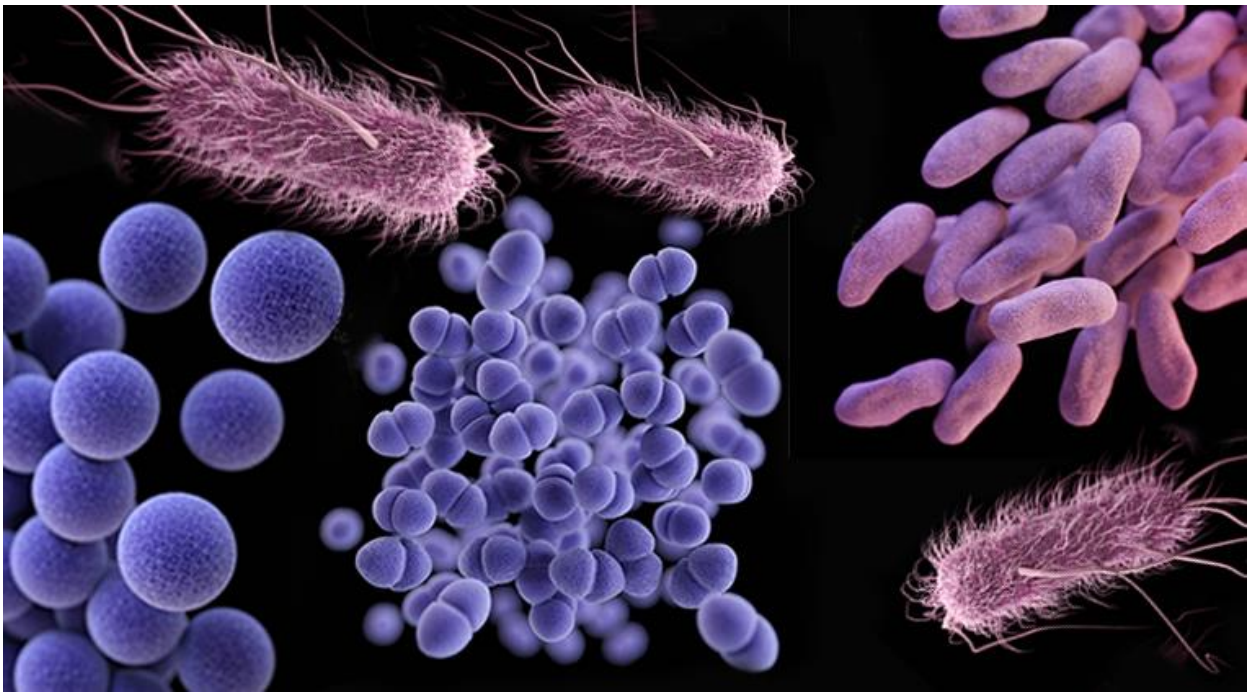
Antimicrobial Resistance in Common Hospital Pathogens in Ontario

Annual Laboratory and Hospital Survey Report 2015



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Public Health Ontario acknowledges the financial support of the Ontario Government.

Cover photo:

This photo depicts a cluster of vancomycin-resistant Enterococcus (VRE) bacteria, Carbapenem-resistant Enterobacteriaceae (CRE) bacteria, methicillin-resistant Staphylococcus aureus (MRSA) bacteria, and extended-spectrum ß-lactamase-producing Enterobacteriaceae (ESBLs) bacteria.

Photo Credit: CDC/James Archer PHIL ID #16882, PHIL ID # 16872, PHIL ID #21915, PHIL ID #19059

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PHO and IQMH assume no responsibility for the results of the use of this document by anyone.

Authors

Michelle E. Policarpio, MSc
Epidemiologist
Infection Prevention and Control
Public Health Ontario

Jennifer Robertson, PhD
Manager
Infection Prevention and Control
Public Health Ontario

Samir N. Patel, PhD, FCCM
Deputy Chief Microbiology
Public Health Ontario Laboratory
Public Health Ontario

Jennie Johnstone, MD, PhD, FRCPC
IPAC Physician and Scientist
Infection Prevention and Control
Public Health Ontario

Elaine Kerr, ART, BA
Consultant Technologist
Institute for Quality Management
in Healthcare

Eva Truong, BA
Administrative Assistant
Infection Prevention and Control
Public Health Ontario

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Contents

Executive Summary

Objective: The objective of this report is to provide findings of surveys on burden of antimicrobial-resistant organisms (ARO) and infection control practices in Ontario.

Methods: In 2016, the Institute for Quality Management in Healthcare (IQMH) sent a survey assessing the number of antimicrobial-resistant organisms (AROs) isolated in 2015 to all licensed bacteriology laboratories that perform bacteriological testing in Ontario. Similarly, Public Health Ontario (PHO) sent a survey to infection prevention and control teams of all hospitals that provide in-patient care assessing infection control practices related to AROs in 2015. The results for both the laboratory and infection control surveys were compared to a similar 2013 IQMH comprehensive survey.

Results: A total of 72 of 75 laboratories responded to the IQMH survey. Based on data provided by laboratories, there was a 26% increase in patients colonized or infected with methicillin-resistant *Staphylococcus aureus* (MRSA) in 2015 compared to 2013. The increase in MRSA cases were observed in all regions of Ontario with eastern Ontario (postal code K) reporting the highest increase. Among patients with MRSA, 31% of patients were thought to acquire MRSA in healthcare settings, 15% in nursing home settings, and 54% in the community settings.

Laboratories across the province reported 756 new patients with a clinical (i.e., non-screening) isolate of VRE in 2015, a 55% decrease compared to 1683 new patients with clinical VRE isolates reported in 2013. However, among patients with VRE infection, 61/756 (8%) patients were reported to have VRE bacteremia. This was higher than the 84/1683 (4%) patients with VRE bacteremia reported in 2013.

Laboratories also reported increased resistance to both 3rd generation cephalosporins and ciprofloxacin among both *Escherichia coli* and *Klebsiella* spp in 2015 compared to 2013 results. On the other hand, approximately 13% of *Pseudomonas aeruginosa* was resistant ciprofloxacin in 2015 which was slightly lower than close to 15% found in 2013. Among *Acinetobacter* spp., ciprofloxacin resistance increased from approximately 6% in 2013 to approximately 7% in 2015.

In 2015, 235 patients were identified as colonized or infected with carbapenemase-producing *Enterobacteriaceae* (CPE) in Ontario. Among these patients, a majority were *E. coli* (n =140), and *Klebsiella* spp (n = 78) positive for carbapenemase. Similar to 2013, New-Delhi metallo-beta-lactamase (NDM) mediated resistant *Enterobacteriaceae* were the most commonly isolated CPE organisms in 2015.

130 out of 222 hospitals responded to the infection control survey. Similar to 2013, all 130 hospitals reported having a MRSA screening program. A majority of hospitals screened patients who were directly admitted from other healthcare institutions and nursing homes or were roommates of MRSA positive patients.

The proportion of hospitals that reported not screening for VRE increased from 9% (18/194) in 2013 to 21% (27/129) in 2015. Of those hospitals that do have a VRE screening program, the majority of them

screen roommates of VRE colonized or infected patients or those who were directly admitted from other healthcare institutions or nursing homes.

In 2015, only 39% of hospitals screened patients for extended spectrum beta-lactamase (ESBL) organisms, which is lower than 56% of hospitals in 2013. Hospitals in Ontario have varying practices in recommending additional precautions for those patients who are colonized or infected with ESBL organisms.

Similarly, only 56% of hospitals have a screening program to identify patients with CPE. This was identical to the proportion that was reported in 2013. Of those hospitals that have a CPE screening program, the majority of them screen for CPE in patients with history of hospitalization in another country.

Conclusions: These surveys provide us with the ability to monitor the burden of AROs as well as infection control practices related to AROs in Ontario over time. Overall, AROs remain a problem in Ontario and the numbers are rising for most AROs. Continued surveillance and monitoring efforts among laboratories and hospitals are important to help inform policies and practices to prevent the spread of resistant organisms in health care settings.

Background

Antimicrobial resistance is a global public health problem. The World Health Organization (WHO) reports that there were high proportions of antimicrobial-resistant bacteria that cause common infections in all regions of the word.[1] In the United States, the Centers for Disease Control and Prevention (CDC) estimates that at least 2 million illnesses and 23,000 deaths annually were caused by antimicrobial resistance.[2] In Canada, Zoutman et al. calculated that the incidence of health care associated infections or hospital-associated infections (HAIs) (based on US estimates) was 220,000 per year, resulting in more than 8,000 deaths.[3] Control of antimicrobial-resistant organisms (AROs) requires coordinated efforts from various sectors, and collection, analysis, and dissemination of data is the first step in understanding this problem.

Between 1996 and 2014, the Institute for Quality Management in Healthcare (IQMH), previously known as the Quality Management Program – Laboratory Services (QMP-LS), administered an annual survey on antimicrobial resistance in common hospital pathogens to all licensed Ontario bacteriology laboratories. Data collected from this annual survey was summarized in a report which was shared to all laboratories, and posted on the IQMH website for public access. This survey was consistently administered for years, providing a reliable annual update of information on AROs and trends over time. Due to the close working relationship that QMP-LS had with laboratories through their accreditation and proficiency programs, Ontario laboratories responded to the survey with nearly 100% completion rate. This unique collaboration allowed all laboratories in the jurisdiction to gather information of laboratory and infection control practices related to the control of AROs.

Due to IQMH's new strategic direction, the survey was not administered in 2015 to capture the 2014 data. Subsequently, Public Health Ontario (PHO) and IQMH established a partnership to continue this important surveillance program in Ontario. As part of this collaboration, IQMH will continue to administer the laboratory survey among laboratories while PHO will administer the hospital survey, analyze both datasets and coordinate the development and promotion of the final report. Not only will this help inform policy and provide continuous information on AROs in the province, but will further strengthen PHO's collaborative relationship with IQMH and Ontario laboratories.

Report Objectives and Scope

The objective of this report is to provide information and share findings of the surveys on antimicrobial resistance in common hospital pathogens among laboratories and hospitals in Ontario for the year 2015. As in the previous IQMH reports, the 2015 report provides information on the burden of AROs, laboratory information and screening practices as well as infection control practices related to methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), antibiotic-resistant Gram-negative bacilli, and carbapenemase-producing Enterobacteriaceae (CPE). *Clostridium difficile* was not included in these surveys but will be included in future surveys.

Methods

Two separate surveys were conducted in 2016 by IQMH and PHO to assess the number of ARO isolates and infection control practices related to ARO. In February 2016, IQMH conducted the laboratory-based survey. This survey included information on laboratory type, number of new patients identified and other laboratory practices and experiences in 2015 related to MRSA, VRE, antibiotic-resistant gram-negative bacilli, and CPE. It was administered to all 75 currently licensed bacteriology laboratories in Ontario using IQMH's pre-existing questionnaire interface.

In March 2016, PHO conducted a hospital-based survey among hospitals in Ontario using FluidSurvey. All 222 hospitals which provide inpatient care were invited to participate in the survey. This hospital survey included questions about hospital admissions and infection control practices for the period of 2015.

The survey items in both questionnaires were similar to the 2013 IQMH comprehensive survey questionnaire. Each survey ran for approximately one month. Data from both surveys were extracted from their current interface and cleaned by a PHO epidemiologist in collaboration with an IQMH consultant technologist. Data were analyzed using SAS Enterprise Guide and Microsoft Excel.

Results

A total of 72 of the 75 currently licensed bacteriology laboratories responded to the laboratory based survey; 56 hospital-based, 15 community-based, and 1 public health. These 72 laboratories provide service for 205 hospitals in Ontario.

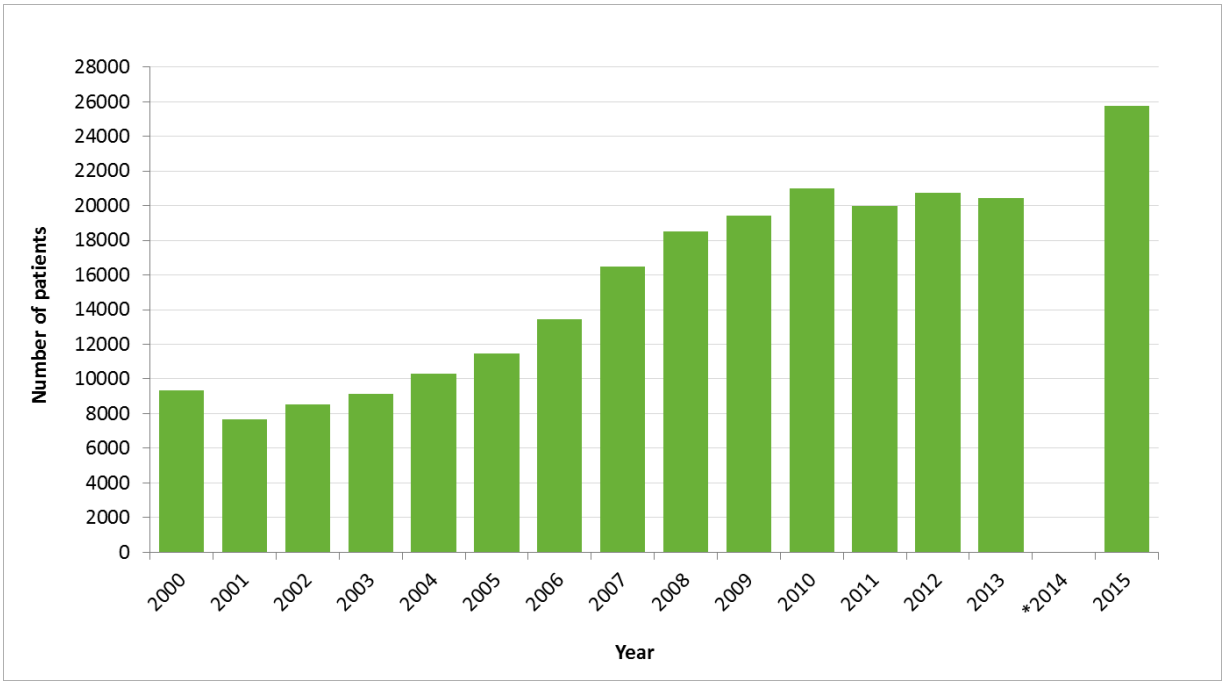
130 of the 222 hospitals (59%) that provide inpatient care responded to the hospital-based survey.

Methicillin-Resistant *Staphylococcus aureus* (MRSA)

Laboratory Data

Laboratories reported a total of 25,767 patients colonized or infected with MRSA (median: 182 patients; range: 0–3,803 patients). This represents a 26% increase from 2013 (Figure 1).

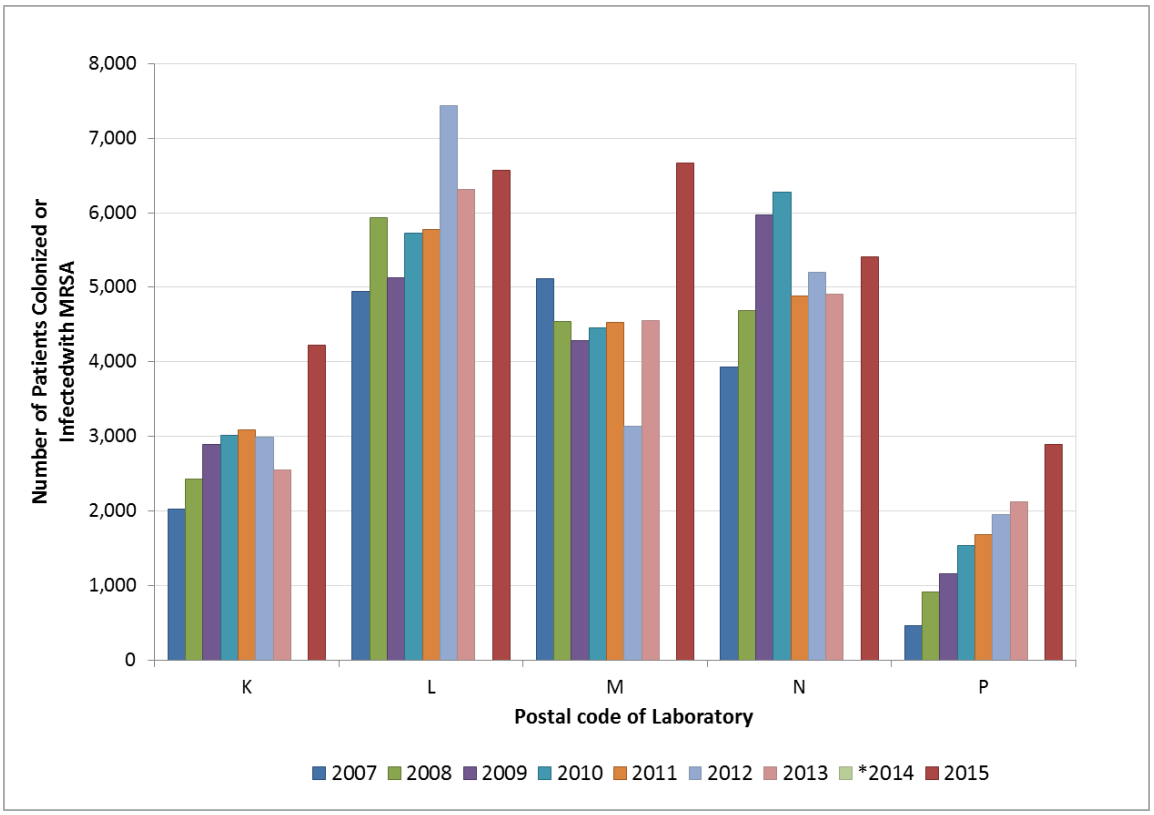
Figure 1. Number of patients colonized or infected with MRSA in Ontario, 2000 to 2015*



*Survey not conducted in 2014

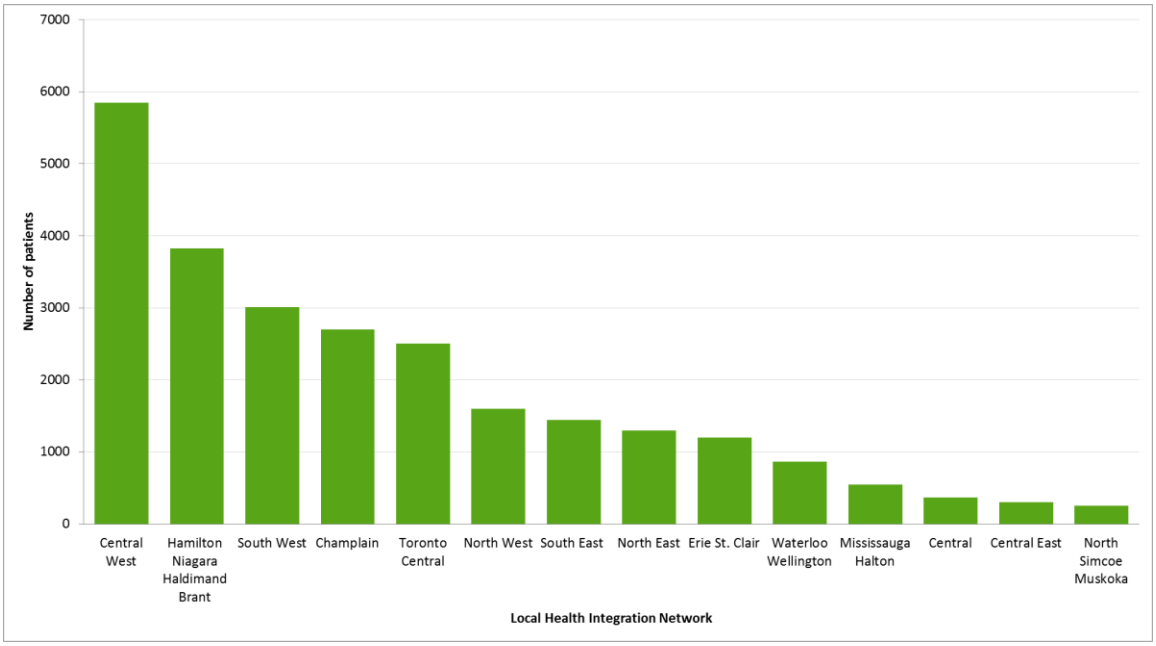
MRSA numbers increased for all geographic regions from 2013 to 2015 (Figure 2).The most notable increase was reported in eastern Ontario (postal code K) with a 66% increase from 2013; and in metropolitan Toronto (postal code M) with a 44% increase. In 2015, the highest increase was observed in Central West Local Health Integration Network (LHIN) (Figure 3).

Figure 2. Number of patients colonized or infected with MRSA, stratified by geographic regions in Ontario, 2007 to 2015*



*Survey not conducted in 2014

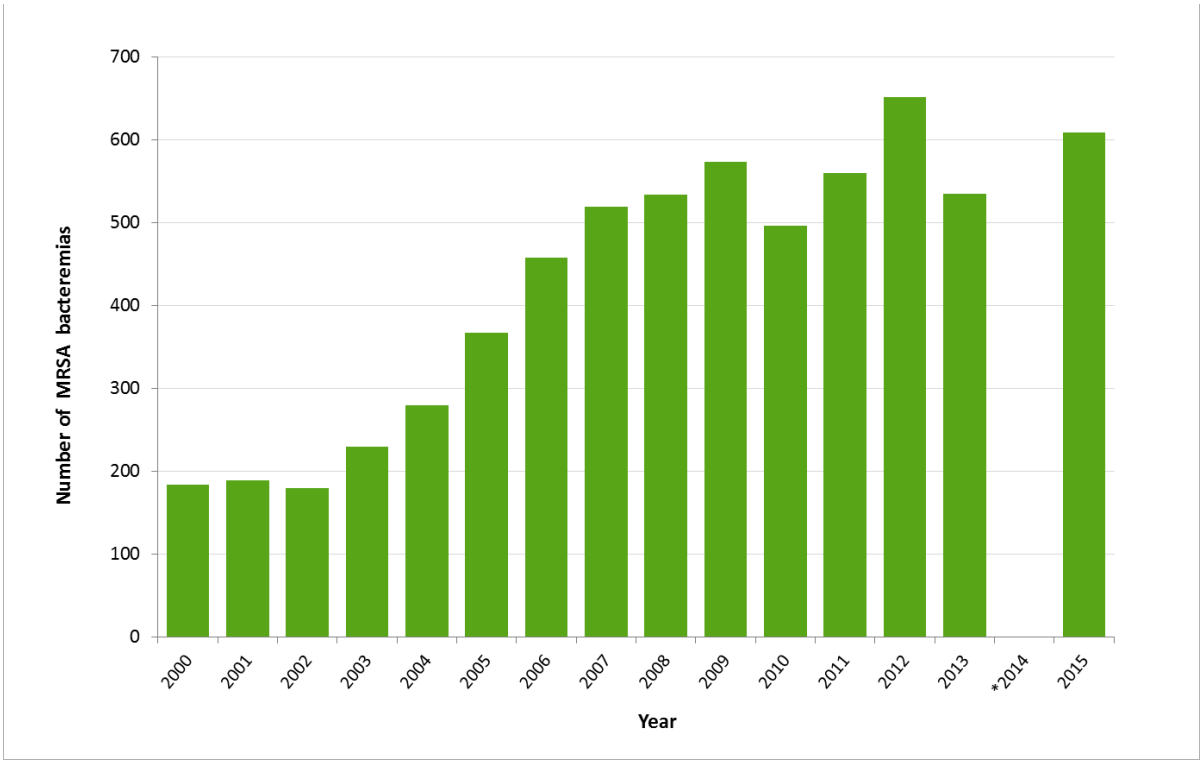
Figure 3. Number of patients colonized or infected with MRSA, Ontario, 2015, stratified by LHIN



Laboratories were able to provide the site of acquisition for 9,440 of the 25,767 (37%) patients with MRSA. Of these, 2,898 (31%, down from 34% in 2013) patients were thought to have acquired MRSA in health care settings (2,332 in the reporting hospital and 566 in another hospital), 1,420 (15%, down from 17% in 2013) in a nursing home, and 5,123 (54%, up from 49% in 2013) in the community. The proportion of MRSA that were reported to be community-acquired was highest in Central West (24%).

For those laboratories that could record whether patients were infected or colonized with MRSA, the percentage of patients infected was 38% (8,171/21,254), which is the same percentage as in 2013.

Figure 4. Number of MRSA bacteremias reported by laboratories in Ontario, 2000 to 2015*



*Survey not conducted in 2014

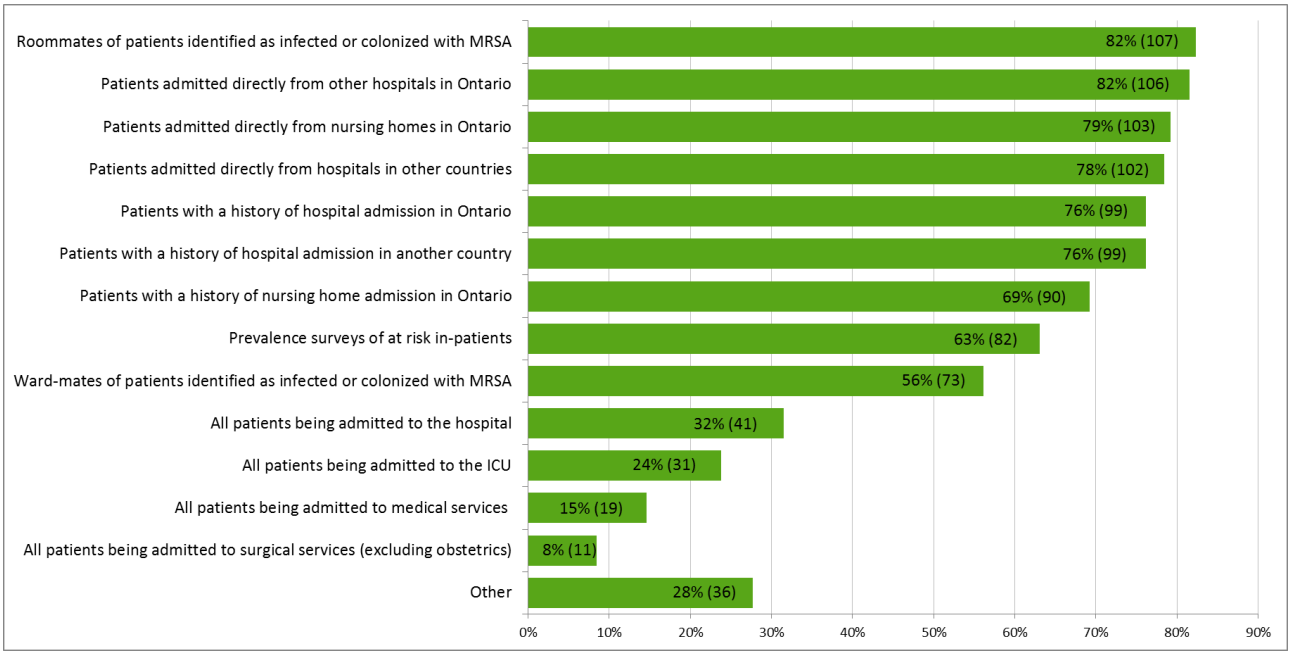
The number of reported MRSA bacteremias in 2015 increased by 14% from 535 in 2013 to 609 in 2015 (see Figure 4). Excluding those with missing data, 15% (609/4,191) of all *S. aureus* isolated from blood cultures were MRSA, which is the same percentage as in 2013. Of these, the highest percentage of positive blood cultures came from laboratories/ hospitals in Toronto Central (21%; 126/609).

A total of 60 laboratories (14 community, 45 hospitals, and 1 public health lab) serving 182 hospitals reported screening for vancomycin-intermediate resistance (VISA) and/or heterogeneous VISA (hVISA). Twenty-nine laboratories use brain heart infusion (BHI) 6mg/L agar screen plates. Of these, 17 laboratories used additional automated or non-automated system to screen for VISA/hVISA isolates. Further, three hospital-based laboratories (one hospital each in Champlain, Central East, and North East LHINs) reported a total of seven patients with VISA in 2015 compared to three patients reported with VISA in 2013.

Hospital Data

All 130 hospital respondents reported having a screening program for MRSA. The majority of hospitals (81.5% or 106/130) screen patients directly admitted from other hospitals in Ontario. Most hospitals (82% or 107/130) also reported screening roommates of patients identified as colonized or infected with MRSA as part of their screening program (Figure 5).

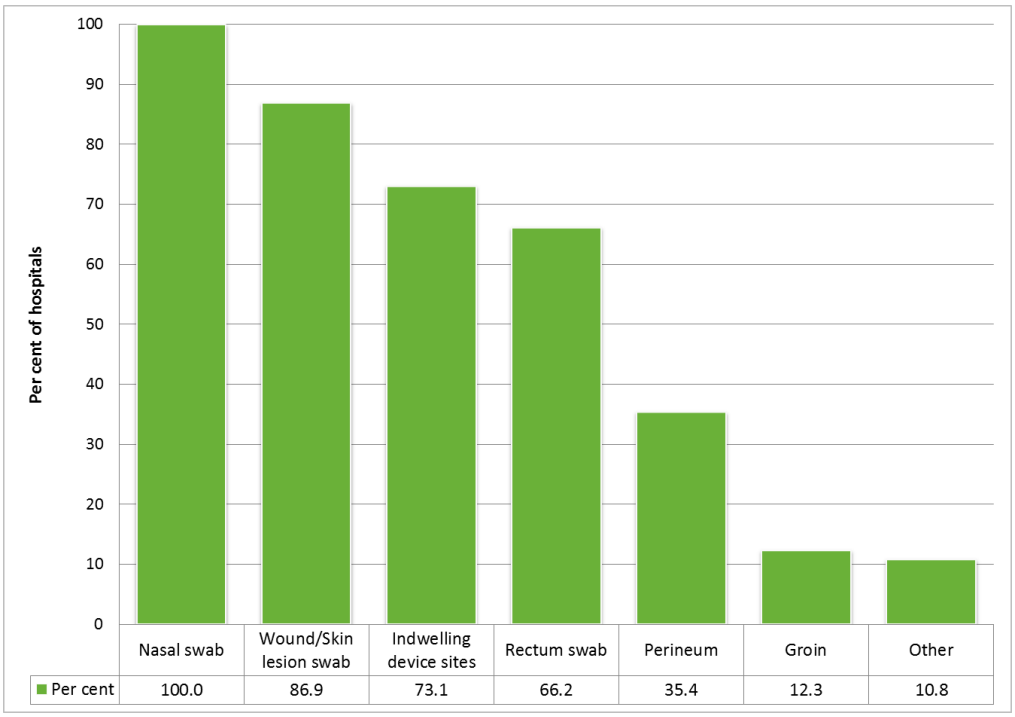
Figure 5. Patients included in the MRSA screening program (n=130)



Hospitals provided varying periods when screening patients with a history of admission to hospital. Of those that responded, 79% (90/114) specified one year as the time period they include when screening patients with a recent history of previous admission.

All 130 hospitals reported obtaining nasal swabs for screening MRSA. A variable proportion of hospital also screen other body sites (Figure 6).

Figure 6. Body sites used for MRSA screening (n=130)



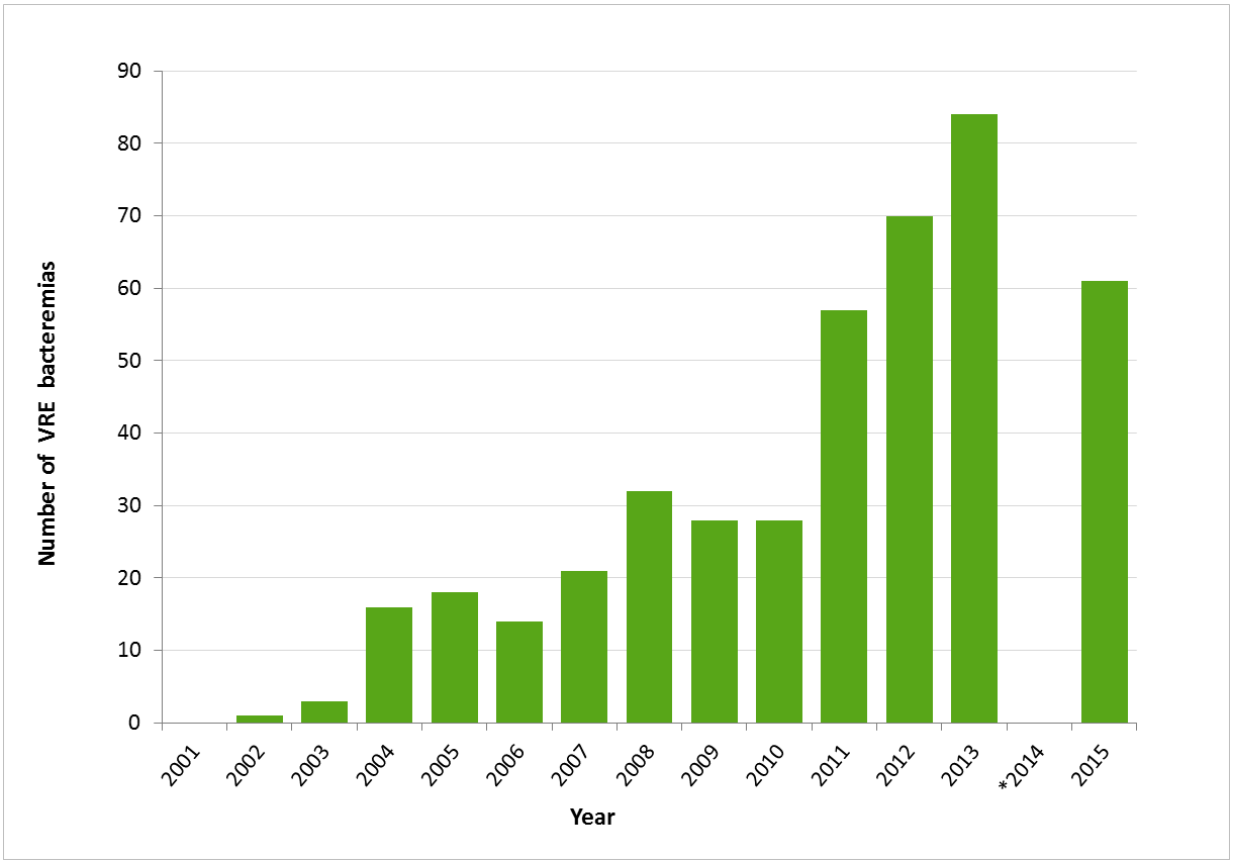
Vancomycin-Resistant Enterococci (VRE)

Laboratory Data

Laboratories across the province reported 756 new patients with a clinical (i.e., non-screening) isolate of VRE in 2015, a 55% decrease compared to 1683 new patients with clinical VRE isolates reported in 2013. Of these isolates, 88% (667/756) were *Enterococcus faecium* and 3% (26/756) were *Enterococcus faecalis*. Laboratories were unable to provide species identification for the remaining 8% (63/756) of these patients' isolates. Eight laboratories providing service for 47 hospitals reported identifying the mechanism of vancomycin resistance using PCR testing (n = 6) or antimicrobial susceptibility testing (n = 2) methodology. In these laboratories, the majority (99%; 161/162) had isolates containing *vanA*. The majority of the laboratories (90%; 65/72) test all clinically significant enterococci for vancomycin-resistance.

The number of patients with VRE bacteremia decreased from 84 in 2013 to 61 in 2015 (27% decrease) (Figure 7). Overall, 3% (61/2,122) of the enterococcal bacteremias were attributed to VRE in 2015 which is comparable to 4% (84/1840) reported in 2013. However, among patients with VRE infection, 61/756 (8%) patients were reported to have VRE bacteremia which was higher than 84/1683 (5%) patients with VRE bacteremia reported in 2013.

Figure 7. Number of VRE bacteremias reported by laboratories in Ontario, 2001 to 2015*



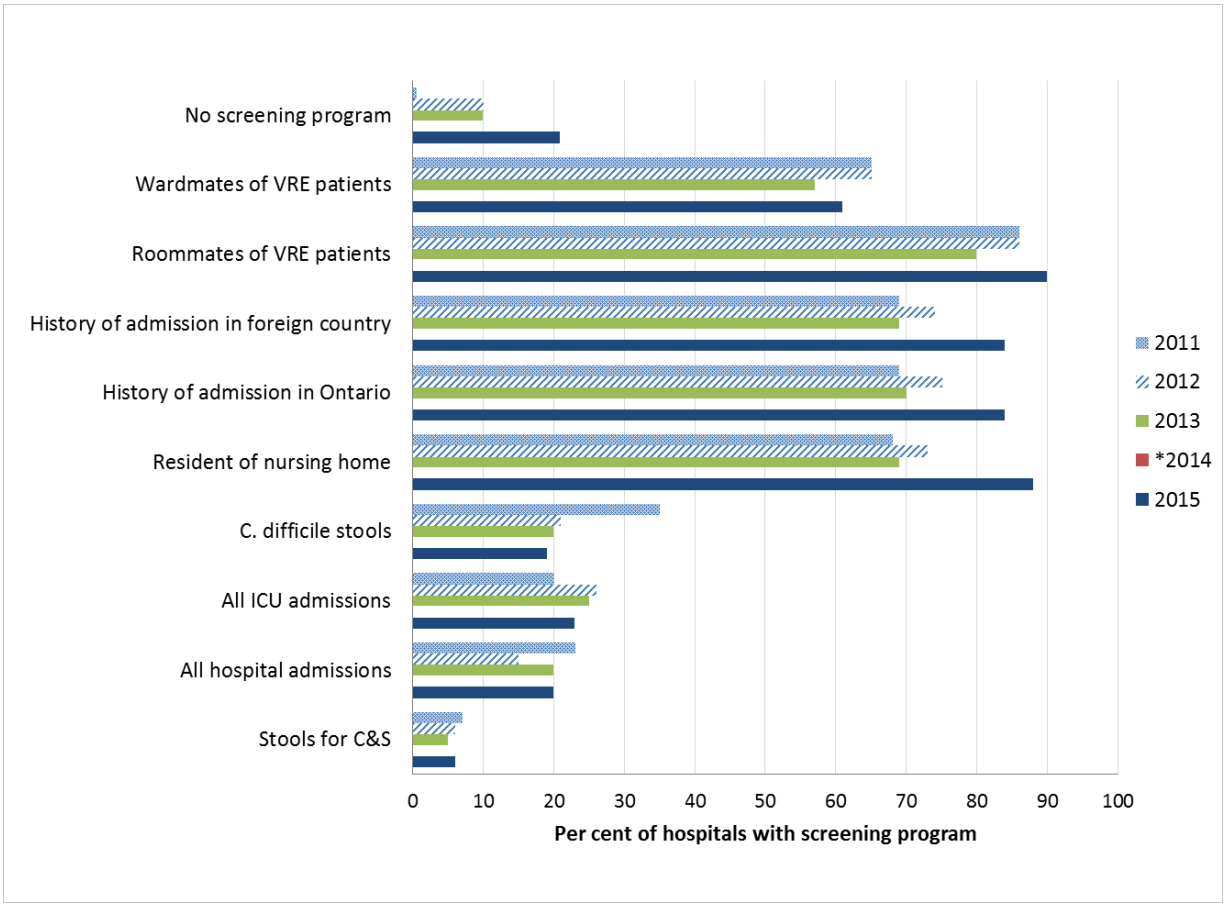
*Survey not conducted in 2014

Seven of 68 (10%) laboratories (2 in North West, 1 each in Central East, Central West, North Simcoe Muskoka, South West and Toronto Central LHIN) reported identifying 15 patients colonized or infected with an enterococcal isolate containing the *vanA* gene by PCR but was susceptible *in vitro* to vancomycin. The number of patients with *vanA* susceptible isolates in 2015 was more than half that observed in 2013 when 33 patients were identified. Of the 15 patients, 8 were reported by 1 laboratory serving 11 hospitals.

Hospital Data

Twenty-seven of the 129 hospitals (21%) for which information were available reported not having a VRE screening program in 2015, an increase from 9% (18/194) reported in 2013 (Figure 8). Of those with a VRE screening program, 88% (90/102) reported screening residents that were admitted directly from nursing homes in Ontario (up from 69% in 2013) and 90% (92/102) also reported screening roommates of patients identified as colonized or infected with VRE (up from 80% in 2013).

Figure 8: VRE screening criteria used in hospitals in Ontario, 2011-2015*



*Survey not conducted in 2014

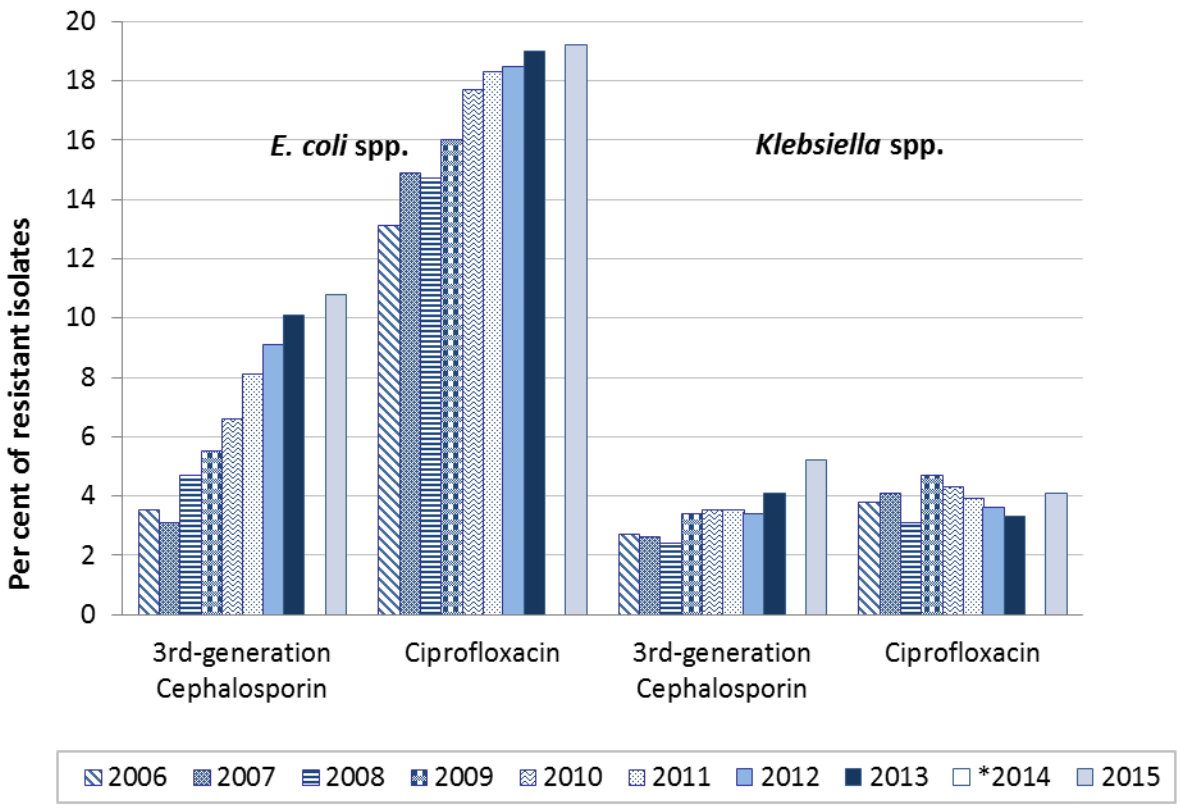
Note: ICU: intensive care unit; C&S :culture and sensitivity

Antibiotic-Resistant Gram-Negative Bacilli

Laboratory Data

In 2015, laboratories reported that the total number of clinical isolates of *Escherichia coli* and *Klebsiella* spp. were 425,484 and 63,466, respectively. Resistance to third-generation cephalosporins and ciprofloxacin increased in both *E. coli* and *Klebsiella* spp. in 2015 compared to 2013 (Figure 9).

Figure 9. Resistance to third-generation cephalosporins and ciprofloxacin in isolates of *E. coli* and *Klebsiella* spp. in Ontario, 2006 to 2015*

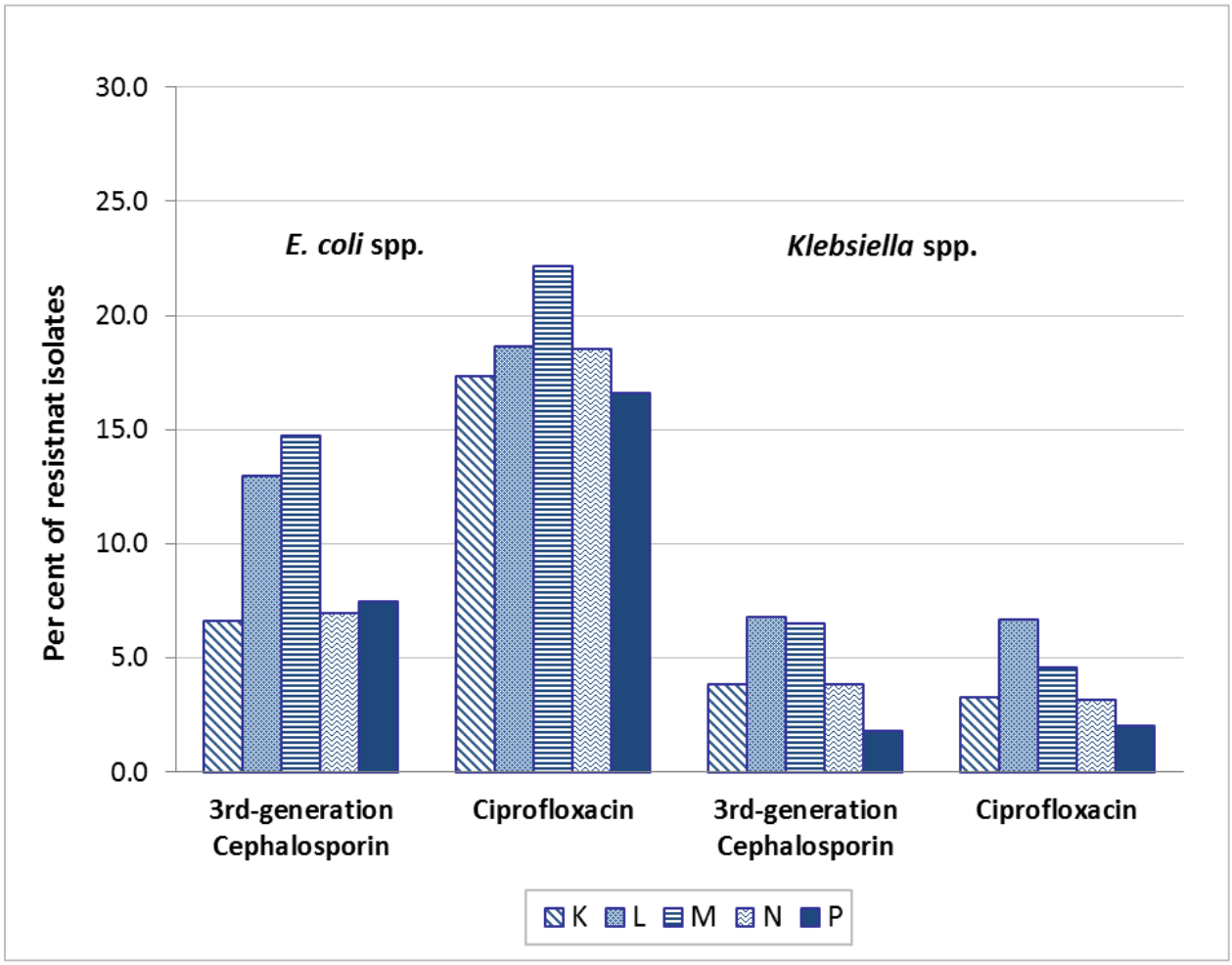


*Survey not conducted in 2014

Third-generation cephalosporin and ciprofloxacin-resistant isolates were reported from all areas of the province, with the prevalence of resistance in *E. coli* most common in laboratories in metropolitan Toronto (postal code M) and in *Klebsiella* spp. in central Ontario (postal code L) (Figure 10). Laboratories reported that 0.03% (117/367,077) of *E. coli* isolates were resistant to imipenem/meropenem, and

0.07% (187/282,540) were resistant to ertapenem. Additionally, 0.17% (92/54,822) *Klebsiella* spp. isolates were resistant to imipenem/meropenem and 0.27% (146/54,599) were resistant to ertapenem.

Figure 10. Resistance to third-generation cephalosporins and ciprofloxacin in isolates of *E. coli* and *Klebsiella* spp. by region, Ontario, 2015



Laboratories providing data on resistance in *Pseudomonas aeruginosa* in 2015 identified 13.6% (5,214/38,417) of isolates were resistant to ciprofloxacin (down from 14.8% in 2013) and 9.1% (3,433/37,561) were resistant to imipenem/meropenem (a slight increase from 8.8% in 2013). Laboratories providing data reported 0.6% (227/37,525) of *P. aeruginosa* isolates as resistant to all antimicrobial agents tested. These isolates were reported from all areas of the province: 2% (5/227) in eastern Ontario (postal code K), 1% (3/227) in central Ontario (postal code L), 20% (46/227) in metropolitan Toronto (postal code M), 75% (170/227) in southwestern Ontario (postal code N) and 1% (3/227) in northern Ontario (postal code P).

A total of 168 of the 2,470 isolates (6.8%) of *Acinetobacter* spp. were resistant to ciprofloxacin, a proportion higher than that reported in 2013 (5.8%). Of the 2,393 isolates reported in 2015, 93 isolates (3.9%) of *Acinetobacter* spp. were reported to be resistant to imipenem/ meropenem, higher than the proportion reported in 2013 (2.2%).

Hospital Data

In 2015, 50 of the 129 hospitals (39%) which provided information reported having a screening program to identify patients colonized with extended-spectrum beta-lactamase (ESBL)-producing *E. coli* or *Klebsiella* spp. This decreased from 56% in 2013.

Thirty of the 50 hospitals with a screening program (60%) screen patients with a history of admission in another country while 27 (54%) screen roommates of colonized/infected patients. As in 2013, the rectal swab is the most common screening specimen in 2015 (44% or 57/ 129). Excluding hospitals with missing or incomplete information, 12% (15/124) recommended no additional precautions for patients colonized or infected with *E. coli* or *Klebsiella* spp. resistant to third-generation cephalosporins, whereas 64% (79/124) recommended additional precautions for all such patients, and 24% (30/124) recommended additional precautions for some patients (e.g. patients in the intensive care unit, if patient is soiling environment, clinical isolates only). Of the 120 hospitals that provided details on additional precautions, 53% (63/120) recommended private room plus contact precautions, 35% (42/120) recommended contact precautions without a private room, 8% (10/120) did not recommend additional precautions, 3% (3/120) recommended private room only, and the remaining 2% (2/120) specified other recommendations.

Carbapenemase-Producing *Enterobacteriaceae* (CPE)

Laboratory Data

The majority of laboratories (92%; 66/72) in Ontario reported screening *Enterobacteriaceae* isolates for carbapenemase-producing *Enterobacteriaceae* (CPE). Of the 66 laboratories screening *Enterobacteriaceae* for carbapenemase production, 85% (56/66) screen all organisms and 14% (9/65) screen some *Enterobacteriaceae*; the remaining laboratory did not specify which organisms are being screened. In terms of isolates, 85% (56/66) screen all clinically significant isolates for carbapenemase production, 14% (9/66) screen sterile site isolates, 9% (6/66) screen all isolates, and 14% (9/66) specified other isolate screening criteria.

More than half of laboratories that reported CPE screening information (61%; 40/66) use one or more of the screening criteria recommended by IQMH. This includes meropenem MIC of 0.25 mg/L or greater, meropenem zone diameter of ≤26 mm using the Rosco MRP10 meropenem tablet or meropenem zone diameter of ≤25 mm using the standard meropenem (10µg) disk.[4] Further testing in individual laboratories on screen-positive isolates includes: the Rosco KPC + MBL Confirm kit (performed by 23 laboratories), the modified Hodge test (performed by five laboratories), and PCR testing (performed by four laboratories, three of which also refer confirmed CPE isolates to Public Health Ontario). Thirty-two laboratories (48%; 32/66) that do not perform further tests forward screen-positive isolates to a reference laboratory for testing.

Of the 69 laboratories that screen for CPE and test and report carbapenem susceptibility, 26% (18/69) do not test for CPE using ertapenem. Of the remaining 51 laboratories, 61% (31/51) use an MIC ≥2 mg/L

as the breakpoint to interpret ertapenem resistance consistent with CLSI changes in breakpoints made in 2010. Six laboratories changed their interpretive breakpoints in 2015 to reflect these breakpoints. For imipenem/meropenem resistance interpretation, 60% (39/65) of those that reported testing, use an MIC ≥4 mg/L consistent with CLSI breakpoint changes made in 2010. Seven laboratories changed their interpretive breakpoints for meropenem in 2015 to reflect these breakpoints.

Twenty-nine laboratories (29/60; 48%) reported a total of 140 patients with at least one carbapenem-resistant *E. coli* isolate. Among these 140 patients, 44 patients had isolates that were confirmed to be carbapenemase producers (37 NDM [84%]; 1 KPC [2.3%]; 5 OXA48 [11.4%]; 3 other [6.8%]). Additionally, 22 laboratories (37%; excludes those with missing information) reported 78 patients with carbapenem-resistant *Klebsiella* spp. Of the 78 patients, 35 patients (45%) had confirmed carbapenemase-producing isolates (20 NDM (57.1%); 7 KPC (20%); 12 OXA48 (34%); 1 other (3%)). Laboratories also identified 17 patients as having at least one isolate of a non-*E. coli*, non-*Klebsiella* spp. *Enterobacteriaceae* that was confirmed to be a carbapenemase-producer. Of the 96 patients in total identified with a CPE, approximately half (47%; 45/96) were in Toronto Central LHIN (Table 1).

Table 1. CPE-positive patients by LHIN, Ontario, 2015 (n=96)

Local Health Integration Network (LHIN)	n (%)
Toronto Central	45 (47%)
Central West	28 (29%)
Central	5 (5%)
Mississauga Halton	4 (4%)
Hamilton Niagara Haldimand Brant	3 (3%)
Champlain	3 (3%)
South West	2 (2%)
South East	2 (2%)
North East	2 (2%)
Central East	1 (1%)
Erie St. Clair	1 (1%)
Waterloo Wellington	0 (0%)
North West	0 (0%)
North Simcoe Muskoka	0 (0%)

Hospital Data

Seventy-two of the 128 hospitals (56%) for which information was available reported having a screening program to identify patients colonized or infected with a CPE. Of those that currently have a program, it most frequently includes screening patients with a history of hospital admission in another country (83% or 60/72) and/or patients admitted directly from hospitals in another country (79%;57/72).

Of the 117 hospitals providing information about precautions used for CPE-infected or colonized patients, 58% (68/117) recommend a private room and contact precautions, 38% (44/117) recommend contact precautions without a private room, 2% (2/118) recommend a private room only, and the remaining 3% (4/118) do not recommend additional precautions. It is recommended that hospitals follow the current CPE guidelines developed by Infection, Prevention, and Control (IPAC) subcommittee of Provincial Infectious Disease Advisory Committee (PIDAC). More than half of the hospitals (52%; 29/56) that did not have a screening program identified that the population served by their facility is not at risk for CPE acquisition. Other barriers reported by these non-screening hospitals include lack of laboratory testing capacity (38%; 21/56), lack of resources (27%; 15/56), and/or lack of senior management approval (18% or 10/56).

Limitations

Although these surveys had strengths including annual updates of information on laboratory screening and infection control practices related to antimicrobial-resistant organisms and high response rates, several limitations merit consideration.

For the laboratory survey, the number of "new" patients was assumed not to be duplicated by another testing laboratory though most likely there will be a number of patients who may have been identified and reported by multiple laboratories due to different hospital visits or admissions within that year. This would overestimate the burden of ARO in Ontario. The number of patients attributed to sources such as another hospital or nursing home, or community may also not be as accurate as some patients may visit several facilities within a short period of time, making it difficult to determine a source. And while every effort was made to look at the trends, on some occasions, comparison could only be made with the most recent survey data (i.e., 2013 data) due to the unavailability of historical data.

For both the laboratory and hospital surveys, several assumptions were made during the data cleaning process (Appendix 1 provides a detailed list of these assumptions). Results may have varied from the previous survey due to the change in the way recent surveys were administered and analyzed. Further, results of this report may not be comparable to other surveillance systems due to different methods employed in collecting data and level of reporting implemented in each of the surveillance systems (i.e., provincial, national level).

Conclusions

AROs contribute to significant morbidity and mortality among hospitalized patients[1,2]. Increased prevalence of ARO is a significant public health threat as there are limited antimicrobial options available to treat infections caused by these organisms[1,2].

In this survey, an increasing trend in the number of MRSA acquisitions and MRSA bacteremias overall was observed. The data show that the number of health care-associated MRSA has decreased though community-acquired MRSA have increased when compared to 2013 data. This suggests that continued attention on improving infection control practices may have decreased the number of MRSA isolates acquired in nosocomial settings relative to 2013 survey results.

Although VRE bacteremias reported by laboratories increased from 2011 through 2013, we observed a decrease from 2013 to 2015 in Ontario in this survey. This decreasing trend was also observed for VRE clinical isolates reported in 2015 compared to 2013. Based on comparison of data of 2011, 2013 and 2015, it is difficult to conclude whether VRE clinical isolates are increasing, decreasing or staying the same in Ontario. Further surveillance in future years is needed to make any inference. Similar to 2013, most of these clinical (i.e., non-screening) isolates were vancomycin-resistant *Enterococcus faecium* (88%). Compared to 2013, a larger proportion of hospitals (21% versus 9%) reported not having a VRE screening program in 2015. However, most hospitals with a VRE screening program reported screening roommates of patients identified as colonized or infected with VRE (up from 80% in 2013 to 90% in 2015).

A complicating factor in the discussion of VRE is the recent identification of *vanA*-containing isolates with a non-*vanRS* (and as of yet unidentified) promoter.[5,6] These strains are phenotypically variable- they may appear fully susceptible, intermediate or resistant to vancomycin. It appears that they may be able to develop vancomycin resistance when exposed to vancomycin, which may make them important to identify in clinical cultures.[7,8] The current laboratory survey data showed that the incidence of these isolates have decreased across different LHINs with five laboratories identifying 33 patients in 2013 to seven laboratories reporting 15 patients in 2015. Toronto Central LHIN had the highest number of cases, perhaps due to their testing and reporting practices. A better understanding of both their epidemiology and the response of infections to vancomycin therapy is needed.

Resistance to third generation cephalosphorins and ciprofloxacin increased in *E. coli* and *Klebsiella* spp. The prevalence of this resistance in *E. coli* was most common in metropolitan Toronto laboratories while the prevalence of this resistance in *Klebsiella spp* was most common in central Ontario.

We did not capture the proportion of *E.coli* and *Klebsiella* spp that were ESBL. However, it is interesting to note that the number of hospitals with screening programs for ESBL-producing organisms has decreased in 2015. It is unclear however, whether this is because hospitals are seeing more community-acquired ESBL-containing organisms rather than health care associated, or whether hospitals have redirected their infection control efforts on CPE.

The majority (92%) of the laboratories reported screening for CPE; of these, 85% responded that they screen all clinically significant isolates. Additionally, the number of patients that had isolates of *E. coli* and *Klebsiella* spp. that were CPE increased from 2013 to 2015. While the rates of CPE remain relatively low compared to other AROs, CPE is anticipated to increase in frequency over the next few years.[5] CPE-positive patients were mostly coming from Toronto Central and Central West LHINs which may be due to travel and migration patterns in these regions. In 2015, 57% of the laboratories surveyed reported using recommendations by IQMH.[4] It is recommended that laboratories in Ontario follow IQMH guidelines when screening for CPE isolates, as other criteria such as CLSI (REF) will miss 15% of CPE isolates.

Overall, AROs remain a problem in Ontario and for most AROs the numbers are rising. Continued surveillance and monitoring efforts among laboratories and hospitals are important to help inform policies and practices to prevent the spread of these resistant organisms in health care settings.

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Appendix A. Assumptions and Data Cleaning Procedures

Laboratory data:

1. The numbers provided in the survey were assumed to be accurate.
2. To avoid duplicate entries, supplementary questionnaires received from laboratories which send specimens to a centralized laboratory were deleted from the dataset if data from their laboratories were already captured by the centralized laboratory. Information that was in the supplementary questionnaire that was not in the centralized laboratory questionnaire was manually added to the latter.
3. Character values in numeric variables were changed to numeric values where possible. Responses such as “NA”, “not available”, “unable to determine” were changed to blanks.
4. For duplicated laboratories grouped with other laboratories, the numbers were assumed to be coming from different laboratories since separating the counts were not feasible.
5. Where the subtotals did not match the total number of isolates, the total number of isolates was used.
6. If the screening question was not completed but practices were specified in follow-up responses, the laboratory was assumed to conduct screening related to the ARO in question.

Hospital data:

1. If the screening program question was not completed but follow- up responses were indicative of a positive response, the hospital was assumed to have a screening program in place.
2. Infection control practices submitted by the corporation were assumed to apply across all institutions under the corporation.

Public Health Ontario
480 University Avenue, Suite 300
Toronto, Ontario
M5G 1V2

647.260.7100
communications@oahpp.ca
www.publichealthontario.ca