West Virginia

Carbapenem-Resistant Organisms &

Carbapenemase-Producing Organisms

2023 Surveillance Report

West Virginia Department of HEALTH

Healthcare-Associated Infections and
Antimicrobial Resistance Program
Office of Epidemiology and Prevention Services
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Charleston, West Virginia 25301

Carbapenem-Resistant Organisms & Carbapenemase-Producing Organisms in West Virginia
January 1, 2023 – December 31, 2023

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CRO and CPO Overview

CRO is a type of multidrug-resistant organism (MDRO) that can cause infections and colonization, particularly in healthcare settings. They are difficult to treat and are included in the Centers for Disease Control and Prevention's (CDC) 2019 urgent threats report (2019 Antibiotic Resistance Threats Report, 2024). These organisms can cause a wide range of infections such as those of the urinary tract, bloodstream, respiratory tract, and wounds. They have developed resistance to a last-line antibiotic class, the carbapenems. Bacteria in the taxonomic order called Enterobacterales (CRE), and others like *Acinetobacter baumannii* (CRAB), in the *Moraxellaceae* family, and *Pseudomonas aeruginosa* (CRPA), in the *Pseudomonadaceae* family, are commonly found in the environment and can cause the same types of infections. They are associated with a high mortality rate depending on the type of bacteria. Some studies indicate that rate may be as high as 50%.

CPO infections are those that have acquired mobile genetic elements, also known as plasmids, that carry genes with the ability to produce enzymes that actively hydrolyze or break down carbapenem antibiotics. *Klebsiella pneumoniae* carbapenemase (KPC) is most common in the United States, followed by New Delhi metallo-β-lactamase (NDM), and oxacillinase-like carbapenemase-(OXA-like) producing infections. Of the ninety-three CPO cases in West Virginia in 2023, about 37% were KPC. The next most common is OXA-like at 12%. The remaining half includes NDM, Verona integron-encoded metallo- β-lactamase (VIM) and other unknown types. These plasmids are easily exchanged between different bacteria, thus facilitating the rapid spread of carbapenem resistance. CDC recommends more stringent infection prevention practices in areas where CPO is prevalent as these organisms are suspected to be responsible for much of the spread throughout the country. Infections may be carbapenem-resistant without being carbapenemase-producing, vice versa, or have both characteristics.

Risk Factors

CRO and CPO infections are a major concern for patients in healthcare facilities. Some bacteria are resistant to nearly all antibiotics, leaving more toxic or less effective treatment options. The primary risk factors for CRO and/or CPO acquisition in the United States include exposure to healthcare and exposure to antibiotics. Patients who require devices (e.g., urinary catheters) and patients taking long courses of some antibiotics are most at risk. Healthcare-related risk factors include requiring help with activities of daily living like toileting and bathing, exposure to an intensive care unit, and mechanical ventilation. Several antibiotics have been associated with these infections, including carbapenems that have already been discussed, as well as cephalosporins, fluoroquinolones, and vancomycin.

Reporting Requirements and Surveillance Information

In 2017, a case of CRO in West Virginia was defined as an *Enterbacterale* isolate that was resistant to at least one carbapenem antibiotic (doripenem, ertapenem, imipenem, and meropenem) OR a documented carbapenemase producer (e.g., KPC, NDM, VIM, IMP, OXA-48) demonstrated by a recognized test (e.g., polymerase chain reaction (PCR), metallo-β-lactamase test, modified Hodge test, Carba NP, matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF). There were four exceptions to this case definition: *Proteus* spp., *Providencia* spp., *Morganella* spp., and *Stenophormonas* spp. These organisms are intrinsically resistant to imipenem and need to be resistant to one carbapenem other than imipenem OR be a documented carbapenemase producer. This definition remained the same until December 31, 2022.

Beginning on January 1, 2023, West Virginia changed the case definition to include CRAB and CRPA. This expansion aligned our surveillance efforts with national standardized practices. Consistent classification of CRO and/or CPO counts facilitates reporting to professional audiences, policymakers, and the public. Further, it creates actionable epidemiology for healthcare facilities and public health officials, enabling effective prevention, detection, and response. The overarching goal is to contain the spread of CRO/CPO improving accountability of potential new antimicrobial resistance threats that often arise quickly.

Limitations

There are several limitations that should be noted in the data summarized in this report. Not all laboratories have the equipment and/or resources to test carbapenemase production. Without this information, intensity of infection prevention efforts may be inadequate. Additionally, timeliness of knowing carbapenemase production status is essential to investigate cases before organisms can be spread. The West Virginia Healthcare-Associated Infections/Antimicrobial Resistance (HAI/AR) program, along with the West Virginia Office of Laboratory Services (OLS), can provide carbapenemase testing. Through collaboration with CDC's Antimicrobial Resistance Laboratory Network (ARLN) mid-Atlantic division, testing is readily available. Awareness of this capability is a challenge. Communication is ongoing to recruit new participants into this program.

In addition to the laboratory and/or provider reported CRO/CPO results, information captured in disease case investigation relies on the local health departments' successful contact with the case-patient and performing an interview style investigation. Information collected in disease investigations relies on self-reporting by the case-patient. This can make investigation completion difficult and/or inaccurate if the case-patient has issues with recall, does not wish to complete the interview, or provides false information. Additionally, interviewers may not enter needed information into the West Virginia Electronic Disease Surveillance System (WVEDSS). Some of that information includes specimen source, culture type, detection of carbapenemase production, and public health actions taken.

Completeness of CRO and/or CPO case investigations in WVEDSS is also a limitation. The following tables define and illustrate statewide completeness for 2023.

Table 1.1, Completeness Elements and Criteria, Statewide

Data Element	**Criteria for "Complete"**
CRO organisms	Name of organism entered.
Specimen source	Has a valid source entered.
Culture type	"Clinical" or "Surveillance" entered.
Detection of carbapenemase production by a recognized test?	May be "Unknown" until further information becomes available. Update with "No," "Not Tested," or "Yes" when determined. If "Yes," select "Hodge Test," "IMP PCR," "KPC PCR," "NDM PCR," "OXA 48-like PCR," and/or "VIM PCR."
Was the patient prescribed antibiotics more than 2 times in the past 6 months?	Response other than "Unknown."
Was the patient hospitalized at the time of specimen collection?	Response other than "Unknown."
Does the patient reside in a Nursing Home (NH) or other Long Term Care Facility (LTCF)?	Response other than "Unknown."
If "yes," address of facility.	Enter the complete address including zip code.
Did the patient visit any other healthcare facilities six months before their CRE diagnosis?	Response other than "Unknown." Enter all facilities with complete addresses including zip codes.
Any indwelling device in place at any time in the past two calendar days prior to initial culture?	Response other than "Unknown."
CRO/CPO initial assessment conducted with LTCF.	Response other than "Unknown."
CDC CRO toolkit provided to and discussed with LTCF.	Response other than "Unknown."
Patient and/or family interviewed and given education.	Response other than "Unknown."
Patient is lost to follow-up.	Response other than "Unknown." Must document at least three failed attempts in the "General Comments" box in the "Case Info" tab before entering "Yes."

Table 1.2, Completeness Data, Statewide, 2023

Overall Score	%	Completed	N
CRO & CPO Organism	100%	334	334
Specimen Source	91%	296	324
Culture Type	96%	310	324
Carbapenemase Production	29%	93	324
*Mechanism/Test Type	95%	88	93
Antibiotics more than twice?	30%	226	324
Hospitalized?	92%	299	324
Resident of NH or LTCF	92%	299	324
**Address of facility	98%	116	118
Other facilities visited	75%	244	324
Indwelling devices	23%	75	324
**Assessment conducted at LTCF	71%	84	118
**Toolkit provided to LTCF	73%	86	118
Patient/Family interviewed/educated	46%	54	324

* Mechanism/Test Type “N” differs from total because not all isolates were tested for mechanism/test type.

**Address of facility, Assessment conducted, and Toolkit provided to LTCF “N” differs from the total because only LTCFs were included in this number.

CRO and CPO in West Virginia

In 2023 eight patients had two organisms reported from the same collected specimen. This is an increase from years past. No one had more than one organism reported in 2018; one patient in 2019 had two organisms reported; all patients had only one organism reported in 2020; one patient had two organisms reported in 2021; and five patients had more than one organism reported in 2022.

The organism combinations in 2023 included:

- *Klebsiella pneumoniae* and *Acinetobacter baumannii*
- *Klebsiella pneumoniae* and *Proteus mirabilis*
- *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*
- *Klebsiella pneumoniae* and *Enterobacter cloacae complex*
- *Morganella morganii* and *Enterobacter cloacae*
- *Morganella morganii* and *Proteus mirabilis*
- *Pseudomonas aeruginosa* and *Providencia stuartii*
- *Pseudomonas aeruginosa* and *Enterobacter cloacae complex*

Nineteen distinct organisms were reported in 324 patients. The most common organism identified was *Klebsiella pneumoniae* with 92, followed by *Pseudomonas aeruginosa* with 79, then *Acinetobacter baumannii* with 43. The remaining organisms in descending order were *Escherichia coli*, *Morganella morganii*, *Proteus* spp., *Providencia* spp., *Citrobacter freundii*, *Enterobacter* spp., *Klebsiella* spp., *Serratia marcescens*, *Pantoea* spp., *Raoultella* spp.

Table 2.1, CRO and CPO Incidence Statewide, West Virginia, 2023

	Total Cases	**Population in 2020**	**Incidence Rates (Per 100,000)**
CRO	N = 227	1,793,716	12.7
CPO	N = 97	1,793,716	5.4

Table 2.2, CRO and CPO Isolates Statewide, West Virginia, 2023

Organism Cultured	CRO	CPO
	(N=227)	(N=97)
Klebsiella pneumoniae	43 (18.9%)	48 (49.5%)
Pseudomonas aeruginosa	76 (33.5%)	5 (5.2%)
Enterobacter cloacae	34 (15.5%)	16 (16.5%)
Acinetobacter baumannii	23 (10.1%)	20 (20.6%)
Escherichia coli	11 (4.8%)	2 (3.3%)
Morganella morganii	10 (4.4%)	2 (1.8%)
Other	29 (12.8%)	4 (3.1%)

CRO and CPO by Surveillance Region

During the year 2023, the southern surveillance region had the highest number of CROs (figure 3.1) with 88 cases, and the highest number of CPOs (figure 3.2) with 58 cases. The central region had the least number of CROs with 21 cases and the eastern region had the least number of CPOs with 6 cases.

Figure 3.1, CRO Incidence by Surveillance Region, 2023 (N=227)

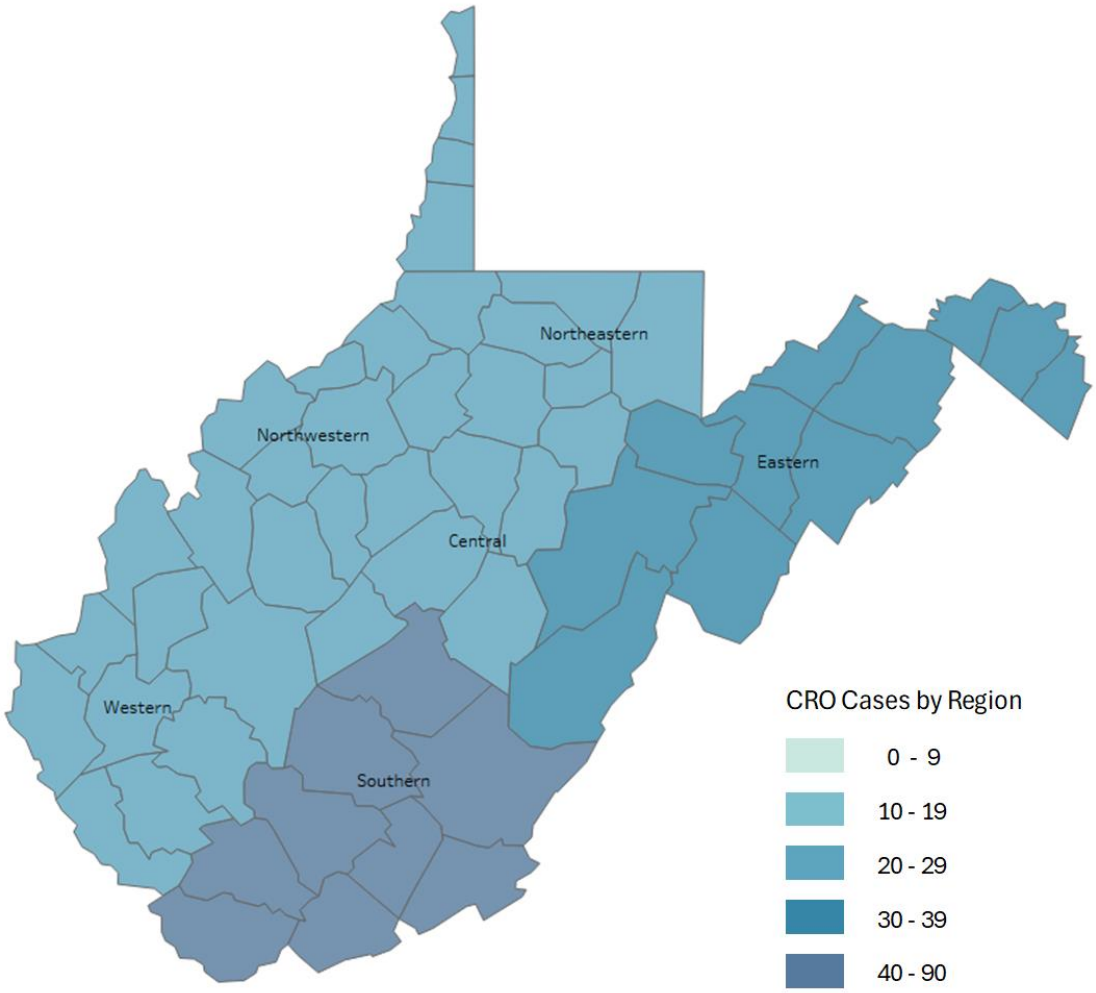
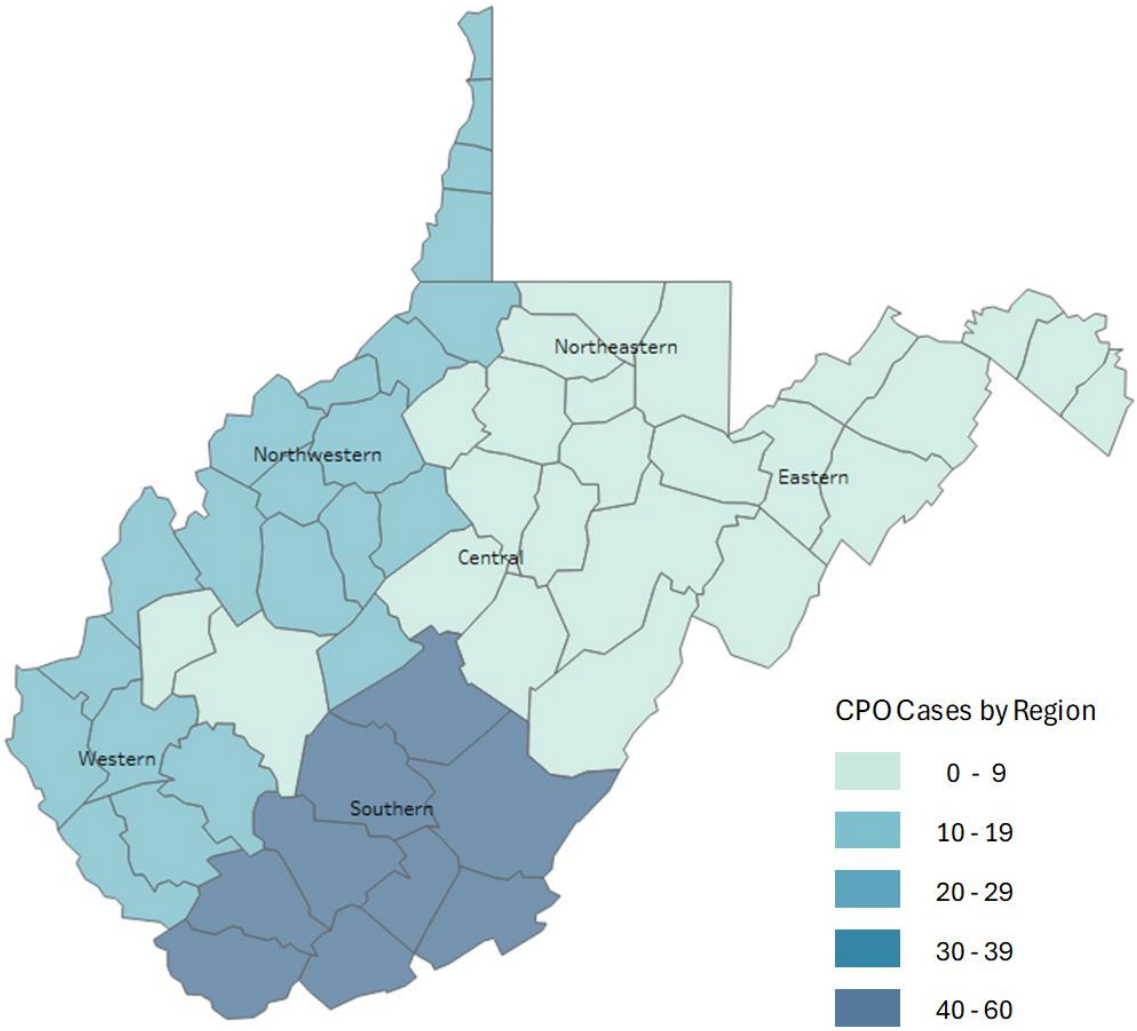


Figure 3.2, CPO Incidence by Surveillance Region, 2023 (N=97)



CRO and CPO in Central Surveillance Region

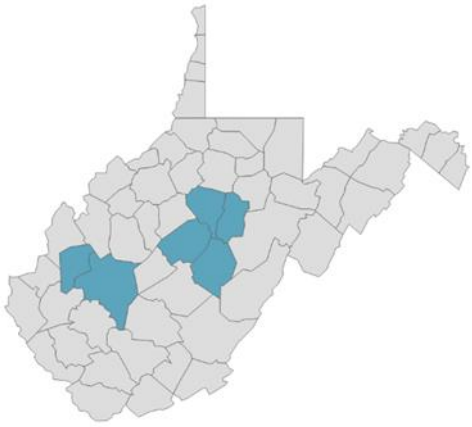
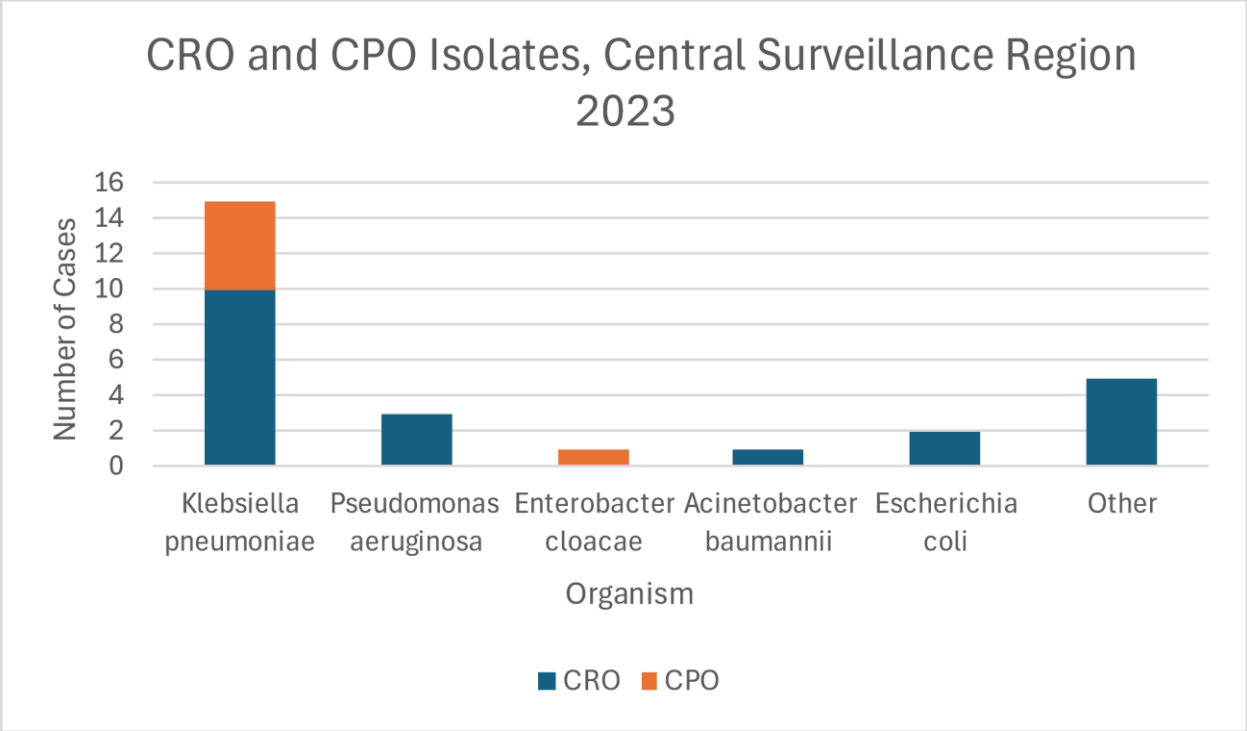


Table 4.1, CRO and CPO Isolates, Central Surveillance Region, 2023

Organism	CRO (N=21)	CPO (N=6)
Klebsiella pneumoniae	10 (47.7%)	5 (83.3%)
Pseudomonas aeruginosa	3 (14.3%)	0 (0%)
Enterobacter cloacae	0 (0%)	1 (16.7%)
Acinetobacter baumannii	1 (4.8%)	0 (0%)
Escherichia coli	2 (9.5%)	0 (0%)
Other	5 (23.7%)	0 (0%)

Figure 4.1, CRO and CPO Isolates, Central Surveillance Region, 2023



CRO and CPO in Eastern Surveillance Region

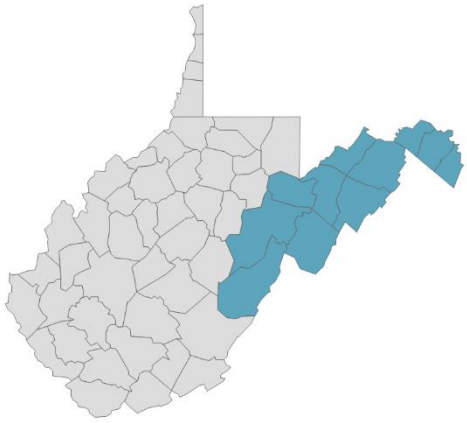
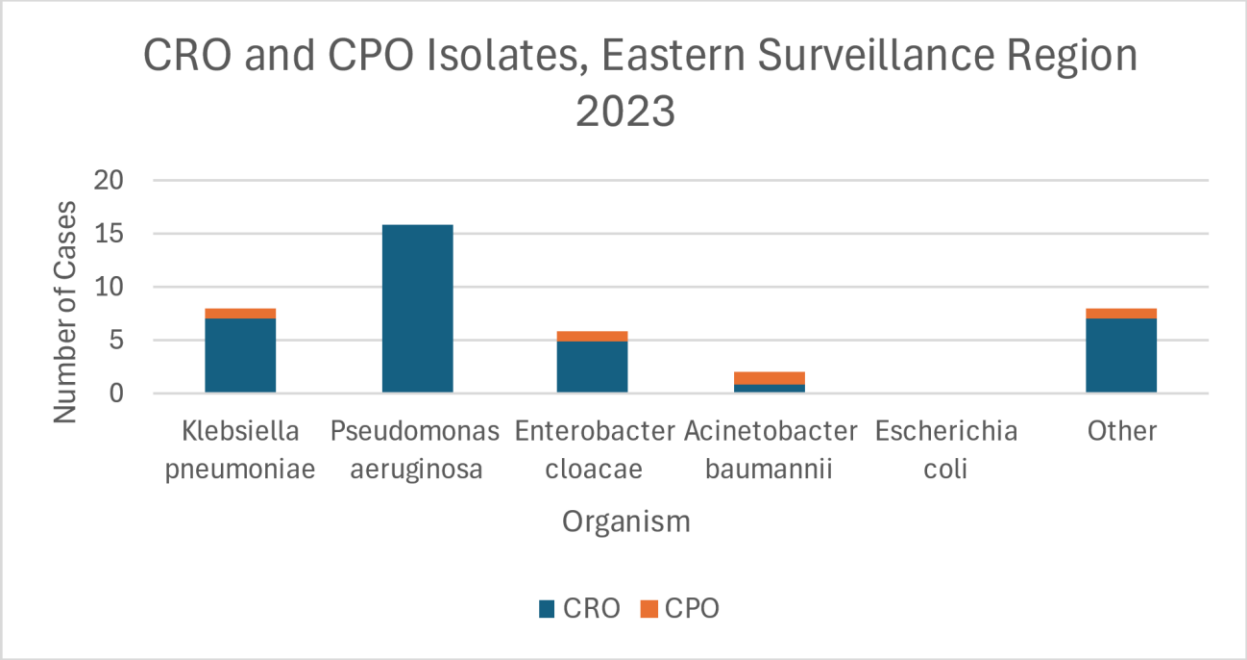


Table 5.1, CRO and CPO Isolates, Eastern Surveillance Region, 2023

Organism	CRO (N=36)	CPO (N=4)
Klebsiella pneumoniae	7 (19.4%)	1 (25%)
Pseudomonas aeruginosa	16 (44.4%)	0 (0%)
Enterobacter cloacae	5 (13.9%)	1 (25%)
Acinetobacter baumannii	1 (2.8%)	1 (25 %)
Escherichia coli	0 (0%)	0 (0%)
Other	7 (19.5%)	1 (25%)

Figure 5.1, CRO and CPO Isolates, Eastern Surveillance Region, 2023



CRO and CPO in Northeastern Surveillance Region

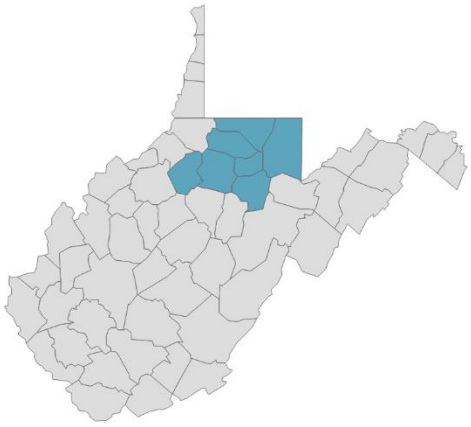
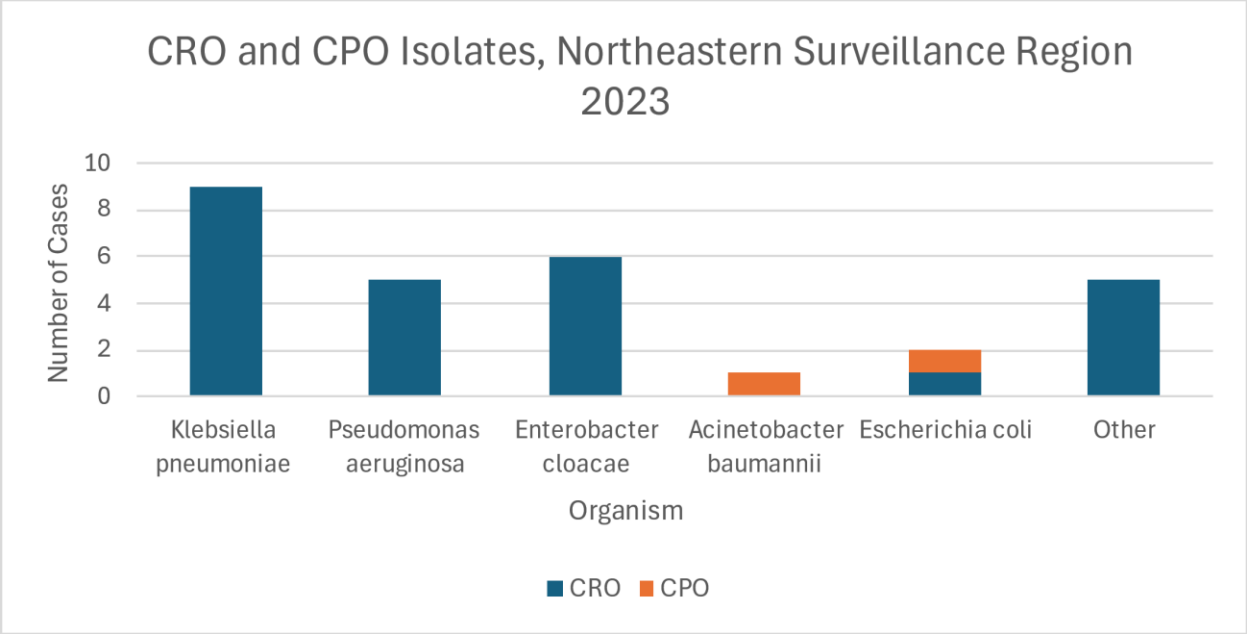


Table 6.1, CRO and CPO Isolates, Northeastern Surveillance Region, 2023

Organism	CRO (N= 26)	CPO (N=2)
Klebsiella pneumoniae	9 (34.6%)	0 (0%)
Pseudomonas aeruginosa	5 (19.2%)	0 (0%)
Enterobacter cloacae	6 (23.2%)	0 (0%)
Acinetobacter baumannii	0 (0%)	1 (50%)
Escherichia coli	1 (3.8%)	1 (50%)
Other	5 (19.2%)	0 (0%)

Figure 6.1, CRO and CPO Isolates, Northeastern Surveillance Region, 2023

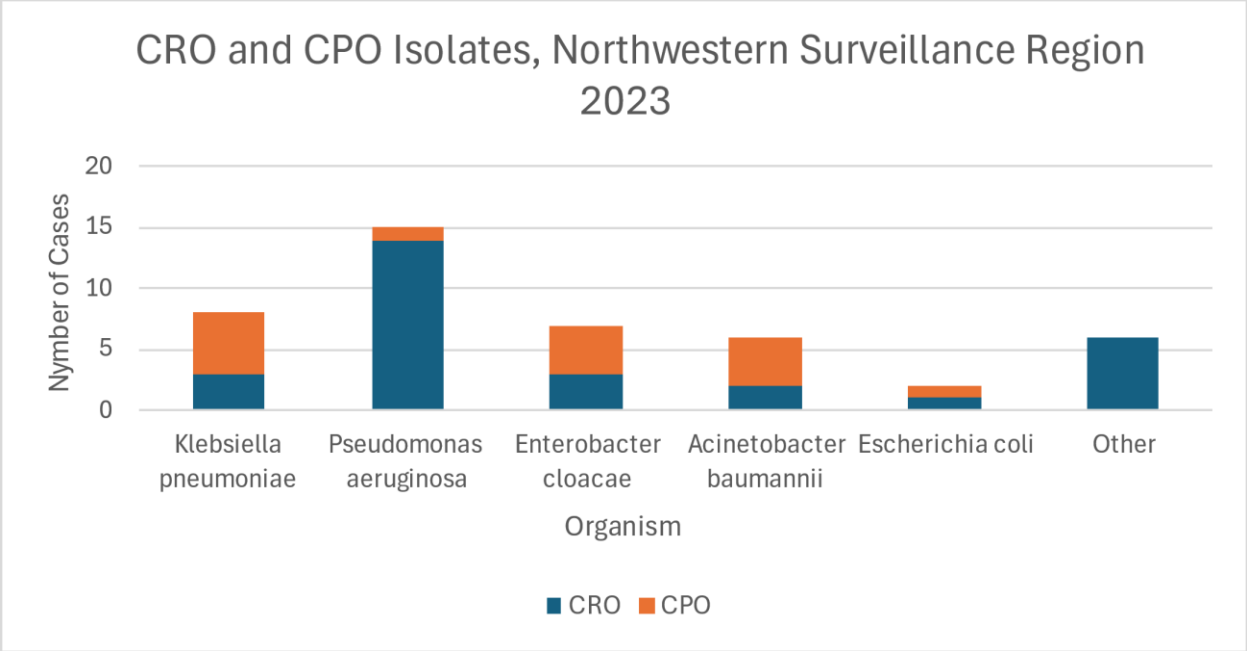


CRO and CPO in Northwestern Surveillance Region

Table 7.1, CRO and CPO Isolates, Northwestern Surveillance Region, 2023

Organism	CRO (N= 29)	CPO (N=15)
Klebsiella pneumoniae	3 (10.3%)	5 (33.3%)
Pseudomonas aeruginosa	14 (48.3%)	1 (6.7%)
Enterobacter cloacae	3 (10.3%)	4 (26.7%)
Acinetobacter baumannii	2 (6.9%)	4 (26.7%)
Escherichia coli	1 (3.4%)	1 (6.7%)
Other	6 (20.8%)	0 (0%)

Figure 7.1, CRO and CPO Isolates, Northwestern Surveillance Region, 2023



CRO and CPO in Southern Surveillance Region

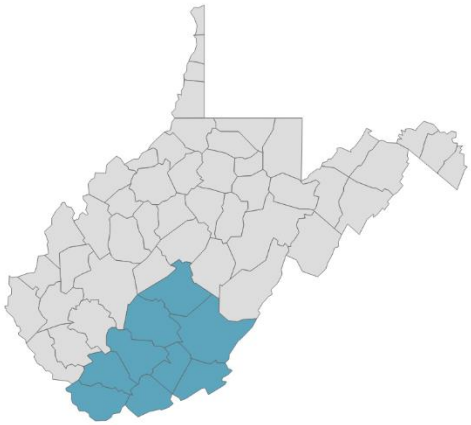
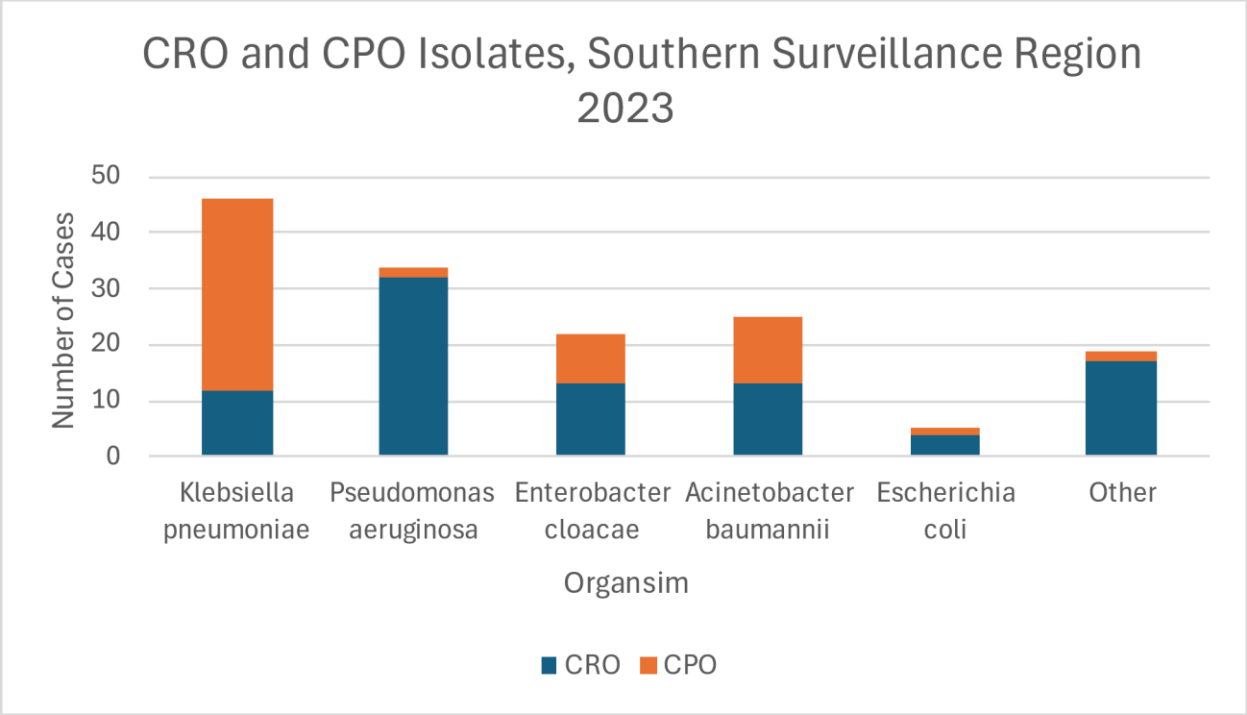


Table 8.1, CRO and CPO Isolates, Southern Surveillance Region, 2023

Organism	CRO (N=91)	CPO (N=60)
Klebsiella pneumoniae	12 (13.3%)	34 (56.7%)
Pseudomonas aeruginosa	32 (35.6%)	2 (3.3%)
Enterobacter cloacae	13 (14.4%)	9 (15%)
Acinetobacter baumannii	13 (14.4%)	12 (20%)
Escherichia coli	4 (4.4%)	1 (1.7%)
Other	17 (17.9%)	2 (3.3%)

Figure 8.1, CRO and CPO Isolates, Southern Surveillance Region, 2023

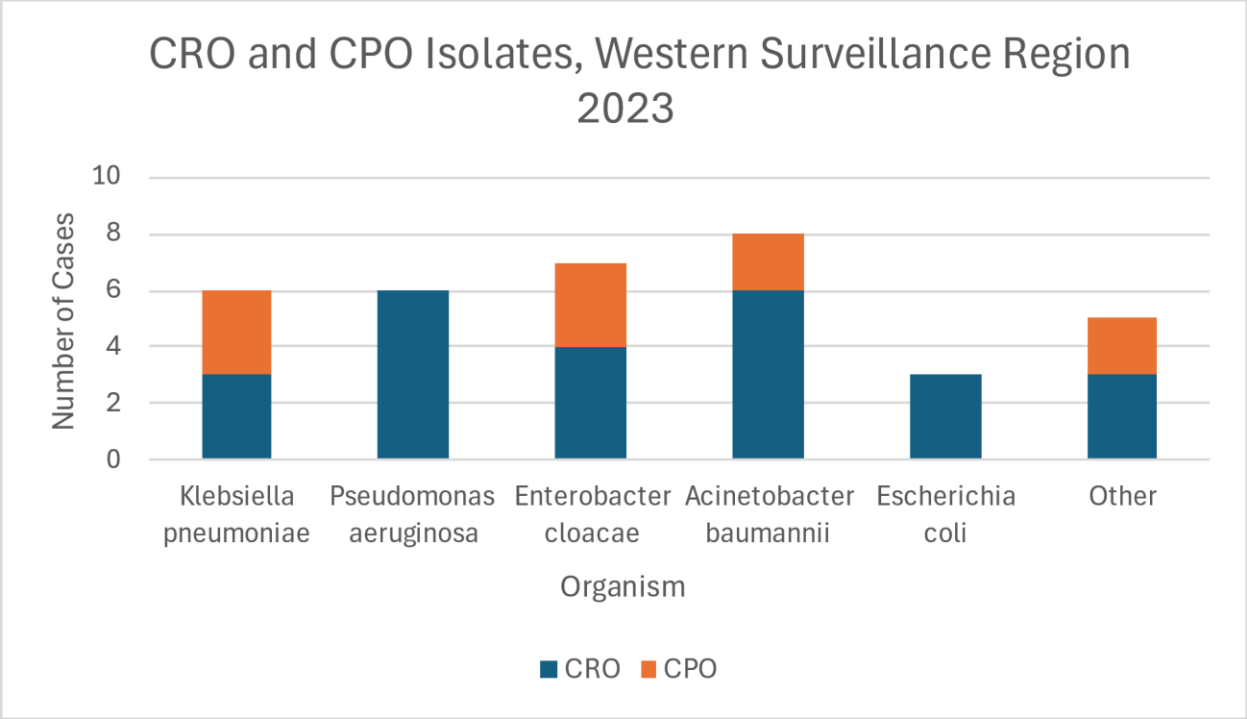


CRO and CPO in Western Surveillance Region

Table 9.1, CRO and CPO Isolates, Western Surveillance Region, 2023

Organism	CRO (N=25)	CPO (N=10)
Klebsiella pneumoniae	3 (12%)	3 (30%)
Pseudomonas aeruginosa	6 (24%)	0 (0%)
Enterobacter cloacae	4 (16%)	3 (30%)
Acinetobacter baumannii	6 (24%)	2 (20%)
Escherichia coli	3 (12%)	0 (0%)
Other	3 (12%)	2 (20%)

Figure 9.1, CRO and CPO Isolates, Western Surveillance Region, 2023



Demographics

CRO and CPO Cases by Gender

Of the 220 CRO cases in 2023, female patients made up the majority accounting for 55.5% of cases. Conversely, more male patients (55%) had CPO-positive infections.

Table 10.1, CRO and CPO Cases by Gender, West Virginia, 2023

	Number of Cases	Female	Male
CRO	N = 220	122 (55%)	98 (45%)
CPO	N = 93	41 (44%)	52 (56%)

Graph 10.1, CRO and CPO Cases by Gender, West Virginia, 2023

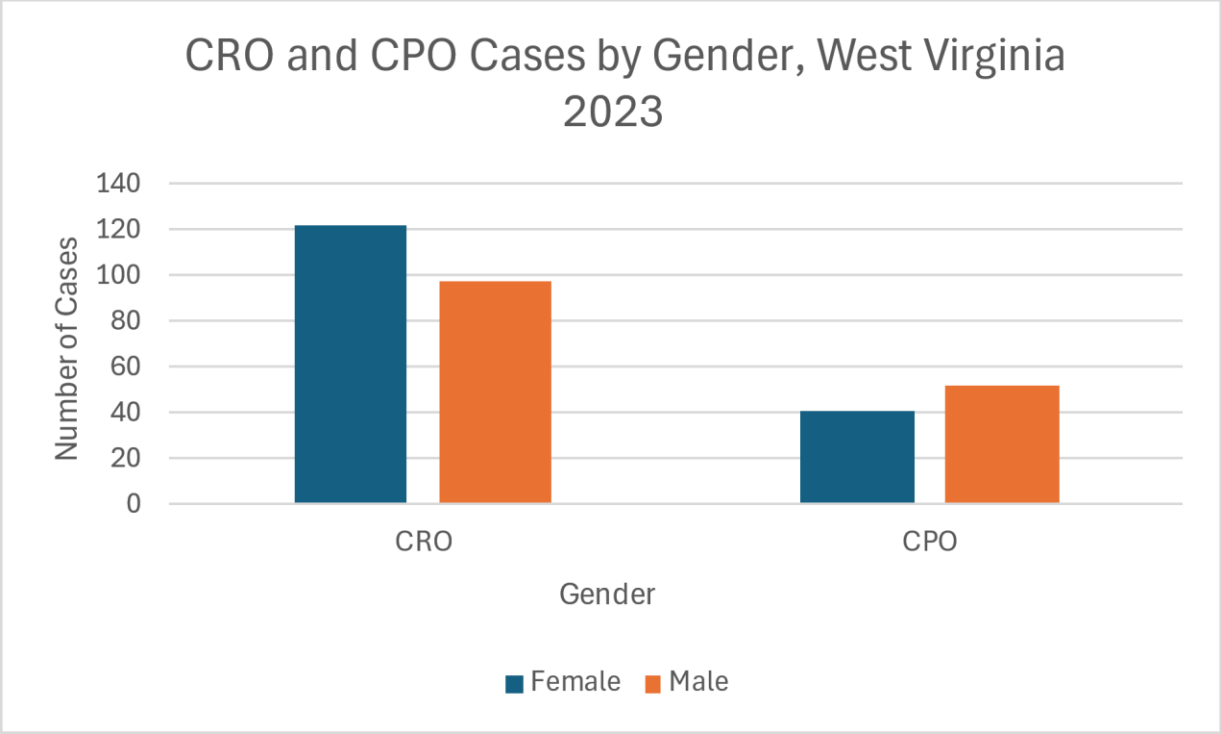


Table 10.2, Gender of CRO Cases by Surveillance Region, West Virginia, 2023

Gender	Northwest (N =27)	Northeast (N =25)	East (N =34)	South (N =88)	West (N =25)	Central (N =21)
Male	14	11	14	38	11	10
Female	13	14	20	50	14	11
Unknown	0	0	0	0	0	0

Table 10.3, Gender of CPO Cases by Surveillance Region, West Virginia, 2023

Gender	Northwest (N=15)	Northeast (N = 2)	East (N = 4)	South (N =58)	West (N =10)	Central (N =5)
Male	7	2	1	33	6	4
Female	8	0	3	25	4	1
Unknown	0	0	0	0	0	0

CRO and CPO Cases by Age

The majority of reported CRO cases during the one-year period were between the ages of 17 and 97, with the average age being 66 on a scale of 2 to 100 years. Most reported CPO cases during the same period were between the ages of 37 and 95, with the average age being 66.

Figure 11.1, CRO and CPO Cases by Age, West Virginia, 2023

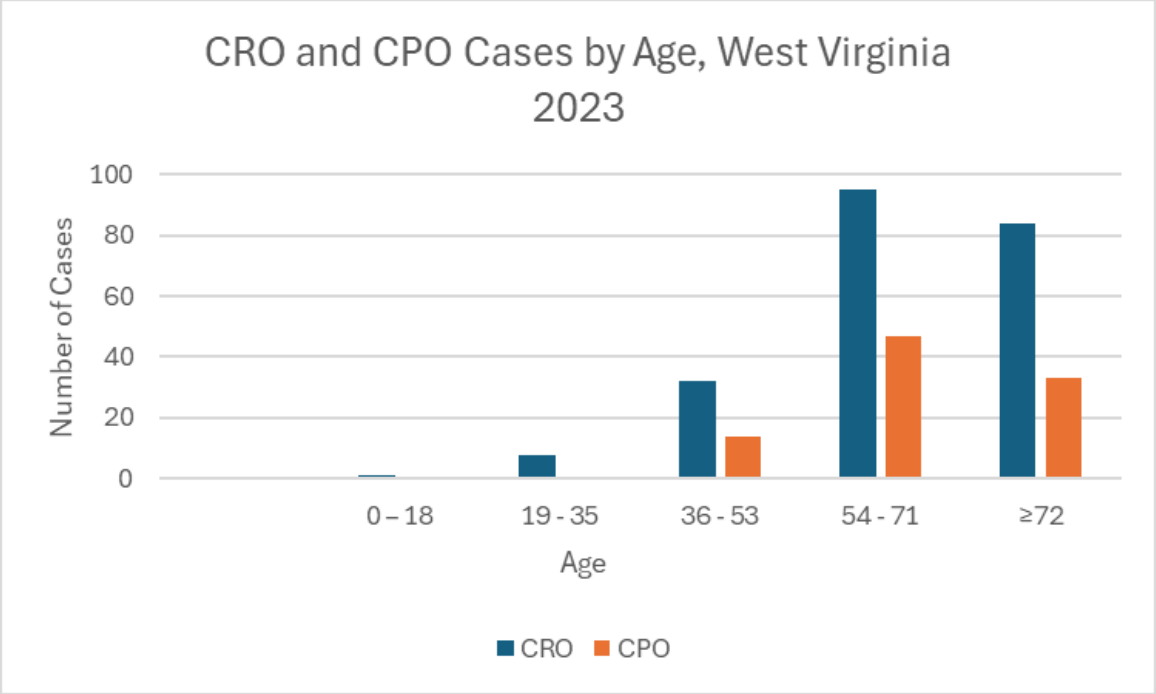


Table 11.1, Age of CRO Cases by Surveillance Region, West Virginia, 2023

Age	Northwest (N =27)	Northeast (N =25)	East (N =34)	South (N =88)	West (N =25)	Central (N =21)
Age, years (Avg.)	70	67	64	65	65	72
0 – 18	0	0	0	1	0	0
19 - 35	0	1	2	3	1	1
36 - 53	3	3	7	15	3	1
54 - 71	14	10	13	38	14	6
≥72	10	11	12	31	7	13

Table 11.2, Age of CPO Cases by Surveillance Region, West Virginia, 2023

Age	Northwest (N=15)	Northeast (N = 2)	East (N = 4)	South (N =58)	West (N =10)	Central (N =5)
Age, years (Avg.)	64	69	59	68	64	68
0 – 18	0	0	0	0	0	0
19 - 35	0	0	0	0	0	0
36 - 53	6	0	1	6	1	0
54 - 71	3	1	3	30	7	3
≥72	6	1	0	22	2	2

CRO and CPO Cases by Race

According to population statistics, nearly 93% of West Virginians are white with about 91% reported as not Hispanic or Latino (United States Census Bureau, 2022). The proportion of CRO and CPO cases combined in 2023 was similar. Seven percent of people with CRO/CPO infections were black or African American, and 90% were white. None of the cases were American Indian or Alaska Native, Asian, Native Hawaiian, or other Pacific Islander. The remaining three percent of cases were unknown (OR OTHER).

Figure 12.1, CRO and CPO Cases by Race, West Virginia, 2023

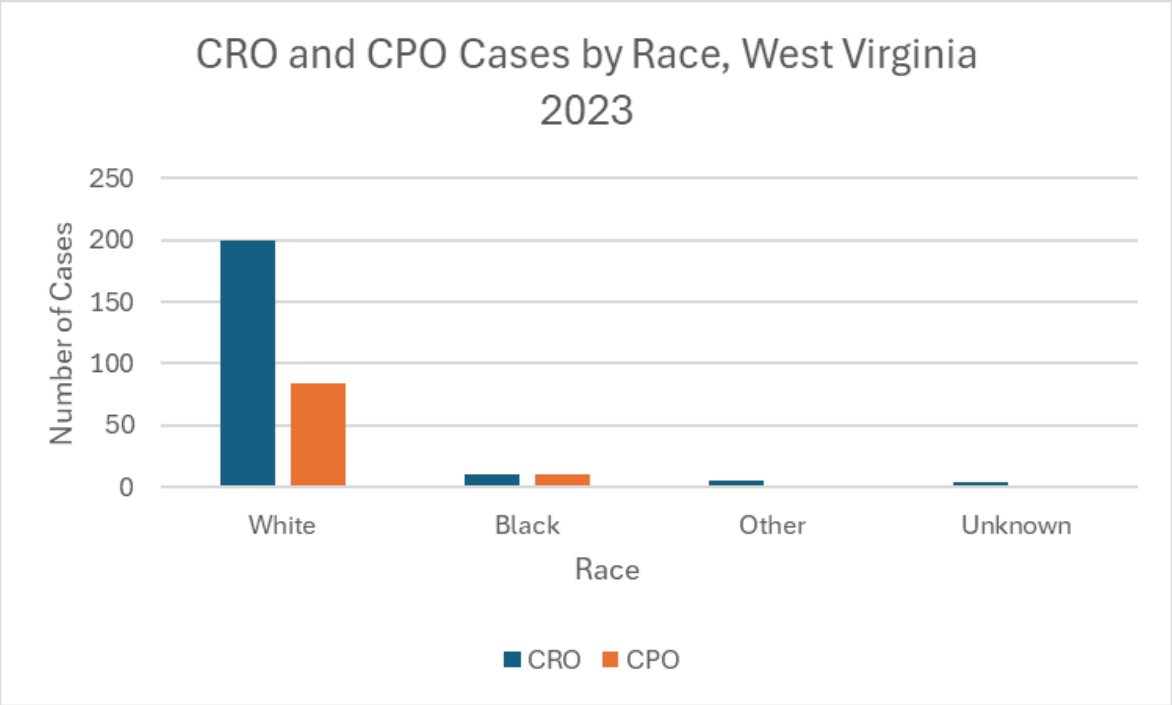


Table 12.1, Race of CRO Cases by Surveillance Region, West Virginia, 2023

Race	Northwest (N =27)	Northeast (N =25)	East (N =34)	South (N =88)	West (N =25)	Central (N =21)
White	25	25	30	81	21	18
Black	1	0	0	6	1	3
Other	0	0	2	1	2	0
Unknown	1	0	2	0	1	0

Table 12.2, Race of CPO Cases by Surveillance Region, West Virginia, 2023

Race	Northwest (N=15)	Northeast (N = 2)	East (N = 4)	South (N =58)	West (N =10)	Central (N =5)
White	15	1	4	50	9	5
Black	0	1	0	8	1	0
Other	0	0	0	0	0	0
Unknown	0	0	0	0	0	0

CRO and CPO Cases by Ethnicity

Figure 13.1, CRO and CPO Cases by Ethnicity, West Virginia, 2023

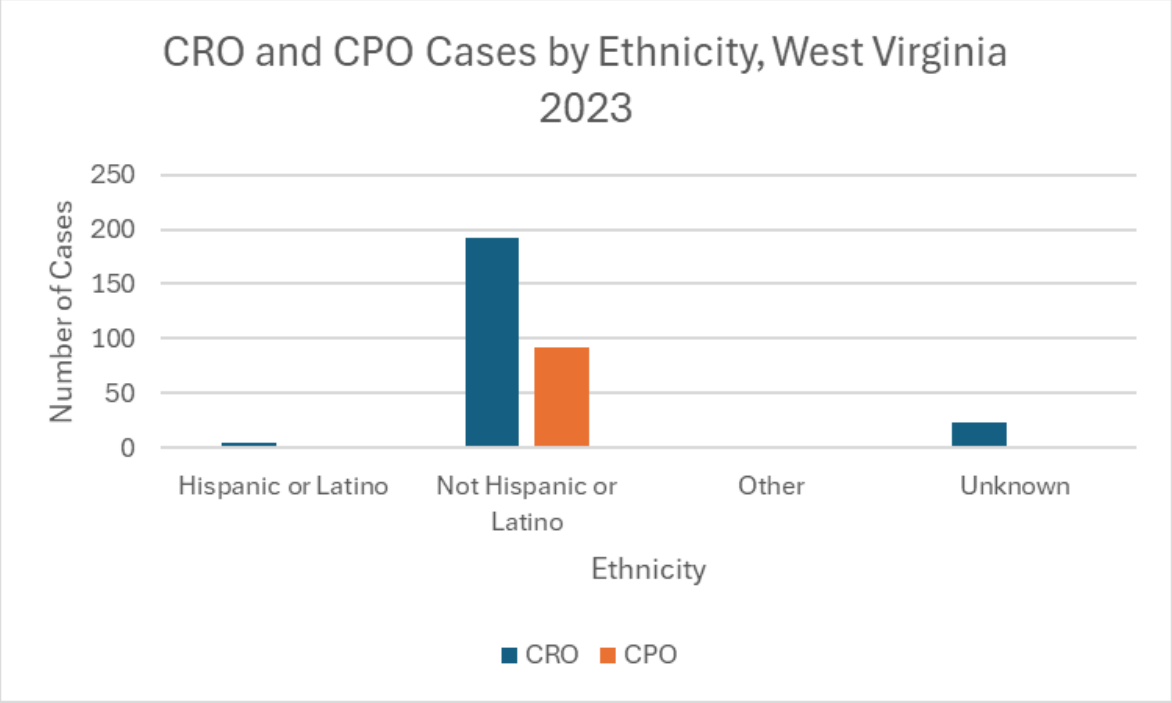


Table 13.1, Ethnicity of CRO Cases by Surveillance Region, West Virginia, 2023

Ethnicity	Northwest (N =27)	Northeast (N =25)	East (N =34)	South (N =88)	West (N =25)	Central (N =21)
Hispanic or Latino	0	0	1	0	3	0
Not Hispanic or Latino	24	24	30	73	21	20
Other	0	0	0	0	0	0
Unknown	2	1	3	15	1	1

Table 13.2, Ethnicity of CPO Cases by Surveillance Region, West Virginia, 2023

Ethnicity	Northwest (N=15)	Northeast (N = 2)	East (N = 4)	South (N =58)	West (N =10)	Central (N =5)
Hispanic or Latino	0	0	0	0	0	0
Not Hispanic or Latino	15	2	2	58	10	5
Other	0	0	0	0	0	0
Unknown	0	0	2	0	0	0

Social Vulnerability

Many factors impact a community's capacity to prepare for and respond to disease outbreaks and other public health situations including CRO and CPO transmission. Some of these include poverty level, unemployment, level of education, presence of physical or mental disability, lack of transportation or housing, and racial and ethnic status. According to a recent report from the West Virginia Geographic Information Systems (GIS) Technical Center, the five counties with the highest social vulnerability (SVI) index scores in ascending order are: Webster, Clay, Mingo, Wyoming, and McDowell. The top three counties are part of the southern surveillance region.

The number of CROs and CPOs in each surveillance region may or may not be linked to higher SVI scores. Webster county was part of the central surveillance region in 2023. Overall, SVI score in that region was 0.4775, indicating a low to medium level of vulnerability. Only one of a total of 21 CROs was reported in

Webster County. Of the five CPOs in the central region, none were in Webster. Clay county, in the northwestern region, had only one reported CPO in 2023 and no CROs. The overall SVI score in the northwest was 0.3757, indicating a low to medium vulnerability level. Mingo county, in the western region, had seven CROs and three CPOs. Overall, SVI score there was also low to medium at 0.4756. Wyoming and McDowell counties, in the southern surveillance region, reported five and four CROs respectively. Only four CPOs were reported in Wyoming county with none in McDowell. Of note, the overall SVI score in the south, where the top two counties with the highest SVI scores are located, was highest in the state at 0.6033, indicating a medium to high vulnerability risk.

Of the 1.74 million people in West Virginia, 292,000 (16.8%) live below the federal poverty level (FPL). The national average is 12.5%. The FPL in the Mountain State in 2023 was $14,580 annually for a single-person household, or $30,000 a year for a family of four. West Virginia is consistently ranked as one of the poorest states in the country. In fact, McDowell County consistently ranks in the top five counties in the country with the highest poverty rate. Poverty impacts healthcare access by making it difficult for residents to afford needed medical services, often leading to delayed care, lack of preventative interventions, and potentially prohibitive costs due to limited health insurance coverage.

More research is needed to determine if there is a connection between social vulnerability and incidence of antimicrobial resistant infections in West Virginia. Use of SVIs will continue to increase, presenting the opportunity to provide public health interventions that address specific population needs.

Discussion

The spread of carbapenem-resistant and carbapenemase-producing organism infections is considered an urgent public health threat. A large portion of the burden rests on the southern region of the state; however, health facilities throughout the state should implement prevention and control plans as no health facility is likely to remain unaffected.

This data should be interpreted with some caution. West Virginia conducts passive surveillance and relies on laboratory or facility reporting of cases. Although CRO and CPO are reportable for laboratories and providers in West Virginia, some cases may go unreported. Determining the true cause of hospitalization is not possible during the analysis of this data, as the information gathered pertains only to patient status at the time of specimen collection. There are some limitations to determining accurate incidence, chief among them assessing the population at risk. While some infections may be acquired in the community, the majority have historically been associated with exposure to healthcare facilities and prolonged use of broad-spectrum antibiotics. Hospital populations are not stable, making it difficult to ascertain who is at risk.

Surveillance of carbapenem resistance and carbapenemase production are only part of public health's efforts to prevent and control MDRO infections. The first *Candida auris* (*C. auris*) case was identified in West Virginia in 2023. *C. auris* is a type of yeast that can cause severe illness, particularly in immunocompromised people with co-morbidities, lengthy and/or frequent hospitalizations, and a history of antimicrobial overuse or misuse. Several clinical and screening cases have been identified since then. Future annual reports will be expanded to include an overview of MDRO in the state.

Recommendations

Despite the limitations, this data has implications for important infection prevention activities. Healthcare facilities in all regions of the state should adhere to recommendations for standard and contact precautions, or enhanced barrier precautions (EBP) in nursing homes, for patients who are infected or colonized with a CRO and/or CPO organism. A robust infection prevention program includes antibiotic

stewardship implemented facility wide. These programs should include appropriate use of first-line treatments of common conditions that are supported by evidence-based practices. Healthcare facilities should consider the implementation of CDC's core elements for antibiotic stewardship relative to the facility type. Educating providers, patients, and the public on the dangers of overusing antibiotics remains an important investment of time and effort on the part of state and local health departments.

Healthcare facilities that need assistance with building or improving their infection prevention programs may request assistance from the West Virginia Office of Epidemiology and Prevention Services (OEPS) Healthcare-Associated Infections / Antimicrobial Resistance program (HAI/AR). The *Infection Control Assessment and Response* (ICAR) program has been established to assist facilities in identifying gaps in infection control and to guide patient safety measures in a variety of healthcare facilities. Another resource OEPS can provide is the WV Project Firstline program. This program offers innovative and accessible infection control education for all frontline healthcare workers so they can protect their patients, their coworkers, and themselves from infectious disease threats in healthcare.

Summary

In summary, CRO and CPO infections continue to be a concern in West Virginia. The high prevalence of risk factors, increased antibiotic use, and the difficulty in treating these organisms make surveillance and response an urgent priority. It is crucial for healthcare facilities and public health officials to work together to prevent and control the spread of these organisms to protect the health and well-being of West Virginians.