Emerging Infections Program (EIP) Network Report
Healthcare-Associated Infections Community Interface Activity
Multi-site Gram-negative Surveillance Initiative
Carbapenem-Resistant Enterobacterales (CRE) Surveillance, 2023

Case Definition:

A carbapenem-resistant Enterobacterales (CRE) case was defined as isolation of *Escherichia coli*, *Klebsiella aerogenes*, *Enterobacter cloacae* complex, *Klebsiella pneumoniae,* or *Klebsiella oxytoca* with the following criteria:

- Carbapenem-resistant (doripenem, imipenem, meropenem, or ertapenem) using the current Clinical and Laboratory Standards Institute (CLSI) clinical breakpoints (1);
- Isolated from a normally sterile specimen (e.g., blood, cerebrospinal fluid, pleural fluid, pericardial fluid, peritoneal fluid, joint/synovial fluid, bone, internal body sites, or muscle) or urine;
- Identified in residents of the surveillance area in 2023.

Surveillance Catchment Areas:

California (3 county San Francisco area), Colorado (5 county Denver area); Connecticut (statewide); Georgia (8 county Atlanta area); Maryland (4 county Baltimore area); Minnesota (2 county Minneapolis – St. Paul area); New Mexico (1 county Albuquerque area); New York (1 county Rochester area); Oregon (3 county Portland area); and Tennessee (8 county Nashville area).

Population:

The surveillance area represents 23,176,096 persons.
Source: U.S. Census Bureau, Population Division, Vintage 2023 Special Tabulation.

Methods:

Case finding was active, laboratory-based, and population-based. Clinical laboratories that serve residents of the surveillance area were routinely contacted for case identification through a query of minimum inhibitory concentration (MIC) values from automated testing instruments. When possible, the MIC values obtained directly from the automated testing instruments were used to determine if an isolate met the phenotypic case definition. An incident CRE case was defined as the first CRE isolate meeting the case definition from a patient during a 30-day period.

Standardized case report forms were completed for incident cases through review of medical records. Inpatient and outpatient medical records were reviewed for information on patient demographics, clinical syndrome, outcome of illness, and relevant healthcare exposures.

Race/ethnicity was considered missing if a patient had unknown ethnicity (regardless of reported race) or if a patient had unknown race and was not Hispanic or Latino. New for 2023 data, Bayesian Improved Surname Geocoding (BISG) was used to impute missing race/ethnicity (2). BISG applies Bayes' Theorem to calculate a patient's probability of identifying with each racial/ethnic group given their surname and home census tract or county. Probabilities for patients with known race/ethnicity were set to 1 for their reported race/ethnicity group and 0 for all other racial/ethnic groups. Race/ethnicity-stratified case counts were calculated by summing the probabilities for each racial/ethnic group.

A convenience sample of CRE isolates (N=666) was collected from EIP sites and submitted to CDC for additional testing, including species confirmatory testing, antimicrobial susceptibility testing by reference broth microdilution

with a metallo-β-lactamase (MBL) screen, screening for carbapenemase production using the Modified Carbapenem Inactivation Method (mCIM), real-time polymerase chain reaction (PCR) screening for carbapenemase-encoding genes, including *bla*$_{KPC}$, *bla*$_{NDM}$, and *bla*$_{OXA-48-like}$ genes, and PCR testing for other carbapenemase genes (i.e., *bla*$_{VIM,}$ *bla*$_{IMP}$) if MBL screen positive and negative for *bla*$_{KPC}$, *bla*$_{NDM}$, and *bla*$_{OXA-48-like}$ genes.

Incidence rates for CRE cases were calculated using the 2023 U.S. Census estimates of the surveillance area population as the denominator. Assessment of vital status in patients admitted to a hospital occurred at the time of discharge from the acute care hospital. For patients in a long-term care facility, long-term acute care facility, or in an outpatient dialysis center, vital status was assessed 30 days after culture collection. For all other patients, vital status was assessed using medical records from the healthcare facility encounter associated with the culture.

CRE surveillance data underwent regular data cleaning to ensure accuracy and completeness. Patients with complete case report form data as of 11/26/2025 were included in this analysis. Because data can be updated as needed, analyses of datasets generated on a different date may yield slightly different results.

Results:

Table 1. Specimen Sources for CRE Cases by Organism, 2023 (N=1773)

Organism	Total	Urine No.	Urine %	Blood[a] No.	Blood[a] %	Other sterile specimens No.	Other sterile specimens %
Enterobacter cloacae complex	623	517	83.0	65	10.4	41	6.6
Klebsiella pneumoniae	524	440	84.0	63	12.0	21	4.0
Escherichia coli	462	407	88.1	43	9.3	12	2.6
Klebsiella aerogenes	115	100	87.0	11	9.6	4	3.5
Klebsiella oxytoca	49	44	89.8	4	8.2	1	2.0
Total	1773	1508	85.1	186	10.5	79	4.5

[a] Category may include cases with both a positive blood and urine specimen collected

Table 2. Incidence Rates of CRE Cases by Sex, Age, and Race/ethnicity, 2023 (N=1773)

Sex	No. of Cases	%	Incidence Rate[a]
Female	1028	58.0	8.7
Male	740	41.7	6.5
Missing value	5	0.3	-

Age group, years	No. of Cases	%	Incidence Rate[a]
0–18	38	2.1	0.7
19–49	273	15.4	2.7
50–64	323	18.2	7.5
65–79	668	37.7	22.9
≥80	471	26.6	57.5

Race/Ethnicity[b]	No. of Cases[f]	%	Incidence Rate
Hispanic or Latino, any race	181	10.2	4.5
Not Hispanic or Latino – Asian or Native Hawaiian/Other Pacific Islander[c]	136	7.7	5.7
Not Hispanic or Latino - Asian only[d]	110	6.2	4.7
Not Hispanic or Latino - Native Hawaiian/Other Pacific Islander only[d]	1	0.1	2.3
Not Hispanic or Latino – Black or African American	419	23.6	10.3
Not Hispanic or Latino – White	1006	56.7	8.4
Not Hispanic or Latino – American Indian or Alaska Native or Multiracial	32	1.8	4.2
Not Hispanic or Latino – American Indian or Alaska Native only[d]	15	0.8	14.8
Not Hispanic or Latino – Multiracial only[d]	7	0.4	1.1

Total	No. of Cases	%	Incidence Rate[a]
Invasive cases[e]	279	15.7	1.2
All cases	1773	100.0	7.7

[a] Cases per 100,000 population for EIP site surveillance areas (crude rates)

[b] Race/ethnicity was imputed for cases with missing race/ethnicity (9.9%, n=175) using BISG, as described in the methods section. The number of cases reported (i.e., non- missing) by race/ethnicity were 166 (Hispanic or Latino, any race), 111 (not Hispanic or Latino – Asian and/or Native Hawaiian/Other Pacific Island), 384 (Not Hispanic or Latino – Black or African American), 915 (Not Hispanic or Latino – White), and 22 (Not Hispanic or Latino – American Indian or Alaska Native or Multiracial).

[c] Case-patients with reported race/ethnicity of both "Not Hispanic or Latino – Asian" and "Not Hispanic or Latino – Native Hawaiian/Other Pacific Islander" were categorized as "Not Hispanic or Latino - Multiracial". This is consistent with the United States Census Bureau denominator data. However, the BISG method does not distinguish between these two racial/ethnic groups, so a small proportion of case-patients with missing race/ethnicity who are multiracial ("Not Hispanic or Latino – Asian" and "Not Hispanic or Latino – Native Hawaiian/Other Pacific Islander") may have been imputed as "Non-Hispanic or Latino – Asian or Native Hawaiian/Other Pacific Islander.

[d] Case counts include reported (i.e., non-missing) data only. Missing data for these racial/ethnic groups were not separately imputed because BISG combines each of these groups with another racial/ethnic group.

[e] Invasive cases include cases with a sterile incident specimen source or an incident urine specimen with a subsequent non-incident sterile specimen collected on the date of incident specimen collection or in the 29 days after.

[f] Subcategories may not add to total due to rounding.

Table 3. Selected Characteristics of CRE Cases, 2023 (N=1773)

Location of patient on the 3rd calendar day before incident specimen collection	No. of Cases	%
Private residence or other location	1126	63.5
Acute-care hospital (inpatient)	330	18.6
Long-term care facility	251	14.2
Long-term acute care hospital	23	1.3
Homeless[a]	7	0.4
Unknown or another location	36	2.0

[a] Includes patients documented as experiencing homelessness at the time of positive culture. A patient experiencing homelessness is defined as an individual who lacks permanent housing

Location of incident specimen collection	No. of Cases	%
Outpatient setting or emergency department	1178	66.4
Acute care hospital	444	25.0
Long-term care facility	111	6.3
Long-term acute care hospital	22	1.2
Unknown	18	1.0

Infection types[a]	No. of Cases	%
Urinary tract infection	1154	65.1
Bacteremia[b]	262	14.8
Septic shock	74	4.2
Other	181	10.2
None[c]	209	11.8
Unknown	119	6.7

[a] Patients could have more than one type of infection reported

[b] Bacteremia includes cases with a positive blood specimen (incident or non-incident) or a documented diagnosis of sepsis, bacteremia, or blood stream infection

[c] No infection types reported

Table 4. Selected Clinical Characteristics of CRE Cases, 2023 (N=1773)

Charlson comorbidity index	No. of Cases	%
0	307	17.3
1	286	16.1
≥2	1128	63.6
Unknown	52	2.9
Median (interquartile range)	2	1–4

Underlying conditions [a]	No. of Cases	%
Urinary tract problems/abnormalities	734	41.4
Neurologic condition, any	708	39.9
Diabetes mellitus	665	37.5
Cardiovascular disease[b]	662	37.3
Chronic renal disease	558	31.5
Skin condition	437	24.6
Chronic pulmonary disease[c]	428	24.1
Malignancy (hematologic or solid organ)	367	20.7
Gastrointestinal disease[d]	274	15.5
Transplant (hematopoietic stem cell or solid organ)	71	4.0
Unknown	52	2.9

SARS-CoV-2 testing	No. of Cases	%
Positive test for SARS-CoV-2 during hospitalization and on or before the date of incident specimen collection[e]	18/809	2.2%

[a] Patients could have more than one underlying condition reported

[b] Defined as myocardial infarction, congestive heart failure, congenital heart disease, stroke, transient ischemic attack, or peripheral vascular disease

[c] Defined as cystic fibrosis or any chronic respiratory condition resulting in symptomatic dyspnea

[d] Defined as diverticular disease, inflammatory bowel disease, peptic ulcer disease, short gut syndrome, or liver disease

[e] Among patients in the hospital on the date of incident specimen collection. Excludes patients who were admitted to the hospital after the date of incident specimen collection. A positive SARS-CoV-2 test was defined as any positive viral test for SARS-CoV-2, including antigen and nucleic acid amplification tests. Serologic tests were excluded

Table 5. Selected Healthcare Exposures or Risk Factors of CRE Cases, 2023[a] (N=1773)

Exposure	No. of Cases	%
Healthcare facility stay in the year before the date of incident specimen collection – any healthcare facility stay	1147	64.7
Healthcare facility stay in the year before the date of incident specimen collection – acute care hospitalization	1095	61.8
Healthcare facility stay in the year before the date of incident specimen collection – long-term care facility residence	448	25.3
Healthcare facility stay in the year before the date of incident specimen collection – long-term acute care hospitalization	53	3.0
Surgery in the year before the date of incident specimen collection	538	30.3
Specimen collected ≥3 days after hospital admission	298	16.8
Chronic dialysis	81	4.6
Selected medical device(s) in place in the 2 calendar days before the date of incident specimen collection – urinary catheter	617	34.8
Selected medical device(s) in place in the 2 calendar days before the date of incident specimen collection – central venous catheter	268	15.1
Selected medical device(s) in place in the 2 calendar days before the date of incident specimen collection – other [b]	340	19.2
None of the above healthcare exposures [c]	326	18.4
Healthcare exposures are unknown	55	3.1
International travel in the 12 months prior to date of incident specimen	91	5.1

[a] Patients could have more than one prior healthcare or exposure risk factor reported

[b] Other medical devices: endotracheal or nasotracheal tube, tracheostomy, gastrostomy tube, nephrostomy tube, nasogastric tube

[c] Defined as having no healthcare exposures in the year before specimen collection, no selected medical devices in place in the 2 days before specimen collection, and specimen collected before calendar day 3 after hospital admission if hospitalized

Table 6. Outcomes of Incident CRE Cases, 2023 (N=1773)

Outcomes	No. of Cases	%
Outcome– hospitalized on the day of or in the 29 days after the date of incident specimen collection[a,b]	1001	56.5
Outcome– ICU admission in the 6 days after the date of incident specimen collection[a]	141	8.0
Hospitalized patient discharged to – private residence or other location	546/1001	54.5
Hospitalized patient discharged to – long-term care facility	307/1001	30.7
Hospitalized patient discharged to – died during hospitalization	112/1001	11.2
Hospitalized patient discharged to – long-term acute care hospital	25/1001	2.5
Hospitalized patient discharged to – other	6/1001	0.6
Hospitalized patient discharged to – unknown	5/1001	0.5
Died within 30 days of incident specimen collection date	86	4.9
Cases with an incident sterile site specimen	46/265	17.4
Cases with an incident urine specimen[c]	40/1508	2.7

[a] Patients could have more than one outcome

[b] Data include 330 cases considered to be hospital-onset

[c] No incident CRE cases had a subsequent non-incident blood specimen collected on the date of incident specimen collection or in the 29 days after

Laboratory Characterization:

7.a. Molecular Characteristics of CRE Isolates Based on Testing Performed at CDC, 2023 (N=666)

Organism	Isolates Submitted to CDC	Carbapenemase-producing, [a,b,c] - N	%
Enterobacter cloacae complex	263	40	15.2
Klebsiella pneumoniae[d]	214	121	56.5
Escherichia coli	132	79	59.8
Klebsiella aerogenes	36	1	2.8
Klebsiella oxytoca	21	14	66.7
Total	**666**	**255**	**38.3**

Table 7.b. Molecular Characteristics of CRE Isolates Based on Testing Performed at CDC, by Carbapenemase Gene[e], 2023 (N=666)

Organism	*bla*$_{KPC}$ - N	*bla*$_{KPC}$ - %	*bla*$_{NDM}$ - N	*bla*$_{NDM}$ - %	*bla*$_{OXA-48-like}$ - N	*bla*$_{OXA-48-like}$ - %	*bla*$_{VIM}$ - N	*bla*$_{VIM}$ - %	*bla*$_{IMP}$ - N	*bla*$_{IMP}$ - %
Enterobacter cloacae complex	24	9.1	14	5.3	0	0.0	0	0.0	3	1.1
Klebsiella pneumoniae[d]	87	40.7	24	11.2	16	7.5	0	0.0	2	0.9
Escherichia coli	16	12.1	57	43.2	6	4.5	0	0.0	0	0.0
Klebsiella aerogenes	1	2.8	0	0.0	0	0.0	0	0.0	0	0.0
Klebsiella oxytoca	8	38.1	5	23.8	1	4.8	0	0.0	0	0.0
Total	**136**	**20.4**	**100**	**15.0**	**23**	**3.5**	**0**	**0.0**	**5**	**0.8**

Table 7.c. Confirmatory Antimicrobial Susceptibility Results of CRE Isolates Submitted to CDC, 2023 (N=666)

Organism	Carbapenem-resistant - N	Carbapenem-resistant - %
Enterobacter cloacae complex	178	67.7
Klebsiella pneumoniae[d]	194	90.7
Escherichia coli	113	85.6
Klebsiella aerogenes	23	63.9
Klebsiella oxytoca	19	90.5
Total	**527**	**79.1**

[a] Testing was performed by PCR

[b] Carbapenemase-producing isolates were collected from urine (n=201/255; 78.8%), blood (n=30/255; 11.8%), and other normally sterile specimens (n=24/255; 9.4%)

[c] 243 isolates tested positive by both PCR and mCIM; 12 isolates were positive by PCR and negative or indeterminate by mCIM. One isolate was mCIM positive and PCR negative.

[d] Includes *Klebsiella pneumoniae* and *Klebsiella variicola*

[e] Six carbapenemase-producing isolates were not carbapenem-resistant (four isolates with *bla*$_{KPC}$, one isolate with *bla*$_{OXA-48,}$ and one isolate with *bla*$_{NDM}$) based on testing by CDC. Nine isolates carried two carbapemenase genes (five isolates with *bla*$_{NDM}$ */bla*$_{OXA-48}$, three isolates with *bla*$_{KPC}$ */bla*$_{IMP}$, and one isolate with *bla*$_{KPC}$ */bla*$_{NDM}$).

Summary:

Surveillance data from 2023 represent the twelfth full year of population-based surveillance for CRE (2011 was a pilot year) through the Emerging Infections Program. The overall crude incidence rate of CRE in 2023 was 7.7 cases per 100,000 persons. This is a 19.7% increase in the crude CRE incidence rate reported in 2022 (3). The incidence rate increased with increasing age, was higher in females than in males, and highest in persons who were Not Hispanic or Latino–American Indian/Alaska Native or Not Hispanic or Latino–Black/African American than in persons of other races or ethnicities. More cases of CRE were isolated from a urine source than from normally sterile body sites. Underlying conditions were commonly reported, with more than half of CRE cases having a Charlson comorbidity index of ≥2. Prior healthcare exposures were reported for most cases, with an admission to a healthcare setting in the prior year, presence of indwelling medical devices, and surgery in the prior year being the most common exposures. Approximately half of the CRE cases were hospitalized, and overall crude 30-day mortality was 4.9%, with a higher 30-day mortality observed in cases with a sterile-site specimen source compared to those with a urine specimen source. Two percent of patients in the hospital on the date of incident specimen collection had a positive viral test for SARS-CoV-2 during their hospitalization and on or before the date of incident specimen collection.

Among the 666 CRE isolates submitted to CDC, 38.3% were carbapenemase-producing, representing an increase from 24.2% in 2022; 79.1 % confirmed as carbapenem resistant representing an increase from 59.5% in 2022. KPC was detected in 20.4% of the isolates (up from 13.5% in 2022), NDM in 15.0% of the isolates (up from 8.2%), OXA-48-like in 3.5% of the isolates (up from 2.7%). IMP was detected in 0.8% of isolates, and VIM in 0% of isolates.

References:

1. CLSI. *Performance Standards for Antimicrobial Susceptibility Testing.* 33nd ed. CLSI supplement M100. Wayne, PA: Clinical and Laboratory Standards Institute; 2023.

2. Elliott MN, Morrison PA, Fremont A, McCaffrey DF, Pantoja P, Lurie N. Using the Census Bureau's Surname List to Improve Estimates of Race/Ethnicity and Associated Disparities. RAND website. Available at: Using the Census Bureau's Surname List to Improve Estimates of Race/Ethnicity and Associated Disparities | RAND (https://www.rand.org/pubs/external_publications/EP20090611.html#document-details) Accessed September 19, 2025.

3. Centers for Disease Control and Prevention. 2024. Emerging Infections Program, Healthcare-Associated Infections – Community Interface Surveillance Report, Multi-site Gram-negative Surveillance Initiative (MuGSI), Carbapenem-Resistant Enterobacterales Surveillance, 2022. Available at: https://www.cdc.gov/healthcare-associated-infections/media/pdfs/2022-CRE-Report-508.pdf

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For more information, visit our web sites:

- Multi-site Gram-negative Surveillance Initiative (MuGSI) (https://www.cdc.gov/healthcare-associated-infections/php/haic-eip/mugsi.html)
- Antimicrobial Resistance & Patient Safety Portal Emerging Infections Program | A.R. & Patient Safety Portal