

Carbapenemase-Producing Organisms (CPOs) in Michigan



2018-2024 Surveillance Report

Michigan Department of Health and Human Services (MDHHS)

Healthcare-associated Infections (HAI) Section

2025

Surveillance Report for Carbapenemase-Producing Organisms (CPOs) in Michigan, 2018-2024

Executive Summary

Beginning in 2018, Michigan has required Carbapenemase-producing Carbapenem-resistant Enterobacterales (CP-CRE) reporting to enhance surveillance for this group of antibiotic-resistant bacteria that has posed a significant challenge to healthcare systems. In 2024, this was expanded to include carbapenemase-producing carbapenem-resistant *Pseudomonas aeruginosa* (CP-CRPA) and carbapenemase-producing carbapenem-resistant *Acinetobacter baumannii* (CP-CRAB). This summary provides an overview of CPO surveillance data in Michigan from 2018 to 2024 based on available information reported to the Michigan Disease Surveillance System.

Key Updated Findings:

- **The number of reported CPO cases has doubled over the seven years of public health surveillance in Michigan from 2018-2024.** There was a 31% increase in reported cases in 2020 during the COVID-19 pandemic. CPO cases have continued to rise 60% since, likely due to a combination of increased surveillance efforts through case definition changes, required isolate submission, public health response and prevention efforts to screen high-risk patients, as well as true increases in the incidence of CPOs across Michigan.
- **Along with the overall rise in CPO cases, there has been a substantial 1271% rise in NDM carbapenemase detections over the surveillance period, resulting in NDM carbapenemases being present in 30% of all CPO cases by 2024.** This trend has been seen across all “big three” Enterobacterales of *Klebsiella* spp., *E. coli*, and *Enterobacter* spp. OXA-48 has also increased during this period, though to a lesser extent, primarily in *Klebsiella* spp. and *E. coli*. These trends are consistent with the overall national picture of CPOs in the United States from other data sources including isolates tested through the Center for Disease Control and Prevention’s (CDC) Antimicrobial Resistant Laboratory Network, CDC’s Emerging Infections Program, and others.
- The majority of CPO cases have continued to be reported from jurisdictions in Southeast Michigan, with the highest number of cases reported from the City of Detroit, Wayne and Oakland Counties. Common risk factors among CPO cases continue to include acute care hospitalization, long-term care facility stays, recent surgery, presence of indwelling medical devices, older age and preexisting health conditions.



Enterobacterales is an order of Gram-negative bacteria that includes many families, genera, and species. Enterobacterales organisms are normally found in the human intestines. Sometimes these bacteria spread outside the gut and can cause serious invasive infections which may be difficult to treat.

Pseudomonas is a group of bacteria commonly found in the environment, like in soil and water. The most common type causing infections among humans is *Pseudomonas aeruginosa*. *P. aeruginosa* can cause infections in the blood, lungs (pneumonia), urinary tract, or other parts of the body after surgery.

Acinetobacter is a group of bacteria (germs) commonly found in the environment, like in soil and water. Germs in the *Acinetobacter baumannii* family account for most *Acinetobacter* infections in humans. This type is sometimes referred to as "*Acinetobacter baumannii* complex." Infections caused by *A. baumannii* rarely occur outside of healthcare settings. *A. baumannii* can cause infections in the blood, urinary tract, lungs (pneumonia) or wounds. In some cases, people can carry the bacteria without being infected, known as colonization.

Carbapenems are a powerful class of antibiotics and are typically reserved for the treatment of serious infections. [Carbapenem-resistant Enterobacterales \(CRE\)](#), [carbapenem-resistant *P. aeruginosa* \(CRPA\)](#), [carbapenem-resistant *Acinetobacter baumannii* \(CRAB\)](#), and other multidrug-resistant Gram-negative bacteria are increasingly common causes of healthcare-associated infections. Many different mechanisms can lead to carbapenem resistance. A particular mechanism of carbapenem-resistance, carbapenemase production, results in enzymes that hydrolyze carbapenem antibiotics, thereby disabling the drug molecules and conferring resistance. Carbapenemase genes are usually transmitted on mobile genetic elements (often plasmids) that can be passed from one bacterial species to another. Therefore, Carbapenemase-producing carbapenem-resistant Enterobacterales (CP-CRE), carbapenem-resistant *P. aeruginosa* (CP-CRPA), and carbapenem-resistant *A. baumannii* (CP-CRAB) are considered an urgent public health threat due to their ability to inactivate carbapenems, make treatment challenging for positive clinical outcomes, and spread rapidly in healthcare settings.

The most common Enterobacterales to be CP-CRE include the "big three": *Klebsiella* species, *Enterobacter* species, and *Escherichia coli* (*E. coli*). However, other less common genera can also be CP-CRE including: *Citrobacter* spp., *Morganella* spp., *Proteus* spp., *Providencia* spp., *Raoultella* spp., *Serratia* spp., *Hafnia* spp., and others.

Five types of carbapenemases of public health concern commonly identified in CRE, CRPA, and CRAB, include but are not limited to:

- *Klebsiella pneumoniae* carbapenemase (KPC)
- New Delhi metallo- β -lactamase (NDM)
- Oxacillin-hydrolyzing β -lactamase-48 (OXA-48)
- Verona integron-encoded metallo- β -lactamase (VIM)

- Imipenem-hydrolyzing β -lactamase (IMP)

Similar to other multi-drug resistant organisms (MDROs), robust infection prevention practices are essential to prevent spread of carbapenem resistance. When any carbapenem-resistant isolate is identified by a clinical lab, healthcare providers and infection prevention staff should be immediately notified so proper treatment and infection prevention measures can be implemented. Use of infection prevention precautions in both [acute care](#) and [long-term care](#) settings is recommended for patients in healthcare facilities who are infected or colonized with a carbapenem-resistant organism.

Information about a patient’s infection or colonization with an epidemiologically important organism, including CPOs, *Candida auris*, *Clostridium difficile*, vancomycin-resistant *Enterococcus*, methicillin-resistant *Staphylococcus aureus* or others, should be noted in the medical record and communicated to other healthcare providers and facilities receiving the patient [in transfer](#).

CPO surveillance is essential for early detection, infection prevention, antimicrobial stewardship, and public health planning to estimate CPO burden statewide. By monitoring CPOs and implementing appropriate measures, healthcare systems can mitigate the spread of these resistant organisms and preserve the effectiveness of antibiotics for patient and community health.



CPO Case Reporting

Physicians, healthcare providers, and laboratories must report communicable diseases to the Michigan Disease Surveillance System (MDSS) or the local health department according to criteria in the [Health Care Professional's Guide to Disease Reporting in Michigan](#).

CPO surveillance began in January 1, 2018 by including it in the [required reportable diseases list](#). Some aspects of the criteria have expanded over the following years, as described below.

Table 1. Surveillance Reporting Criteria

Criteria	2018-2021	2022-2023	2024
Reportable Organism	<i>Enterobacter</i> spp., <i>Escherichia coli</i> , or <i>Klebsiella</i> spp.	Enterobacterales, all genera	Enterobacterales, all genera, <i>Pseudomonas aeruginosa</i> , or <i>Acinetobacter</i> spp.
Laboratory Isolate Submission	Isolates of CP-CRE are requested to be submitted to MDHHS BOL	Isolates of CP-CRE are required to be submitted to MDHHS BOL	Isolates of CP-CRE, CP-CRPA, and CP-CRAB are required to be submitted to MDHHS BOL
Healthcare Record Reports	Healthcare record contains a diagnosis of an eligible carbapenemase-producing organism or any of the following carbapenemase genes: KPC, NDM, VIM IMP, OXA-48, other novel carbapenemase gene		

Carbapenemase production by phenotypic method	Positive test result for carbapenemase production by a phenotypic method (e.g., Carba-NP, carbapenem inactivation method (CIM), modified carbapenemase inactivation method (mCIM), EDTA-modified carbapenem inactivation method (eCIM))
Carbapenem resistance gene	Positive test result for a carbapenem resistance gene by a recognized test (e.g., Polymerase chain reaction (PCR), Cepheid Xpert Carba-R®, Verigene BC-GN®, Eplex® BCID GN Panel, FilmArray™ BCID, FilmArray™ pneumonia panel, BD MAX™ Check-Points, whole genome sequencing)
Susceptibility Testing	<p>If laboratories are unable to detect carbapenemases in eligible organisms (i.e., cannot test for carbapenemase production or carbapenem resistance genes), report:</p> <p>Any isolate with a minimum inhibitory concentration (MIC) of ≥ 4 $\mu\text{g/mL}$ for doripenem, imipenem, or meropenem, or ≥ 2 $\mu\text{g/mL}$ for ertapenem based on antimicrobial susceptibility testing.</p> <p>Additional guidance beginning in 2022: <i>Morganella</i>, <i>Proteus</i>, <i>Providencia</i> spp. may have intrinsic resistance to imipenem. Only those isolates that are resistant to 1 or more carbapenems other than imipenem should be reported.</p>



Case Classification

The surveillance case definition has been modified over time. From 2018 to 2021, CP-CRE case classification only included *Klebsiella spp.*, *Escherichia coli*, or *Enterobacter spp.* Beginning January 1, 2022, CP-CRE case classification included all genera in the order Enterobacterales. Then starting January 1, 2024, CPO case classification also included *Pseudomonas aeruginosa* and *Acinetobacter spp.*

1. Confirmed CPO

- Enterobacterales organism (2018-2021: only *Klebsiella spp.*, *Escherichia coli*, or *Enterobacter spp.*), or *Pseudomonas aeruginosa* or *Acinetobacter spp.* **AND**
 - Positive phenotypic carbapenemase test **OR**
 - Positive test for a carbapenem resistance gene: KPC, NDM, VIM, IMP, OXA-48, etc.
- Molecular carbapenemase screening test specimen positive for a carbapenemase gene with no organism recovered.

2. Not a Case

- Organism not Enterobacterales, *Pseudomonas aeruginosa*, or *Acinetobacter spp.*
- Negative for phenotypic and molecular tests, regardless of MIC criteria, or phenotypic and molecular tests were not performed.



CPO Laboratory Testing

As of January 1, 2022, all confirmed or suspected CP-CRE isolates identified from clinical laboratories in Michigan are required to be submitted to the Michigan Department of Health and Human Services (MDHHS) Bureau of Laboratories (BOL) for confirmatory testing (per Table 1). Starting in 2024, all CP-CRPA and CP-CRAB isolates were included in submission requirements.

The BOL provides support to perform the following tests:

- Confirm organism identification
- Phenotypic carbapenemase testing: modified carbapenem inactivation method (mCIM)
- Molecular carbapenemase testing: PCR or immunochromatography testing for KPC, NDM, OXA-48 like, IMP, and VIM
- Antimicrobial susceptibility testing (AST)
- Whole genome sequencing

Clinical labs can find more information about specimen submission test requisition forms at michigan.gov/mdhhs/lab

Results from testing at BOL are sent to the submitter and local public health department where the patient resides as well as submitted electronically to the Michigan Disease Surveillance System (MDSS).



CPO Case Investigation and Surveillance

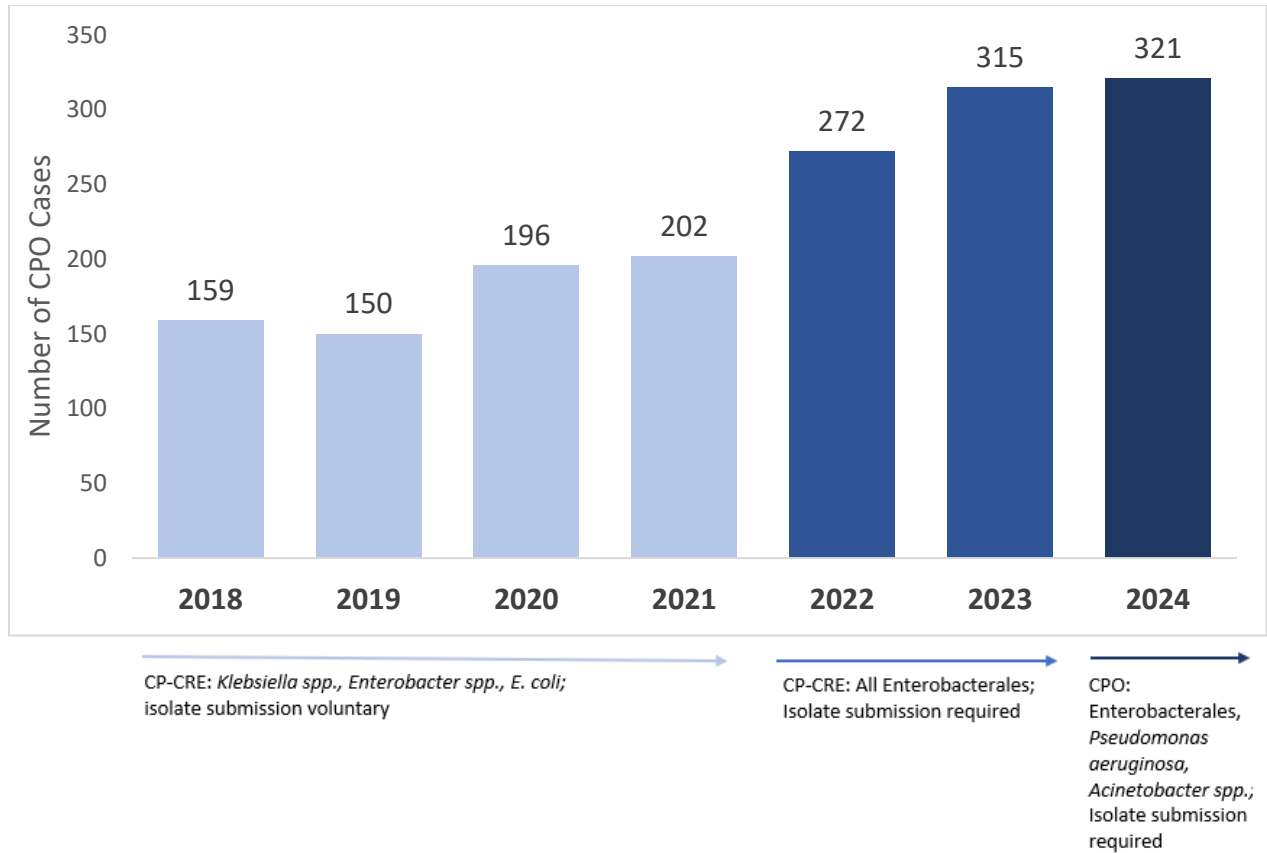
Any report of a person in Michigan known to be infected or colonized with a carbapenemase-producing organism is investigated by the local health department to attempt to determine the likely source and prevent transmission to other patients during healthcare. The [CPO Case Reporting and Investigation Guidance](#) is available for reference.

The MDHHS [Healthcare-associated Infections \(HAI\) Section](#) can offer consultation and assistance with reporting, investigation, and colonization screening testing on samples from patients who are epidemiologically-linked to an index case. For high-risk individuals, CPO screening should be done as soon as feasible to ensure prompt and effective intervention measures to prevent further spread.

The following report includes confirmed CPO cases reported to the Michigan Disease Surveillance System since surveillance began January 1, 2018, through December 31, 2024. Population estimates for each surveillance year were obtained from the [United States Census Bureau](https://data.census.gov/profile). [<https://data.census.gov/profile>].

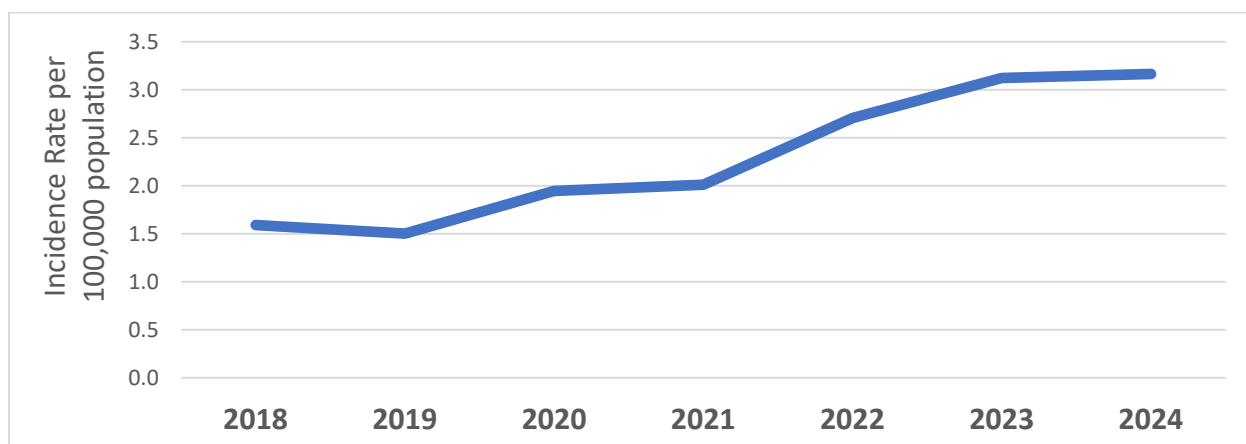


Figure 1. CPO Cases by Year.



The number of reported CPO cases remained stable in the first two years of required reporting between 2018 and 2019. Then, there was a 31% increase in reported cases in 2020, the same year of the start of the COVID-19 pandemic (Figure 1). A similar 35% increase in overall hospital-onset carbapenem-resistant Enterobacterales (CRE) infections between 2019 to 2020 was also seen nationally (CDC [COVID-19: U.S. Impact on Antimicrobial Resistance, Special Report 2022](#)). This dramatic increase was likely due to increased antimicrobial use in hospital and long-term care settings, challenges with implementing effective infection prevention and control practices, and hindered antimicrobial resistant organism surveillance and response. This increase in CPO cases remained stable through 2021. Additionally, a further 39% increase in CPO cases occurred in 2022. This coincided with the inclusion of reporting for all genera of the order Enterobacterales and required submission of isolates for carbapenemase testing, which may have increased the detection of carbapenemase genes among suspected CPO cases, allowing for more accurate case classification as confirmed CPOs, accounting for at least part of the increases observed. However, cases continued to increase by 16% in 2023 when no change in surveillance definitions occurred, likely reflecting true increases in CPO incidence. In 2024, *Pseudomonas aeruginosa* and *Acinetobacter spp.* were added as eligible reportable organisms, and the overall CPO case total increased by 2% over 2023 totals.

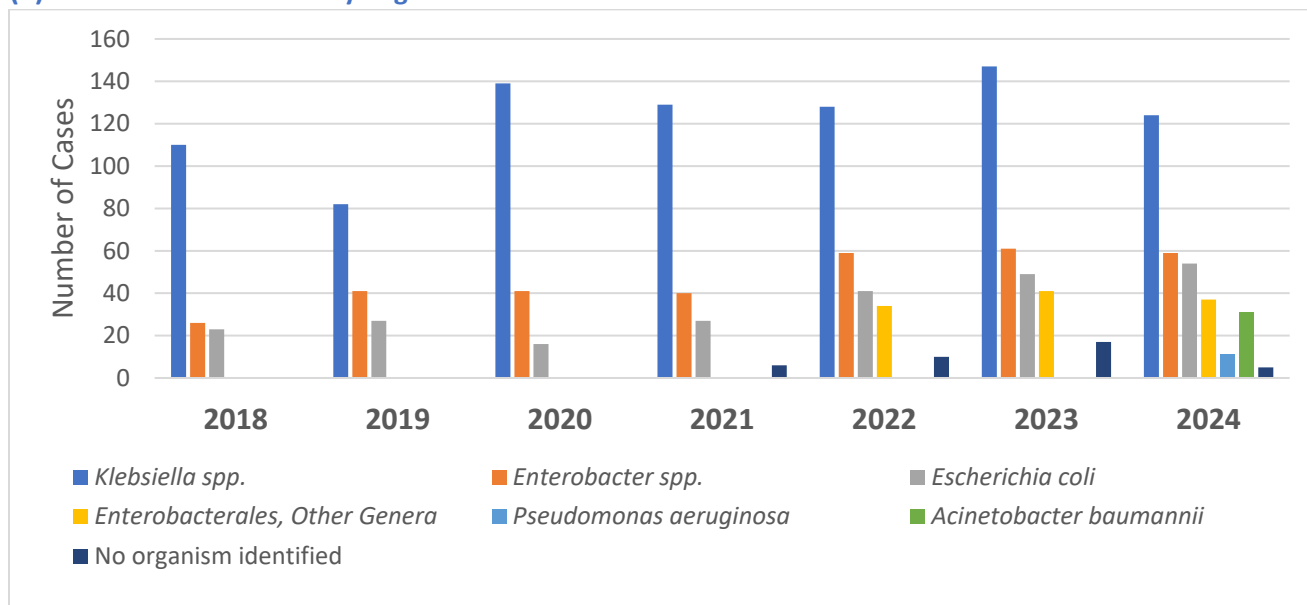
Figure 2. CPO Incidence Rate by Year.



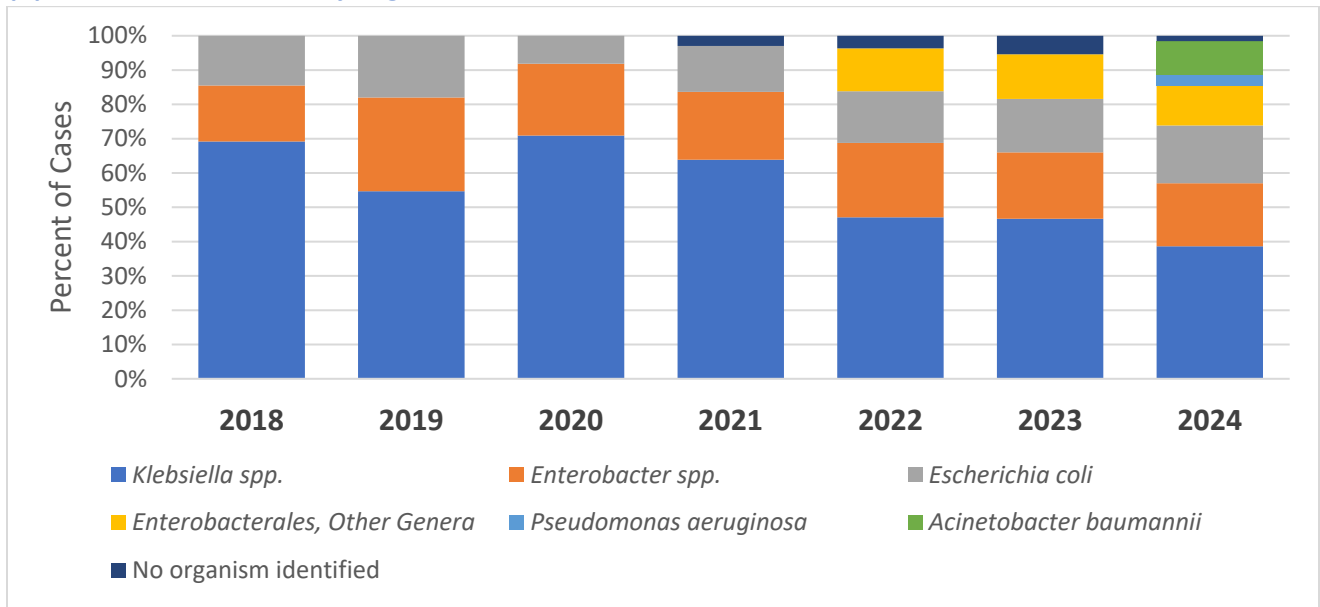
Between 2018 and 2024, the CPO incidence rate in Michigan doubled from 1.6 CPO cases to 3.2 CPO cases per 100,000 population (Figure 2). Similar increases were noted among 2 separate cohorts of U.S. states: the first, an open cohort of 29 states where CRE was reportable, where unadjusted CP-CRE rates increased from 2.22 to 3.67 cases per 100,000 population between 2019-2023 ([Rankin, DA et. al., 2025](#)); the second, U.S. states and jurisdictions participating in CDC’s Multi-site Gram-negative Surveillance Initiative (MuGSI) for CRE surveillance, where overall CRE rates increased from 5.4 to 6.4 cases per 100,000 population between 2018-2022 ([CDC EIP HAICviz](#)).

Figure 3. CPO Cases by Organism and Year.

(a) Number of CPO Cases by Organism.



(b) Percent of CPO Cases by Organism

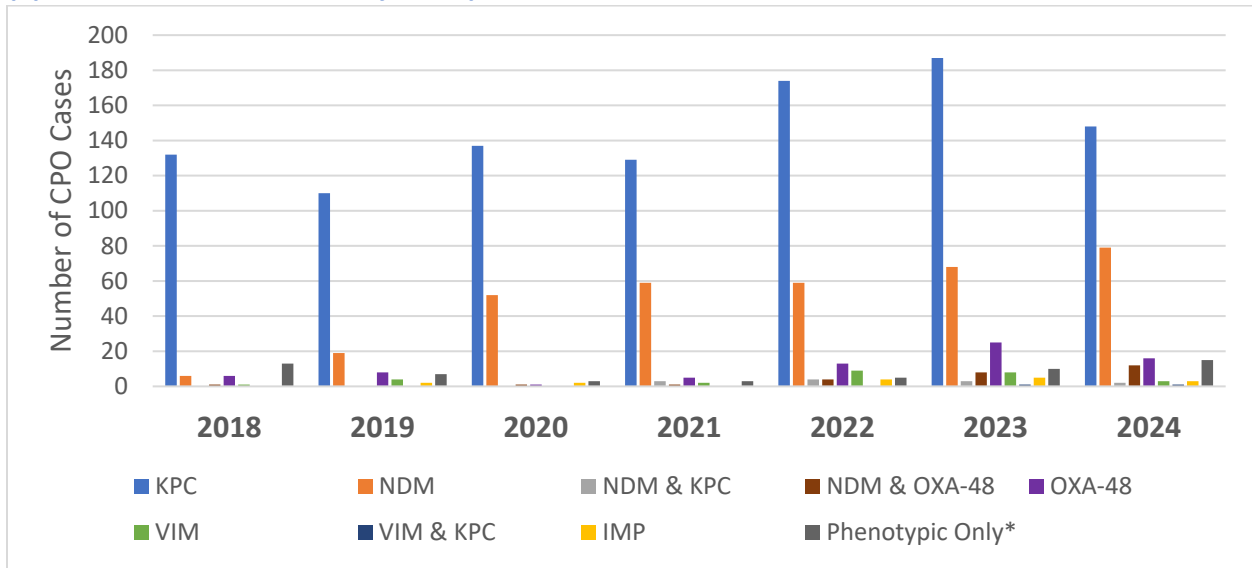


The most common Enterobacterales to be CPOs include the “Big Three”: *Klebsiella* spp., *Enterobacter* spp., and *Escherichia coli* (Sabour, S. et al., 2021). *K. pneumoniae* has consistently remained the most prevalent CPO in Michigan, followed by *E. cloacae* and *E. coli* (Figure 3a, 3b). There was a noted increase in *E. coli* and *E. cloacae* CPO cases identified between 2021 and 2022, which may in part be related to isolate submission requirements allowing for identification of confirmed carbapenemase-producing isolates. Numbers of *E. cloacae* cases have since remained consistent through 2024, while *E. coli* cases have continued to increase, with 54 cases in 2024 representing a 134% increase over the average number of *E. coli* cases seen between 2018-2021.

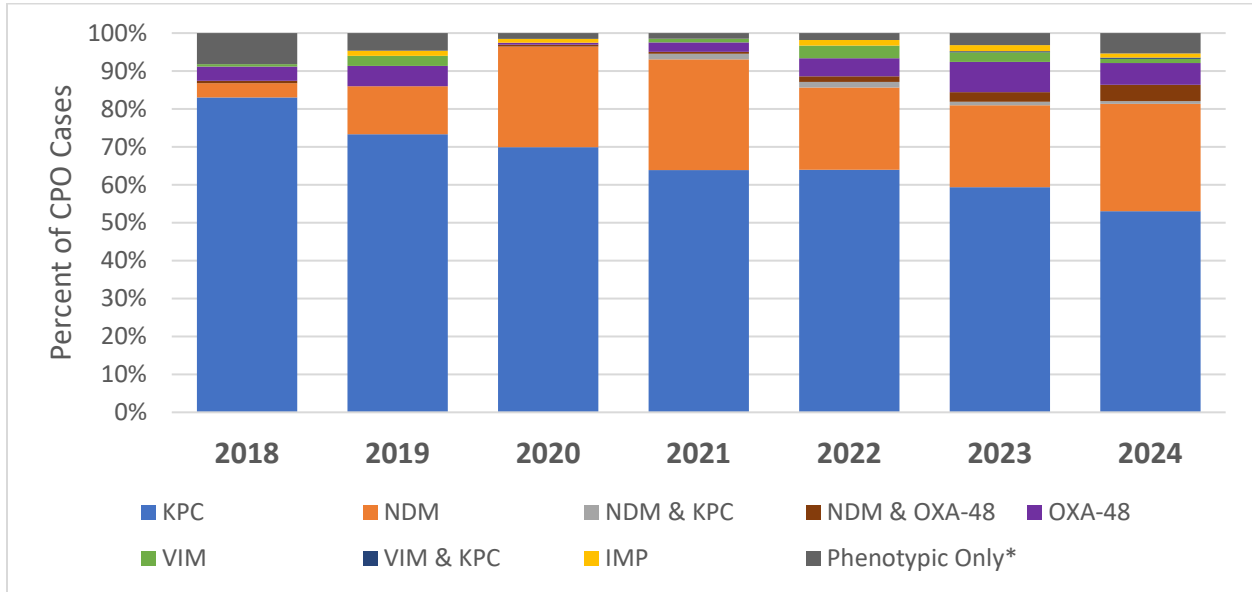
Other less common genera can also be CPOs including: *Citrobacter* spp., *Morganella* spp., *Proteus* spp., *Providencia* spp., *Raoultella* spp., *Serratia* spp., *Hafnia* spp., and others (Shugart, A. et al., 2021). In 2022, less common genera of Enterobacterales were newly included in Michigan surveillance reporting and accounted for about 13% of the total CPO cases each year since (Table S1). In 2024, *P. aeruginosa* and *Acinetobacter* spp. were added to surveillance reporting and accounted for 11 (3%) and 31 (10%) of CPO cases that year, respectively.

Figure 4. CPO Cases Among Enterobacteriales by Carbapenemase Genes Detected and Year.

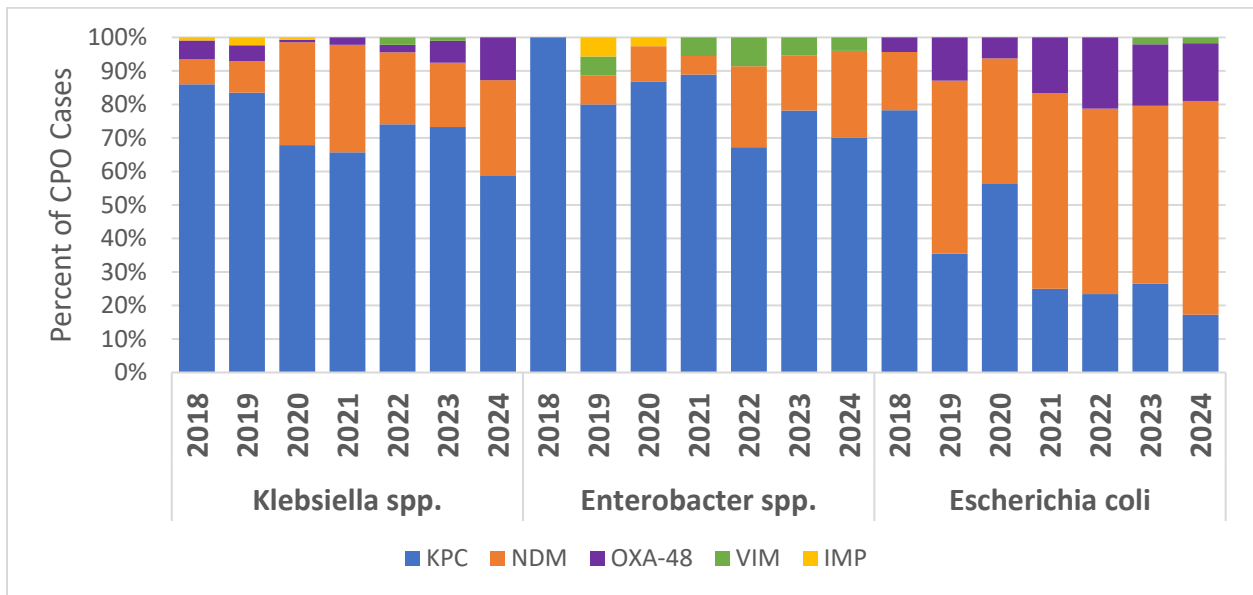
(a) Number of CP-CRE Cases by Carbapenemase.



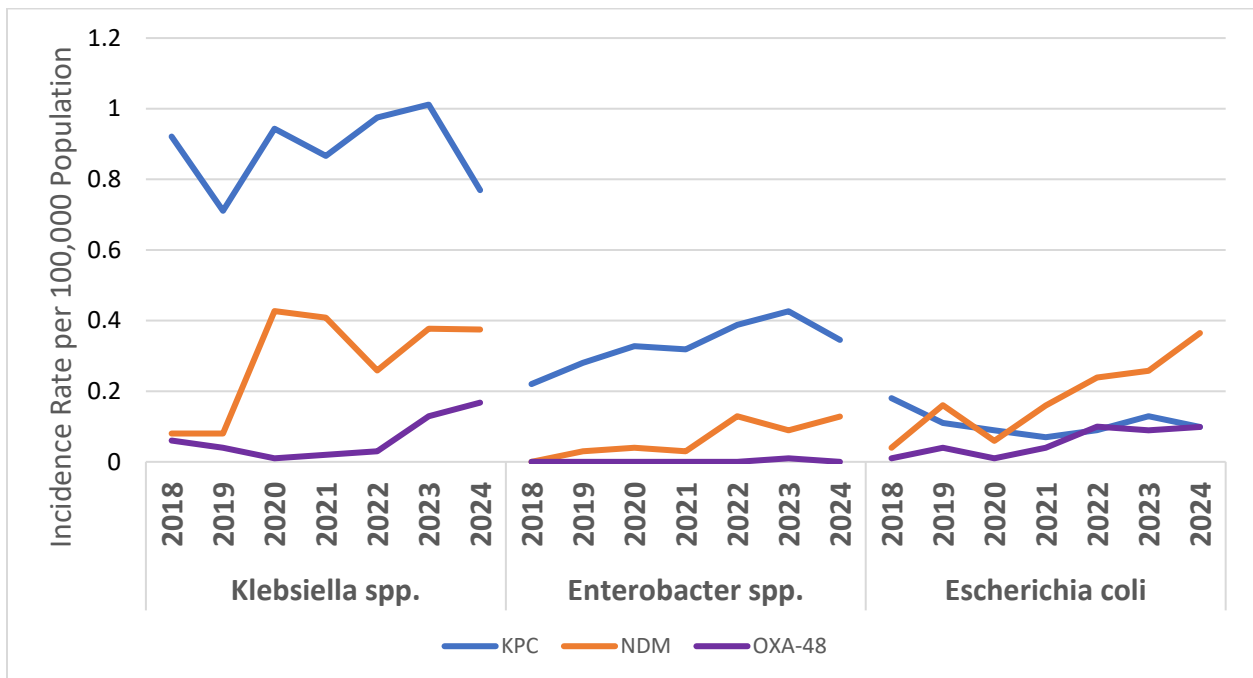
(b) Percent of CP-CRE Cases by Carbapenemase.



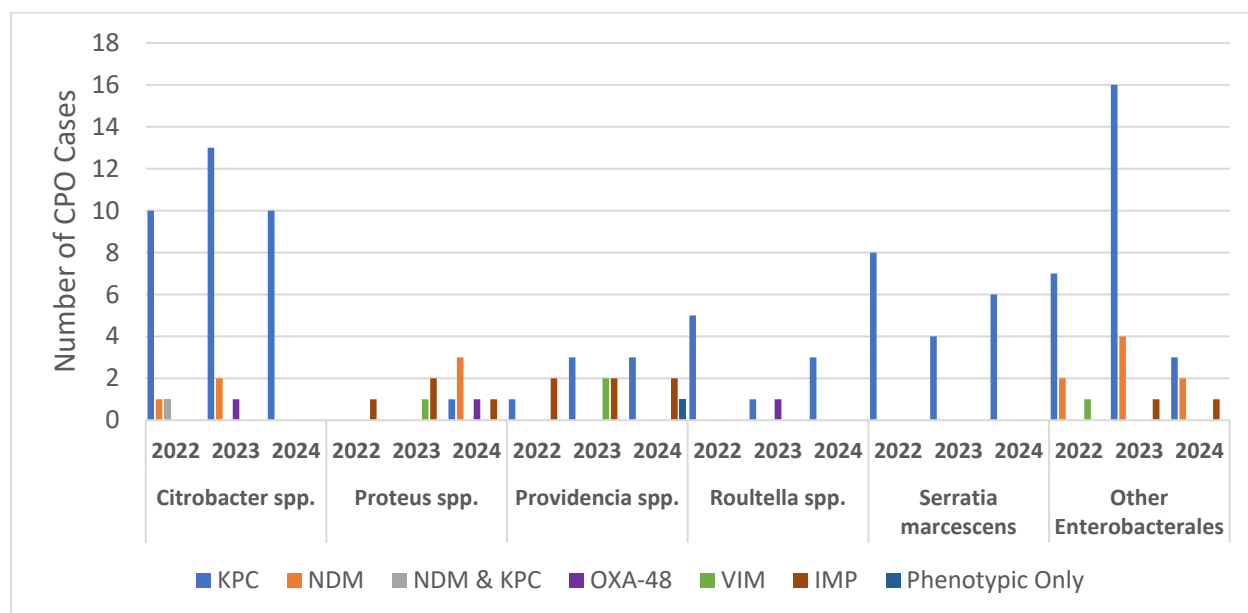
(c) Percent of “Big Three” CP-CRE Cases by Carbapenemase.



(d) “Big Three” CP-CRE Incidence Rates by Carbapenemase.



(e) Number of “Less Common Genera” CP-CRE Cases by Carbapenemase.



Carbapenemase genes present in CPOs vary among CP-CRE, CP-CRRA, and CP-CRAB (Sabour, S. et al., 2021; CDC Antimicrobial Resistance & Patient Safety Portal). Among CP-CRE in Michigan, KPC remains the most prevalent carbapenemase gene, detected in 64% of CP-CRE cases across all surveillance years (Figure 4a, 4b; Table S2). Incidence rates of KPC generally increased across the surveillance period, particularly in *Klebsiella* spp. and *Enterobacter* spp. (Fig 5c, 5d). For KPC-*Klebsiella* spp., incidence peaked in 2023 at 1.01 per 100,000 population, before decreasing in 2024 back to rates similar to 2018-2022. A similar trend was observed for KPC-*Enterobacter* spp., where the incidence rate also peaked in 2023 at 0.43 cases per 100,000 population before decreasing in 2024.

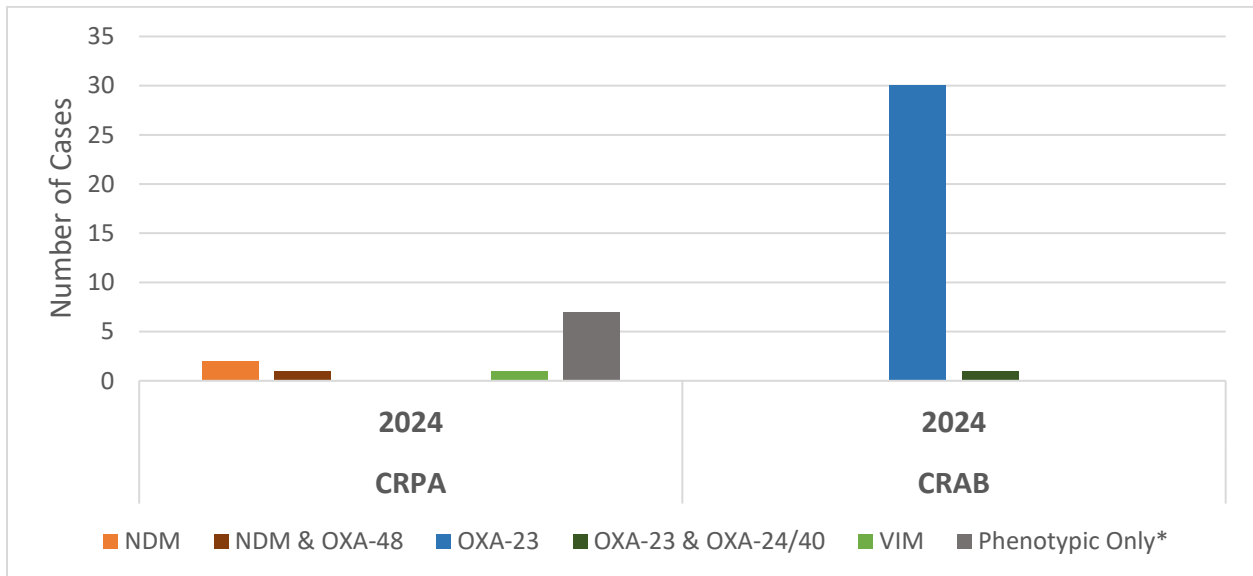
NDM carbapenemases have increased substantially year over year and were present in 29% of all 2024 CP-CRE cases, up from just 4% of CP-CRE cases in 2018 (Fig 4a, 4b). This represents a 1229% increase over the number of cases with NDM between 2018 and 2024. NDM carbapenemases increased across all “Big Three” genera of *Klebsiella* spp., *Enterobacter* spp., and *E. coli* (Fig 5c, 5d). NDM-*Klebsiella* spp. rates increased 433% from 2019 to 2020 during the first year of the COVID pandemic, and incidence rates remained about 0.4 cases per 100,000 population in the following years. In contrast, NDM-*E. coli* rates initially increased from 0.04 to 0.16 cases per 100,000 population between 2018 to 2019, before falling back to 0.06 cases per 100,000 population in 2020. Then, in 2021, rates of NDM-*E. coli* rose again and continued to increase year over year with 0.36 cases per 100,000 population detected in 2024, similar to rates of NDM-*Klebsiella* spp. A similar rise in NDM carbapenemases has also been noted in a cohort of 29 other U.S. states as well (Rankin, DA et. al., 2025).

Detections of OXA-48 carbapenemases have also increased during this surveillance period, though less dramatically than NDM, detected in just 4% of overall CP-CRE cases in 2018 compared to 10% of cases in 2024, primarily driven by increases in OXA-48-*Klebsiella* spp. and OXA-48-*E. coli*.

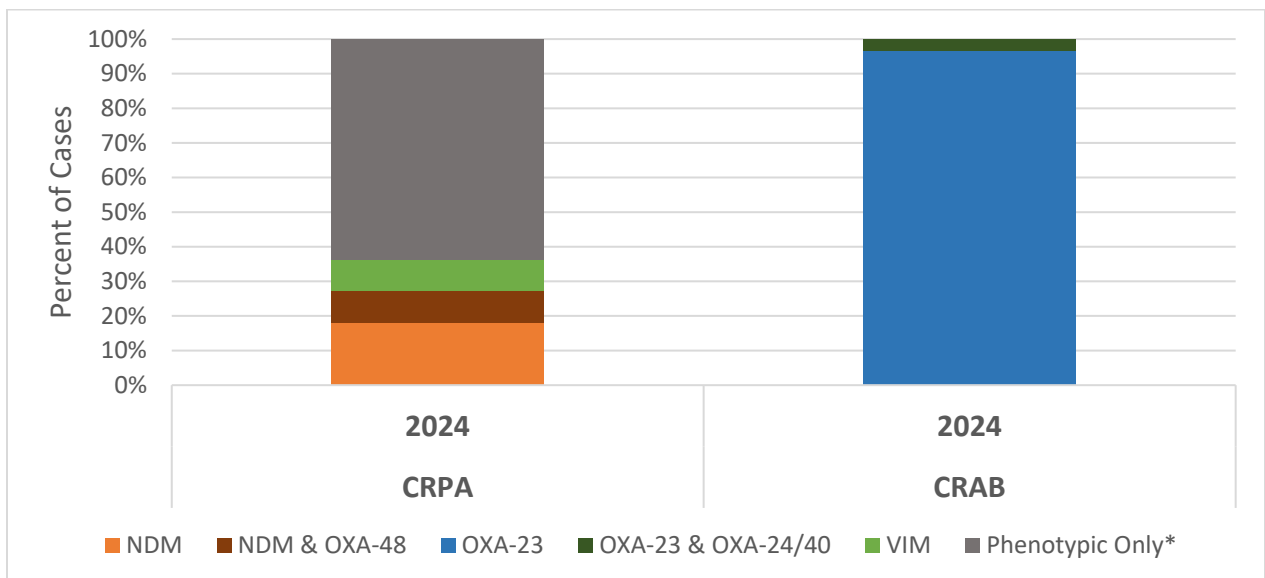
Similar to the “Big Three” CP-CRE organisms, KPC is also the most prevalent carbapenemase gene detected among the less common genera Enterobacterales (Fig 5e); although IMP carbapenemases are also noted to be common among *Proteus* spp. and *Providencia* spp.

Figure 5. CPO Cases Among *Pseudomonas aeruginosa* and *Acinetobacter baumannii* by Carbapenemase Genes and Year.

(a) Number of CP-CRPA and CP-CRAB Cases by Carbapenemase.



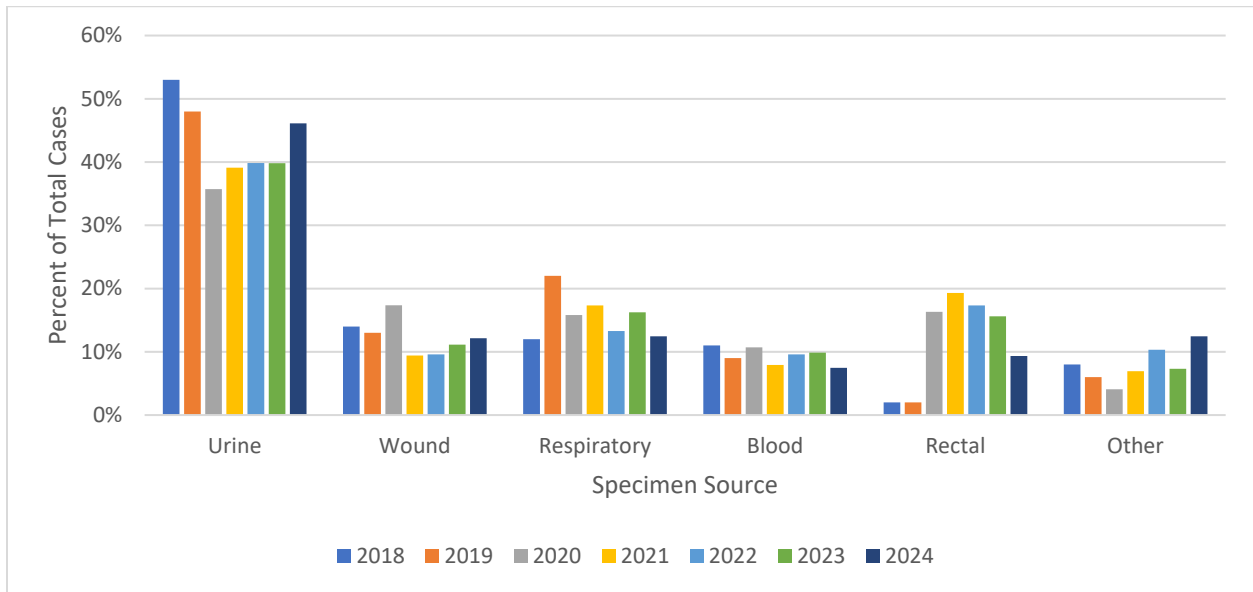
(b) Percent of CP-CRPA and CP-CRAB by Cases Carbapenemase.



* Phenotypic only CPO isolates are those that were positive for carbapenemase production by a phenotypic test (e.g., mCIM) but were either not further tested to determine the associated carbapenemase genes present or for isolates that were tested by PCR and were negative for all carbapenemase gene targets tested.

Among CP-CRPA in Michigan, a carbapenemase gene was detected in just over a third of all CRPA with carbapenemase production detected by a phenotypic test (Figure 5a, 5b). The carbapenemase genes detected among CRPA were NDM (2, 18%), NDM in combination with OXA-48 (1, 9%), and VIM (1, 9%). Among CP-CRAB, none of the five most common carbapenemase genes (KPC, NDM, OXA-48, VIM, IMP) were detected in 2024. Instead, all CP-CRAB cases had carbapenemase genes most commonly found in *Acinetobacter* spp. detected, including OXA-23 (31, 100%), and in combination with OXA-24/40 (1, 3%).

Figure 6. Specimen Source of Confirmed CPO Cases by Year.



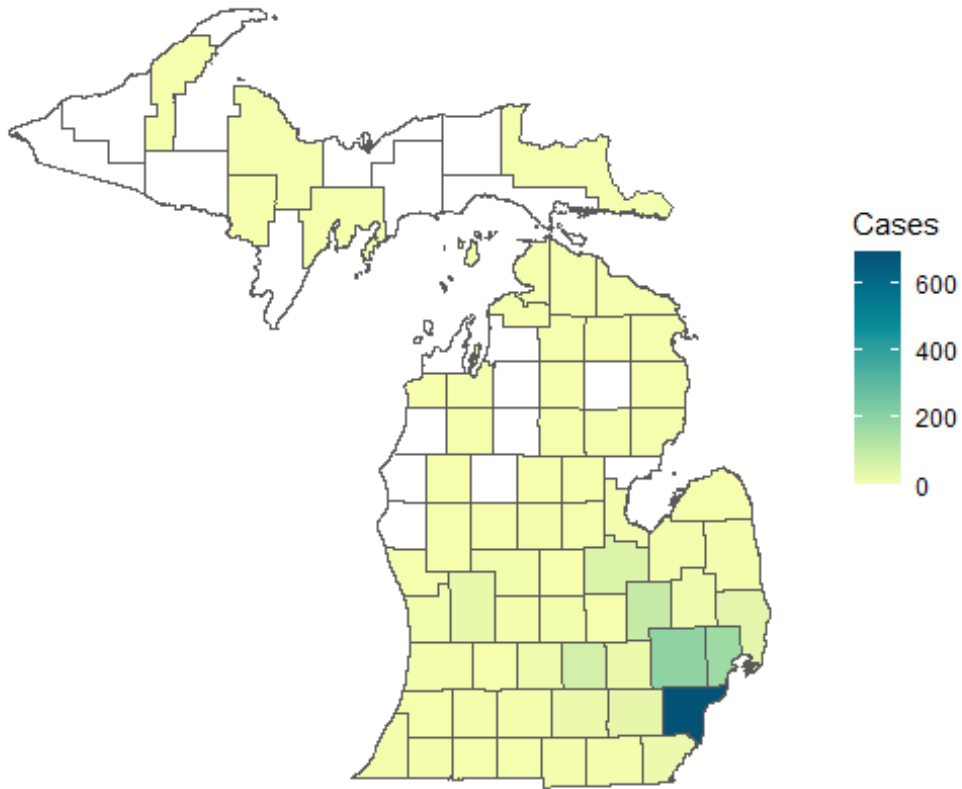
The most common specimen source for CPO isolates is urine (43%). “Other” specimens included body fluid, bone, and tissue (Figure 6). CPO detections from rectal specimens increased most notably between 2020 and 2023. This likely reflects increased surveillance activities for CPO in the state including both: 1) colonization screening of high-risk patients resulting from an increased detection of targeted CPOs from clinical cultures or outbreak detection (response-based screening) and 2) increased capacity/activities for CRE colonization screening conducted upon admission to healthcare facilities (prevention-based screening).

Table 1. Demographic and Clinical Characteristics of Confirmed CPO Cases.

Clinical Characteristic	Cases with Data Available, N	Cases with Characteristic	
Age, mean (range), years	1615	65 (1 - >89)	
		n	%
Male Sex	1615	890	55%
Race	1615		
Caucasian		809	50%
Black or African American		499	31%
Asian		54	3%
American Indian or Alaska Native		6	0.4%
Other		94	6%
Unknown		153	9%
Comorbidities	1134		
Cardiovascular disease		601	53%
Chronic lung disease		325	29%
Diabetes mellitus		472	42%
Malignancy		132	12%
Para- /Hemi- /Quadri- plegia		127	11%
Renal failure		264	23%
Indwelling Medical Device use	1339		
Central venous catheter	950	363	38%
Urinary catheter	1003	553	55%
Mechanical ventilation	1054	389	37%
Wound VAC	846	72	9%
Feeding tube	830	395	48%
Healthcare Exposures	954		
Acute care hospitalization in last 90 days	948	737	78%
Long-term acute care hospitalization in last 90 days	770	129	17%
Long-term care facility stay in last 90 days	878	400	46%
Hemodialysis in last 90 days	912	163	18%
Surgery in last 90 days	903	526	58%
Solid organ transplant, ever	779	42	5%
Travel			
International travel in last 6 months	669	85	13%

Annual CPO case demographics and clinical characteristics of CPO cases remained similar overall for each year between 2018-2024 (Table 1). The most common risk factors were healthcare facility exposure, including acute care hospitalization in the last 90 days (78%), followed by surgery in the last 90 days (58%), and long-term care facility stay in the last 90 days (46%). Overall, 41% of confirmed CPO cases had an indwelling medical device and 49% had at least one major comorbid condition.

Figure 7. Jurisdiction of CPO Cases.*

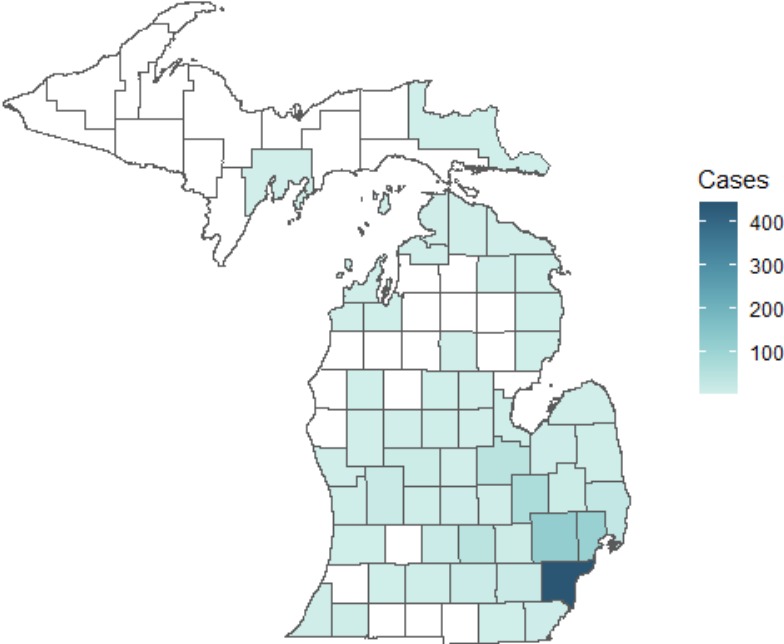


*Case counts for the City of Detroit are shown with counts for Wayne County.

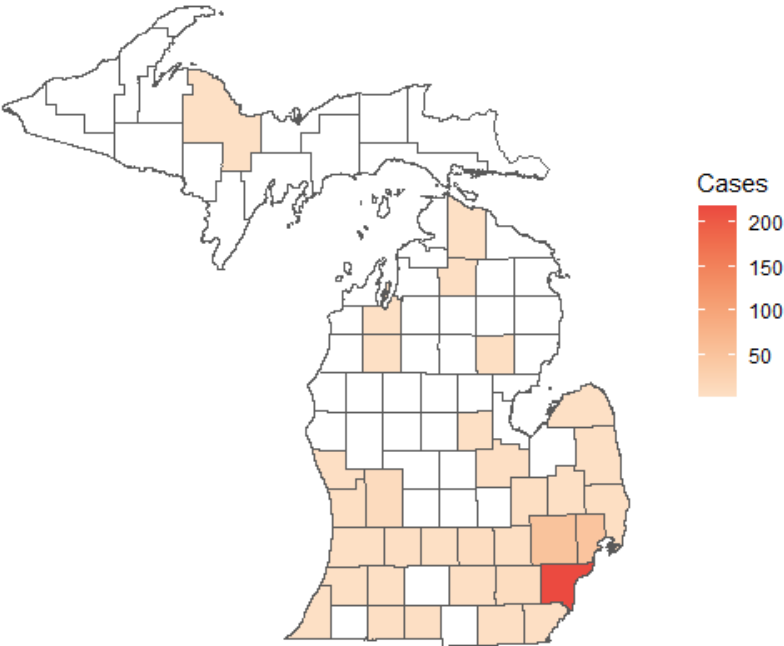
For the seven-year period between 2018 to 2024, the majority of confirmed CP-CRE cases have reported residence in Southeast Michigan (Figure 7), which aligns with the geographic population density in the state. The highest number of CPO cases reported was within the City of Detroit (454) and Wayne County (236), followed by Oakland County (194) and Macomb County (167).

Figure 8. Jurisdiction of CPO Cases by Carbapenemase Gene.*

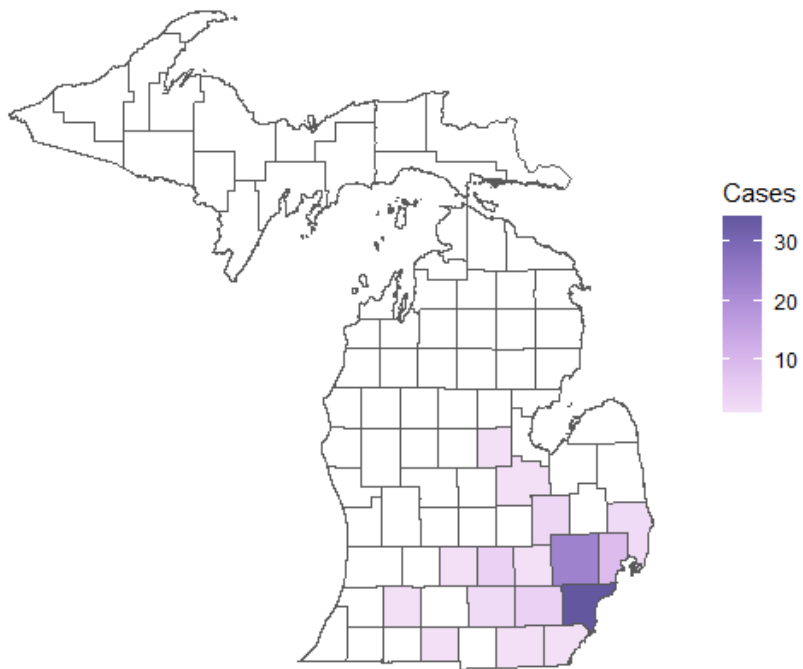
(a) KPC



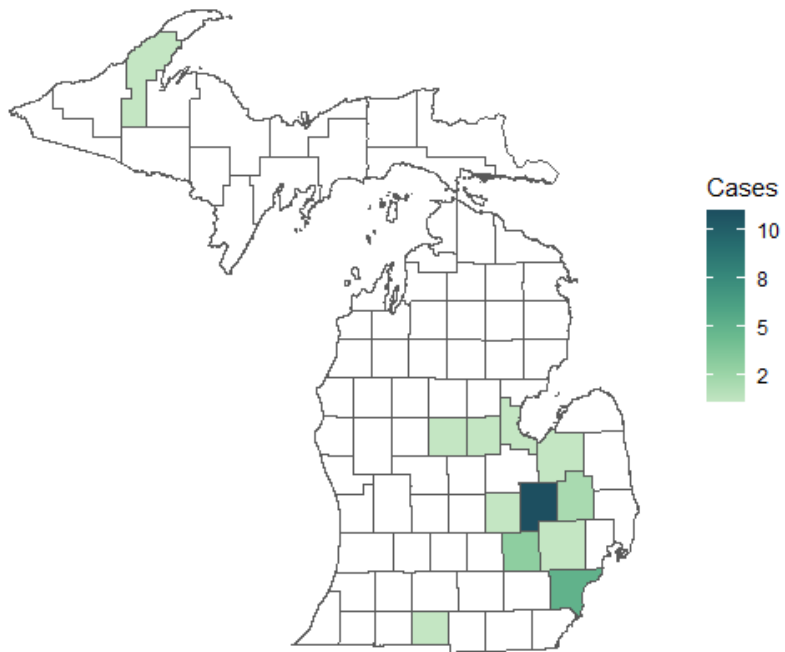
(b) NDM



(c) OXA-48



(d) VIM



[Interim Guidance for Public Health Strategies to Prevent the Spread of Novel or Targeted Multidrug-resistant Organisms \(MDROs\)](#)

- Response-driven strategies to contain individual cases as they are identified; guidance document outlines ongoing, long-term strategies to proactively identify patients/residents infected or colonized with, and reduce transmission of, novel and targeted MDROs. [Interim Guidance for a Public Health Response to Contain Novel or Targeted Multidrug-resistant Organisms \(MDROs\)](#)
- Michigan resources and tools for CPO Reporting and Investigation [Healthcare-Associated Infections \(michigan.gov\)](#)



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Supplemental Tables

Table S1. CPO Cases by Organism.

Organism	2018	2019	2020	2021	2022	2023	2024
Total CPO cases, n	159	150	196	202	272	315	321
Most Common Enterobacterales, n (%)	159 (100)	150 (100)	196 (100)	196 (97)	228 (84)	257 (82)	237 (74)
<i>Enterobacter asburiae</i>						1	
<i>Enterobacter cloacae</i>	26	41	41	40	59	59	59
<i>Enterobacter hormaechei</i>						1	
<i>Escherichia coli</i>	23	27	16	27	41	49	54
<i>Klebsiella aerogenes</i>	4	1	2	3		1	5
<i>Klebsiella oxytoca</i>	3	10	8	4	9	10	7
<i>Klebsiella pneumoniae</i>	102	70	128	121	118	134	109
<i>Klebsiella variicola</i>	1	1	1	1	1	2	3
Less Common Enterobacterales, n (%)					34 (13)	41 (13)	37 (12)
<i>Citrobacter farmeri</i>							1
<i>Citrobacter freundii</i>					11	14	9
<i>Citrobacter koseri</i>						3	
<i>Kluyvera cryocrescens</i>						1	
<i>Morganella morganii</i>						3	1
<i>Pantoea spp.</i>						1	
<i>Proteus mirabilis</i>					2	2	5
<i>Proteus vulgaris</i>						1	1
<i>Providencia rettgeri</i>					3	3	3
<i>Providencia stuartii</i>					2	4	3
<i>Raoultella ornithinolytica</i>					5	2	2
<i>Raoultella planticola</i>							1
<i>Serratia marcescens</i>					11	7	11
<i>Pseudomonas aeruginosa</i>, n (%)							11 (3)
<i>Acinetobacter baumannii</i>, n (%)							31 (10)
No organism,* n (%)				6 (3)	10 (4)	17 (5)	5 (2)

* Positive colonization screens by PCR with no organism recovered on culture.

Table S2. CPO Cases by Carbapenemase Gene.

Carbapenemase Genes	2018	2019	2020	2021	2022	2023	2024
Total CPO cases	159	150	196	202	272	315	321
KPC	132	110	137	129	174	187	148
NDM	6	19	52	59	59	68	81
NDM & KPC				3	4	3	2
NDM & OXA-48	1		1	1	4	8	13
OXA-23							30
OXA-23 & OXA-24/40							1
OXA-48	6	8	1	5	13	25	16
VIM	1	4		2	9	8	3
VIM & KPC						1	1
IMP		2	2		4	5	4
Phenotypic only	13	7	3	3	5	10	22

Table S3. CPO Cases by Carbapenemase Gene and Jurisdiction.*†‡

Jurisdiction by Case Residence	KPC	NDM	VIM	IMP	OXA-48	CPO
Alcona	2					2
Alger						
Allegan	2	1		1		7
Alpena	2					2
Antrim						
Arenac						
Baraga						
Barry		2				2
Bay	4		1			5
Benzie	1					2
Berrien	3	1		1		5
Branch		2	1		1	4
Calhoun	5			1		7
Cass	6					6
Charlevoix	1					1
Cheboygan	1	1				4
Chippewa	2					4
Clare	2					2
Clinton	7					10
Crawford						0
Delta	1					1

Dickinson						0
Eaton	13	1			1	15
Emmet	3					3
Genesee	67	3	11	2	3	89
Gladwin	1					1
Gogebic						
Grand Traverse	2	1				3
Gratiot	1					1
Hillsdale				2		5
Houghton			1	1		2
Huron	1	1				2
Ingham	41	6			4	67
Ionia	4			1		6
Iosco	2					3
Iron						
Isabella	5		1			8
Jackson	13	2			2	19
Kalamazoo	2	1			1	6
Kalkaska						
Kent	16	9		1		26
Keweenaw						
Lake	2					2
Lapeer	10	1	2			14
Leelanau	1			1		
Lenawee	2	2			1	6
Livingston	8	3	3	1	1	21
Luce						
Mackinac						
Macomb	107	48		3	9	167
Manistee						
Marquette		1				3
Mason						
Mecosta	1					1
Menominee						
Midland	1	1	1		1	4
Missaukee						
Monroe	7	2			1	18
Montcalm	10					10
Montmorency	1					1
Muskegon	1	2				4
Newaygo	1					1
Oakland	119	50	1		23	194
Oceana						

Ogemaw		3				3
Ontonagon						
Osceola						
Oscoda						
Otsego		2				2
Ottawa	4	3				9
Presque Isle	1					3
Roscommon	1					1
Saginaw	43	2		1		49
Sanilac	5	1				37
Schoolcraft						3
Shiawassee	3		1			6
St. Clair	28	3		2		
St. Joseph		2				4
Tuscola	7		1			7
Van Buren		1		1		2
Washtenaw	15	7			4	32
Wayne	136	78	3	1	20	236
Wexford		1				1
City of Detroit	306	140	2	0	14	454

*CPO case isolates with more than 1 carbapenemase gene present are counted in each column for the respective carbapenemase genes detected. Therefore, the total count of all genes may exceed the total CPO cases in some counties.

†CPO cases that were positive for carbapenemase production by a phenotypic test (e.g., mCIM) but were either not further tested to determine the associated carbapenemase genes present or for isolates that were tested by PCR and were negative for all carbapenemase gene targets tested are included in the CPO counts only.

‡14 cases (1 KPC, 13 OXA-48) did not have an address available in MDSS and are excluded from the table.

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