reported instance of death due to C. testosterone infection was reported in 2018 by Cetin et al. A 10-year-old boy with serious underlying conditions (cerebral palsy, scoliosis, and long-term support with home mechanical ventilation) was diagnosed with pneumonia due to C. testosterone infection [58]. The patient was treated with appropriate antimicrobial therapy, and after 21 days of treatment infection was cured but due to the patient’s poor health conditions, he died on day 50 of hospitalization. No deaths have been associated with C. kerstersii or any other Comamonas spp (Tables 3 and 4).
Table 2. Incidences of *Comamonas testosteroni* infection from 1987 to 2022. Main characteristics of the case reports.

| Author (Ref.) | Year | Sex/Age       | Country | Co-Morbidity          | Type of Infection         | Susceptible to * | Resistance to * | Antibiotic Treatment                                      | Outcome            |
|---------------|------|---------------|---------|-----------------------|---------------------------|------------------|-----------------|----------------------------------------------------------|--------------------|
| Atkinson et al., 1975 [59] | 1966 | F/31 yr old USA | Rheumatic heart disease | Septicemia | N/A | N/A | Kanamycin, Tetracycline | Full recovery |
| Grover Smith, 1979 [60] | 1979 | M/48 yr old USA | Atrophic right leg | Pyarthrosis Septicemia | Amikacin, Ampicillin, Carbenicillin, Cephalothin, Chloramphenicol, Colistin, Gentamicin, Kanamycin, Tetracycline, Tobramycin | N/A | Cephalothin, Gentamicin. Followed by Ampicillin for 21 days. | Full recovery |
| Barbaro et al., 1987 [54] | 1983 | M/31 yr old USA | None | Perforated appendix | N/A | N/A | Cefoxitin then drainage, then Ampicillin, Clindamycin, Gentamicin, Ampicillin, Clindamycin, Tobramycin | Full recovery |
| Barbaro et al., 1987 [54] | 1983 | M/11 yr old USA | None | Perforated appendix | N/A | N/A | Cefoxitin | Full recovery |
| Barbaro et al., 1987 [54] | 1983 | F/59 yr old USA | Alcoholic Cirrhosis | Meningitis | N/A | N/A | Cefoxitin, Moxalactam, Nafcillin | Full recovery |
| Barbaro et al., 1987 [54] | 1984 | F/21 yr old USA | Pregnant | Perforated appendicitis | Cefoxitin | N/A | Surgery, Iv Cefoxitin for 9 days | Full recovery |
| Barbaro et al., 1987 [54] | 1984 | F/12 yr old USA | None | Perforated appendicitis | N/A | N/A | Cefoxitin | Full recovery |
| Barbaro et al., 1987 [54] | 1985 | F/84 yr old USA | Congestive heart failure | Urine tract infection | N/A | N/A | Ampicillin | Full recovery |
| Barbaro et al., 1987 [54] | 1985 | M/24 yr old USA | None | Perforated appendicitis | N/A | N/A | Cefoxitin | Full recovery |
| Barbaro et al., 1987 [54] | 1985 | F/New-born USA | Maternal IV drug abuse, Premature birth | Sepsis | N/A | N/A | Ampicillin, amikacin | Died |
| Barbaro et al., 1987 [54] | 1985 | Stillborn USA | Maternal IV drug abuse, premature birth | Sepsis | N/A | N/A | None | Died |
| Franzetti et al., 1992 [61] | 1992 | N/A Italy | AIDS | Respiratory infection | N/A | N/A | Ceftazidime | Full recovery |
| Le Moal et al., 2001 [62] | 2001 | F/75 yr old France | Breast cancer | Bacteremia | Aztreonam, Ceftazidime, Piperacillin, Ticarcillin | N/A | N/A | Ceftazidime, Gentamicin for 10 days | Full recovery |
Table 2. Cont.

| Author (Ref.) | Year | Sex/Age | Country | Co-Morbidity | Type of Infection | Susceptible to * | Resistance to * | Antibiotic Treatment | Outcome |
|---------------|------|---------|---------|--------------|------------------|-----------------|-----------------|----------------------|---------|
| Arda et al., 2003 [63] | 2003 | M/50 yr old | Turkey | Undergone cholesteatoma operation | Purulent meningitis | Ceftriaxone, Cefazidime, Meropenem | N/A | Ceftriaxone (were 3 mg/mL), Cefazidime (0.75 mg/mL), and Meropenem (0.47 mg/mL), then changed to Meropenem, 3 g/day and operation to remove the cholesteatoma | Full recovery |
| Smith et al., 2003 [64] | 2003 | M/89 yr old | USA | N/A | Bacteremia | N/A | N/A | Levofloxacin | Full recovery |
| Cooper et al., 2005 [22] | 2005 | M/49 yr old | USA | None | Endocarditis | N/A | N/A | Initially Cefipime, Gentamicin, switched to Ampicillin, then followed by surgery and 6 weeks of IV antibiotic treatment | Full recovery |
| Gul et al., 2007 [65] | 2006 | M/22 yr old | Turkey | None | Bacteremia due to perforated appendicitis | N/A | N/A | Iv Cefazolin 1 g was given before surgery, Iv Cefazolin 1 g every 8 h after surgery | Full recovery |
| Abraham and Simon, 2007 [7] | 2007 | F/54 yr old | USA | Metastatic esophageal cancer, an indwelling central venous catheter | Bacteremia, septic shock | N/A | N/A | Cefepime, Vancomycin, Azithromycin, Drotrecogin alfa, Glucocorticosteroids, Norepinephrine Vasopressin, then was changed to Cefepime and Ciprofloxacin for 16 days | Full recovery |
| Garolo et al., 2007 [66] | 2007 | M/63 yr old | Poland | Lumbar discectomy | Spondylodiscitis | N/A | N/A | Eicoplanine (600 mg e.v./day), Ciprofloxacin (400 mg 2 times/day), then Ciprofloxacin, Cotrimoxazole | Full recovery |
| Jin et al., 2008 [55] | 2008 | M/54 yr old | USA | Alcoholic | Purulent Meningitis | N/A | N/A | Moxifloxacin | Died |
| Author (Ref.)            | Year | Sex/Age          | Country     | Co-Morbidity                          | Type of Infection                  | Susceptible to *                          | Resistance to *                          | Antibiotic Treatment                                                                 | Outcome            |
|-------------------------|------|------------------|-------------|---------------------------------------|------------------------------------|------------------------------------------|------------------------------------------|-----------------------------------------------------------------------------------|--------------------|
| Reddy et al., 2009 [67] | 2009 | F/82 yr old      | India       | Diabetes, Cataract surgery            | Post-operative endophthalmitis     | Ceftazidime, Chloramphenicol, Ciprofloxacin, Gatifloxacin, Moxifloxacin, Ofloxacin | Amikacin, Gentamicin, Tobramycin         | Intraocular injection of 1 mg Vancomycin and 1 mg Ceftazidime, Ciprofloxacin (oral and topical), steroids (oral and topical) and Cycloplegics then intravitreal Ceftazidime (1 mg), topical ceftazidime | Full recovery      |
| Katırcıoğlu et al., 2010 [68] | 2010 | M/83 yr old      | Turkey      | Hypertension and ischemic cerebrovascular incident | Sepsis                            | Amikacin, Ciprofloxacin, Piperacillin-Tazobactam | Aztreonam, Cefepime, Ceftriaxon, Ceftazidime, Cefoperazon-Sulbactam, Tobramycin, Imipenem Ampicillin, Penicillin, Rocephin. | Piperacillin-Tazobactam, Amikacin for 10 days | Full recovery      |
| Nseir et al., 2011 [69]  | 2011 | F/64 yr old      | Israel      | Diabetes mellitus Patient on hemodialysis | Bacteremia (Catheter-related)      | Ceftazidime, Gentamycin, Quinolones      | N/A                                      | Vancomycin, ceftriaxone, Ceftriaxone, clarithromycin Radiofrequency ablation for liver tumor, Cefmetazon (1 g every 8 h), Gentamicin (60 mg every 8 h), then changed for IV Levofloxacin (500 mg once a day), oral Levofloxacin (500 mg every day) for 4 days IV Oxacillin (2 g every 6 h), Cephalosporin, then IV Ciprofloxacin (400 mg for every 12 h) for 8 days | Died               |
| Ozden et al., 2011 [70]  | 2011 | M/10 yr old      | Turkey      | Cerebral palsy, tracheostomy          | Infection                         | N/A                                      | N/A                                      | Full recovery                                              |                    |
| Tsui et al., 2011 [71]   | 2011 | M/73 yr old      | Taiwan      | Chronic hepatitis B, liver cirrhosis, hepatocellular carcinoma | Bacteremia                        | N/A                                      | N/A                                      | Full recovery                                              |                    |
| Tsui et al., 2011 [71]   | 2011 | M/54 yr old      | Taiwan      | Alcoholic, Mild obstructive lung disease, replaced hip joints | Bacteremia                        | N/A                                      | N/A                                      | Full recovery                                              |                    |
| Author (Ref.) | Year | Sex/Age | Country | Co-Morbidity | Type of Infection | Susceptible to * | Resistance to * | Antibiotic Treatment | Outcome |
|--------------|------|---------|---------|--------------|------------------|-----------------|-----------------|---------------------|---------|
| Farshad et al., 2012 [72] | 2010 | M/10 yr old | Iran | Brain Medullo-blastoma, chemotherapy | Bacteremia | Amikacin, Ampicillin, Aztreonam Ceftazidine, Ceftriaxone, Cefuroxime, Gentamicin, Cephalexin, Ciprofloxacin, Imipenem, Meropenem, Piperacillin/Tazobactam Tobramycin, Ticarcillin, Tetracycline, Amikacin, Ampicillin, Aztreonam Ceftazidine, Ceftriaxone, Cefuroxime, Gentamicin, Cephalexin, Ciprofloxacin, Imipenem, Meropenem, Piperacillin/Tazobactam Tobramycin, Ticarcillin, Tetracycline | N/A | Iv Ciprofloxacin (10 mg/kg/day for 21 days), Amikacin (15 mg/kg/day for 21 days) | Full recovery |
| Farshad et al., 2012 [72] | 2010 | F/19 yr old | Iran | Osteosarcoma, chemotherapy | Bacteremia, septic shock | Amikacin, Ampicillin, Aztreonam Ceftazidine, Ceftriaxone, Cefuroxime, Gentamicin, Cephalexin, Ciprofloxacin, Imipenem, Meropenem, Piperacillin/Tazobactam Tobramycin, Ticarcillin, Tetracycline | N/A | Iv Vancomycin (60 mg/kg/day for 14 days) and Imipenem (100 mg/kg/day for 14 days), then oral Ciprofloxacin (30 mg/kg/day for three weeks) | Full recovery |
| Al Ramahi et al., 2013 [73] | 2013 | M/47 yr old | Jordan | Renal failure, maintained on hemodialysis | Bacteremia | Cefepime, Ciprofloxacin, Cotrimoxazole, Levofloxacin, Ofloxacin, Polymyxin B, Tigecycline | Amikacin, Gentamicin, Imipenem, Meropenem, Piperacillin/Tazobactam with intermediate sensitivity for Ceftazidime | Ceftepime (1 g daily for 14 days), then oral Cyclosporine 200 mg twice daily, Mycophenolate Mofetil 360 mg twice daily Prednisone 30 mg twice daily, oral INH 300 mg once daily | Full recovery |
| Bayhan et al., 2013 [74] | 2013 | M/16 yr old | Turkey | None | Peritonitis due to perforated appendicitis | Amicasin, Ampicillin, Ampicillin-Sulbactam, Ceftazidime, Cefazolin, Ciprofloxacin, Gentamicin, Imipenem, Piperacillin | Ceftriaxone, Cefuroxime, SXT | Removal of appendix, Saline peritoneal lavage, IV Amicasin, Ampicillin, Clindamycin (5 days) | Full recovery |
| Altun et al., 2013 [75] | 2013 | F/29 yr old | Turkey | End-stage renal failure, hypertensive nephrosclerosis, CAPD | Peritonitis | N/A | N/A | Iv Vancomycin, oral Ciprofloxacin (14 days) | Full recovery |
| Author (Ref.)            | Year | Sex/Age | Country          | Co-Morbidity                                                                 | Type of Infection               | Susceptible to *                                                                 | Resistance to *                                                                 | Antibiotic Treatment                                                                 | Outcome       |
|-------------------------|------|---------|------------------|------------------------------------------------------------------------------|---------------------------------|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|----------------|----------------|
| Orsini et al., 2014     | 2014 | F/80 yr old | USA              | Hypertension, diabetes mellitus, hiatal hernia, osteoarthritis, cholelithiasis, obesity | Polymicrobial bacteremia        | Ceftazidime, Carbapenems, Piperacillin/Tazobactam, SXT                            | N/A                                                                | Initially Ceftriaxone (2 g IV daily), then Nafcillin (2 g IV every 4 h), Cefazolin (1 g IV every 8 h) and Doripenem (250 mg IV every 8 h) | Full recovery |
| Swain and Rout, 2015    | 2015 | F/50 yr old | India            | Diabetes mellitus complicated with chronic renal disease                    | Bacteremia, septic shock       | Ceftazidime, Cefoperazone-Sulbactam, Meropenem                                    | Amikacin, Ciprofloxacin, Gentamicin, Piperacillin-Tazobactam Gentamicin, Imipenem, Meropenem, Netilmicin, Piperacillin-Tazobactam | Piperacillin-Tazobactum (3.375 gm IV 6 hourly), then changed for Cefoperazone-Sulbactam | Died          |
| Duran et al., 2015      | 2015 | M/51 yr old | Turkey            | Tachycardia                                                                  | Endocarditis                    | Amikacin, Ciprofloxacin, Cefazidime, Cefoperazone-Sulbactam, Cefepime, Colistin Tigecycline | N/A                                                                | Cardiovascular surgery, Ciprofloxacin                                        | Full recovery |
| Kim et al., 2015        | 2015 | F/42 yr old | Korea             | Meningioma was removed 6 days before infection                              | Septic shock                    | N/A                                                                              | N/A                                                                | Initially Piperacillin/Tazobactam, Levofoxacin, Metronidazole iv, renal replacement therapy, Immunoglobulin IV Meropenem/Levofoxacin, then cefazidime with levofoxacin | Full recovery |
| Khalki et al., 2016     | 2015 | N/A/18   | Morocco           | None                                                                         | Acute appendicitis             | Amino-penicillins, Aztreonam, Ciprofloxacin, Nalidixic acid, Norfloxacin, SXT    | N/A                                                                | Surgery, Aminosidine-clavulanic acid IV for 48 h, then taken orally for 8 days | Full recovery |
| Pekintürk and Akgünés, 2016 | 2016 | M/62 yr old | Turkey            | Left hemiparesis and type II diabetes                                       | Bacteremia                      | Aztreonam, Colistin                                                             | N/A                                                                | Died          |
Table 2. Cont.

| Author (Ref.)                  | Year | Sex/Age | Country    | Co-Morbidity                                      | Type of Infection | Susceptible to * | Resistance to * | Antibiotic Treatment                                                                 | Outcome            |
|-------------------------------|------|---------|------------|--------------------------------------------------|-------------------|------------------|-----------------|---------------------------------------------------------------------------------------|--------------------|
| Parolin et al., 2016 [80]     | 2016 | F/4 yr old | Italy      | End-stage renal disease, idiopathic epilepsy     | Peritonitis       | N/A              | N/A             | Initially IV Ceftazidime, Teicoplanin, then changed to Ciprofloxacin for 3 weeks       | Full recovery      |
| Hung et al., 2017 [81]        | 2017 | F/63 yr old | Taiwan     | Hemodialysis patient                             | Visceral perforation | Ceftriazone, Ceftazidime, Gentamicin | Ciprofloxacin | Cefazolin Followed by ceftriazone Iv Ceftriazone (80 mg per kg per dose once a day for 14 days | Full recovery      |
| Ruziaki and Hashami, 2017 [82]| 2017 | F/1 yr old | Oman       | None                                             | Sepsis             | Gentamycin, Imipenem, Meropenem, Piperacillin–Tazobactam | N/A            | Full recovery                                                                                   | Died               |
| Yasayancan and Koseoglu, 2017 [57] | 2017 | M/68 yr old | Turkey     | Lung cancer, adrenal metastasis                  | Polymicrobial Bacteremia | Cefepime, Colistin, Levofloxacin, Tigecycline | N/A            | Piperacillin–Tazobactam and ciprofloxacin iv, then Cefepime Teicoplanin, then Tigecycline/Colistin Surgery, IV Cefazolin (100 mg/kg), Amikacin (15 mg/kg), Metronidazole (30 mg/kg) | Died               |
| Tartar and Tartar, 2020 [83]  | 2017 | M/14 yr old | Turkey     | None                                             | Perforated appendicitis | Amikacin, Ampicillin–Sulbactam, Ceftazidime, Cefazolin, Ciprofloxacin, Gentamicin, Imipenem, Piperacillin, SXT | N/A            | Full recovery                                                                                   | Full recovery      |
| Tartar and Tartar, 2020 [83]  | 2017 | F/5 yr old  | Turkey     | None                                             | Acute appendicitis | Amikacin, Ertapenem, Ciprofloxacin, Gentamicin, Imipenem, Piperacillin, SXT | N/A            | Full recovery                                                                                   | Full recovery      |
| Farooq et al., 2017 [20]      | 2017 | F/65 yr old | India      | Colostomy                                        | Gastroenteritis   | Amikacin, Ceefepime, Ceftoperazone/Sulbactam, Gentamicin, Imipenem Cotrimoxazole, Minocycline, Meropenem, Piperacillin/Tazobactam, Tigecycline | Aztreonam, Ciprofloxacin, Levofloxacin | Oral Ciprofloxacin (500 mg for 3 days), probiotics                              | Full recovery      |
| Cetin et al., 2018 [57]       | 2018 | M/10 yr old | Turkey     | Cerebral palsy, scoliosis, supported with long-term home mechanical ventilation | Pneumonia          | Amikacin, Ceftazidime, Cefepime, Imipenem, Levofloxacin, Meropenem, Netilmicin, Piperacillin, Piperacillin-Tazobactam, Tigecycline | Aminoglycosides, Ciprofloxacin, Levofloxacin | Amikacin (1 × 225 mg), Piperacillin–Tazobactam (3 × 1.5 g) Vancomycin (4 × 150 mg), | Died               |
| Author (Ref.) | Year   | Sex/Age       | Country | Co-Morbidity                          | Type of Infection | Susceptible to * | Resistance to * | Antibiotic Treatment                                                                 | Outcome     |
|--------------|--------|---------------|---------|---------------------------------------|-------------------|------------------|-----------------|-------------------------------------------------------------------------------------|-------------|
| Lovell and Forde, 2019 [84] | 2019    | M/39 yr old   | Barbados | Alcoholism, asthma, pancreatitis       | Bacteremia        | Cefepime, Cefotaxime, Ceftriazone, Ciprofloxacin, Levofloxacin, Meropenem, Piperacillin-Tazobactam, SXT | Cefazolin, Ertapenem, Gentamicin | Initially Meropenem 1 g IV every 8 h, Fluconazole 800 mg IV, a 21-day course of Meropenem and a 14-day course of Fluconazole (unsuccessfully), then SXT | Full recovery |
| Tiwari and Nanda, 2019 [85] | 2019    | F/46 yr old   | India   | None                                  | Bacteremia        | Cefuroxime, Ciprofloxacin, Colistin, Gentamicin, Imipenem, Meropenem, Tigecycline, Cotrimoxazole | Piperacillin-Tazobactam | Piperacillin-Tazobactam, Vancomycin, then changed for Gentamicin (4 mg/kg/daily) and Imipenem (25 mg/kg 8 hourly) for 10 days | Full recovery |
| Buyukberber et al., 2021 [86] | 2020    | F/4 yr old    | Turkey  | Previous urinary surgery              | Urinary tract infection | Ceftazidime, Ciprofloxacin, Meropenem, Piperacillin/tazobactam Aminoglycosides, Amoxicillin/Clavulanic acid, 2nd, and 3rd generation Cephalosporins, Carbapenems, Colistin, Ticarcillin | Amikacin, Gentamicin, Imipenem, SXT | Amikacin Followed by Ceftazidime | Full recovery |
| Miloudi et al., 2021 [87] | 2020    | N/A/12        | Morocco | None                                  | Acute appendicitis | Ciprofloxacin, Norfloxacin, SXT | Aminoglycosides, Amoxicillin/Clavulanic acid (3 g/24 h for 15 days) | Appendectomy and surgical drainage, Full recovery |
| Ayhanci et al., 2021 [88] | 2021    | M/51 yr old   | Turkey  | None                                  | Bacteriemia       | Gentamicin, Levofloxacin, Imipenem, Meropenem | N/A | Levofloxacin 500 mg/day w | Full recovery |
| Sammoni et al., 2022 [89] | 2022    | M/16 yr old   | Syria   | Burn victim                           | Sepsis            | Colistin         | N/A | Ceftazolin and Ceftriazone Followed by Colistin-amikacin for 14 days | Full recovery |

F—Female, M—Male, N/A—Not Available, SXT sulfamethoxazole-Trimethoprim. * Antibiotic susceptibility testing was carried out using a variety of methods, including disk diffusion testing, agar and broth dilution testing and E-testing methods.
Table 3. Incidences of *Comamonas kerstersii* infection from 2013 to 2022. Main characteristics of the case reports.

| Author (Ref.) | Year | Sex/Age | Country | Co-Morbidity | Type of Infection | Susceptible to * | Resistance to * | Antibiotic Treatment | Outcome |
|---------------|------|---------|---------|--------------|------------------|-----------------|-----------------|---------------------|---------|
| Almuzara et al., 2013 [90] | 2013 | F/43 yr old | Argentina | Ovarian tumor with peritoneal metastases | Sigmoid perforation by foreign body (biliary stent), rectovaginal fistula, and colostomy | Amikacin, Ampicillin, Ampicillin-Sulbactam, Cephalothin, Cefoxitin, Cefotaxime, Ceftazidime, Cefepime, Colistin, Gentamicin, Imipenem, Meropenem, Piperacillin-Tazobactam, SXT | Ciprofloxacin | Ampicillin-Sulbactam, Piperacillin-Tazobactam, Ertapenem | Full recovery |
| Almuzara et al., 2013 [90] | 2013 | M/48 yr old | Argentina | None | Perforated appendix | Amikacin, Ampicillin, Ampicillin-Sulbactam, Cephalothin, Cefoxitin, Cefotaxime, Ceftazidime, Cefepime, Ciprofloxacin, Colistin, Gentamicin, Imipenem, Meropenem, Piperacillin-Tazobactam, SXT | N/A | Ampicillin-Sulbactam, Ciprofloxacin, Amoxicillin-Clavulanic acid | Full recovery |
| Almuzara et al., 2013 [90] | 2013 | F/10 yr old | Argentina | None | Perforated gangrenous appendix | Amikacin, Ampicillin, Ampicillin-Sulbactam, Cephalothin, Cefoxitin, Cefotaxime, Ceftazidime, Cefepime, Colistin, Gentamicin, Imipenem, Meropenem, Piperacillin-Tazobactam, SXT | Ciprofloxacin | Ampicillin, Metronidazole, Gentamicin, and then Amoxicillin-Clavulanic acid | Full recovery |
| Almuzara et al., 2013 [90] | 2013 | F/21 yr old | Argentina | None | Perforated gangrenous appendix | Amikacin, Ampicillin, Ampicillin-Sulbactam, Cephalothin, Cefoxitin, Cefotaxime, Ceftazidime, Cefepime, Colistin, Gentamicin, Imipenem, Meropenem, Piperacillin-Tazobactam, SXT | Ciprofloxacin | Ampicillin, Metronidazole, Gentamicin | Full recovery |
Table 3. Cont.

| Author (Ref.)         | Year | Sex/Age   | Country              | Co-Morbidity               | Type of Infection                  | Susceptible to *                                      | Resistance to *                                      | Antibiotic Treatment                                                                 | Outcome                      |
|-----------------------|------|-----------|----------------------|----------------------------|------------------------------------|------------------------------------------------------|------------------------------------------------------|----------------------------------------------------------------------------------------|-----------------------------|
| Biswas et al., 2014  | 2014 | M/10 yr old | United Kingdom       | None                       | Perforated appendix                | Amikacin, Ceftazidime, Ciprofloxacin, Colistin, Gentamicin, Meropenem, Piperacillin-Tazobactam | N/A                                                                                     | Open appendectomy, Piperacillin-Tazobactam (5 days), Amoxicillin-Clavulanic acid, Ciprofloxacin Surgery, Amoxicillin-Clavulanic acid, Gentamicin, Metronidazole (intravenously, 3 days), Amoxicillin-Clavulanic acid (orally) | Full recovery               |
| Biswas et al., 2014  | 2014 | M/9 yr old | United Kingdom       | None                       | Septic shock (due to perforated appendix) | Amoxicillin-Clavulanic acid, Ceftazidime, Colistin, Gentamicin, Meropenem, Piperacillin-Tazobactam | Ciprofloxacin                                                                 |                                                                                       | Full recovery               |
| Opota et al., 2014   | 2014 | M/65 yr old | Switzerland          | Diabetes                   | Bacteremia with sign of diverticulosis | Ceftazidime, Ciprofloxacin, Meropenem, Imipenem, Minocycline, Levofloxacin, SXT | N/A                                                                                     | Imipenem-Cilastatin (10 days)                                                  | Full recovery               |
| Almuzara et al., 2017 | 2017 | F/54 yr old | Argentina            | Obesity, hypertension, diabetes | Septic shock                        | SXT, Metronidazole                                   | Pipercillin/Tazobactam, Vancomycin               | SXT 15 mg/kg (intravenously every 12 h) and Metronidazole 500 mg (intravenously every 8 h), 30 days Ceftriaxone (intravenously 2 g/day, 6 days), Metronidazole (orally 500 mg/12 h, 8 days), Doxycycline (orally 100 mg/12 h, 8 days), Amoxicillin/Clavulanic acid (orally 500 mg/8 h, 14 days) | Full recovery               |
| Almuzara et al., 2017 | 2017 | F/15 yr old | Argentina            | None                       | Pelvic peritonitis due to genital tract infection | N/A                                                                                   | N/A                                                                                     |                                                                                       | Full recovery               |
| Almuzara et al., 2018 | 2018 | F/5 yr old  | Argentina            | None                       | Urinary tract infection              | Amikacin, Ampicillin, Ampicillin/Sulbactam, Cephalothin, Colistin, Ceftazidime, Ciprofloxacin, Gentamicin, Imipenem, Meropenem, Piperacillin-Tazobactam, SXT | Ceftriaxone                                                                 | Pipercillin/Tazobactam (intravenously 200 mg/kg per day, every 8 h, 10-days), Amoxicillin/Clavulanic acid (orally 50 mg/kg per day, 14 days) | Full recovery               |
| Author (Ref.)                  | Year | Sex/Age   | Country   | Co-Morbidity | Type of Infection | Susceptible to * | Resistance to * | Antibiotic Treatment                                                                 | Outcome                      |
|--------------------------------|------|-----------|-----------|--------------|-------------------|-------------------|----------------|--------------------------------------------------------------------------------------|-------------------------------|
| Zhou et al., 2018 [95]         | 2018 | M/31 yr old | China     | None         | Acute peritonitis, perforated appendix (with abdominal abscess) | All except Ciprofloxacin Levofloxacin, SXT | Ciprofloxacin Levofloxacin, SXT | Exploratory laparotomy, appendectomy, tube drainage, Cefuroxime and metronidazole (14 days) Surgery (left thoracotomy exploration, repair of oesophageal hiatal hernia, laparotomy exploration, partial colectomy, colostomy), Piperacillin-Tazobactam (Intravenously 4.5 g, every 8 h, 14 days) | Full recovery                 |
| Liu et al., 2020 [96]          | 2020 | M/62 yr old | China     | None         | Intra-abdominal infection due to perforated colon | Amikacin, Cefazidime, Cefepime, Ciprofloxacin, Ceftazidime, Cefuroxime, Levofloxacin, Meropenem, Minocycline, Piperacillin-Tazobactam, SXT | Cephalothin, Cefotaxime, Ciprofloxacin, Gentamicin | Full recovery                                     |
| Palacio et al., 2020 [97]      | 2020 | M/16 yr old | Uruguay   | None         | Acute appendicitis | Amikacin, Ampicillin Sulbactam, Ceftazidime, Cefepime, Gentamicin, Piperacillin/Tazobactam, Meropenem, Imipenem, Cotrimoxazole | N/A                           | Laparoscopic surgery, Piperacillin/Tazobactam (intravenously, 4.5 g every 6 h, 10 days) | Full recovery                 |
| Farfán-Cano et al., 2020 [98]  | 2020 | M/14 yr old | Ecuador   | None         | Perforated appendicitis | N/A                           | N/A                           | Piperacillin/Tazobactam (14 days) Ciprofloxacin and Metronidazole IV for 10 days Conventional Appendectomy, Ciprofloxacin, and Metronidazole Laparoscopic appendectomy Conventional Appendectomy, Ampicillin/Sulbactam + Metronidazole Conventional appendectomy, Ampicillin/Sulbactam | Full recovery                 |
| Farfán-Cano et al., 2020 [99]  | 2020 | F/27 yr old | Ecuador   | Obesity and being on lactation period | Acute appendicitis | N/A                           | N/A                           | Piperacillin/Sulbactam + Metronidazole Conventional appendectomy, Ampicillin/Sulbactam | Full recovery                 |
| Farfán-Cano et al., 2021 [99]  | 2020 | M/29 yr old | Ecuador   | None         | Acute appendicitis | N/A                           | N/A                           | Piperacillin/Sulbactam + Metronidazole Conventional appendectomy, Ampicillin/Sulbactam | Full recovery                 |
| Farfán-Cano et al., 2021 [99]  | 2020 | M/68 yr old | Ecuador   | None         | Acute appendicitis | N/A                           | N/A                           | Piperacillin/Sulbactam + Metronidazole Conventional appendectomy, Ampicillin/Sulbactam | Full recovery                 |
| Farfán-Cano et al., 2021 [99]  | 2020 | F/16 yr old | Ecuador   | None         | Acute appendicitis | N/A                           | N/A                           | Piperacillin/Sulbactam + Metronidazole Conventional appendectomy, Ampicillin/Sulbactam | Full recovery                 |
| Farfán-Cano et al., 2021 [99]  | 2020 | F/16 yr old | Ecuador   | Psoriasis    | Acute appendicitis | N/A                           | N/A                           | Piperacillin/Sulbactam + Metronidazole Conventional appendectomy, Ampicillin/Sulbactam | Full recovery                 |
Table 3. Cont.

| Author (Ref.) | Year | Sex/Age     | Country | Co-Morbidity         | Type of Infection | Susceptible to *                                      | Resistance to * | Antibiotic Treatment                                      | Outcome |
|---------------|------|-------------|---------|----------------------|-------------------|--------------------------------------------------------|----------------|-----------------------------------------------------------|---------|
| Rong et al., 2022 [100] | 2022 | M/82 yr old | Canada  | Type 2 diabetes      | Bacteremia        | Ceftazidime, Gentamicin, Imipenem, Meropenem,          | Ciprofloxacin  | Piperacillin-tazobactam Followed by intravenous Ceftriaxone   | Full recovery |
|               |      |             |         |                      |                   | Piperacillin/tazobactam, Tobramycin                    |                | (1 g/day) Intravenous Amoxicillin-clavulanic acid, Gentamicin, and |         |
|               |      |             |         |                      |                   | Metronidazole                                          |                | Metronidazole Followed by oral Amoxicillin-Clavulanic acid.  |         |
| Bennani et al., 2022 [101] | 2002 | M/8 yr old  | Morocco | None                 | Acute appendicitis | N/A                                                    | N/A            | Full recovery                                             |         |

F—Female, M—Male, N/A—Not Available, SXT sulfamethoxazole-trimethoprim. * Antibiotic susceptibility testing was carried out using a variety of methods, including disk diffusion testing, agar and broth dilution testing and E-testing methods.

Table 4. Incidences of Comamonas spp. infection from 2000 to 2022. Main characteristics of the case reports.

| Author (Ref.) | Year | Sex/Age     | Country | Co-Morbidity | Type of Infection | Susceptible to *                                      | Resistance to * | Antibiotic Treatment                                      | Outcome |
|---------------|------|-------------|---------|--------------|-------------------|--------------------------------------------------------|----------------|-----------------------------------------------------------|---------|
| Sonnenwirth, 1970 [102] | 1970 | F/71 yr old | USA     | Rheumatic heart disease | Endocarditis | Chloramphenicol, Oxytetracycline, Tetracycline         | Ampicillin, Cephalothin, Colistin, Penicillin, Streptomycin | Penicillin | Full recovery                                             |         |
| Isotalo et al., 2000 [103] | 2000 | M/35 yr old | Canada  | None         | Tenosynovitis (From an animal bite) | N/A                     | N/A            | Intravenous (IV) cefazolin at 1 g/8 h and gentamicin 80 mg/8 h for a total of 72 h | Full recovery |
| Kaeuffer et al., 2018 [104] | 2017 | M/66 yr old | France  | Diabetes, ischemic heart disease, removed sigmoid polyps | Bacteremia and septic shock | Amoxicillin-Clavulanic acid, Ceftazidime, Cefepime, Ciprofloxacin, Imipenem, Piperacillin-Tazobactam | N/A            | Norepinephrine, Cefotaxime, Ciprofloxacin (10 days) | Full recovery |
| Guo et al., 2021 [105] | 2021 | F/60 yr old | China   | Kidney stones. | Urinary Tract Infection | Chloramphenicol, Imipenem, SXT                                      |                | Imipenem-cilastatin 1 g IV for 1 month to fight | Full recovery |

F—Female, M—Male, N/A—Not Available, SXT sulfamethoxazole-trimethoprim. * Antibiotic susceptibility testing was carried out using a variety of methods including disk diffusion testing, agar and broth dilution testing and E-testing methods.
6. Treatment of Comamonas spp. Infections

Antibiotic treatment of Comamonas spp. infections can be difficult. Comamonas spp. can be resistance to various antibiotic families including β-lactams (penicillins, cephalosporins and the development of resistance to carbapenems). To date, no controlled trials of antimicrobial therapies for Comamonas spp. infections in humans have taken place; consequently, antibiotic treatment ought to be based upon results of in vitro susceptibility testing on isolates. A variety of different antibiotics have been employed to treat Comamonas spp. infections found in the literature and, in most cases, they are susceptible to aminoglycosides, fluoroquinolones, carbapenems, piperacillin-tazobactam, trimethoprim-sulfamethoxazole, and cephalosporins (Tables 2–4).

Resistance to β-lactams class antimicrobials can be due to the possession of several genes by Comamonas spp. C. testosteroni S44 possesses a three-gene operon that codes for a Class A β-lactamases (resistance to benzylpenicillin, ampicillin, cefalexin, cefazolin, cefuroxime, ceftriaxone, and cefepime). These genes are CzoA (Class A β-lactamase encoding gene)—inhibits β-lactams antibiotics, CzoR (LysR type transcriptional regulator)—positively affects the expression of CzoA, and the IscR gene—enhances the regulatory effect of CzoR when bounded to its promoter region [106]. Several resistance genes were found in C. kerstersii 8943, including tetA, strB, sul1, blaOXA-1, strA, sul2, catB3 and floR. The blaIMP-8 gene (giving resistance to β-lactam antibiotics) has been found in a Comamonas thiooxydans isolate, which caused a urinary tract infection. This isolate also had a novel class D beta-lactamase gene blaOXA and a aac(6’)-Ib-c gene (resistance to aminoglycoside antibiotics). A variety of efflux pumps were also identified in the genomes of this bacterial isolate. [105]. A study in 2022 found another Comamonas thiooxydans isolate with a plasmid-based blaIMP-1 gene [107]. In a study by Hem et al., 2022, 32 Comamonas. denitrificans and 5 C. testosteroni from wastewater, 1 C. denitrificans from a wetland, and 1 C. aquatica from a lake with public access were sequenced. All were found to be resistant to carbapenem antibiotics. However, only 13 C. denitrificans isolates were found to have an identifiable carbapenemase blaGES-5. No identifiable carbapenemase genes were found in the other isolates. Other C. denitrificans isolates carried extended-spectrum β-lactamase (ESBL) blaOXA genes. This was the first report of resistance to carbapenem antibiotics in both C. denitrificans and C. aquatica; however, carbapenem-resistance was previously reported in a C. testosteroni infection in Turkey in 2015 [77,108].

7. Conclusions

Comamonas spp. are not currently considered important pathogens and are thought of as being of low virulence and of being a lesser danger in comparison to other non-fermenting Gram-negative bacteria such as Pseudomonas aeruginosa. Nevertheless, in this review, fifty-five separate outbreaks of Comamonas spp. infections have been identified from the scientific literature not taking into account unreported/undocumented cases. It must be recommended that the scientific community acknowledge the ability of this organism to elude antimicrobials and thus the potential for antimicrobial resistance transference between organisms, particularly in an era of growing antimicrobial susceptibility concerns.

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