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SURVEILLANCE REPORT

# Carbapenemase-producing *Enterobacteriaceae* in Ontario: 2022 Annual Summary

**Published: December 2023**

## Introduction

Carbapenemase-producing *Enterobacteriaceae* (CPE) are a family of organisms that are resistant to nearly all available antibiotics and are of particular concern in health care settings.[1] These bacteria possess genes that encode carbapenemases, which are enzymes that break down antibiotics including carbapenems; the genes encoding these enzymes can be transferred among *Enterobacteriaceae* and other gram-negative organisms on mobile genetic elements.[2] CPEs are a significant clinical and public health concern as they have the ability to spread rapidly in healthcare settings and are associated with significant morbidity and mortality.[3] Invasive CPE infections have been associated with mortality rates as high as 40-50%.[2]

Canadian surveillance suggests that while the incidence of CPE infection remains low, outbreaks have occurred[4, 5] and rates of CPE infections and colonization's have increased.[3, 6]

From 2012 to 2017, Public Health Ontario conducted hospital-based, voluntary CPE surveillance to understand the changing epidemiology of CPE in Ontario.[7-8] Effective May 1, 2018, the Health Protection and Promotion Act and its regulations for reporting diseases of public health significance (DOPHS) was updated to include CPE colonization and infection.[9] The aim of this amendment to legislation was to strengthen data quality and promote public health infrastructure necessary to monitor and prevent the spread of CPE in hospital and community settings.

The objective of this surveillance report is to summarize information about CPE colonization's and infections in Ontario from **May 1, 2018 to December 31, 2022**.

## Highlights

- A total of 1,768 confirmed CPE cases were reported in Ontario between May 1, 2018 and December 31, 2022, corresponding to an overall incidence rate of 2.4 per 100,000 population.
- There were 586 CPE cases reported in 2022, the highest annual case count reported since CPE became a DOPHS in 2018 (Figure 1).
- A decrease in CPE cases, rates and data completeness in 2020 and 2021 compared to 2019 (Figure 1) may be a result of changes in investigation practices, institutional screening and testing practices and reduced international travel due to the COVID-19 pandemic response.[3,10]

## Case Characteristics

- Of those cases with known colonization/infection status, a greater proportion were identified as colonized with CPE (46.2%) than infected (26.1%). Due to data incompleteness, case status has been reported as unknown for ~40% of cases in 2020-2022, limiting the ability to discern between trends in colonization and infection.
- The median age of CPE cases was 68 years of age, with the majority (66.9%) of cases being over the age of 60. More cases were male (56.8%) than female, additionally the male rate, 2.8 per 100,000 population, was higher than the female rate 2.0 per 100,000 population. The number of CPE cases and rates increased with increasing age, especially males, who had the highest rate of CPE at 8.5 per 100,000 population in men 60 and older (Figure 2).
- 16/1,768 (0.9%) CPE cases resulted in fatal outcomes where CPE was attributed as the underlying cause of death or contributed to the underlying cause of death. There were 23 other fatal cases where the relationship to CPE is reported as unknown.

## Microbiology

- New Delhi metallo-β-lactamase (NDM)-producing carbapenemase was the most frequently reported carbapenemase (888/1,844, 48.2%) followed by Oxacillinase-48 (OXA-48) (493/1,844, 26.7%) and *Klebsiella pneumoniae* carbapenemase (KPC) (314/1,844, 17.0%) (Figure 4).
- *Escherichia coli* was the most commonly reported species of carbapenemase producing *Enterobacteriaceae* encountered (865 or 47.4%), followed by *Klebsiella* species (484 or 26.5%) and *Enterobacter* species (255 or 14.0%).

## Geographic Distribution

- All but one of the 35 Ontario public health units reported at least 1 case of CPE from May 2018 to the end of 2022 (Table 1).
- Substantial differences exist in rates of CPE across Ontario geographies. The highest reported rates of CPE are in Peel Public Health (6.0 cases per 100,000 population) and Toronto Public Health (3.2 cases per 100,000 population) (Figure 4, Table 1).

## Factors associated with CPE acquisition

- Among the 1,768 cases, 1,283 (72.5%) reported risk factor information for CPE (Table 2):
  - 640 (49.9%) reported a hospitalization in Canada in the past year.
  - 589 (45.9%) reported travel outside of Canada in the past year and 361 (61.3%) of these cases also reported receiving healthcare outside of Canada in the past year.
- Among the 361 cases reporting receipt of healthcare abroad in the past year, 152 (42.1%) had travelled to India, 43 (12.0%) had travelled to Pakistan and 19 (5.2%) had travelled to Egypt (Table 3).
- There were 146 cases reporting travel outside of Canada but not receiving healthcare abroad in the past year. Of these, 68 (46.5%) travelled to India, 15 (10.2%) travelled to Pakistan and 11 (7.5%) had travelled to Egypt (Table 3).

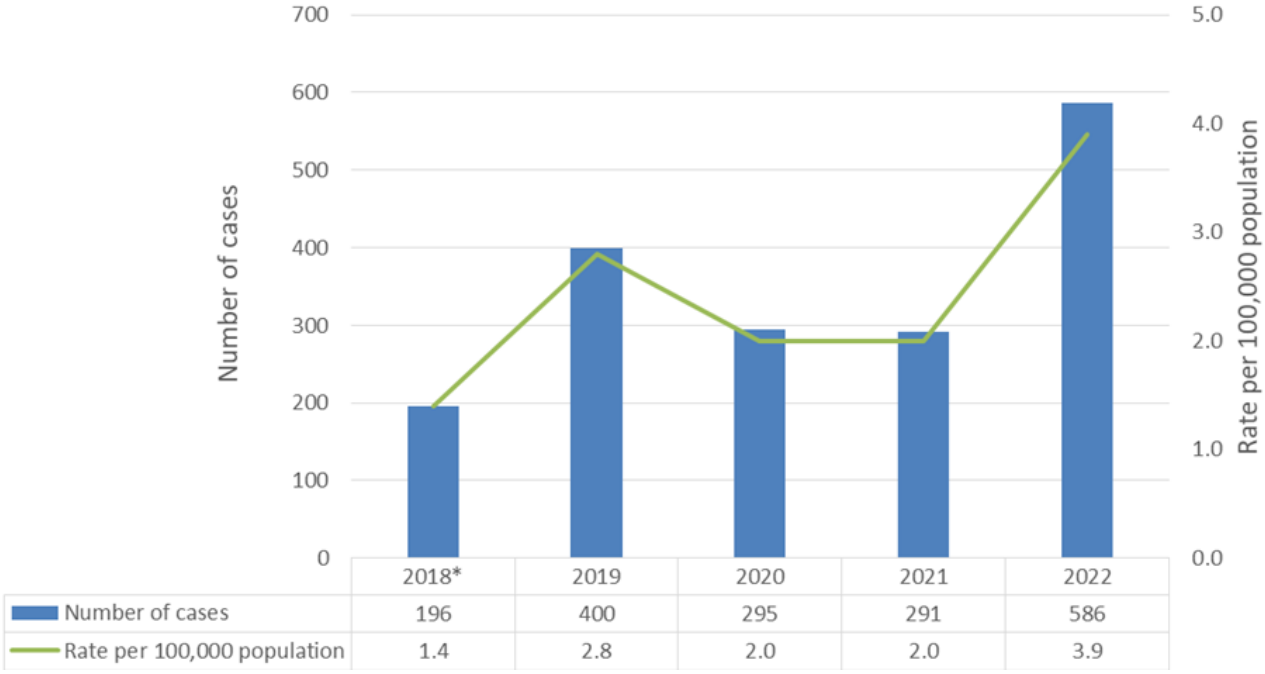
- 474 (36.9%) cases reported they had not traveled outside of Canada in the past year with the majority of these, 358 (75.5%), reporting receipt of healthcare within Canada in the past year. There were 5 cases that reported they had not traveled nor received healthcare in Canada in the past year.

## Outbreaks

- There were 23 outbreaks reported from May 1, 2018 through December 31, 2022 (Table 3):
  - 11/23 (47.8%) outbreaks were reported by Toronto Public Health, no outbreaks were reported by Peel Public Health
  - 68 outbreak-associated cases were reported in total
  - 8 outbreaks of KPC, 7 outbreaks of NDM, 2 outbreaks OXA-48 and 2 outbreaks of VIM
  - Median outbreak duration: 21 days (range: 2-66 days)
  - Median number of cases per outbreak: 2 cases (range: 2-7 cases)

## Case Characteristics

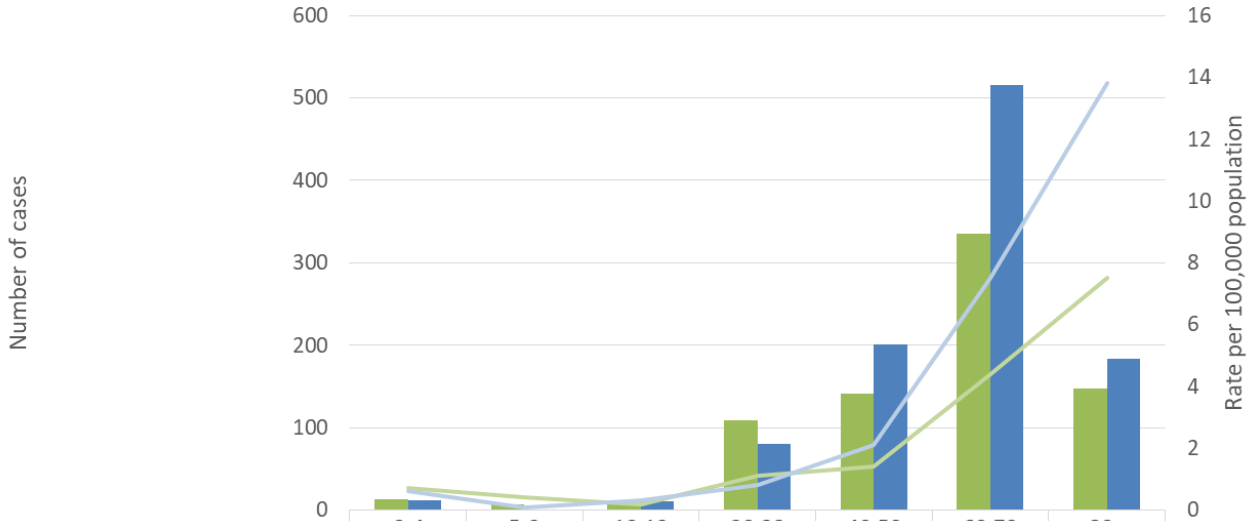
**Figure 1. CPE cases and rates per 100,000 population in Ontario, May 1, 2018 to December 31, 2022**




| | 2018* | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|
| Number of cases | 196 | 400 | 295 | 291 | 586 |
| Rate per 100,000 population | 1.4 | 2.8 | 2.0 | 2.0 | 3.9 |

*2018 is a partial year (May 1, 2018-December 31, 2018)

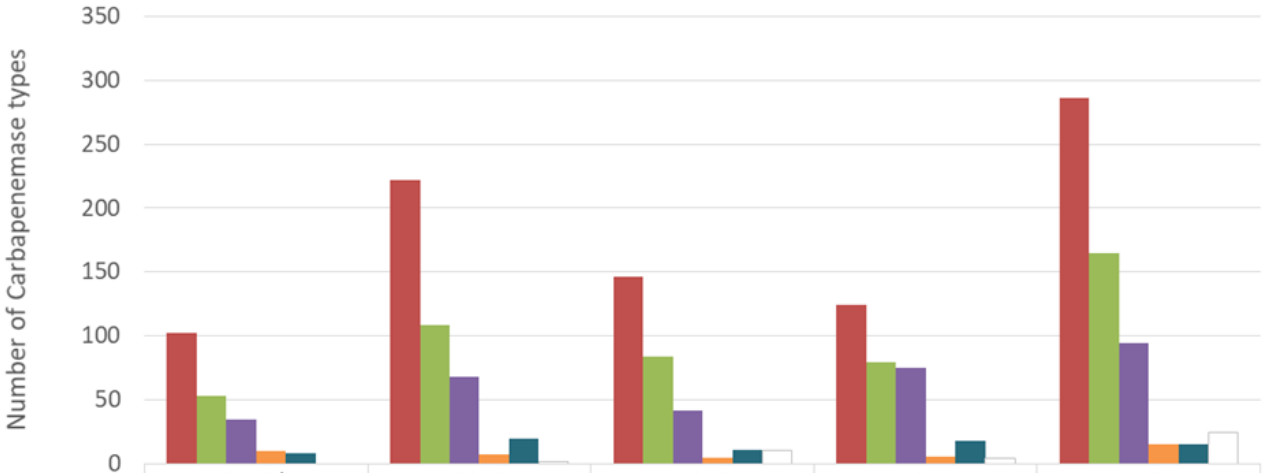
**Figure 2. CPE cases and rates per 100,000 population by age and sex, Ontario, May 1, 2018 to December 31, 2022**




| | 0-4 | 5-9 | 10-19 | 20-39 | 40-59 | 60-79 | 80+ |
|---|---|---|---|---|---|---|---|
| Female number of cases | 13 | 7 | 9 | 109 | 141 | 335 | 148 |
| Male number of cases | 12 | 1 | 11 | 80 | 201 | 516 | 183 |
| Female Rate per 100,000 pop | 0.7 | 0.4 | 0.2 | 1.1 | 1.4 | 4.4 | 7.5 |
| Male Rate per 100,000 pop | 0.6 | 0.1 | 0.3 | 0.8 | 2.1 | 7.5 | 13.8 |

## Microbiology

**Figure 3. Number of carbapenemase types by year, Ontario, May 1, 2018 to December 31, 2022**




| | 2018* | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|
| NDM | 102 | 222 | 146 | 124 | 286 |
| OXA-48 | 53 | 108 | 84 | 79 | 165 |
| KPC | 34 | 68 | 41 | 75 | 94 |
| VIM | 10 | 7 | 4 | 5 | 15 |
| Other** | 8 | 19 | 11 | 18 | 15 |
| Unknown | 0 | 1 | 10 | 4 | 24 |

**Notes**

*2018 is a partial year (May 1, 2018-December 31, 2018)

**Other category contains carbapenemase types: Guiana extended-spectrum β-lactamase (GES), active-on-imipenem (IMP), imipenem-hydrolyzing β-lactamase (IMI), not metalloenzyme carbapenemase (NMC), Serratia marcescens enzymes (SME)

- Some cases reported multiple carbapenemases and therefore the total number of cases and the number of carbapenemases indicated do not match.
- VIM = Verona integron-encoded metallo-ß-lactamase

## Geographic Distribution

**Figure 4. CPE rates by public health unit in Ontario, May 1, 2018 to December 31, 2022**

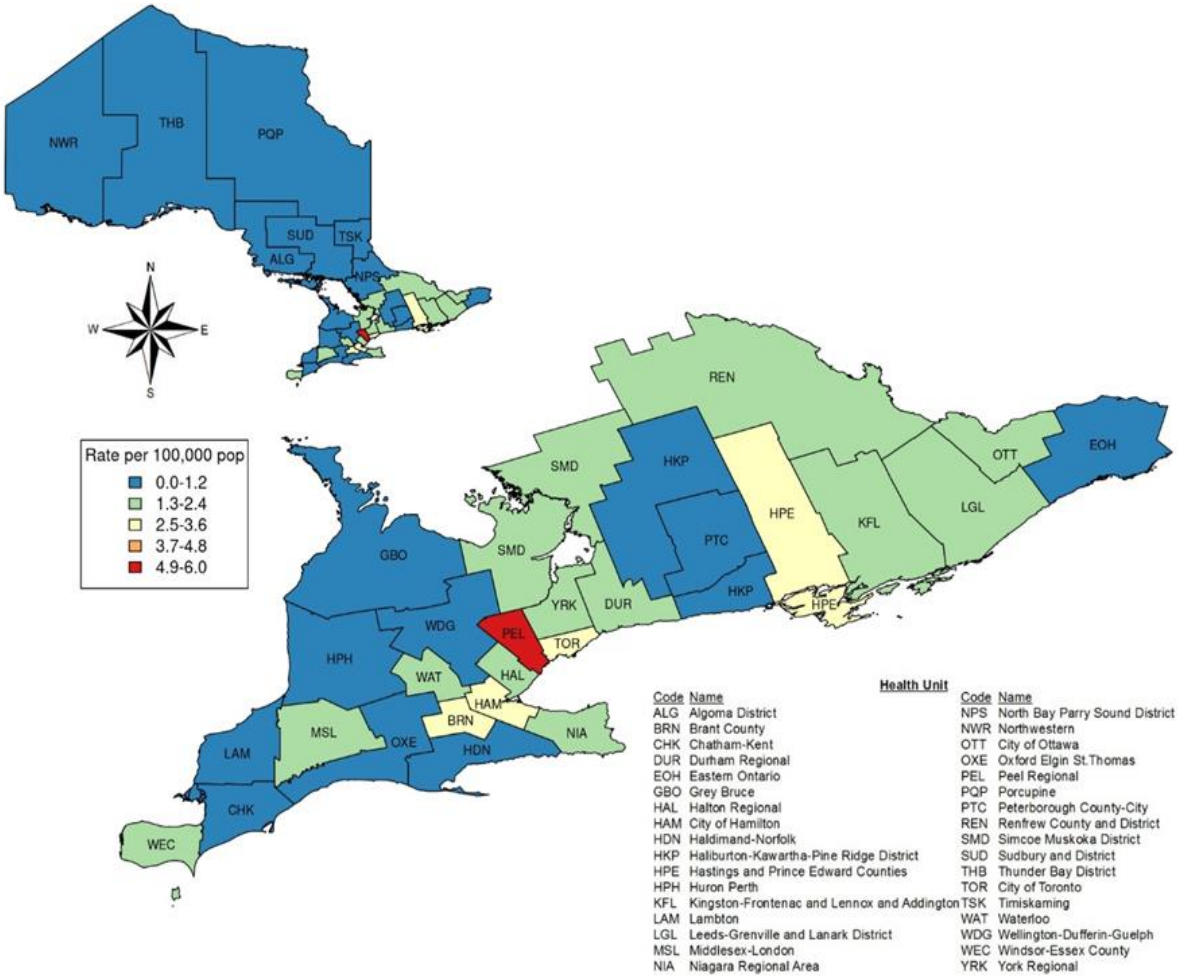


**Table 1. Number of CPE reports and rates per 100,000 population by public health unit and region in Ontario, May 1, 2018 – December 31, 2022**

| Public Health Unit Name | Number of cases | Reporting rate per 100,000 population |
|---|---|---|
| Northwestern Health Unit | 1 | 0.2 |
| Thunder Bay District Health Unit | 4 | 0.5 |
| **TOTAL NORTH WEST** | 5 | 0.4 |
| Algoma Public Health | 6 | 1.0 |
| North Bay Parry Sound District Health Unit | 4 | 0.6 |
| Porcupine Health Unit | 3 | 0.7 |
| Public Health Sudbury & Districts | 5 | 0.5 |
| Timiskaming Health Unit | 0 | 0.0 |
| **TOTAL NORTH EAST** | 18 | 0.6 |
| Eastern Ontario Health Unit | 9 | 0.8 |
| Hastings Prince Edward Public Health | 23 | 2.7 |
| Kingston, Frontenac and Lennox & Addington Public Health | 18 | 1.7 |
| Leeds, Grenville & Lanark District Health Unit | 16 | 1.8 |
| Ottawa Public Health | 106 | 2.0 |
| Renfrew County and District Health Unit | 9 | 1.7 |
| **TOTAL EASTERN** | 181 | 1.9 |
| Durham Region Health Department | 56 | 1.6 |
| Haliburton, Kawartha, Pine Ridge District Health Unit | 9 | 0.9 |
| Peel Public Health | 470 | 6.0 |
| Peterborough Public Health | 8 | 1.1 |
| Simcoe Muskoka District Health Unit | 50 | 1.7 |
| York Region Public Health | 141 | 2.4 |
| **TOTAL CENTRAL EAST** | 734 | 3.3 |

| Public Health Unit Name | Number of cases | Reporting rate per 100,000 population |
|---|---|---|
| Toronto Public Health | 471 | 3.2 |
| **TOTAL TORONTO** | 471 | 3.2 |
| Chatham-Kent Public Health | 1 | 0.2 |
| Grey Bruce Health Unit | 6 | 0.7 |
| Huron Perth Public Health | 3 | 0.4 |
| Lambton Public Health | 2 | 0.3 |
| Middlesex-London Health Unit | 43 | 1.7 |
| Southwestern Public Health | 9 | 0.8 |
| Windsor-Essex County Health Unit | 29 | 1.4 |
| **TOTAL SOUTH WEST** | 93 | 1.1 |
| Brant County Health Unit | 22 | 2.9 |
| City of Hamilton Public Health Services | 76 | 2.6 |
| Haldimand-Norfolk Health Unit | 6 | 1.0 |
| Halton Region Public Health | 44 | 1.4 |
| Niagara Region Public Health | 33 | 1.4 |
| Region of Waterloo Public Health and Emergency Services | 73 | 2.4 |
| Wellington-Dufferin-Guelph Public Health | 12 | 0.8 |
| **TOTAL CENTRAL WEST** | 266 | 1.9 |
| **TOTAL ONTARIO** | 1768 | 2.4 |

## Factors associated with CPE acquisition

**Table 2. Risk factors for CPE cases in Ontario, May 2018-December 2022**

| Risk Factors | Cases | Proportion (%) † |
|---|---|---|
| Chronic illness/underlying medical condition | 985 | 76.8 |
| Hospitalization in Canada in the last 12 months | 640 | 49.9 |
| Travel outside of Canada in the last 12 months | 589 | 45.9 |
| Medical/surgical procedure in Canada in the last 12 months | 535 | 41.7 |
| Received health care outside of Canada in the last 12 months | 361 | 28.1 |
| Other | 301 | 23.5 |
| Known previous colonization with CPE | 68 | 5.3 |
| Resident of a long term care facility | 53 | 4.1 |
| Known contact with confirmed case in the last 12 months | 36 | 2.8 |
| **Total number of cases with a reported risk factor †** | **1,283** | **-** |

† Only cases reporting risk factors were included in the denominator. Cases may report more than one risk factor.

**Table 3. Most frequent destinations for CPE cases reporting travel, May 2018-December 2022**

| Sub region | Country | All travel cases† | Percentage of travel cases reporting healthcare abroad† | Percentage of travel cases not reporting healthcare abroad† |
|---|---|---|---|---|
| **Total Number of cases reporting travel†** | **All** | **587** | **61.2% (359/587)** | **24.8% (146/587)** |
| Southern Asia | India | 269 | 56.5% (152/269) | 25.3% (68/269) |
| Southern Asia | Pakistan | 67 | 64.2% (43/67) | 22.4% (15/67) |
| Northern Africa | Egypt | 34 | 55.9% (19/34) | 32.4% (11/34) |
| North America | United States of America | 16 | 50.0% (8/16) | 50.0% (8/16) |
| Southeast Asia | Viet Nam | 10 | 90.0% (9/10) | 10.0% (1/10) |
| Southern Asia | Bangladesh | 10 | 70.0% (7/10) | 20.0% (2/10) |
| Caribbean and Bermuda | Cuba | 9 | 77.8% (7/9) | 22.2% (2/9) |
| Southern Asia | Sri Lanka | 9 | 77.8% (7/9) | 11.1% (1/9) |
| Central America | Mexico | 8 | 37.5% (3/8) | 62.5% (5/8) |
| West Central Asia and the Middle East | Iran | 8 | 100% (8/8) | 0 .0% (0/8) |

† Only cases reporting travel and destination were included. Cases may report travel to >1 country and not all travel cases reported destination or health care receipt abroad.

## Outbreaks

**Table 4. CPE outbreaks by Ontario public health unit and carbapenemase, May 1, 2018 – December 31, 2022**

| Public Health Unit | Number of outbreaks | NDM | OXA-48 | KPC | VIM | IMP | Not specified | Cases per outbreak Median (Range) | Outbreak Duration in days Median (Range) |
|---|---|---|---|---|---|---|---|---|---|
| Toronto Public Health | 11 | 3 | 1 | 5 | 2 | - | - | 2 (2-5) | 19 (2-57) |
| City of Hamilton Public Health Services | 5 | 2 | 0 | 2 | 0 | - | 1 | 3 (2-5) | 22 (21-45) |
| Ottawa Public Health | 3 | - | - | 1 | - | - | 2 | 3 (2-7) | 55 (42-66) |
| Hastings Prince Edward Public Health | 1 | 1 | - | - | - | - | - | 5 | 21 |
| Haldimand-Norfolk Health Unit | 1 | 1 | - | - | - | - | - | 4 | 29 |
| Windsor-Essex County Health Unit | 1 | - | 1 | - | - | - | - | 3 | 14 |
| Haliburton, Kawartha, Pine Ridge District Health Unit | 1 | - | - | - | | 1 | - | 2 | 34 |
| **TOTAL** | **23** | **7** | **2** | **8** | **2** | **1** | **3** | **2 (21-7)** | **21 (2-66)** |

# Technical Notes

## Purpose

This report summarizes data extracted from the integrated Public Health Information System (iPHIS), the electronic reporting system for reportable diseases in Ontario. Data for both individual cases and outbreak data were extracted from iPHIS on September 22, 2023. Extracted data included demographics, personal health information, laboratory specimen results and risk factors.

The purpose of this section is to provide technical information for the CPE Surveillance Report. Technical information includes an in-depth explanation of analytic methods used in the report, and a description of data limitations. Data from this report are not directly comparable to estimates produced in previous reports.

## Data Sources

**CASE DATA:**

- The data for this report were based on information entered in the Ontario Ministry of Health, integrated Public Health Information System (iPHIS) database as of September 22, 2023.
- IPHIS is a dynamic disease reporting system which allows ongoing updates to data previously entered. As a result, data extracted from iPHIS represent a snapshot at the time of extraction and may differ from previous or subsequent reports.

**ONTARIO POPULATION DATA:**

- Statistics Canada. Table 17-10-0134-01: estimates of population (2016 census and administrative data), by age group and sex for July 1st, Canada, provinces, territories, health regions (2018 boundaries) and peer groups [Internet]. Ottawa, ON: Government of Canada; 2022 Mar 22 [extracted 2022 Mar 25]. Available from: https://doi.org/10.25318/1710013401-eng
- Population Reporting. Population Projections Public Health Unit, 2021-2046 [data file]. Toronto ON: Ministry of Finance [producer]; Toronto, ON: Ontario. Ministry of Health, IntelliHealth Ontario [distributor]; [data extracted 2022 Jan 13].

**IPHIS DATA CAVEATS:**

- The data only represent cases reported to public health and recorded in iPHIS. As a result, all counts will be subject to varying degrees of underreporting due to a variety of factors, such as disease awareness and medical care seeking behaviours (which may depend on severity of illness, clinical practice), and reporting behaviours. Changes in laboratory testing may also affect case counts over time.
- Only provincial case classifications, as listed in the Ontario Ministry of Health surveillance case definitions[9] are included in the report counts. Cases are excluded if they do not meet the provincial case classifications in place at the time that the case was reported.
- Cases are presented based on ‘Specimen Collection Date’. If not available, the Reported Date was used.
- Orientation of case counts by geography is based on the diagnosing health unit (DHU). DHU refers to the case's public health unit of residence at the time of illness onset and not necessarily the location of identification. Cases for which the DHU was reported as MOHLTC (to signify a case that is not a resident of Ontario) have been excluded from the analyses.

- Risk factors were based on information reported in iPHIS and may not be fully captured for every case. See the Risk Factors subsection for details.
- Cases for which the Disposition status was reported as ENTERED IN ERROR, DOES NOT MEET DEFINITION, DUPLICATE-DO NOT USE, or any variation on these values have been excluded.

## Case Counts

Case counts of CPE include:

- Carbapenemase-Producing Enterobacteriaceae-Infection
- Carbapenemase-Producing Enterobacteriaceae-Colonization
- Carbapenemase-Producing Enterobacteriaceae-Unspecified

Where multiple cases with the same carbapenemase are entered in iPHIS for a client, only the first case is included.

## Outcome

Deaths are determined by using the Outcome and Type of Death fields in iPHIS. Deaths were counted where the Outcome value is 'Fatal' and the Type of Death value is not 'Reportable disease was unrelated to cause of death'. Data on deaths may be under-reported as these events may occur after the completion of public health follow up of cases.

## Rates

To calculate public health unit CPE rates, the number of CPE cases per diagnosing health unit was divided by the health unit specific population and multiplied by 100,000. The CPE rate for Ontario was calculated by dividing the total number of confirmed CPE cases by the total Ontario population and multiplied by 100,000.

## Risk Factors

- For each risk factor, proportions were calculated as the number of 'yes' responses divided by the total number of cases with risk factor information reported.
- Where cases indicated receipt of health care outside of Canada in the last 12 months but did not indicate travel outside of Canada in the last 12 months, it was assumed that the case travelled outside Canada in the last 12 months.
- Due to changes during initial iPHIS configuration for CPE reporting, risk factor variables that captured the same or similar concepts were combined for analysis purposes, outlined below. Risk factor definitions are provided in the CPE iPHIS User Guide.
- The following fields were combined to create the risk factor "Inpatient hospitalization in Canada in the last 12 months":
    - Hospitalization in Canada in the last 12 months (available from May 2018 to January 2019)
    - Previous hospitalization at the reporting hospital in the last 12 months (available January 2019 onwards)
    - Other inpatient hospitalization in Canada in the last 12 months (available January 2019 onwards)

- The following fields were combined to create the risk factor "*Health care received outside of Canada in the last 12 months"*:
    - Medical/surgical procedure outside of Canada in the last 12 months (available from May 2018 onwards)
    - Hospitalization outside of Canada in the last 12 months (available from May 2018 onwards)
- The following fields were combined to create the risk factor "*Health care received inside of Canada in the last 12 months"*:
    - Medical/surgical procedure inside of Canada in the last 12 months – excluding endoscopic procedures (specify procedure and hospital/clinic) (available from May 2018 onwards)
    - Endoscopic procedure in Canada in the last 12 months
    - Hospitalization in Canada in the last 12 months (available from May 2018 to January 2019)
    - Previous hospitalization at the reporting hospital in the last 12 months (available January 2019 onwards)
    - Other inpatient hospitalization in Canada in the last 12 months (available January 2019 onwards)

## Outbreaks

- Where the number of cases reported in the outbreak summary and the number of individual cases reported do not match, the highest number of cases was used
- Outbreak duration was defined as the number of days from the outbreak report date and the date the outbreak was declared over.

## Data Limitations

- Asymptomatic individuals colonized with CPE are only identified if they are tested for CPE at a health care facility. Colonized cases are more likely to have chronic underlying medical conditions that predispose them to health care utilization. Asymptomatic cases in the community may be underrepresented.
- Changes to hospital CPE screening practices may affect case counts over time.
- Diagnosing health units investigate and collect data on cases; however, loss to follow-up may occur, particularly for patients discharged from health care facilities.
- Missing data may affect the reliability of conclusions drawn from the available data.

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## Citation

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