



# West Virginia Carbapenem-Resistant *Enterobacteriaceae* (CRE) Surveillance Report

January 1, 2018 – December 31, 2022

**Carbapenem-Resistant *Enterobacteriaceae* (CRE) in West Virginia  
January 1, 2018 – December 31, 2022**

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**West Virginia Carbapenem-Resistant *Enterobacteriaceae* (CRE)  
Five-Year Surveillance Report  
West Virginia Department of Health  
Bureau for Public Health  
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## **Carbapenem-Resistant *Enterobacteriaceae* (CRE) Overview**

*Enterobacterale* is a family of bacteria that commonly colonizes the human digestive tract. These organisms can cause a wide range of infections, including urinary tract infections, blood infections and sepsis, respiratory infections, and wound infections. Carbapenem-resistant *Enterobacteriales* (CRE) are organisms in this family that have developed resistance to a last-line antibiotic class, the carbapenems. Other types of bacteria 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. CRAB and CRPA, like CRE, are often extremely difficult to treat and are associated with a high mortality rate; up to 50% in some studies<sup>1</sup>. Carbapenemases, enzymes that inactivate carbapenem antibiotics, are typically located on mobile bits of genetic material called plasmids. These plasmids are easily exchanged between different bacteria, thus facilitating the rapid spread of carbapenem resistance. The Centers for Disease Control and Prevention (CDC) recommends more stringent infection prevention practices in areas where Carbapenemase-Producing Carbapenem-Resistant *Enterobacteriaceae* (CP-CRE) are prevalent as these organisms are suspected to be responsible for much of the spread throughout the country.

## **Risk Factors**

CRE infections are a major concern for patients in health care facilities. Some bacteria in this family are resistant to nearly all antibiotics, leaving more toxic or less effective treatment options. The primary risk factors for CRE acquisition in the United States include exposure to health care and exposure to antibiotics. Patients who require devices (e.g., catheters) and patients taking long courses of some antibiotics are most at risk for CRE infections. Health care-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 getting CRE, including carbapenems that have already been discussed, as well as cephalosporins, fluoroquinolones, and vancomycin.

## **Reporting Requirements and Surveillance Information**

Since August 2013, West Virginia State Code under the West Virginia Reportable Disease Legislative Rule (64CSR7) has required that laboratories testing specimens from West Virginia residents to report cases of carbapenem-resistant *Enterobacteriaceae* to the local health department of the patient's county of residence within one week. The rule establishes procedures governing the reporting of certain diseases and conditions, unusual health events, and clusters or outbreaks of diseases to the West Virginia Department of Health's Bureau for Public Health. It also establishes the responsibility of various individuals and facilities in controlling communicable disease. Disease information is captured in the West Virginia Electronic Disease Surveillance System (WVEDSS) through laboratory reports, provider reports, and case-patient interviews.

In 2017, a case of CRE in West Virginia was defined as an *Enterobacterale* isolate that is 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

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<sup>1</sup> CDC, 2015 CRE Toolkit - Guidance for Control of Carbapenem-resistant *Enterobacteriaceae* (CRE)

recognized test (e.g., polymerase chain reaction (PCR), metallo- $\beta$ -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 *Stenotrophomonas* spp. These organisms are intrinsically resistant to imipenem and must be resistant to one carbapenem other than imipenem OR be a documented carbapenemase producer. This definition remained the same until December 31, 2022. The following surveillance report summarizes data from CRE cases between January 1, 2018, and December 31, 2022.

## **Limitations**

There are several limitations that should be noted in the data summarized in this report. In addition to the laboratory and/or provider reported CRE 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. The 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 WVEDSS (e.g., specimen source, culture type, detection of carbapenemase production, and public health actions taken). Further, the statewide COVID-19 response began in West Virginia in March 2020, requiring most public health professionals to direct their resources to detect, investigate, and attempt to reduce the spread of COVID-19. This ongoing response impacted the completeness of CRE reports.

The data presented in this report are provisional as the information in WVEDSS is continuously reviewed for quality assurance purposes and subject to changes as duplicate profiles are merged and additional laboratory and/or clinical information is received.

Completeness for CRE case investigations in WVEDSS is also a limitation. The following tables illustrate statewide completeness for each year between 2018 and 2022. The year with the highest percentage of overall completeness was 2020, with a score of 79.909%. The lowest completeness percentage occurred in 2021, at 64.726%.



Table 1.1, Completeness Elements and Criteria, Statewide

| Data Element  | Criteria for “Complete”  |
|---|--|
| CRE 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 complete address including zip code.   |
| Did the patient visit any other healthcare facilities in the 6 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 2 calendar days prior to initial culture?  | Response other than “Unknown.”   |
| CRE initial assessment conducted with LTCF.   | Response other than “Unknown.”   |
| CDC CRE 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 3 failed attempts in the “General Comments” box in the “Case Info” tab before entering “Yes.”  |

Table 1.2, Completeness Data, Statewide, 2018-2019

|  | 2018    |                  |          | 2019    |                  |          |
|--|---------|------------------|----------|---------|------------------|----------|
| <b>Overall Score</b>                       | 73.050% |                  |          | 69.463% |                  |          |
|  |         | <b>Completed</b> | <b>N</b> |         | <b>Completed</b> | <b>N</b> |
| <b>CRE Organism</b>                        | 100%    | 133              | 133      | 100%    | 150              | 150      |
| <b>Specimen Source</b>                     | 0       | 0                | 133      | 40.000% | 60               | 150      |
| <b>Culture Type</b>                        | 90.909% | 121              | 133      | 100%    | 150              | 150      |
| <b>Carbapenemase Production</b>            | 72.180% | 96               | 133      | 62.000% | 93               | 150      |
| <b>Mechanism/Test Type</b>                 | 70.000% | 7                | 10       | 77.777% | 14               | 18       |
| <b>Antibiotics more than twice?</b>        | 60.902% | 81               | 133      | 63.333% | 95               | 150      |
| <b>Hospitalized?</b>                       | 86.466% | 115              | 133      | 94.000% | 141              | 150      |
| <b>Resident of NH or LTCF?</b>             | 81.954% | 109              | 133      | 88.666% | 133              | 150      |
| <b>Address of Facility</b>                 | 76.000% | 19               | 25       | 54.285% | 19               | 35       |
| <b>Other facilities visited</b>            | 66.917% | 89               | 133      | 69.333% | 104              | 150      |
| <b>Indwelling devices</b>                  | 70.676% | 94               | 133      | 70.666% | 106              | 150      |
| <b>Assessment conducted at LTCF</b>        | 80.000% | 20               | 25       | 77.142% | 27               | 35       |
| <b>Toolkit provided to LTCF</b>            | 88.000% | 22               | 25       | 80.000% | 28               | 35       |
| <b>Patient/Family interviewed/educated</b> | 63.909% | 85               | 133      | 38.000% | 57               | 150      |

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

\*Address of Facility and Assessment conducted at LTCF “N” differs from total because only LTCFs were included in this number.

Table 1.3, Completeness Data, Statewide, 2020-2021

|                                     | 2020    |           |    | 2021    |           |    |
|-------------------------------------|---------|-----------|----|---------|-----------|----|
| Overall Score                       | 79.909% |           |    | 64.726% |           |    |
|                                     |         | Completed | N  |         | Completed | N  |
| CRE Organism                        | 100%    | 100       | 80 | 96.907% | 94        | 97 |
| Specimen Source                     | 96.250% | 77        | 80 | 59.793% | 58        | 97 |
| Culture Type                        | 100%    | 80        | 80 | 89.690% | 87        | 97 |
| Carbapenemase Production            | 37.500% | 30        | 80 | 62.886% | 61        | 97 |
| Mechanism/Test Type                 | 75.000% | 9         | 12 | 71.428% | 15        | 21 |
| Antibiotics more than twice?        | 56.250% | 45        | 80 | 41.237% | 40        | 97 |
| Hospitalized?                       | 90.000% | 72        | 80 | 78.350% | 76        | 97 |
| Resident of NH or LTCF?             | 82.500% | 66        | 80 | 68.041% | 66        | 97 |
| Address of Facility                 | 86.363% | 19        | 22 | 50.000% | 9         | 18 |
| Other facilities visited            | 65.000% | 52        | 80 | 45.360% | 44        | 97 |
| Indwelling devices                  | 72.500% | 58        | 80 | 50.515% | 49        | 97 |
| Assessment conducted at LTCF        | 77.272% | 17        | 22 | 77.777% | 14        | 18 |
| Toolkit provided to LTCF            | 81.818% | 18        | 22 | 66.666% | 12        | 18 |
| Patient/Family interviewed/educated | 71.250% | 57        | 80 | 50.515% | 49        | 97 |

Table 1.4, Completeness Data, Statewide, 2022

|                                     | 2022    |           |     |
|-------------------------------------|---------|-----------|-----|
| Overall Score                       | 70.725% |           |     |
|                                     |         | Completed | N   |
| CRE Organism                        | 92.079% | 93        | 101 |
| Specimen Source                     | 67.326% | 68        | 101 |
| Culture Type                        | 91.089% | 92        | 101 |
| Carbapenemase Production            | 50.495% | 51        | 101 |
| Mechanism/Test Type                 | 65.517% | 19        | 29  |
| Antibiotics more than twice?        | 53.465% | 54        | 101 |
| Hospitalized?                       | 79.207% | 80        | 101 |
| Resident of NH or LTCF?             | 76.237% | 77        | 101 |
| Address of Facility                 | 53.846% | 21        | 39  |
| Other facilities visited            | 54.455% | 55        | 101 |
| Indwelling devices                  | 66.333% | 67        | 101 |
| Assessment conducted at LTCF        | 87.179% | 34        | 39  |
| Toolkit provided to LTCF            | 94.871% | 37        | 39  |
| Patient/Family interviewed/educated | 35.643% | 36        | 101 |

### CRE in West Virginia

In 2018, all patients had only one organism reported. In 2019, one patient was diagnosed with two or more organisms including *Klebsiella oxytoca* and *Raoutella ornithinolytica*. In 2020, all patients had only one organism reported, where in 2021, *Klebsiella pneumoniae* and *Enterobacter cloacae* were identified. During 2022, five patients were diagnosed with more than one CRE these included:

- One had *Acinetobacter baumannii* and *Proteus mirabilis*
- One *Klebsiella pneumoniae* and *Enterobacter cloacae* complex
- One had *Klebsiella pneumoniae* and *Proteus mirabilis*
- One had *Klebsiella pneumoniae* and *Escherichia coli*
- One had had *Klebsiella pneumoniae* and *Providencia stuartii*

All patients in 2018 and 2020 had only one organism reported. In 2019 and 2021, one patient each year was diagnosed with two or more organisms.

- One in 2019 had *Klebsiella oxytoca* and *Raoutella ornithinolytica*
- One in 2021 had *Klebsiella pneumoniae* and *Enterobacter cloacae*.

Five patients were diagnosed with more than one CRE in 2022.

- One had *Acinetobacter baumannii* and *Proteus mirabilis*
- One had *Klebsiella pneumoniae* and *Enterobacter cloacae* complex had *Klebsiella pneumoniae*
- One had *pneumoniae* and *Proteus mirabilis*
- One had *Klebsiella pneumoniae* and *Escherichia coli*
- One had *Klebsiella pneumoniae* and *Providencia stuartii*

Between January 1, 2018, and December 31, 2022, nineteen distinct organisms were reported from 561 patients. Most organisms identified were *Enterobacter cloacae* with 219 (39%) isolates. *Klebsiella pneumoniae* followed with 208 (37%) isolates (Figure 1). The remainder of this report will be on *K. pneumoniae*, *Enterobacter* species, and *Escherichia coli*.

The most common organism identified in 2018 was *Enterobacter cloacae* followed by *Klebsiella pneumoniae*. That trend continued until 2021 when *Klebsiella pneumoniae* was the most common at 44% of identified organisms followed by *Enterobacter cloacae* at 37%. In 2022, the majority of CRE cases were *Klebsiella pneumoniae* at 58%.

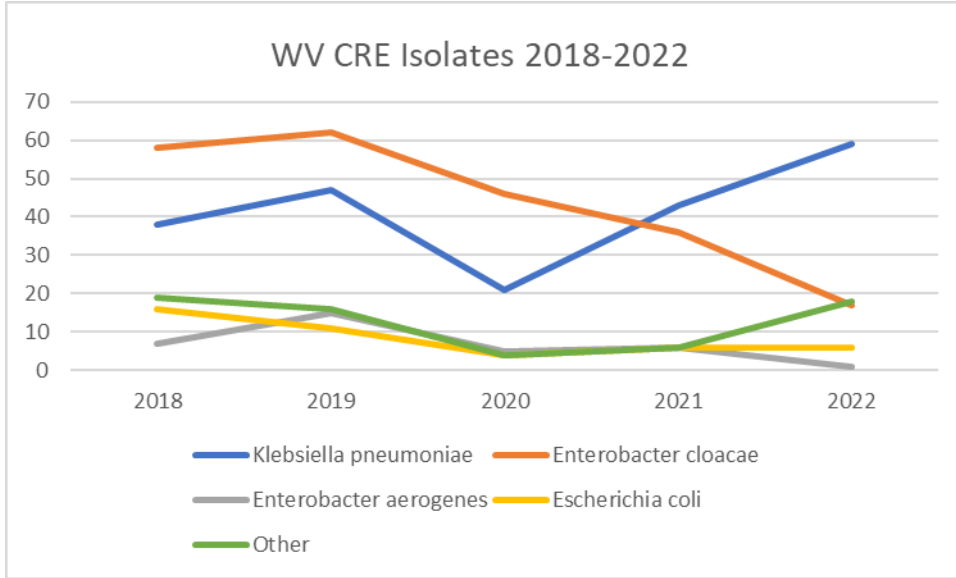
Table 2.1, CRE Incidence Statewide, West Virginia, 2018-2022

|      | Total Cases | Population in 2020 | Incidence Rates<br>(Per 100,000) |
|------|-------------|--------------------|----------------------------------|
| 2018 | N = 133     | 1,793,716          | 0.74                             |
| 2019 | N = 150     | 1,793,716          | 0.84                             |
| 2020 | N = 80      | 1,793,716          | 0.45                             |
| 2021 | N = 97      | 1,793,716          | 0.54                             |
| 2022 | N = 101     | 1,793,716          | 0.56                             |

Table 2.2, CRE Isolates Statewide, West Virginia, 2018-2022

|                               | 2018       | 2019     | 2020     | 2021     | 2022     |
|-------------------------------|------------|----------|----------|----------|----------|
|                               | (N= 133)   | (N= 150) | (N=80)   | (N=97)   | (N=101)  |
| Organism Cultured             |            |          |          |          |          |
| <i>Klebsiella pneumoniae</i>  | 38 (28.5%) | 47 (31%) | 21 (26%) | 43 (44%) | 59 (58%) |
| <i>Enterobacter cloacae</i>   | 58 (44%)   | 62 (41%) | 46 (58%) | 36 (37%) | 17 (17%) |
| <i>Enterobacter aerogenes</i> | 7 (5%)     | 15 (10%) | 5 (6%)   | 6 (6%)   | 1 (1%)   |
| <i>Escherichia coli</i>       | 16 (12%)   | 11 (7%)  | 4 (5%)   | 6 (6%)   | 6 (6%)   |
| Other                         | 19 (14%)   | 16 (11%) | 4 (5%)   | 6 (6%)   | 18 (18%) |

Figure 2.1, CRE Isolates Statewide, West Virginia, 2018-2022



## CRE by Surveillance Region and Year

During the year 2018, the southern surveillance region had the highest number of CREs with 36 cases. The northwestern region had the least number with 6 cases. The following year, the southern surveillance region had 38 cases and the central surveillance region had 50 cases reported. In 2020, no region had more than 30 cases. In 2021, the southern region had the greatest number of cases with 31 reported. In 2022, the southern and central regions reported 27 and 21 cases, respectively.

Figure 3.1, CRE Incidence by Surveillance Region, 2018 (N=133)

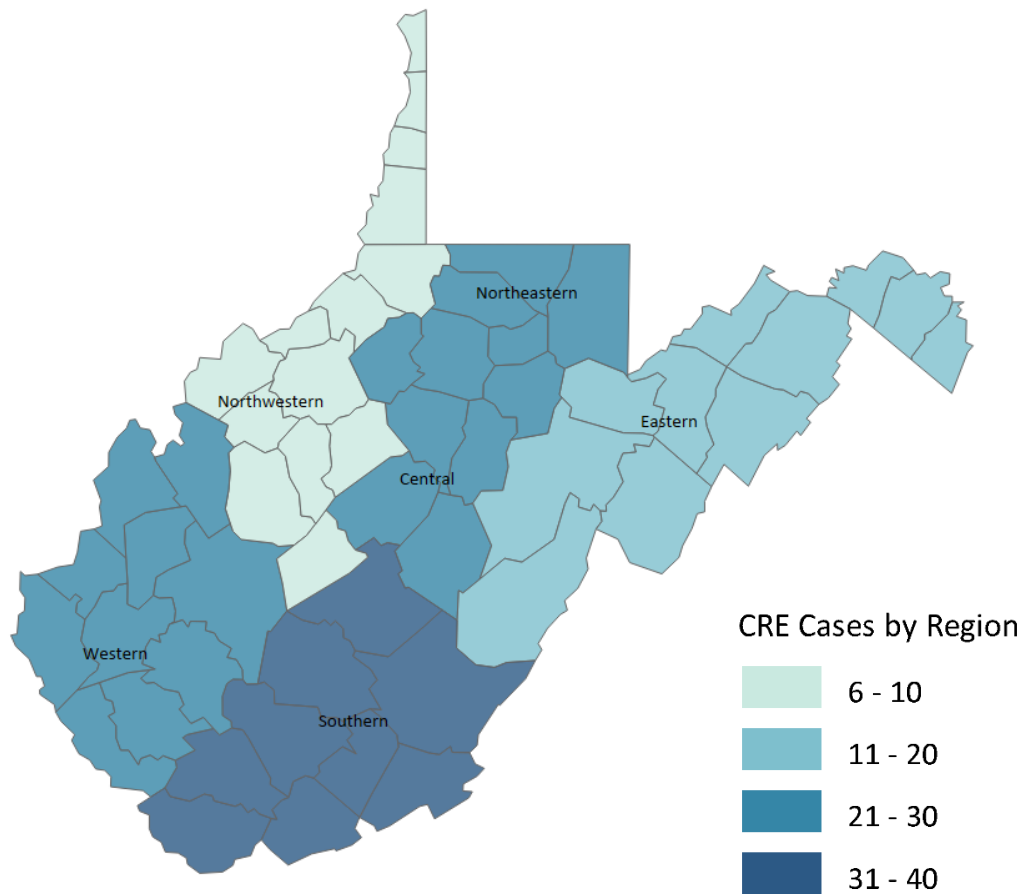


Figure 3.2, CRE Incidence by Surveillance Region, 2019 (N=150)

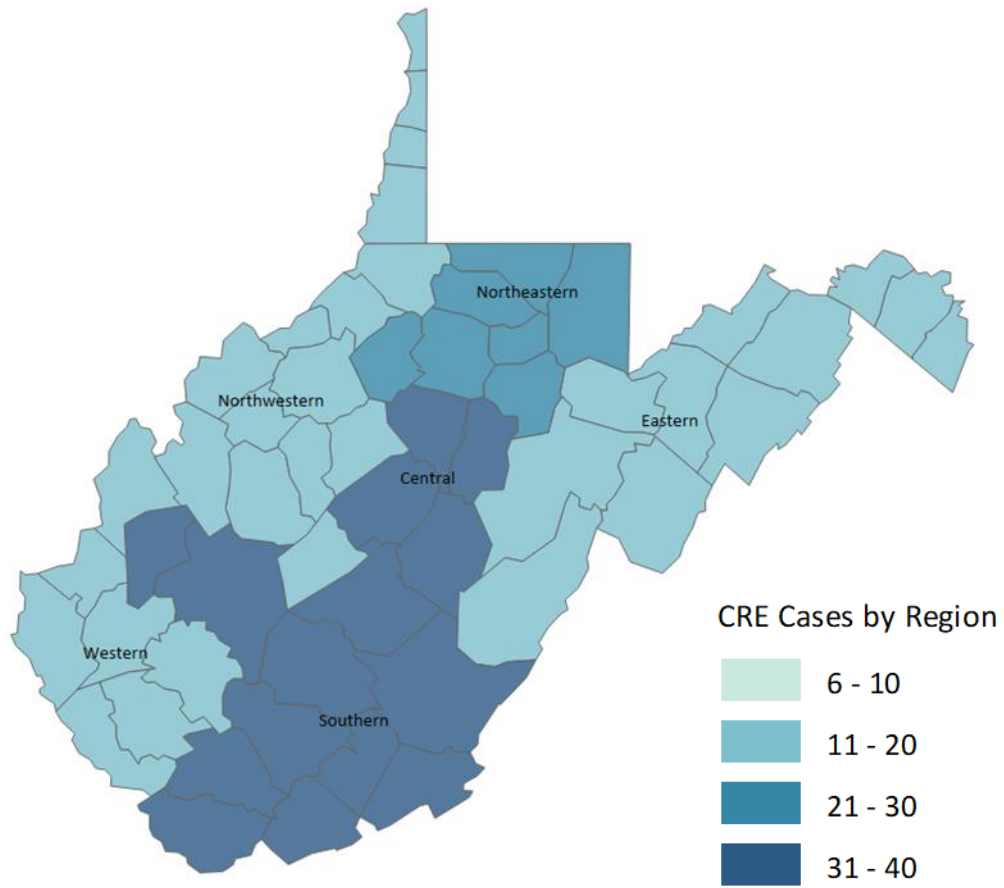




Figure 3.3, CRE Incidence by Surveillance Region, 2020 (N=80)

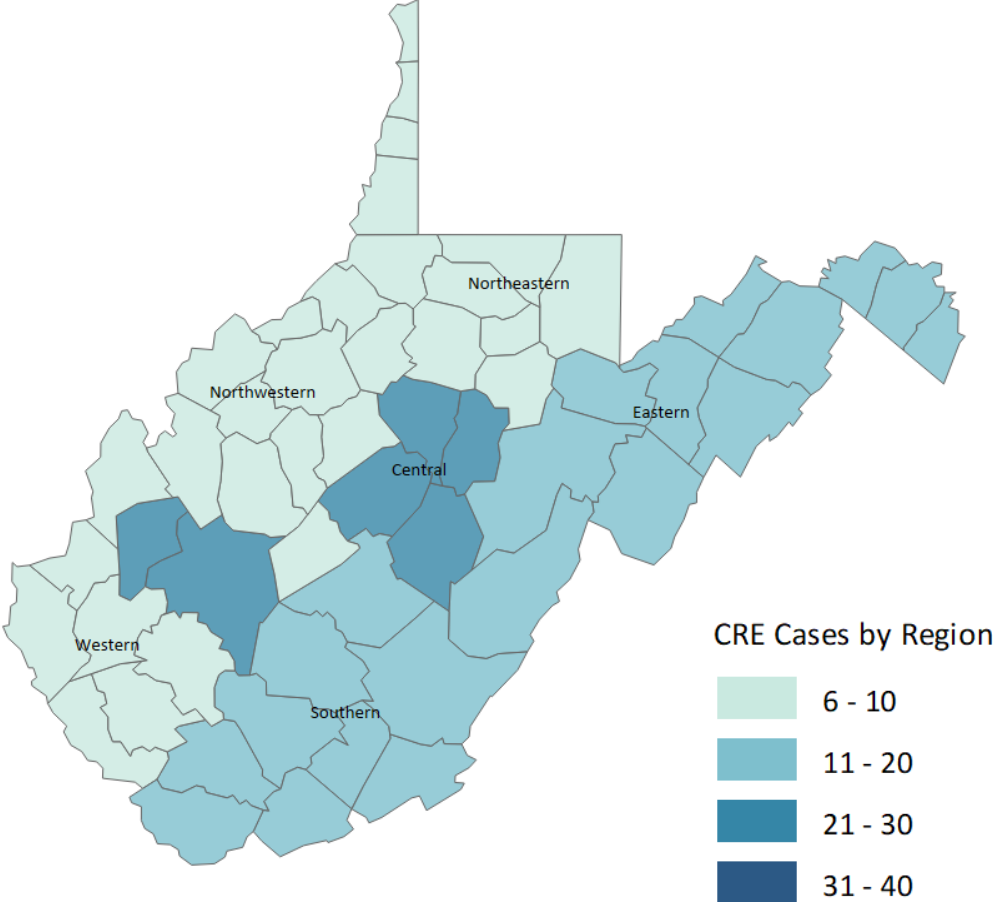


Figure 3.4, CRE Incidence by Surveillance Region, 2021 (N=97)

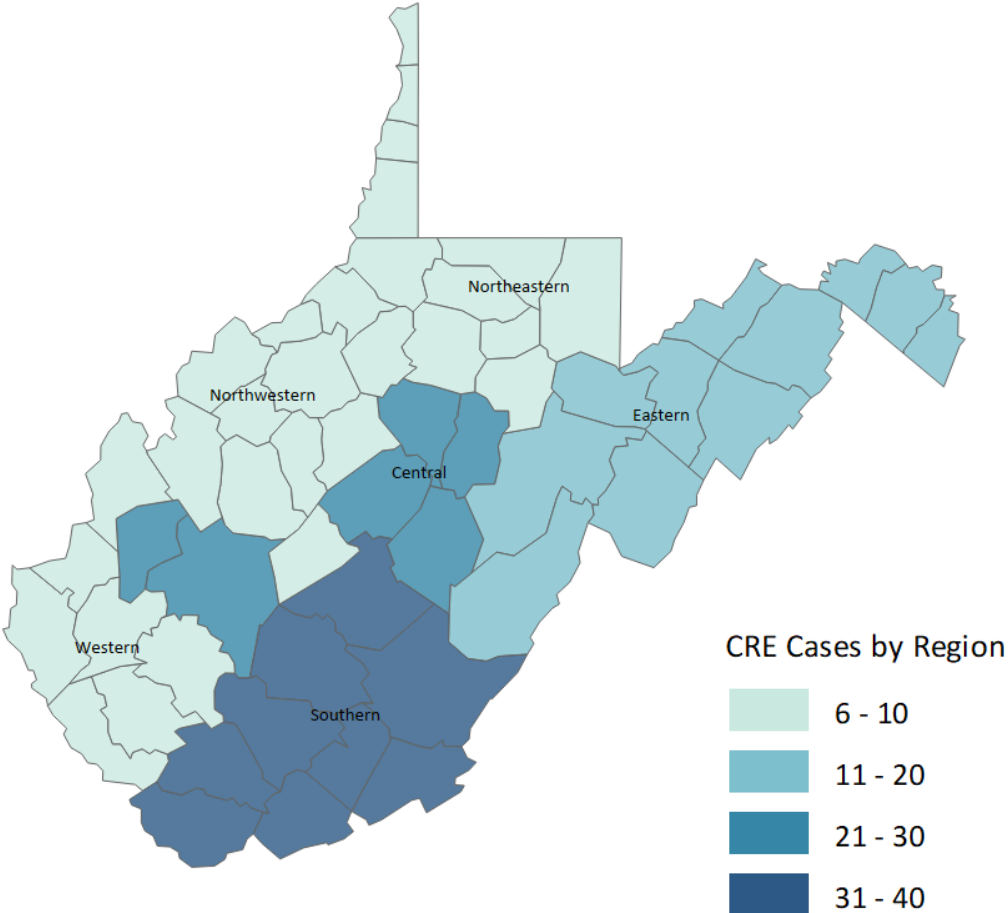
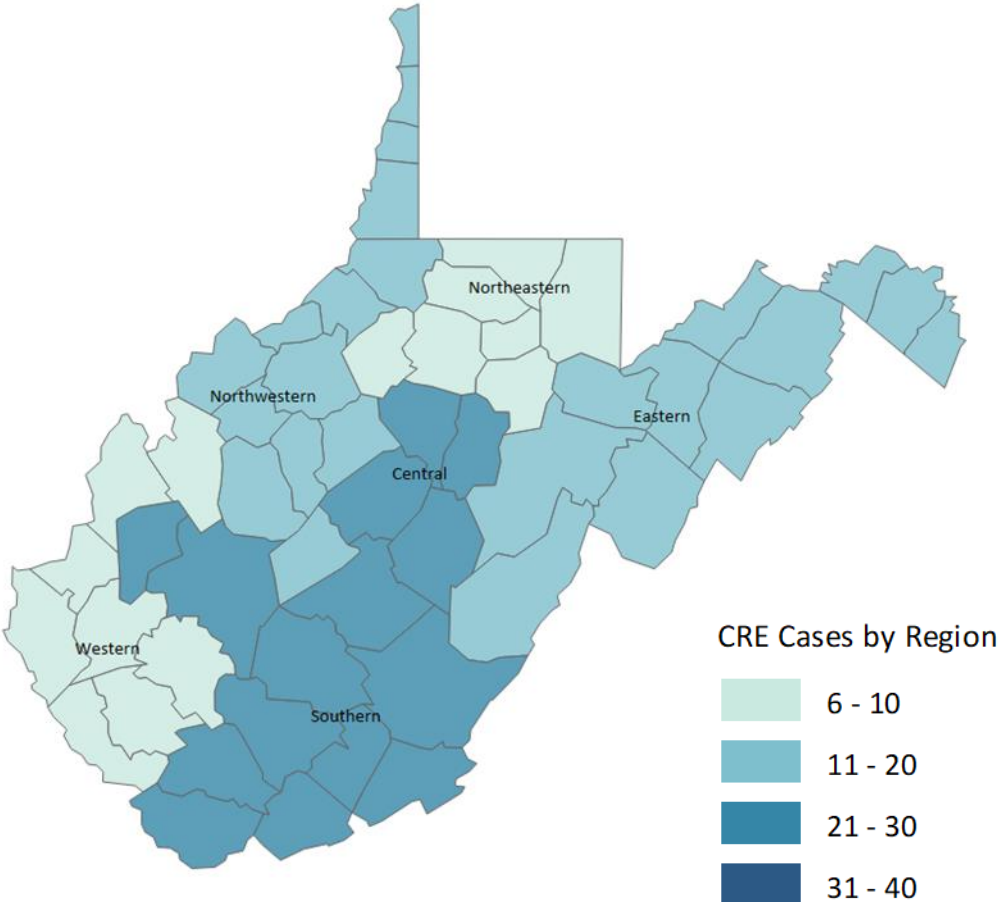


Figure 3.5, CRE Incidence by Surveillance Region, 2022 (N=101)



## CRE in Central Surveillance Region

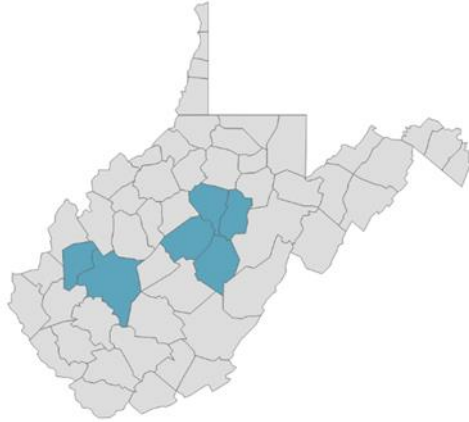
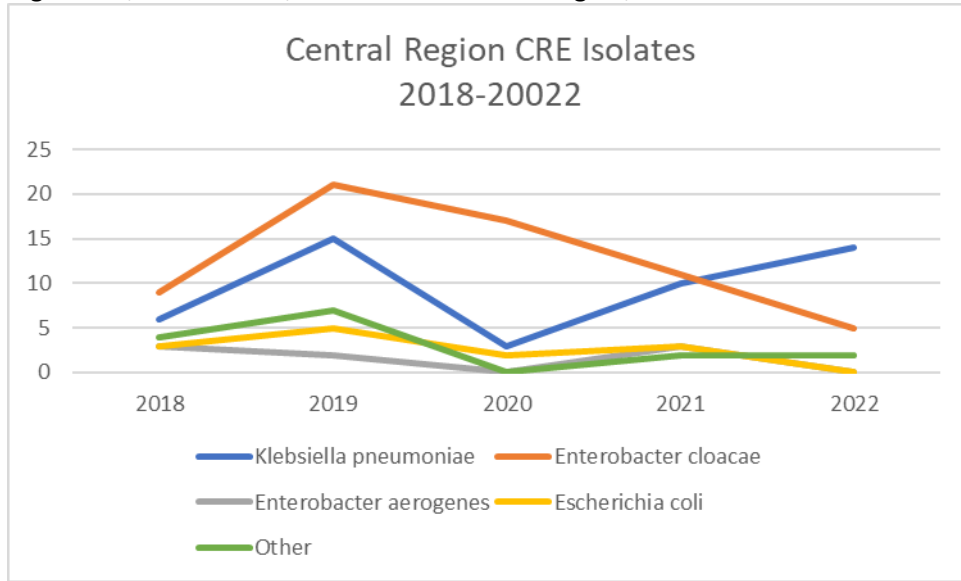


Table 4.1, CRE Isolates, Central Surveillance Region, 2018-2022

| Central Region, West Virginia CRE Isolates 2018-2022 |         |          |          |          |          |
|--|---------|----------|----------|----------|----------|
|  | 2018    | 2019     | 2020     | 2021     | 2022     |
|  | (N= 25) | (N=50)   | (N= 22)  | (N=29)   | (N=21)   |
| Organism Cultured                                    |         |          |          |          |          |
| <i>Klebsiella pneumoniae</i>                         | 6 (24%) | 15 (30%) | 3 (14%)  | 10 (34%) | 14 (67%) |
| <i>Enterobacter cloacae</i>                          | 9 (36%) | 21 (42%) | 17 (77%) | 11 (38%) | 5 (24%)  |
| <i>Enterobacter aerogenes</i>                        | 3 (12%) | 2 (4%)   | 0 (0%)   | 3 (10%)  | 0 (0%)   |
| <i>Escherichia coli</i>                              | 3 (12%) | 5 (10%)  | 2 (9%)   | 3 (10%)  | 0 (0%)   |
| Other  | 4 (16%) | 7 (14%)  | 0 (0%)   | 2 (7%)   | 2 (9%)   |

Figure 4.1, CRE Isolates, Central Surveillance Region, 2018-2022



## CRE in Eastern Surveillance Region

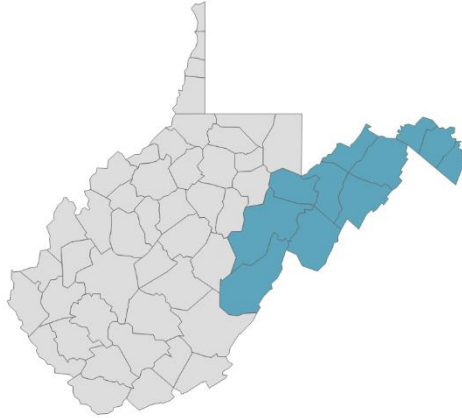
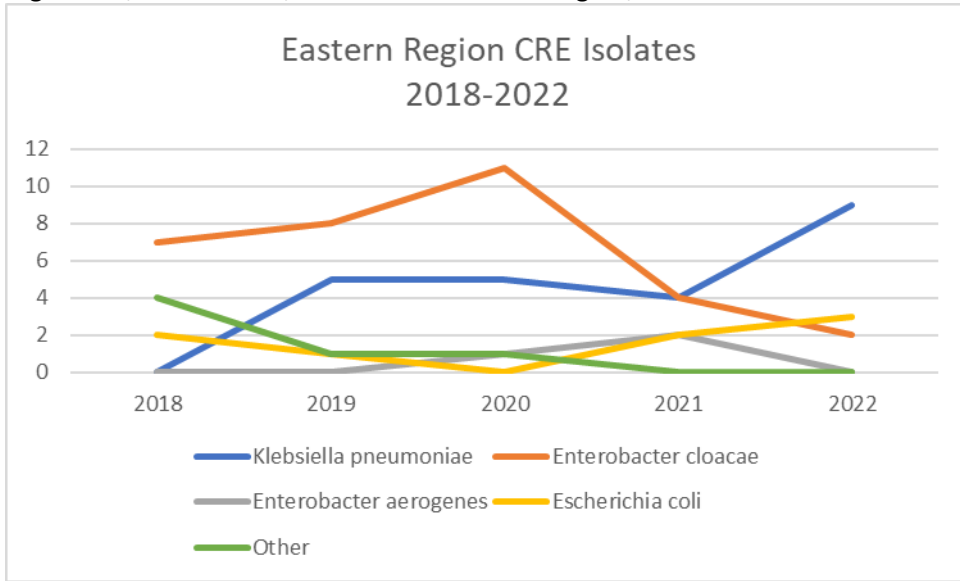


Table 5.1, CRE Isolates, Eastern Surveillance Region, 2018-2022

| Eastern Region, West Virginia CRE Isolates 2018-2022 |         |          |          |          |         |
|--|---------|----------|----------|----------|---------|
|  | 2018    | 2019     | 2020     | 2021     | 2022    |
|  | (N=18)  | (N=15)   | (N=18)   | (N=12)   | (N=14)  |
| <b>Organism Cultured</b>                             |         |          |          |          |         |
| <i>Klebsiella pneumoniae</i>                         | 5 (28%) | 5 (33 %) | 5 (28%)  | 4 (33 %) | 9 (64%) |
| <i>Enterobacter cloacae</i>                          | 7 (39%) | 8 (53 %) | 11 (61%) | 4 (33%)  | 2 (14%) |
| <i>Enterobacter aerogenes</i>                        | 0 (0%)  | 0 (0 %)  | 1 (5%)   | 2 (17%)  | 0 (0%)  |
| <i>Escherichia coli</i>                              | 2 (11%) | 1 (7 %)  | 0 (0%)   | 2 (17%)  | 3 (21%) |
| <i>Other</i>   | 4 (22%) | 1 (7 %)  | 1 (5%)   | 0 (0%)   | 0 (0%)  |

Figure 5.1, CRE Isolates, Eastern Surveillance Region, 2018-2022



## CRE in Northeastern Surveillance Region

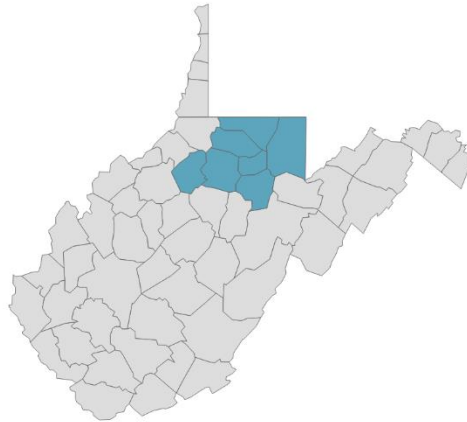
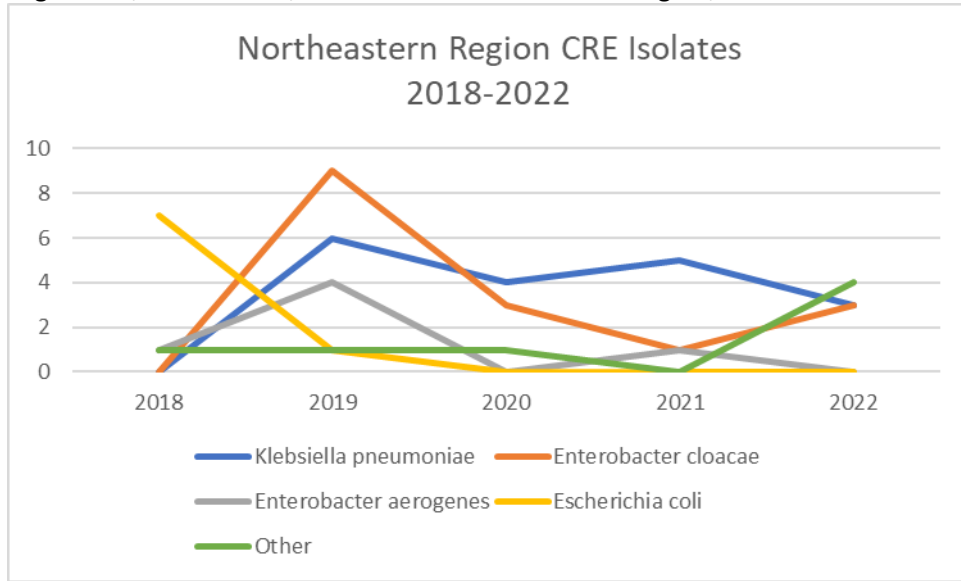


Table 6.1, CRE Isolates, Northeastern Surveillance Region, 2018-2022

| Northeastern Region, West Virginia CRE Isolates 2018-2022 |          |          |         |          |         |
|---|----------|----------|---------|----------|---------|
|   | 2018     | 2019     | 2020    | 2021     | 2022    |
|   | (N= 25)  | (N=21)   | (N=8)   | (N=7)    | (N=10)  |
| Organism Cultured   |          |          |         |          |         |
| <i>Klebsiella pneumoniae</i>                              | 7 (28 %) | 6 (28 %) | 4 (50%) | 5 (71 %) | 3 (30%) |
| <i>Enterobacter cloacae</i>                               | 14 (56%) | 9 (43 %) | 3 (38%) | 1 (14%)  | 3 (30%) |
| <i>Enterobacter aerogenes</i>                             | 1 (4%)   | 4 (19 %) | 0 (0%)  | 1 (14%)  | 0 (0%)  |
| <i>Escherichia coli</i>                                   | 2 (8%)   | 1 (5 %)  | 0 (0%)  | 0 (0 %)  | 0 (0%)  |
| Other   | 1 (4%)   | 1 (5 %)  | 1 (12%) | 0 (0 %)  | 4 (40%) |



Figure 6.1, CRE Isolates, Northwestern Surveillance Region, 2018-2022



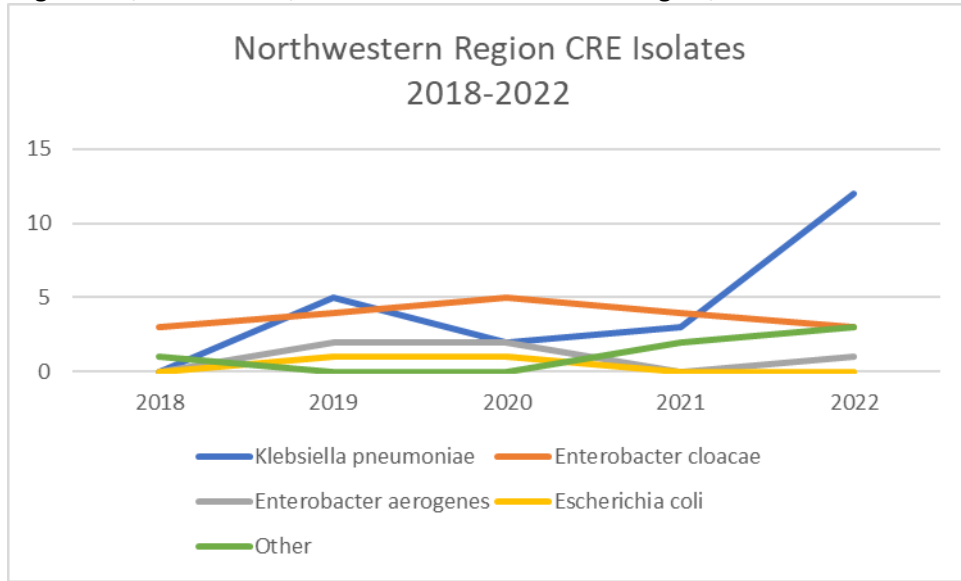
## CRE in Northwestern Surveillance Region



Table 7.1, CRE Isolates, Northwestern Surveillance Region, 2018-2022

| Northwestern Region, West Virginia CRE Isolates 2018-2022 |         |         |         |          |          |
|---|---------|---------|---------|----------|----------|
|   | 2018    | 2019    | 2020    | 2021     | 2022     |
|   | (N= 6)  | (N= 12) | (N=10)  | (N= 9)   | (N=19)   |
| Organism Cultured   |         |         |         |          |          |
| <i>Klebsiella pneumoniae</i>                              | 2 (33%) | 5 (42%) | 2 (20%) | 3 (33%)  | 12 (63%) |
| <i>Enterobacter cloacae</i>                               | 3 (50%) | 4 (33%) | 5 (50%) | 4 (44 %) | 3 (16%)  |
| <i>Enterobacter aerogenes</i>                             | 0 (0%)  | 2 (17%) | 2 (20%) | 0 (0%)   | 1 (5%)   |
| <i>Escherichia coli</i>                                   | 0 (0%)  | 1 (8%)  | 1 (10%) | 0 (0 %)  | 0 (0%)   |
| Other   | 1 (17%) | 0 (0%)  | 0 (0 %) | 2 (22%)  | 3 (16%)  |

Figure 7.1, CRE Isolates, Northwestern Surveillance Region, 2018-2022



## CRE in Southern Surveillance Region

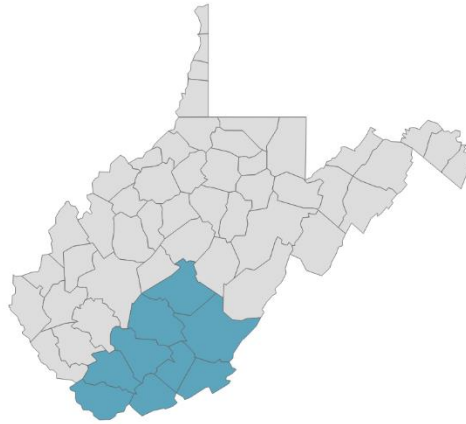
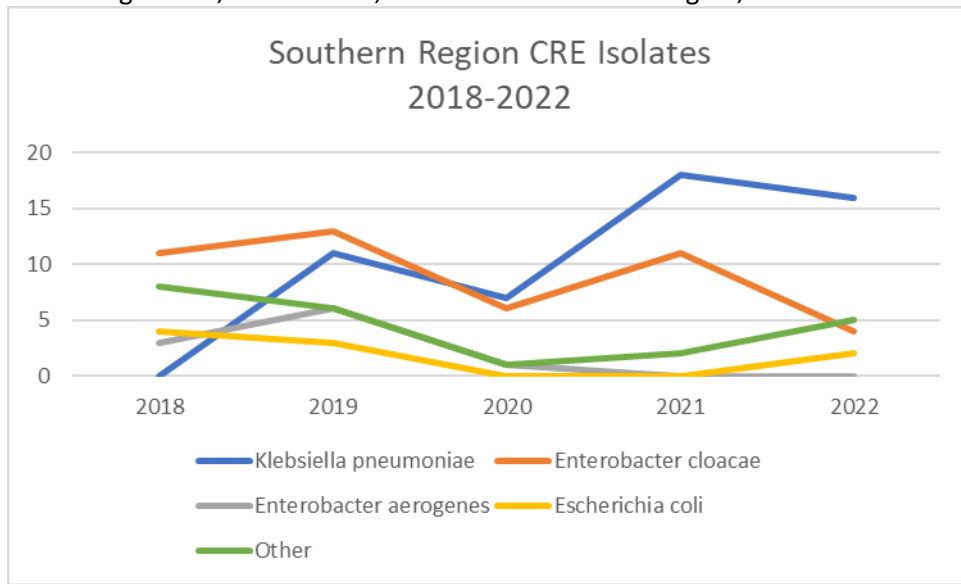


Table 8.1, CRE Isolates, Southern Surveillance Region, 2018-2022

| Southern Region, West Virginia CRE Isolates 2018-2022 |          |          |         |          |          |
|---|----------|----------|---------|----------|----------|
|   | 2018     | 2019     | 2020    | 2021     | 2022     |
|   | (N= 36)  | (N= 38)  | (N=15)  | (N=31)   | (N=27)   |
| Organism Cultured                                     |          |          |         |          |          |
| <i>Klebsiella pneumoniae</i>                          | 10 (28%) | 11 (29%) | 7 (47%) | 18 (58%) | 16 (59%) |
| <i>Enterobacter cloacae</i>                           | 11 (31%) | 13 (34%) | 6 (40%) | 11 (35%) | 4 (15%)  |
| <i>Enterobacter aerogenes</i>                         | 3 (8%)   | 6 (16%)  | 1 (7%)  | 0 (0%)   | 0 (0%)   |
| <i>Escherichia coli</i>                               | 4 (11%)  | 3 (8%)   | 0 (0%)  | 0 (0%)   | 2 (7%)   |
| Other   | 8 (22%)  | 6 (16%)  | 1 (7%)  | 2 (6%)   | 5 (19%)  |

Figure 8.1, CRE Isolates, Southern Surveillance Region, 2018-2022



## CRE in Western Surveillance Region

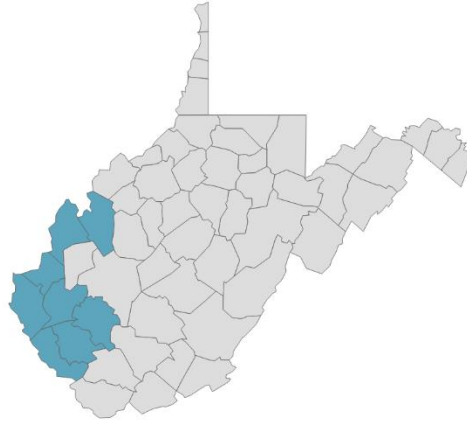
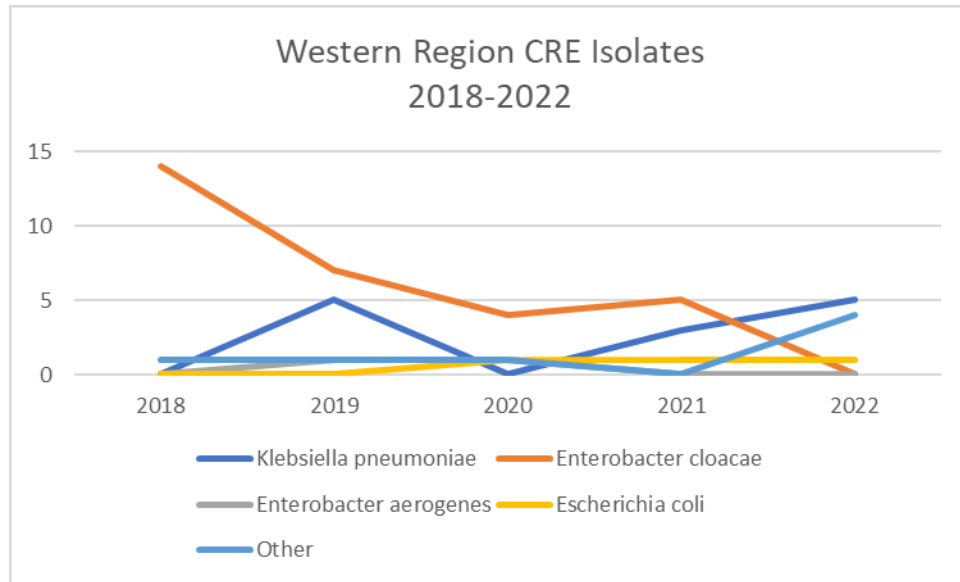


Table 9.1, CRE Isolates, Western Surveillance Region, 2018-2022

| Western Region, West Virginia CRE Isolates 2018-2022 |                |                |                |               |                |
|--|----------------|----------------|----------------|---------------|----------------|
| Organism Cultured                                    | 2018<br>(N=23) | 2019<br>(N=14) | 2020<br>(N= 7) | 2021<br>(N=9) | 2022<br>(N=10) |
| <b>Organism Cultured</b>                             |                |                |                |               |                |
| <i>Klebsiella pneumoniae</i>                         | 8 (35%)        | 5 (36%)        | 0 (0%)         | 3 (33%)       | 5 (50%)        |
| <i>Enterobacter cloacae</i>                          | 14 (61%)       | 7 (50%)        | 4 (57%)        | 5 (56%)       | 0 (0%)         |
| <i>Enterobacter aerogenes</i>                        | 0 (0%)         | 1 (7%)         | 1 (14%)        | 0 (0 %)       | 0 ( 0%)        |
| <i>Escherichia coli</i>                              | 0 (0%)         | 0 (0%)         | 1 (14%)        | 1 (11 %)      | 1 (10%)        |
| Other  | 1 (4%)         | 1 (7%)         | 1 (14%)        | 0 (0%)        | 4 ( 40%)       |

Figure 9.1, CRE Isolates, Southern Surveillance Region, 2018-2022



## Demographics

### CRE Cases by Gender

Females made up the majority of cases over the five-year period.

In 2018, about 62% (83 cases) of the cases were female, while the remaining 37% (50 cases) were male. The following year, about the same percentage (62%) of cases were female. Again in 2020, more women (62%) were infected with CRE. The proportion of CRE cases was almost equal in 2021, with 48 males and 49 females with infection. In 2022, females made up a slightly higher percentage of cases at 51%.

Table 10.1 CRE Cases by Gender 2018-2022

|      | Total Cases | Female   | Male     |
|------|-------------|----------|----------|
| 2018 | N = 133     | 83 (62%) | 50 (37%) |
| 2019 | N = 150     | 93 (62%) | 57 (37%) |
| 2020 | N = 80      | 50 (62%) | 30 (37%) |
| 2021 | N = 97      | 49 (51%) | 48 (49%) |
| 2022 | N = 101     | 51 (51%) | 49 (49%) |

Graph 10.1 CRE Cases by Gender 2018-2022

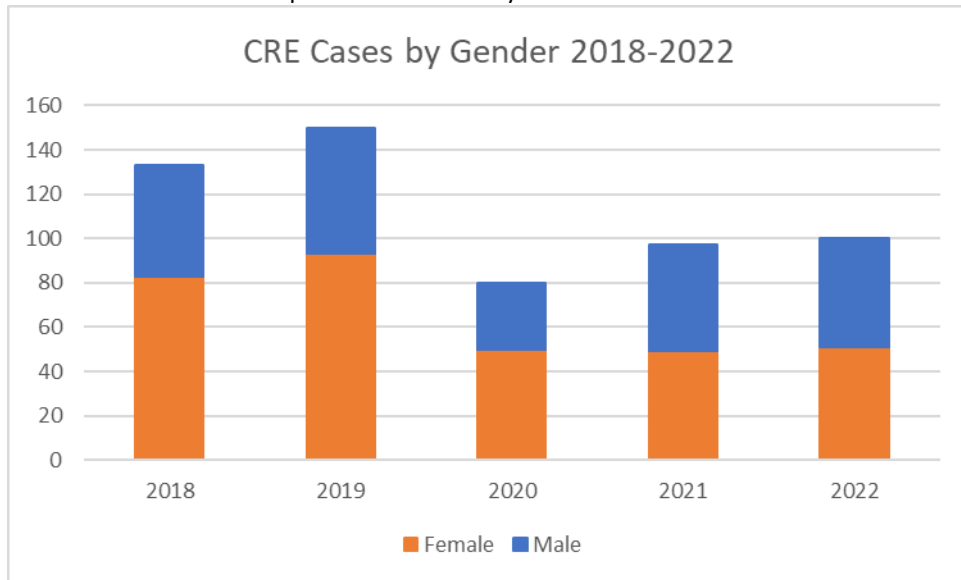


Table 10.2, Gender of CRE Cases by Surveillance Region, West Virginia, 2018

| 2018    | Northwest (N = 6) | Northeast (N = 25) | East (N = 18) | South (N = 36) | West (N = 24) | Central (N = 25) |
|---------|-------------------|--------------------|---------------|----------------|---------------|------------------|
| Male    | 3                 | 10                 | 3             | 13             | 12            | 9                |
| Female  | 3                 | 15                 | 15            | 23             | 12            | 16               |
| Unknown | 0                 | 0                  | 0             | 0              | 0             | 0                |

Table 10.3, Gender of CRE Cases by Surveillance Region, West Virginia, 2019

| 2019    | Northwest (N = 12) | Northeast (N = 21) | East (N = 15) | South (N = 38) | West (N = 14) | Central (N = 50) |
|---------|--------------------|--------------------|---------------|----------------|---------------|------------------|
| Male    | 3                  | 5                  | 5             | 25             | 5             | 14               |
| Female  | 9                  | 16                 | 10            | 13             | 9             | 36               |
| Unknown | 0                  | 0                  | 0             | 0              | 0             | 0                |



Table 10.4, Gender of CRE Cases by Surveillance Region, West Virginia, 2020

| 2020    | Northwest<br>(N = 10) | Northeast<br>(N = 8) | East (N = 18) | South (N = 15) | West (N = 7) | Central (N = 22) |
|---------|-----------------------|----------------------|---------------|----------------|--------------|------------------|
| Male    | 5                     | 4                    | 6             | 3              | 4            | 9                |
| Female  | 5                     | 4                    | 12            | 12             | 3            | 13               |
| Unknown | 0                     | 0                    | 0             | 0              | 0            | 0                |

Table 10.5, Gender of CRE Cases by Surveillance Region, West Virginia, 2021

| 2021    | Northwest<br>(N = 9) | Northeast<br>(N = 7) | East (N = 12) | South (N = 31) | West (N = 9) | Central (N = 29) |
|---------|----------------------|----------------------|---------------|----------------|--------------|------------------|
| Male    | 4                    | 3                    | 8             | 13             | 5            | 15               |
| Female  | 5                    | 4                    | 4             | 18             | 4            | 14               |
| Unknown | 0                    | 0                    | 0             | 0              | 0            | 0                |

Table 10.6, Gender of CRE Cases by Surveillance Region, West Virginia, 2022

| 2022    | Northwest<br>(N = 10) | Northeast<br>(N = 10) | East (N = 14) | South (N = 37) | West (N = 9) | Central (N = 21 ) |
|---------|-----------------------|-----------------------|---------------|----------------|--------------|-------------------|
| Male    | 3                     | 5                     | 5             | 20             | 6            | 8                 |
| Female  | 7                     | 4                     | 9             | 17             | 3            | 12                |
| Unknown | 0                     | 1                     | 0             | 0              | 0            | 1                 |

## CRE Cases by Age

The majority of reported CRE cases during the five-year period were between the ages of 54 and 71, with the average age being 65.54 on a scale of 2 to 100 years.

Table 11.1 CRE Cases by Age 2018-2022

| Year | Total Cases | 0-18   | 19-35  | 36-53    | 54-71    | ≥72      |
|------|-------------|--------|--------|----------|----------|----------|
| 2018 | N = 133     | 2 (2%) | 4 (3%) | 18 (14%) | 56 (42%) | 53 (40%) |
| 2019 | N = 150     | 3 (2%) | 4 (3%) | 29 (19%) | 52 (35%) | 62 (41%) |
| 2020 | N = 80      | 1 (1%) | 3 (4%) | 12 (15%) | 36 (45%) | 28 (35%) |
| 2021 | N = 97      | 2 (2%) | 4 (4%) | 23 (24%) | 39 (40%) | 29 (30%) |
| 2022 | N = 110     | 0 (0%) | 2 (2%) | 18 (18%) | 45 (45%) | 45 (45%) |

Graph 11.1 Cases by Age 2018-2022

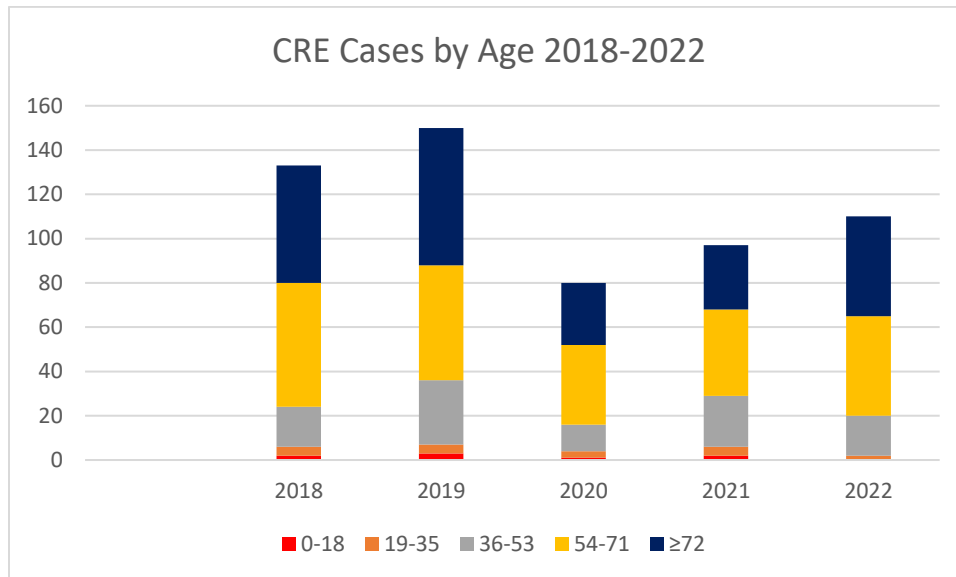


Table 11.2, Age of CRE Cases by Surveillance Region, West Virginia, 2018

| 2018              | Northwest (N = 6) | Northeast (N = 25) | East (N = 18) | South (N = 36) | West (N = 24) | Central (N = 25) |
|-------------------|-------------------|--------------------|---------------|----------------|---------------|------------------|
| Age, years (Avg.) | 59.83             | 68.16              | 62.44         | 67.25          | 68.83         | 67.12            |
| 0 – 18            | 1                 | 0                  | 1             | 0              | 0             | 0                |
| 19 - 35           | 0                 | 1                  | 1             | 1              | 1             | 0                |
| 36 - 53           | 0                 | 2                  | 1             | 8              | 2             | 6                |
| 54 - 71           | 2                 | 11                 | 10            | 13             | 10            | 10               |
| ≥72               | 3                 | 11                 | 5             | 14             | 11            | 9                |

Table 11.3, Age of CRE Cases by Surveillance Region, West Virginia, 2019

| 2019              | Northwest (N = 12) | Northeast (N = 21) | East (N = 15) | South (N = 38) | West (N = 14) | Central (N = 50) |
|-------------------|--------------------|--------------------|---------------|----------------|---------------|------------------|
| Age, years (Avg.) | 69.42              | 63.1               | 68.47         | 66.53          | 61.93         | 66.46            |
| 0 – 18            | 0                  | 1                  | 1             | 0              | 0             | 1                |
| 19 - 35           | 1                  | 0                  | 1             | 1              | 0             | 1                |
| 36 - 53           | 1                  | 7                  | 0             | 7              | 3             | 11               |
| 54 - 71           | 3                  | 6                  | 6             | 18             | 7             | 12               |
| ≥72               | 7                  | 7                  | 7             | 12             | 4             | 25               |

Table 11.4, Age of CRE Cases by Surveillance Region, West Virginia, 2020

| 2020                 | Northwest<br>(N = 10) | Northeast<br>(N = 8) | East (N = 18) | South (N = 15) | West (N = 7) | Central (N = 22) |
|----------------------|-----------------------|----------------------|---------------|----------------|--------------|------------------|
| Age, years<br>(Avg.) | 64.6                  | 69.88                | 67.22         | 65.53          | 58.86        | 64.68            |
| 0 - 18               | 0                     | 0                    | 0             | 0              | 0            | 1                |
| 19 - 35              | 0                     | 0                    | 1             | 1              | 1            | 0                |
| 36 - 53              | 2                     | 0                    | 3             | 2              | 1            | 4                |
| 54 - 71              | 5                     | 6                    | 5             | 8              | 3            | 9                |
| ≥72                  | 3                     | 2                    | 9             | 4              | 2            | 8                |

Table 11.5, Age of CRE Cases by Surveillance Region, West Virginia, 2021

| 2021                 | Northwest<br>(N = 9) | Northeast<br>(N = 7) | East (N = 12) | South (N = 31) | West (N = 9) | Central (N = 29) |
|----------------------|----------------------|----------------------|---------------|----------------|--------------|------------------|
| Age, years<br>(Avg.) | 62.11                | 69.43                | 63.08         | 62.65          | 61.78        | 61.21            |
| 0 - 18               | 0                    | 0                    | 0             | 1              | 0            | 1                |
| 19 - 35              | 1                    | 0                    | 0             | 2              | 0            | 1                |
| 36 - 53              | 2                    | 0                    | 4             | 5              | 4            | 8                |
| 54 - 71              | 4                    | 5                    | 4             | 14             | 1            | 11               |
| ≥72                  | 2                    | 2                    | 4             | 9              | 4            | 8                |

Table 11.6, Age of CRE Cases by Surveillance Region, West Virginia, 2022

| 2022                 | Northwest<br>(N = 19) | Northeast<br>(N = 10) | East (N = 14) | South (N = 37) | West (N = 9) | Central (N = 21) |
|----------------------|-----------------------|-----------------------|---------------|----------------|--------------|------------------|
| Age, years<br>(Avg.) | 71.58                 | 78                    | 69.73         | 67             | 68.56        | 65.90            |
| 0 – 18               | 0                     | 0                     | 0             | 0              | 0            | 0                |
| 19 - 35              | 0                     | 0                     | 2             | 0              | 0            | 0                |
| 36 - 53              | 0                     | 2                     | 3             | 7              | 2            | 4                |
| 54 - 71              | 10                    | 3                     | 4             | 15             | 2            | 11               |
| ≥72                  | 9                     | 5                     | 5             | 15             | 5            | 6                |

**CRE 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 CRE cases between 2018 and 2022 is similar. In 2018, 4% of people with CRE infections were black or African American, and 80% were white. None of the cases were American Indian or Alaska Native, Asian, Native Hawaiian, or other Pacific Islander. The remaining 16% of cases were unknown. Black people made up 3% of cases in 2019, 2% in 2020, 3% in 2021, and 6% in 2022. There were no cases reported as Hispanic or Latino until 2021 and 2022 when two people each year were identified as such.

Table 12.1 CRE Cases by Race 2018-2022

| Year | Total Cases | White        | Black  | Other  | Unknown  |
|------|-------------|--------------|--------|--------|----------|
| 2018 | N = 133     | 107<br>(80%) | 5 (4%) | 0 (0%) | 22 (16%) |
| 2019 | N = 150     | 126<br>(84%) | 4 (3%) | 1 (1%) | 19 (12%) |
| 2020 | N = 80      | 69 (86%)     | 2 (3%) | 0 (0%) | 9 (11%)  |
| 2021 | N = 97      | 89 (92%)     | 3 (3%) | 1 (1%) | 4 (4%)   |
| 2022 | N = 110     | 102<br>(93%) | 6 (5%) | 0 (0%) | 2 (2%)   |

Graph 12.1 CRE Cases by Race 2018-2022

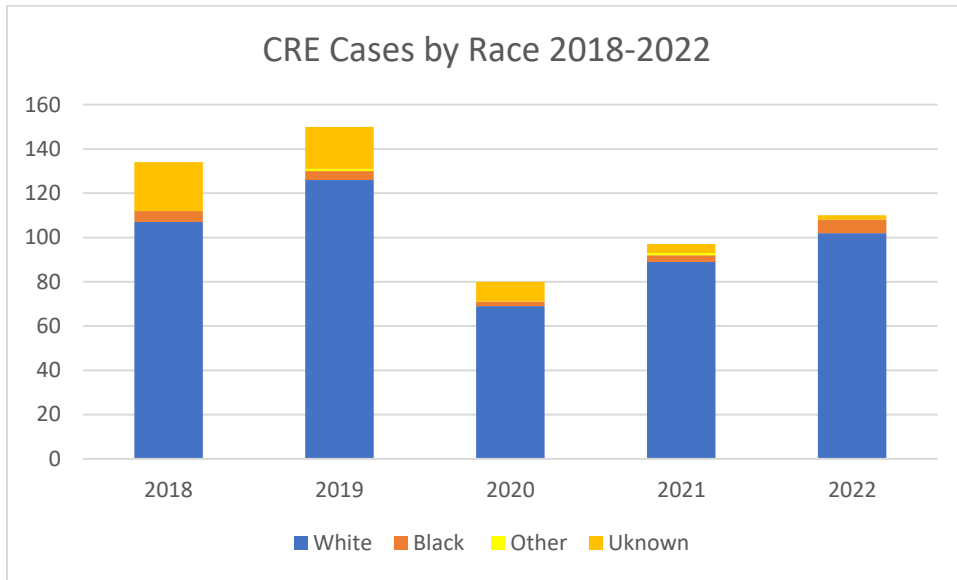


Table 12.2, Race of CRE Cases by Surveillance Region, West Virginia, 2018

| 2018    | Northwest (N = 6) | Northeast (N = 25) | East (N = 18) | South (N = 36) | West (N = 24) | Central (N = 25) |
|---------|-------------------|--------------------|---------------|----------------|---------------|------------------|
| White   | 5                 | 20                 | 16            | 28             | 23            | 15               |
| Black   | 0                 | 1                  | 2             | 2              | 0             | 0                |
| Other   | 0                 | 0                  | 0             | 0              | 0             | 0                |
| Unknown | 1                 | 4                  | 0             | 6              | 1             | 10               |

Table 12.3, Race of CRE Cases by Surveillance Region, West Virginia, 2019

| 2019    | Northwest (N = 12) | Northeast (N = 21) | East (N = 15) | South (N = 38) | West (N = 14) | Central (N = 50) |
|---------|--------------------|--------------------|---------------|----------------|---------------|------------------|
| White   | 11                 | 18                 | 10            | 33             | 13            | 41               |
| Black   | 0                  | 0                  | 1             | 1              | 0             | 2                |
| Other   | 0                  | 0                  | 0             | 1              | 0             | 0                |
| Unknown | 1                  | 3                  | 4             | 3              | 1             | 7                |

Table 12.4, Race of CRE Cases by Surveillance Region, West Virginia, 2020

| 2020    | Northwest<br>(N = 10) | Northeast<br>(N = 8) | East (N = 18) | South (N = 15) | West (N = 7) | Central (N = 22) |
|---------|-----------------------|----------------------|---------------|----------------|--------------|------------------|
| White   | 7                     | 8                    | 17            | 10             | 6            | 21               |
| Black   | 0                     | 0                    | 0             | 1              | 1            | 0                |
| Other   | 0                     | 0                    | 0             | 0              | 0            | 0                |
| Unknown | 3                     | 0                    | 1             | 4              | 0            | 1                |

Table 12.5, Race of CRE Cases by Surveillance Region, West Virginia, 2021

| 2021    | Northwest<br>(N = 9) | Northeast<br>(N = 7) | East (N = 12) | South (N = 31) | West (N = 9) | Central (N = 29) |
|---------|----------------------|----------------------|---------------|----------------|--------------|------------------|
| White   | 8                    | 7                    | 10            | 30             | 8            | 26               |
| Black   | 0                    | 0                    | 2             | 1              | 0            | 0                |
| Other   | 0                    | 0                    | 0             | 0              | 0            | 1                |
| Unknown | 1                    | 0                    | 0             | 0              | 1            | 2                |

Table 12.6, Race of CRE Cases by Surveillance Region, West Virginia, 2022

| 2022    | Northwest<br>(N = 19) | Northeast<br>(N = 10) | East (N = 14) | South (N = 37) | West (N = 9) | Central (N = 21) |
|---------|-----------------------|-----------------------|---------------|----------------|--------------|------------------|
| White   | 19                    | 9                     | 13            | 35             | 8            | 18               |
| Black   | 0                     | 0                     | 1             | 2              | 0            | 3                |
| Other   | 0                     | 0                     | 0             | 0              | 0            | 0                |
| Unknown | 0                     | 1                     | 0             | 0              | 1            | 0                |

## CRE Cases by Ethnicity

Table 13.1 CRE Cases by Race 2018-2022

| Year | Total Cases | Hispanic or Latino | Not Hispanic or Latino | Other  | Unknown  |
|------|-------------|--------------------|------------------------|--------|----------|
| 2018 | N = 133     | 1 (1%)             | 105 (79%)              | 0 (0%) | 27 (20%) |
| 2019 | N = 150     | 0 (0%)             | 116 (77%)              | 0 (0%) | 34 (23%) |
| 2020 | N = 80      | 0                  | 61 (76%)               | 0      | 19 (24%) |
| 2021 | N = 97      | 2 (2%)             | 80 (82%)               | 0 (0%) | 15 (15%) |
| 2022 | N = 110     | 2 (2%)             | 90 (82%)               | 0 (0%) | 18 (16%) |

Graph 13.1 CRE Cases by Race 2018-2022

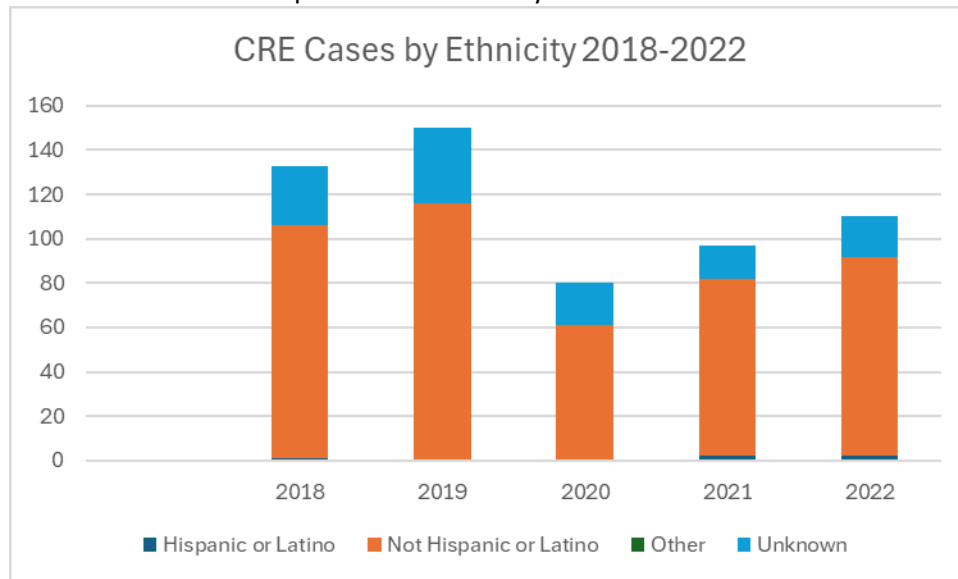


Table 13.2, Ethnicity of CRE Cases by Surveillance Region, West Virginia, 2018

| 2018                   | Northwest (N = 6) | Northeast (N = 25) | East (N = 18) | South (N = 36) | West (N = 24) | Central (N = 25) |
|------------------------|-------------------|--------------------|---------------|----------------|---------------|------------------|
| Hispanic or Latino     | 0                 | 0                  | 1             | 0              | 0             | 0                |
| Not Hispanic or Latino | 5                 | 20                 | 17            | 27             | 21            | 16               |
| Other                  | 0                 | 0                  | 0             | 0              | 0             | 0                |
| Unknown                | 1                 | 5                  | 0             | 9              | 3             | 9                |



Table 13.3, Ethnicity of CRE Cases by Surveillance Region, West Virginia, 2019

| 2019                   | Northwest<br>(N = 12) | Northeast<br>(N = 21) | East (N = 15) | South (N = 38) | West (N = 14) | Central (N = 50) |
|------------------------|-----------------------|-----------------------|---------------|----------------|---------------|------------------|
| Hispanic or Latino     | 0                     | 0                     | 0             | 0              | 0             | 0                |
| Not Hispanic or Latino | 10                    | 19                    | 8             | 32             | 9             | 38               |
| Other                  | 0                     | 0                     | 0             | 0              | 0             | 0                |
| Unknown                | 2                     | 2                     | 7             | 6              | 5             | 12               |

Table 13.4, Ethnicity of CRE Cases by Surveillance Region, West Virginia, 2020

| 2020                   | Northwest<br>(N = 10) | Northeast<br>(N = 8) | East (N = 18) | South (N = 15) | West (N = 7) | Central (N = 22) |
|------------------------|-----------------------|----------------------|---------------|----------------|--------------|------------------|
| Hispanic or Latino     | 0                     | 0                    | 0             | 0              | 0            | 0                |
| Not Hispanic or Latino | 7                     | 8                    | 16            | 8              | 6            | 16               |
| Other                  | 0                     | 0                    | 0             | 0              | 0            | 0                |
| Unknown                | 3                     | 0                    | 2             | 7              | 1            | 6                |

Table 13.5, Ethnicity of CRE Cases by Surveillance Region, West Virginia, 2021

| 2021                   | Northwest<br>(N = 9) | Northeast<br>(N = 7) | East (N = 12) | South (N = 31) | West (N = 9) | Central (N = 29) |
|------------------------|----------------------|----------------------|---------------|----------------|--------------|------------------|
| Hispanic or Latino     | 1                    | 0                    | 1             | 0              | 0            | 0                |
| Not Hispanic or Latino | 6                    | 7                    | 11            | 26             | 6            | 24               |
| Other                  | 0                    | 0                    | 0             | 0              | 0            | 0                |
| Unknown                | 2                    | 0                    | 0             | 5              | 3            | 5                |

Table 13.6, Ethnicity of CRE Cases by Surveillance Region, West Virginia, 2022

| 2022                   | Northwest<br>(N = 19) | Northeast<br>(N = 9) | East (N = 14) | South (N = 37) | West (N = 9) | Central (N = 21) |
|------------------------|-----------------------|----------------------|---------------|----------------|--------------|------------------|
| Hispanic or Latino     | 0                     | 1                    | 0             | 1              | 0            | 0                |
| Not Hispanic or Latino | 18                    | 6                    | 11            | 31             | 5            | 19               |
| Other                  | 0                     | 0                    | 0             | 0              | 0            | 0                |
| Unknown                | 1                     | 3                    | 3             | 5              | 4            | 2                |

## Discussion

The spread of carbapenem resistance among *Enterobacteriaceae* is considered an urgent public health threat by the CDC. The data presented in this report paints a concerning picture of CRE's foothold in West Virginia. 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 of CRE and relies on laboratory or facility reporting of cases. Although CRE is a reportable condition for laboratories 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 an accurate CRE incidence, chief among them assessing the population at risk. While some CRE infections may be acquired in the community, the majority have historically been associated with exposure to health care facilities and prolonged use of broad-spectrum antibiotics. Hospital populations are not stable, making it difficult to ascertain who is at risk. Though somewhat more stable, nursing home populations change over the course of a year as well. The number of people residing in nursing homes is also relatively small, despite a generally older population in West Virginia. According to the Kaiser Family Foundation website, the population residing in West Virginia certified nursing facilities by year was:

- 9,388 in 2018
- 9,478 in 2019
- 9,457 in 2020
- 8,244 in 2021
- 8,714 in 2022 (0.3% of the estimated total state population in 2022)

As the rates for this are calculated using the West Virginia population, the results should be interpreted with some caution and may be higher than stated here. Additional studies would need to be conducted to accurately discern who in West Virginia is at the highest risk of infection with a CRE organism

## Recommendations

Despite the limitations, this data has implications for important infection prevention activities. Health care facilities in all regions of the state should adhere to recommendations for standard and contact precautions for patients who are either infected or colonized with a CRE 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. Health care facilities should consider 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. 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 health care facilities. Another resource OEPS can provide is the WV Project Firstline program. This program offers innovative and accessible infection control education for all frontline health care workers so they can protect their patients, their coworkers, and themselves from infectious disease threats in health care.

## Summary

In summary, CRE infections are concerning in West Virginia. The high prevalence of risk factors, increased antibiotic use, and the difficulty in treating these organisms make CRE surveillance and response an urgent threat and priority. It is crucial for health care 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.