PICNet
PROVINCIAL INFECTION CONTROL NETWORK OF BRITISH COLUMBIA
A program of the Provincial Health Services Authority

Annual surveillance report of healthcare-associated infections in BC acute care facilities

Fiscal Year 2014/15
(April 1, 2014 to March 31, 2015)

Prepared by:
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The Provincial Infection Control Network of British Columbia (PICNet) is a provincially supported professional collaborative that provides guidance and advice on healthcare-associated infection prevention and control in British Columbia. Under the aegis and accountability framework of the Provincial Health Services Authority, PICNet connects healthcare professionals from across the province to develop and create guidelines and tools, with a focus on surveillance, education, and evidence-based practice.

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Executive Summary

Surveillance is a crucial component for the prevention and control of healthcare-associated infections. There are currently four provincial surveillance programs related to healthcare-associated infections in British Columbia acute care facilities. Following are the highlights of the surveillance results for the fiscal year 2014/15 based on the data submitted by the health authorities.

Clostridium difficile infection (CDI) surveillance

- A total of 2,260 cases of CDI were reported among inpatients in 2014/15. Of these, 1,206 (53.4%) were defined as new cases that were healthcare-associated with the reporting facility. This was the lowest annual number of total CDI cases, and the lowest number of new cases as well, since the inception of the provincial CDI surveillance program in 2009/10.
- Overall, the provincial rate of CDI associated with the reporting facility has decreased from 8.6 per 10,000 inpatient days in 2009/10 to 4.2 per 10,000 inpatient days in 2014/15 — a decrease of 51.2%. A statistically significant downward trend was observed in four of the six health authorities over the past six years.
- The greatest decrease was observed in facilities with more than 250 beds, and tertiary/referral or regional hospitals, and teaching hospitals. The gaps in the CDI rates between the different sizes and types of facilities have narrowed over the past six years, and the difference in the rates was not statistically significant in 2014/15.
- The rate of CDI varied by fiscal quarter in 2014/15, with a significant increase in quarter 4 (Q4) from the preview two quarters. Part of reason for the increase in Q4 may be associated with increased norovirus activity during that period, which can lead to increased testing for *C. difficile*. The health authorities are closely monitoring the situation.
- The proportion of relapses of CDI and intensive care unit admissions due to CDI or CDI-related complications also decreased in the last three years.

Methicillin-resistant *Staphylococcus aureus* (MRSA) surveillance

- A total of 3,130 cases of MRSA were newly identified among inpatients during 2014/15. Of these, 1,552 (49.5%) were defined as healthcare-associated with the reporting facility. Compared to 2013/14, both the total number of cases and the number of healthcare-associated cases have increased.
- The provincial rate of MRSA associated with the reporting facility was 4.9 per 10,000 inpatient days in 2014/15, which is a statistically significant upward trend from 2010/11 to 2014/2015. The upward trend in provincial MRSA rates occurred despite the enhanced intervention measures on the part of the health authorities over the last few years; these measures are mostly hospital-based and may have little impact on MRSA acquired outside healthcare settings.
- Over half of healthcare-associated MRSA cases (52.3%) associated with the reporting facility were associated with a previous encounter with the reporting facility. Compared to 2013/14, the number of MRSA cases that were associated with a previous encounter with the reporting facility increased in 2014/15 by 78.9%, while the MRSA cases that were associated with current admission to the reporting decreased by 18.8%.

Carbapenemase-producing organisms (CPO) surveillance

- Provincial surveillance for CPO was introduced to acute care facilities in July 2014 in response to recent global increases of CPOs, and an outbreak in a BC hospital.
- From July 2014 to March 31, 2015, 49 new cases of CPO were identified in BC acute care facilities. NDM was the predominant carbapenemase gene, accounting for 61.2% of CPO cases, followed by OXA-48 (14.3%), and KPC (8.2%).
- Over half of the new cases (55.1%) had healthcare exposure outside Canada. Seven cases (14.3%) were transferred from other facilities including three from outside of BC. Nine patients (18.4%) had close contact with a CPO patient or the CPO patient's environment. Eleven cases (22.4%) had no evidence of a healthcare encounter outside Canada, or contact with a known CPO patient, or a stay in a unit with high CPO prevalence in the past six to twelve months.

Hand Hygiene Compliance (HCC)

- Healthcare workers are expected to clean their hands before and after contact with a patient or the patient's immediate environment. Hand cleaning compliance in acute care facilities is audited by trained auditors periodically.
- The provincial overall compliance surpassed the target performance of 80% in each quarter of 2014/15. After weighting by inpatient days in the health authorities to reduce the impact of variations in the opportunities observed, the provincial quarterly compliance was still greater than 80% in 2014/15.
- The weighted provincial hand cleaning compliance has increased significantly from 64% in Q1 of FY 2010/11 to 81% in Q4 of 2014/15.
- Compliance before contact with a patient or the patient's immediate environment continues to be less than the compliance after contact (79% vs 87% in Q4 of 2014/15).
- Nursing staff had the highest rate of compliance (84% in quarter 4 of 2014/15), while physicians had the lowest (72% in Q4 of 2014/15).

Introduction

Healthcare-associated infections (HAI) are infections or colonizations that develop in a patient during or shortly after a healthcare encounter. More than 50% of HAIs are caused by bacteria that are resistant to at least one type of antibiotic (1); such bacteria include methicillin-resistant *Staphylococcus aureus* (MRSA), *Clostridium difficile* (*C. difficile*), and carbapenem resistant gram negative bacteria. Antibiotic resistance results in infections being more difficult to treat. It is estimated that more than 220,000 infections are acquired in hospitals yearly in Canada, resulting in more than 8,000 deaths annually (1).

Surveillance of HAIs is a crucial component of effective infection prevention and control (2,3) and has successfully characterized the magnitude of HAIs, vulnerable patient populations, and risk factors for infections (4). In 2006, the Provincial Infection Control Network of British Columbia (PICNet) began working with the health authorities (HAs) of British Columbia (BC) and related organizations to establish provincial surveillance programs for HAIs in acute care facilities. *Clostridium difficile* infection (CDI) and MRSA were the first two HAIs under provincial surveillance (since 2009 and 2011, respectively). Following recent global increases and an outbreak in a BC hospital, carbapenamase-producing organisms (CPOs) were added to the provincial surveillance programs in 2014.

The provincial surveillance data include all cases of CDI, and incidence (newly-identified) of MRSA and CPO identified in acute care facilities. CDI and MRSA are further classified as either healthcare-associated (HCA), community-associated (CA), or of unknown origin based on the patient's healthcare encounter history. A HCA classification means that the infection was identified around the time when the patient was hospitalized. This does not necessarily indicate that the patient acquired the bacteria during hospitalization. If the patient had no encounter with a healthcare facility, the case is classified as CA. Where no information on relevant hospitalizations is available, it is classified as unknown. For details of surveillance protocols for CDI, MRSA and CPO, please visit PICNet website: https://www.picnet.ca/surveillance/.

A fourth part of the provincial surveillance program is hand cleaning compliance (HCC). Given that hand cleaning is one of the most effective ways of preventing the transmission of HAIs, hand cleaning compliance among healthcare workers is audited periodically, and the audit results have been submitted to PICNet quarterly for public reporting since 2011.

The following report summarizes the surveillance data submitted to PICNet by HAs. The rates of healthcare associated CDI and MRSA, and hand cleaning compliance, are provided to show the overall trend in BC acute care facilities, rather than for comparison between HAs or between facilities. CPO data are presented by the number of new cases, as reliable rates cannot be calculated from a small number of cases. The details of the methodology for this report can be found at http://s.picnet.ca/appendices201415.

Clostridium difficile infection (CDI)

C. difficile is a Gram-positive, spore-forming, anaerobic bacterium that spreads from person to person via the fecal-oral route. Once a person acquires *C. difficile* the manifestation can vary from asymptomatic cases to severe diarrhea, pseudomembranous colitis, toxic megacolon, and, in some instances, death (5).

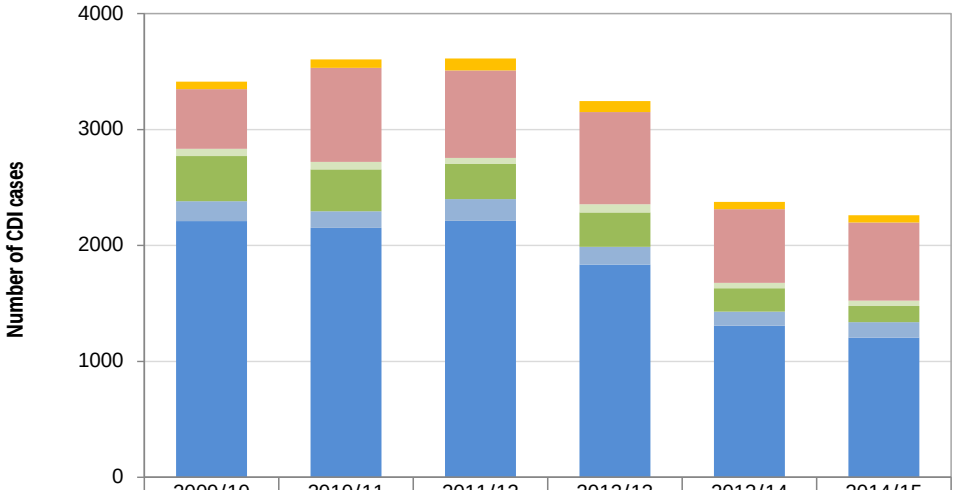
In healthcare facilities, *C. difficile* is commonly transmitted on the hands of infected patients and healthcare professionals, or via contaminated surfaces and objects. Infections result in increased hospital stays and higher morbidity and mortality among patients (6). Elderly patients and people with immune-compromising conditions or serious underlying disease are at increased risk of developing *C. difficile* infection (5).

The following tables and graphs present all CDI, including new cases and relapses, identified among inpatients in BC acute care facilities in FY 2014/15, and provide comparison to the previous years. The complications associated with CDI are also presented.

Overview of CDI cases identified in 2014/15

A total of 2,260 cases of CDI were reported in 2014/15. This represents a 4.9% decrease from 2,376 cases in the previous year (2013/14). This was also the lowest annual number of CDI cases since the inception of the provincial CDI surveillance program in 2009/10 (Figure 1).

Figure 1. Number of all cases of CDI identified in BC acute care facilities by case classification, 2009/10 - 2014/15



	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
Unknown	63	72	104	96	63	62
CA	516	812	753	794	636	674
HCA with another facility, relapse	62	63	54	71	46	47
HCA with reporting facility, relapse	390	362	302	297	201	139
HCA with another facility, new cases	171	143	188	153	121	132
HCA with reporting facility, new cases	2,210	2,152	2,212	1,835	1,309	1,206
Total number of CDI cases	3,422	3,604	3,613	3,246	2,376	2,260

CA: community-associated; HCA: healthcare-associated

Among the cases identified in 2014/15, 1,524 cases (67.4%) were defined as HCA, 674 cases (29.8%) were CA, and 62 cases (2.7%) were of unknown association. Compared with previous years, HCA CDI in 2014/15 decreased in both the number of cases and the proportion among all CDI cases.

Of the 1,524 HCA cases in 2014/15, 1,206 (53.4% of total CDI cases) were new cases of CDI associated with the reporting facility; 132 (5.8%) were new cases of CDI associated with another facility; 139 (6.2%) were relapses of CDI associated with the reporting facility; and 47 (2.1%) were relapses of CDI associated with another facility.

Rate of new CDI associated with the reporting facility in 2014/15

The provincial annual rate of new CDI associated with the reporting facility in 2014/15 was 4.2 per 10,000 inpatient days, with a 95% confidence interval (CI) of 3.9 - 4.4. The rate varied by fiscal quarter and HA (Table 1). The Q4 rate was significantly higher than Q2 and Q3, and was non-signicantly higher than Q1.

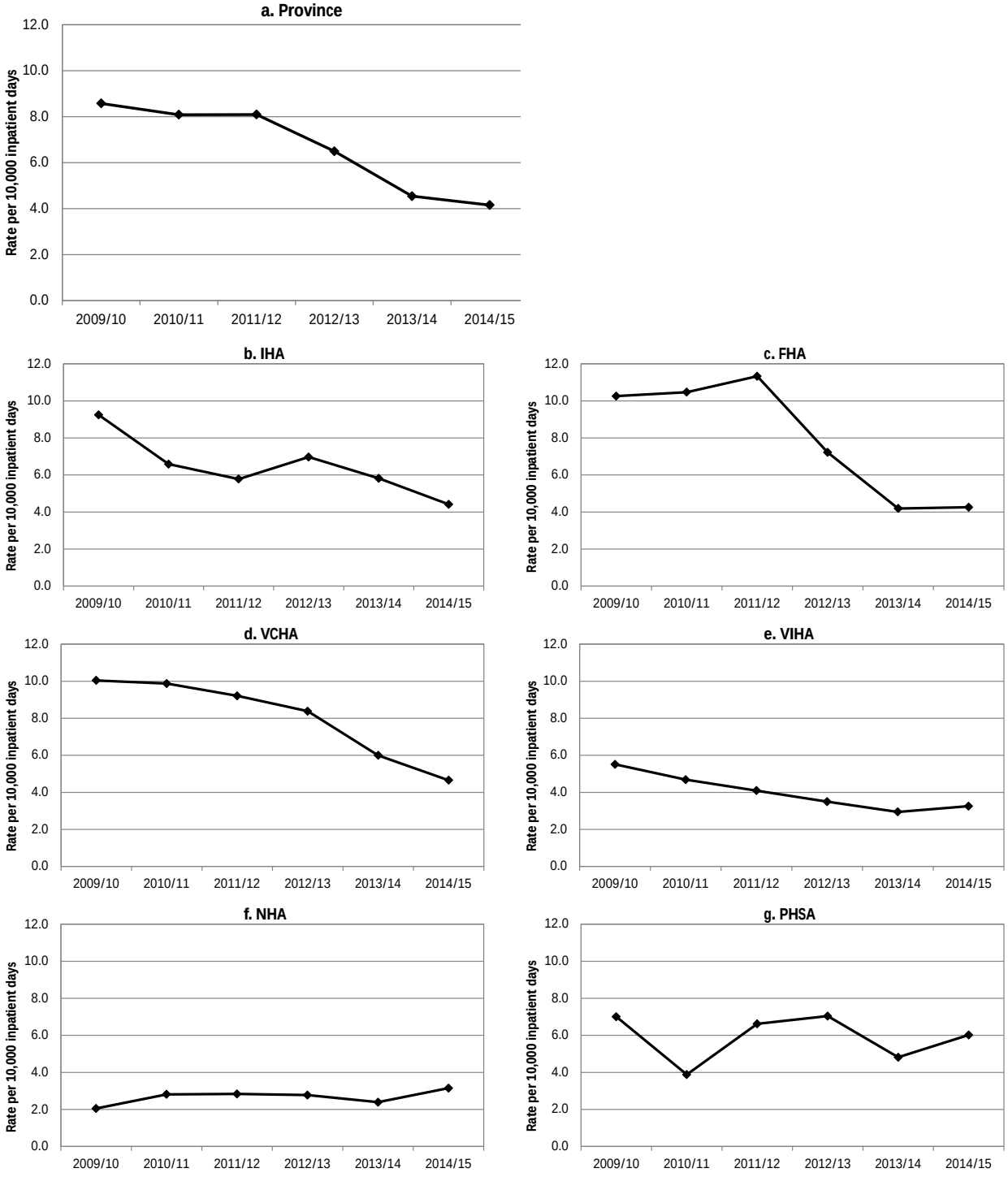
Table 1. Rate of new CDI associated with the reporting facility per 10,000 inpatient days by fiscal quarter and health authority, 2014/15

Quarter	Q1	Q2	Q3	Q4	Annual
IHA	5.3 (4.0-6.9)	3.0 (2.1-4.2)	4.3 (3.2-5.7)	4.9 (3.9-6.2)	4.4 (3.8-5.1)
FHA	4.3 (3.5-5.2)	3.8 (3.1-4.7)	3.0 (2.4-3.8)	5.4 (4.7-6.3)	4.3 (3.9-4.7)
VCHA	4.7 (3.7-6.0)	4.1 (3.2-5.2)	3.9 (3.0-5.0)	5.6 (4.7-6.7)	4.7 (4.2-5.2)
VIHA	2.8 (2.0-4.0)	3.0 (2.1-4.2)	3.5 (2.6-4.8)	3.5 (2.7-4.6)	3.3 (2.8-3.8)
NHA	1.5 (0.7-3.2)	5.0 (3.3-7.6)	2.9 (1.7-5.0)	3.1 (2.0-4.8)	3.1 (2.4-4.1)
PHSA	3.2 (1.3-8.3)	6.6 (3.4-13.1)	7.7 (4.0-14.6)	6.6 (3.3-13.0)	6.0 (4.2-8.6)
Province	**4.1 (3.6-4.6)**	**3.7 (3.3-4.2)**	**3.6 (3.1-4.0)**	**4.9 (4.5-5.4)**	**4.2 (3.9-4.4)**

Trends of CDI associated with the reporting facility

Overall the rate of CDI associated with the reporting facility has decreased since 2009/10. The downward trend was statistically significant at the provincial level (Figure 2.a), as well as four HAs (IHA, FHA, VCHA and VIHA) (Figure 2.b-e). The provincial rate decreased by 51.2% from 8.6 per 10,000 inpatient days in 2009/10 to 4.2 per 10,000 inpatient days in 2014/15.

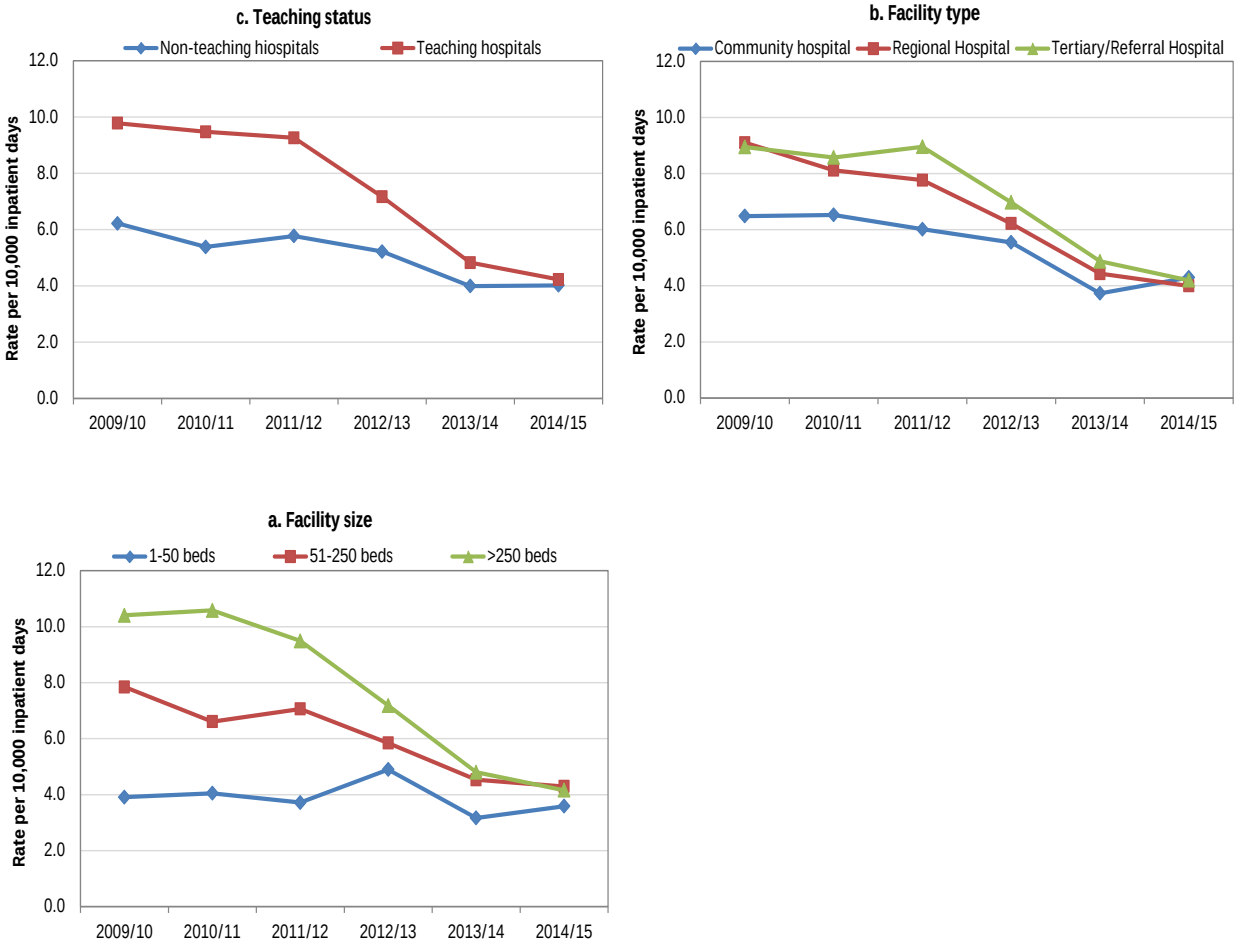
Figure 2. Annual rate of new CDI associated with the reporting facility per 10,000 inpatient days by health authority, 2009/10 - 2014/15



CDI rates are also analyzed by hospital size, hospital type, and teaching status. The three hospital size categories are 1-50 beds, 51-250 beds, and >250 beds. The three hospital types are tertiary/referral, regional hospitals, and community hospitals. There are two hospital teaching categories: teaching and non-teaching. The categories of hospitals are mutually exclusive within each group, but not exclusive between the groups. For example, larger hospitals tend to be tertiary/referral hospitals and also tend to be teaching hospitals. The latter are more likely to care for more severe and more vulnerable patients who are at higher risk for acquiring CDI.

The downward trend in annual CDI rates was statistically significant in each category of facility groups, with the exception of the facilities with 1-50 beds. As demonstrated in Figure 3, larger facilities with more than 250 beds (Figure 3.a), tertiary/referral and regional hospitals (Figure 3.b), and teaching hospitals (Figure 3.c) had a higher historical rate in 2009/2010 than other categories in the same group. During the past six years, those facilities have seen the greatest decrease. The gaps in the CDI rates between the categories in each group have narrowed over the past six years and the rates were not statistically significantly different from each other in 2014/15.

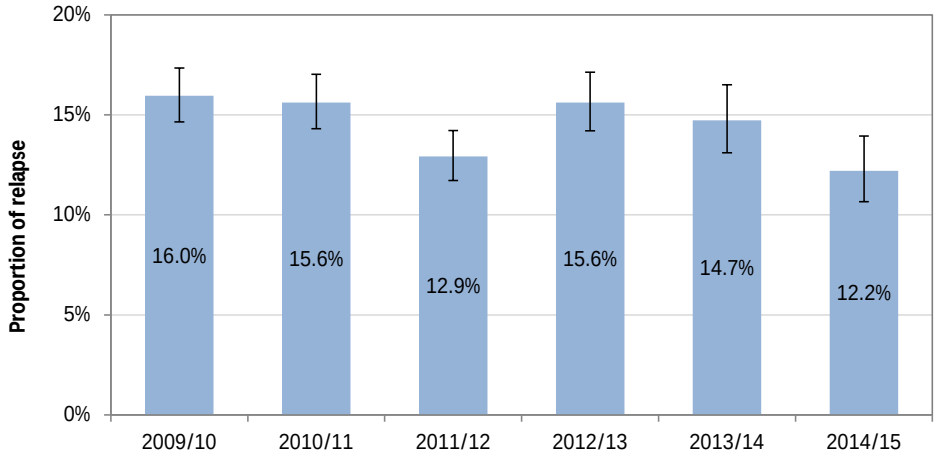
Figure 3. Annual rate of new CDI associated with the reporting facility per 10,000 inpatient days by facility group, 2009/10 - 2014/15



Relapse of healthcare-associated CDI

The HCA CDI were further classified as new infections or relapses, based on the patient's CDI history. Of the 1,524 HCA CDI cases reported in 2014/15, 186 cases were defined as relapses (12.2%, 95% CI: 10.7%-13.9%). Compared to the previous years, the proportion of relapses in 2014/15 was not significantly lower than in 2013/14, but was significantly lower than FY 2012/13. Overall, there is a statistically significant downward trend in the proportion of relapses among all HCA CDI.

Figure 4. Proportion of relapses among healthcare-associated CDI cases, 2009/10 - 2014/15

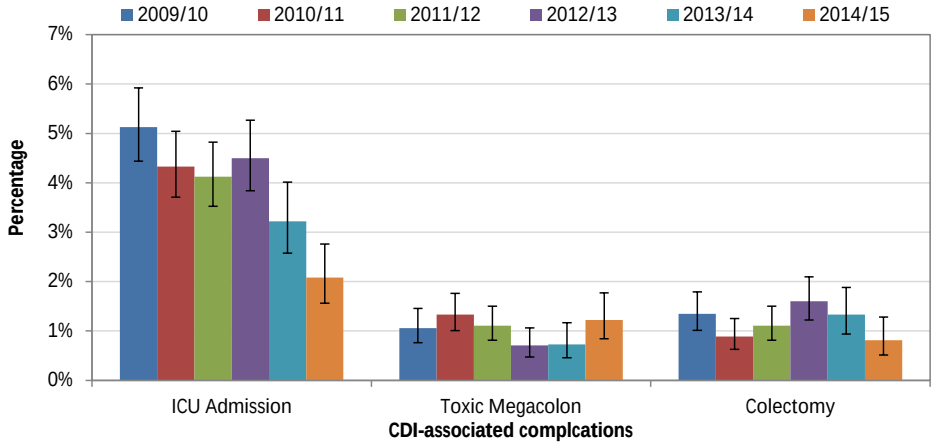


Complications within 30 days of diagnosis

All CDI cases are evaluated for CDI-associated complications at 30 days post-diagnosis, or up to the point of patient discharge or transfer (whichever comes first). These complications include admission to an intensive care unit (ICU), toxic megacolon, and entire or partial colectomy due to CDI or CDI-related complications. Among the 2,212 CDI cases in FY 2014/15 (excluding 48 cases from PHSA, which stopped collecting data on CDI-associated complications from FY 2013/14), 46 (2.1%) were admitted to ICU, 27 (1.2%) developed toxic megacolon, and 18 (0.8%) required entire or partial colectomy.

Compared to previous years (Figure 5), the percentage of ICU admissions in 2014/15 decreased, and was significantly lower than years 2009/10 through 2012/13. The percentage of toxic megacolon or colectomy was within the range of previous years.

Figure 5. CDI-associated complications within 30 days of diagnosis, 2009/10 - 2014/15



Discussion

The number of CDI cases and rate of new cases of CDI associated with the reporting facility continued to decline in FY 2014/15, reaching the lowest level since provincial CDI surveillance began. The decrease was observed in the majority of facilities, especially in the large tertiary hospitals, regional hospitals, and teaching hospitals. The proportion of relapses and ICU admissions due to CDI also decreased over the past three years. These decreases occurred despite two changes to the surveillance methodology. The first was a change in the laboratory protocol for detection of *C. difficile*, when a more sensitive and faster testing method was introduced to the medical microbiology laboratories in 2010 and 2011 (except for VCH, which had already commenced the new testing in 2008) which would be expected to detect more cases of CDI. The second change was during Q4 FY 2011/12 to Q1 FY 2012/13, when two HAs started to apply stringently the frequency of documented diarrheal episodes in defining CDI cases. Given that CDI rates continued to decrease for two fiscal years following the most recent changes, the decreases in the past two years can be seen as reliable, and could be largely attributed to the intervention measures implemented by health authorities and facilities, such as stricter guidelines on antibiotic use, introduction of antimicrobial stewardship, early identification, case management, environmental cleaning, and hand hygiene campaigns.

The rates of CDI were usually higher in the larger tertiary or regional hospitals, as demonstrated during the years 2009/10 - 2013/14 (6), because those hospitals are more likely to care for more severely ill and vulnerable patients who are at higher risk for acquiring CDI. After considerable decreases in those hospitals over the past six years, it is interesting to note that the difference in the CDI rates was not statistically significant between different categories within each group in FY 2014/15. This may indicate that the large, tertiary, or regional hospitals may have been successful at reducing the risks of CDI transmission. On the other hand, the CDI rate did not change significantly in the small facilities with 1-50 beds. Possible explanations might be that smaller hospitals had lower rates to begin with, having very few CDI cases, therefore it is more difficult to achieve a further decrease. In addition, slight change in the number of cases in the small hospitals, even by one case, would affect the rate greatly due to small denominator.

The decreasing trend in the provincial rate of CDI slowed down in FY 2014/15 compared to the previous two years 2012/13 and 2013/14. Especially in Q4 of FY 2014/15, the provincial quarterly rate of CDI increased significantly for the first time after a continual decrease for eight quarters. The increase occurred mostly in the facilities in FHA and VCHA, and no outbreaks of CDI were reported. The increase in Q4 of FY 2014/15 may be partly associated with norovirus activity in long-term care facilities and acute care facilities during that period, resulting in more diarrheal specimens being tested and therefore more *C. difficile* being identified. FHA and VCHA continue to closely monitor CDI rates and trends in their facilities.

Methicillin-resistant *staphylococcus aureus* (MRSA)

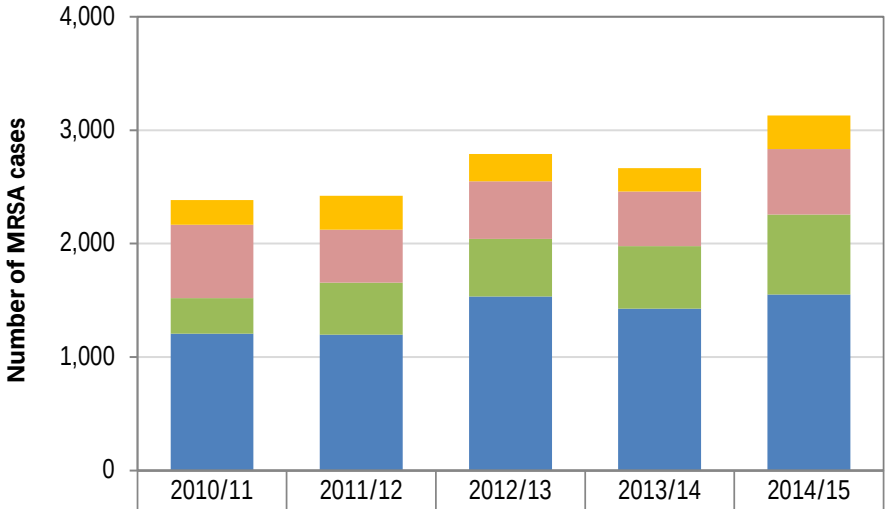
Methicillin-resistant *Staphylococcus aureus* (MRSA) is a type of *S. aureus* that has become resistant to certain antibiotics such as methicillin, penicillin, amoxicillin, etc., and is thus more difficult to treat. MRSA often lives on the skin or in the nose of healthy people without causing symptoms (this is called colonization). Sometimes it can cause infections; most are minor skin and soft tissue infections (e.g. boils or abscesses) and can be treated without antibiotics. In rare cases, MRSA can cause severe invasive infections such as pneumonia (i.e. respiratory tract) and septicemia (i.e. bloodstream).

MRSA is primarily transmitted by direct skin-to-skin contact or contact with contaminated items or surfaces. Initially, MRSA was seen in people who are taking antibiotics or who have healthcare encounters. In the past decades, MRSA has also been found frequently in people who have no contact with the healthcare system (8). The following data summarize the newly identified cases of MRSA among inpatients in the fiscal year 2014/15, with a focus on the MRSA cases associated with the reporting facility.

Overview of MRSA cases

A total of 3,130 cases of MRSA were newly identified among inpatients in BC acute care facilities during 2014/15. This represents a 17.7% increase from the 2,665 cases in 2013/14 (Figure 6). Overall, the number of MRSA cases has increased over the past five years.

Figure 6. Number of newly identified MRSA cases in BC acute care facilities, 2010/11 - 2014/15



	2010/11	2011/12	2012/13	2013/14	2014/15
Unknown	218	299	241	207	297
CA	648	467	506	479	578
HCA with another facility	312	457	507	553	703
HCA with the reporting facility	1,207	1,198	1,535	1,426	1,552
Total number of MRSA cases	2,385	2,421	2,789	2,665	3,130

HCA: healthcare-associated; CA: community-associated

Of the total 3,130 cases, 1,552 (49.5%) were HCA with the reporting facility, 703 (22.5%) were HCA with another facility, 578 (18.5%) were CA, and 297 (9.5%) were of unknown association. Compared to the previous four years, the number of HCA MRSA associated with both the reporting facility and another facility increased in FY 2014/15 (Figure 6).

Since 2013/14, all HCA MRSA cases associated with the reporting facility were further classified as either associated with the current admission or with a previous encounter with the reporting facility in the last twelve months. Among the 1,552 cases associated with the reporting facility, 740 cases (47.7%) were associated with the current admission to the reporting facility. This was an 18.8% decrease from 911 cases in 2013/14. The remaining 812 cases (52.3%) were associated with a previous encounter with the reporting facility in the last twelve months, a 78.9% increase from 454 cases in 2013/14.

Rate of new MRSA associated with the reporting facility in 2014/15

The provincial annual rate of new MRSA associated with the reporting facility was 4.9 per 10,000 inpatient days, with 95% CI of 4.7 - 5.1. The rate varied by fiscal quarter and HA in 2014/15 (Table 1). The provincial rate was lowest in Q1 and highest in Q2. The Q2 rate was significnatly higher than Q1 and Q3, and was non-signicantly higher than Q4 (Table 2).

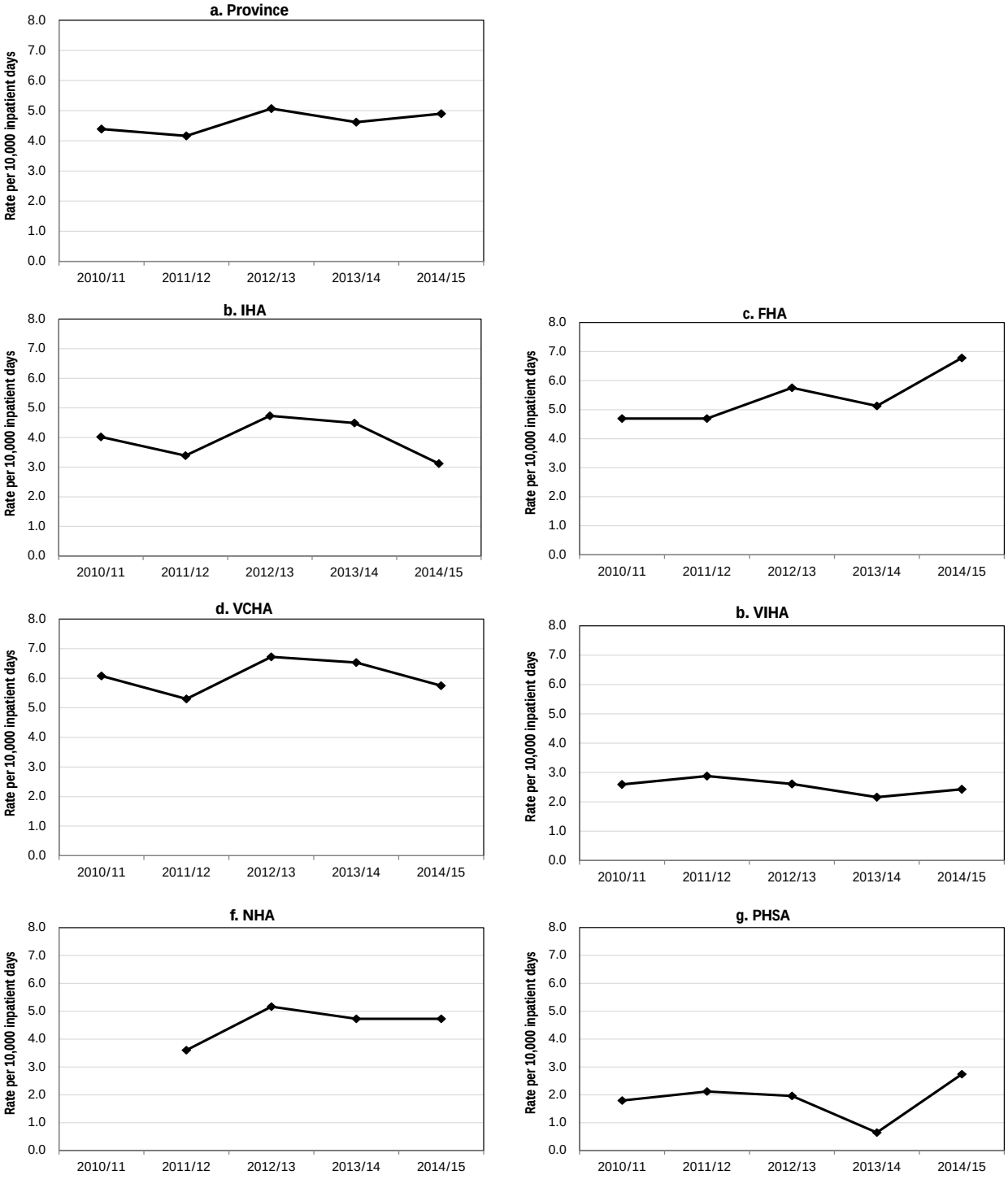
Table 2. Rate of new MRSA associated with the reporting facility per 10,000 inpatient days by fiscal quarter and health authority, 2014/15

Quarter	Q1	Q2	Q3	Q4	Total
IHA	3.6 (2.7-4.9)	3.3 (2.4-4.6)	2.5 (1.8-3.4)	3.2 (2.5-4.2)	3.1 (2.7-3.6)
FHA	5.2 (4.4-6.2)	7.9 (6.9-9.1)	5.8 (4.9-6.8)	7.7 (6.9-8.7)	6.8 (6.3-7.3)
VCHA	4.3 (3.3-5.5)	7.3 (6.0-8.8)	5.2 (4.2-6.5)	6.1 (5.1-7.2)	5.7 (5.2-6.4)
VIHA	2.9 (2.1-4.0)	2.1 (1.5-3.1)	2.5 (1.8-3.5)	2.3 (1.7-3.0)	2.4 (2.1-2.9)
NHA	2.9 (1.8-4.7)	6.4 (4.4-9.2)	5.8 (4.0-8.5)	4.4 (3.0-6.4)	4.7 (3.9-5.8)
PHSA	1.7 (0.7-4.5)	2.2 (0.9-5.2)	4.3 (2.3-8.1)	2.8 (1.3-6.2)	2.7 (1.8-4.1)
Province	4.1 (3.6-4.6)	5.7 (5.2-6.3)	4.4 (4.0-4.9)	5.3 (4.9-5.8)	4.9 (4.7-5.1)

Trend of new MRSA associated with the reporting facility

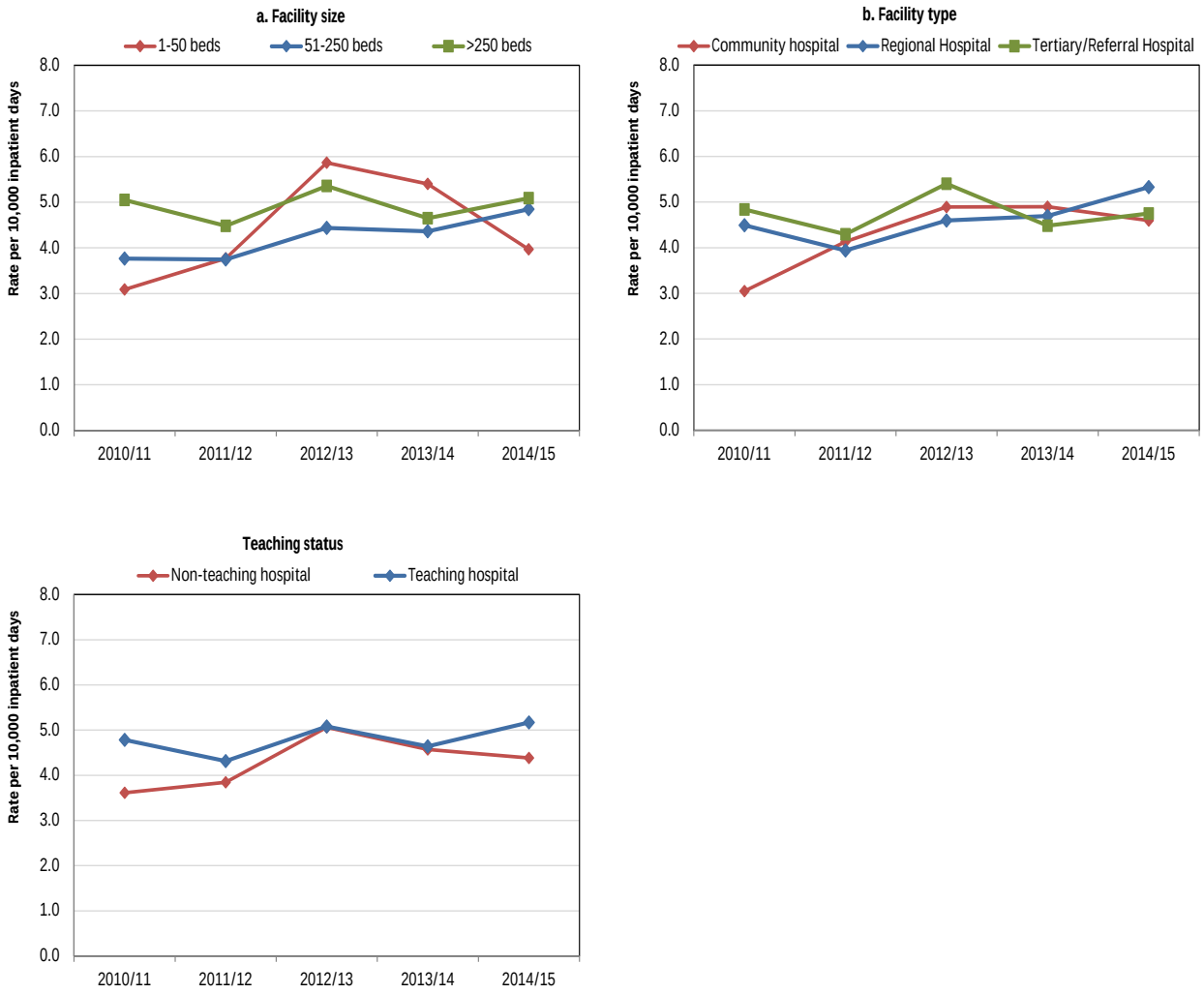
The provincial annual rate of new MRSA associated with the reporting facility in 2014/15 was not statistically significantly different from FY 2013/14 and FY 2012/13, and was significantly higher than 2010/11 and 2011/12 (Figure 7.a). The provincial annual rates of MRSA had statistically significant upward trend from 2010/11 to 2014/2015 (Figure 7.a), but the direction of the trend varied among HAs during this period (Figure 7.b-g).

Figure 7. Annual rate of new MRSA associated with the reporting facility per 10,000 inpatient days by health authority, 2010/11 - 2014/15



The MRSA rate in those facilities with more than 250 beds and in tertiary hospitals fluctuated over the past five years, whereas in facilities with 51-250 beds, in community hospitals and in regional hospitals, the rate generally increased during this period (Figure 8).

Figure 8. Annual rate of new MRSA associated with the reporting facility per 10,000 inpatient days by facility group, 2010/11 - 2014/15



Discussion

The upward trend in the provincial rate of MRSA associated with the reporting facility was surprising, because HAs have enhanced intervention measures on HAIs over the last few years. Such measures include the introduction of antimicrobial stewardship, enforcing environmental cleaning, and encouraging hand hygiene compliance. These combined with other targeted interventions have successfully brought down CDI in acute care facilities, but MRSA incidence did not decline as expected.

Current prevention and control strategies for HAIs including MRSA have mostly been hospital-based and as a result are expected to have little impact outside the hospital setting. MRSA has been isolated from a wide variety of different environments, including community settings, such as public facilities, libraries, athletic centres, public transportation, and natural marine and fresh water environments (9). About 1% of the general population are colonised with MRSA [10]. Patients in the community have been a source of MRSA in healthcare settings.

Furthermore, the classification of HCA MRSA in this report was based on the patient's healthcare encounter history in the past twelve months, which depends on the quality and accessibility of the patient information system. For those MRSA cases that were associated with a previous encounter with the reporting facility or another facility (so-called "healthcare associated, community onset" by the National Healthcare Safety Network [NHSN] of the Center for disease Control and Prevention of the Unite States), it is difficult to determine whether MRSA was actually acquired during the previous healthcare encounter or in the community.

MRSA prevention and control measure may have more effect on cases associated with current admission to the reporting facility (so-called "healthcare associated, facility onset" by NHSN) than those with "healthcare associated, community onset." As reflected in the 2014/15 surveillance results, the number of MRSA cases associated with current admission in the reporting facility decreased by 18.8% compared to the previous year, while MRSA associated with a previous encounter with the reporting facility increased by 78.9%. The number of MRSA associated with another facility also increased from 2013/14.

MRSA in this report represents incidence of MRSA either colonization or infection in BC acute care facilities. Recent data showed that the HCA MRSA infection rate was on the decline in the 57 large, university-affiliated tertiary care hospitals (including 11 hospitals in BC) participating in the Canadian Nosocomial Infection Surveillance Program (CNISP) (11), as well as many hospitals in the United States (12, 13). Because the surveillance data submitted to PICNet did not separate MRSA infection from colonization and MRSA infection developed following MRSA colonization was not captured, further analysis on the MRSA infections was not possible.

Carbapenemase-producing organisms (CPO)

Carbapenems are a class of antibiotic usually reserved to treat serious infections, and are often considered one of the antibiotic treatments of last resort. Recently, some bacteria have developed resistance to carbapenems by producing carbapenemase — an enzyme that breaks down the structure of these antibiotics rendering the organism resistant. These very antibiotic-resistant bacteria are called carbapenemase-producing organisms (CPO). People may have CPO as part of their gut bacterial flora without it causing symptoms (this is called colonization). However, when it causes an infection, there are limited antibiotic treatment options and poor clinical outcomes.

The carbapenemase genes associated with CPO is encoded by highly transmissible genes (14). These genes are typically located on transposons or plasmids which can facilitate transmission of resistance within and between bacterial species (15). Some of the commonly identified carbapenemases include New-Delhi Metallobetalactamase (NDM), *Klebsiella pneumoniae* carbapenemases (KPC), Verona integron–encoded metallo-β-lactamase (VIM), oxacillinase-48 (OXA-48), imipenem (IMP), and *Serratia marcescens* enzyme (SME). The NDM genes were first identified from people who had healthcare exposure in South Asia, and are considered common in healthcare settings there. KPC-producing organisms were first identified in the United States, and are now regularly found in many countries. They have now spread widely around the world (14).

In BC, the first CPO-harboring bacteria were initially introduced into the healthcare system as early as 2008 by travelers returning from endemic regions, who often had exposures to invasive healthcare procedures while there (16). The medical microbiology laboratories across the province have been collaborating on testing for and monitoring of CPOs since 2010. Following an outbreak in a BC hospital in February 2014, mandatory provincial surveillance for CPOs was introduced to BC acute care facilities in July 2014. The provincial surveillance protocol recommended: a) systematic screening for CPOs among patients who had exposure to healthcare outside Canada, or who had contact with a CPO patient or patient's environment; and b) collecting related data to monitor characteristics associated with CPOs to inform best patient care practice. The following data represents the number of new cases of CPO genes identified from July 18, 2014 to March 31, 2015. The historical number of CPO genes identified in BC is also provided.

New cases of CPO in part of 2014/15

The priority of molecular testing for CPO at BCCDC Public Health Laboratory (BCPHL) includes genotyping of carbapenemase genes NDM, KPC, OXA-48, VIM, and IMP. SME gene testing is performed only on *Serratia marcescens*. Other carbapenemase genes, such as OXA-1, OXA-12, OXA-23, OXA-24, OXA-51, OXA-58, etc, are tested among some classes of bacteria that might harbour other carbapenemase genes (e.g. Pseudomonas species), and where indicated based on preliminary testing of the bacteria.

A total of 49 new cases of CPO genes were identified in BC acute care facilities between July 18, 2014 and March 31, 2015. NDM was a predominant carbapenemase gene, accounting for 61.2% of CPO cases, followed by OXA-48 (16.3%), and KPC (6.1%). Other genes identified include OXA-23, OXA-24, and OXA-51 (Table 3).

Table 3. Number of new cases of CPO identified in BC acute care facilities by carbapenemase gene, 2014/07/18 - 2015/3/31

Gene	Number of CPO cases	Percent
NDM	30	61.2%
OXA-48	8	16.3%
KPC	3	6.1%
VIM	1	2.1%
SME	1	2.1%
Other genes	6	12.2%
Total	**49**	**100.0%**

Among the 49 new cases of CPO, 31 (63.3%) were identified from isolates submitted from FHA, 11 cases (22.4%) were from VCHA, 7 cases (14.3%) were from VIHA, and no cases were from other HAs (Table 4).

Table 4. Number of new cases of CPO genes identified in BC acute care facilities by health authority, 2014/7/18 - 2015/3/31

Health authority	Number of CPO cases	Percent
IHA	0	0
FHA	31	63.3%
VCHA	11	22.4%
VIHA	7	14.3%
NHA	0	0
PHSA	0	0
Total	**49**	**100.0%**

Healthcare exposure history of the new CPO cases

The new CPO cases were investigated for healthcare encounter history. Twenty-seven (55.1%) of the 49 new cases reported healthcare exposure outside Canada in the past twelve months (or the past six months for the cases in FHA). Seven patients (14.3%) were transferred from a care unit or healthcare facility with high CPO prevalence, including three cases (6.1%) that were transferred from out of BC. Nine patients (18.4%) had close contact with a CPO patient or the CPO patient's environment (Table 5). There were eleven cases (22.4%) who had no evidence of a health encounter outside Canada, or contact with a known CPO patient, or a stay in the unit with high CPO prevalence in the past twelve or six months.

Table 5. Healthcare exposure history of the new CPO cases, 2014/07/18 - 2015/3/31

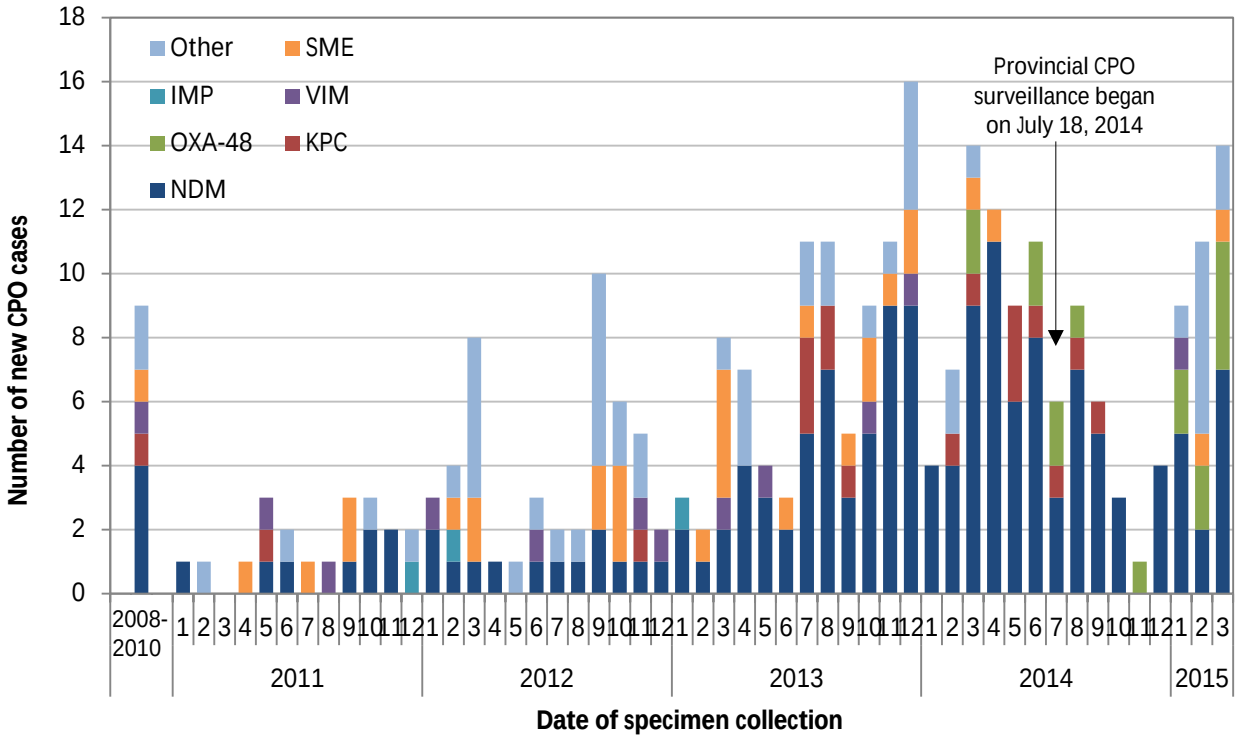
Patient travel history	Yes	No	Unknown/ missing
Healthcare exposure outside Canada	27	21	1
Transferred from a unit with high CPO prevalence	7*	37	5
Close contact with CPO patient or patient's environment	9	26	14

* Including 3 cases transferred from out of BC

Total CPO cases identified in BC

Prior to the start of the provincial CPO surveillance in July 2014, CPO testing data were already being collected by BCPHMRL and the microbiology laboratories in BC. By March 31, 2015, a total of 286 new cases of CPO have been identified since 2008. The most common carbapenemase gene identified was NDM, accounting for 54.2 % of new CPO cases, followed by SME (10.5%), KPC (6.3%), OXA-48 (4.2%), and VIM (4.2%) (Figure 9). Other carbapenemase genes identified, such as OXA-1, OXA-12, OXA-23, OXA-24, OXA-4814, OXA-51, OXA-58, etc, accounted for 18.2% of CPOs.

Figure 9. Number of new CPO cases by carbapenemase gene in BC, 2008 – March 2015



Notes:

i. A new CPO case was a carbapenemase gene that was identified for the first time, or a new gene was identified from the same patient, regardless the species of organism. Duplicate positive of the same gene from the same patient were excluded. Multiple carbapenemase genes identified from the same patient were counted as separate CPO cases.

ii. The number of new CPO cases included CPO identified from the isolates submitted by the community laboratories and the isolates that were recovered from the patients in long-term care facilities and outpatient clinics.

iii. The data prior to the July 17, 2014 were based on the testing at BCPHMRL from the isolates submitted voluntarily.

Discussion

CPOs remained uncommon in BC healthcare facilities in 2014/15; however, the number of CPOs identified has been increasing gradually since 2008. With the implementation of provincial surveillance program, along with increased awareness among clinicians, it is expected that total number of CPO cases may increase due to better screening and detection, while institutional transmission may be reduced. One of the goal of screening high-risk patients is to detect CPOs that are likely imported to BC before they are transmitted within our healthcare facilities. Continuing surveillance for CPOs will enable us to closely monitor the trends of these organisms in BC healthcare settings.

Rapid spread of CPOs in developed countries has been associated with increasing international travel and medical tourism (17,18). About 21% of travelers become colonized with AROs, including CPOs, after visiting regions with poor sanitation (19). Among the new cases of CPOs identified in BC during part of 2014/15, over half of them (27/49 cases) reported healthcare encounters outside Canada in the past six to twelve months. International travel and medical tourism may also play an important role in the variations of CPO rates among the HAs in British Columbia(18), because the regions that have more people that tend to travel to endemic countries or regions are more likely to have acquired and imported CPO when they return home.

On the other hand, a significant proportion of CPO cases (11/49 cases) had no reported healthcare exposure outside Canada or close contact with a known CPO patient. It is unclear whether they acquired CPO within BC or whether they did not report all healthcare encounter history, especially outside Canada.

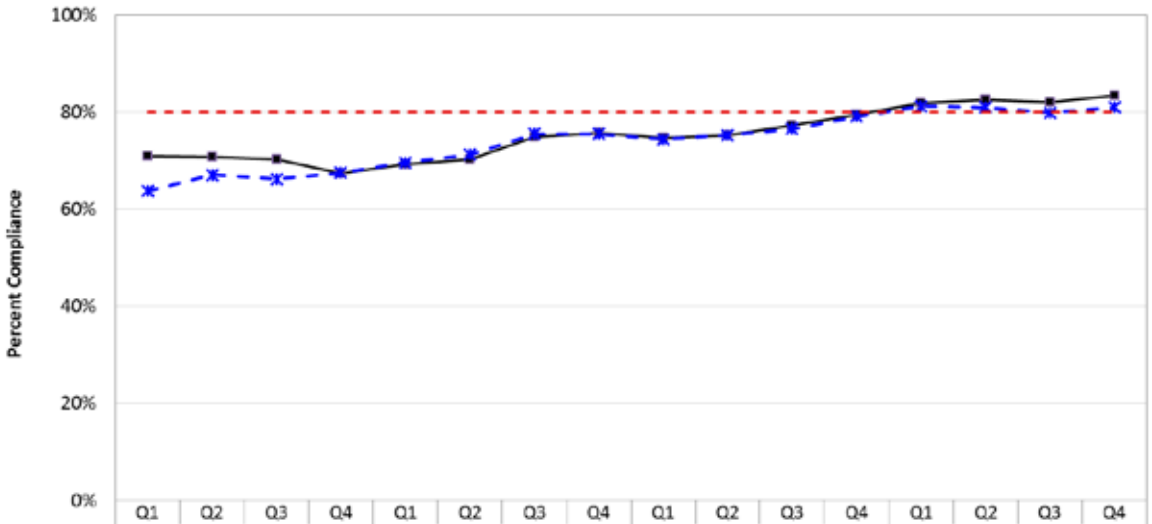
Hand cleaning compliance (HCC)

Hand cleaning, i.e., washing hands with soap and water or cleaning with alcohol-based hand rub (sanitizer), has long been considered the most effective and simplest way of preventing HAIs and limiting the transmission of pathogens, including AROs. To improve and sustain hand cleaning compliance (HCC) in healthcare facilities, BC's Provincial Hand Hygiene Working Group (PHHWG), a committee that was created by the Ministry of Health in 2010, recommended facility-wide audits of HCC and set the target performance at 80% by the end of FY 2014/15. Auditing results of HCC among healthcare workers, including nursing staff, physicians, clinical support services and others such as care aides, food services, and housekeeping, are reported to the senior leaders and fed back to the care unit. The following data present the percent compliance among acute care facilities in FY 2014/15 to demonstrate improvement of HCC from FY 2011/12, when auditing began. To reduce the impact of variations in the number of opportunities observed in different HAs, provincial compliance was weighted by total impatient days during the auditing quarter in each HA.

Overall hand cleaning compliance

Provincial overall compliance has increased gradually from Q1 of 2010/11 and surpassed the target performance of 80% in each quarter of 2014/15 (Figure 10). After weighting by inpatient days in HAs, the provincial quarterly compliance was still over 80%. The upward trend of HCC was statistically significant from Q1 of 2010/11 to Q4 of 2014/15 (χ^2 for trend = 9318.43, $p < 0.001$ for un-weighted HCC; χ^2 for trend = 9324.45, $p < 0.001$ for weighted HCC).

Figure 10. Overall provincial hand cleaning compliance by quarter and year, 2011/12 – 2014/15



	2011/12				2012/13				2013/14				2014/15			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Total opportunities	24491	25459	20960	31657	36974	40001	43239	54854	44834	44050	46100	58009	49567	52225	59151	78864
Number compliant	17363	18028	14743	21311	25572	28096	32391	41577	33467	33149	35597	46089	40574	43092	48541	65772
Percent compliance	71%	71%	70%	67%	69%	70%	75%	76%	75%	75%	77%	79%	82%	83%	82%	83%
Weighted compliance	64%	67%	66%	68%	70%	71%	76%	75%	74%	75%	77%	79%	81%	81%	80%	81%
Target compliance	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%

Note:

i. Data were aggregated by fiscal quarter for FHA, PHC, VIHA, and NHA, and by calendar quarter for IHA, VCHA (except PHC) and PHSA.

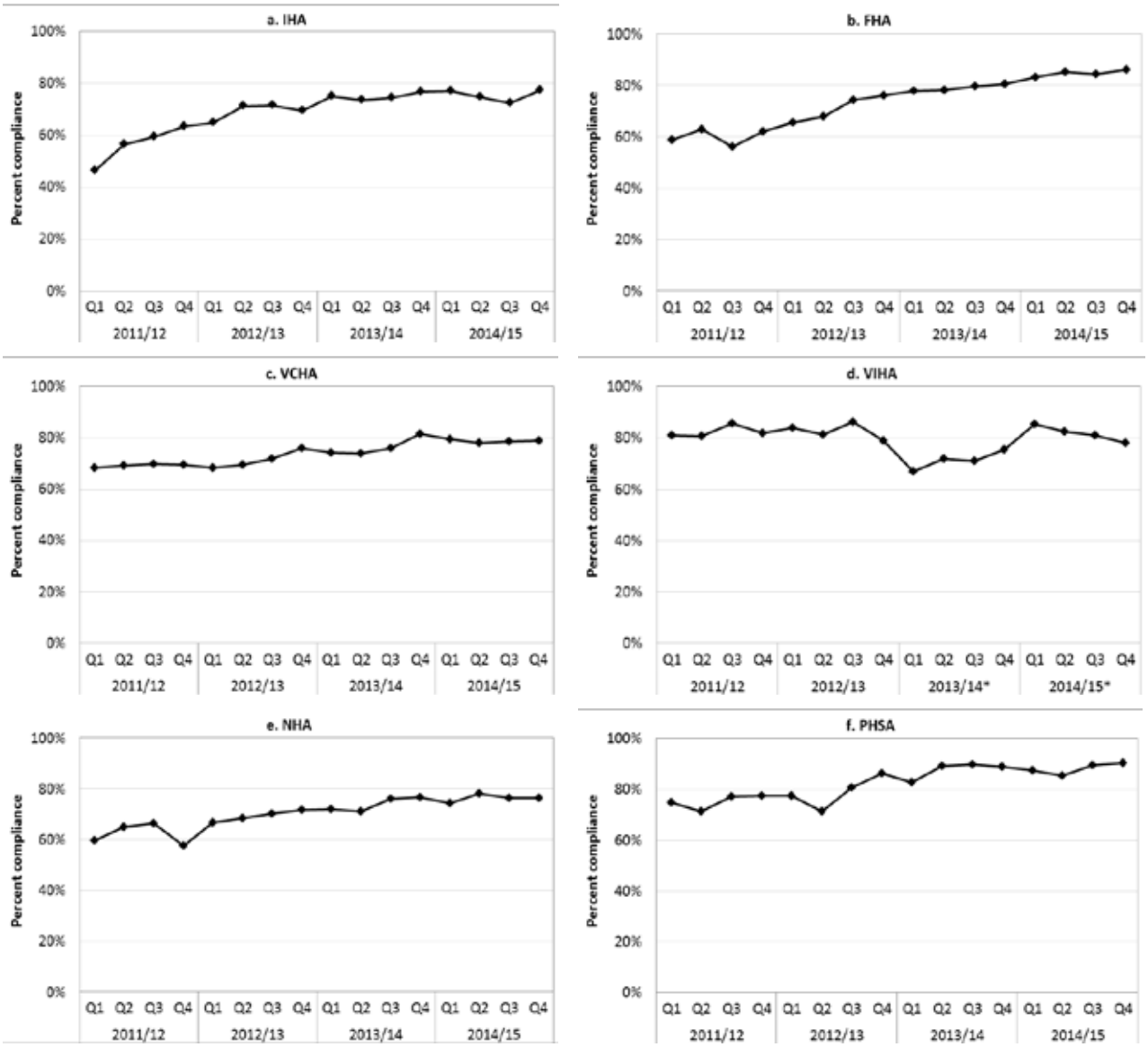
ii. The provincial weighted compliance was calculated using the proportions of inpatient days in the health authorities as the weighting values.

iii. The provincial target, established by the provincial Hand Hygiene Working Group (PHHWG), was to achieve 80% compliance by the end of fiscal year 2014/15 (March 31, 2015).

Hand cleaning compliance by health authority

The improvement in hand cleaning compliance was observed in each HAs, except in VIHA (Figure 11.d), which reported lower percent compliances from Q1 of 2013/14 when dedicated auditors were recruited to conduct auditing in some large facilities.

Figure 11. Hand cleaning compliance by health authority, 2011/12 – 2014/15



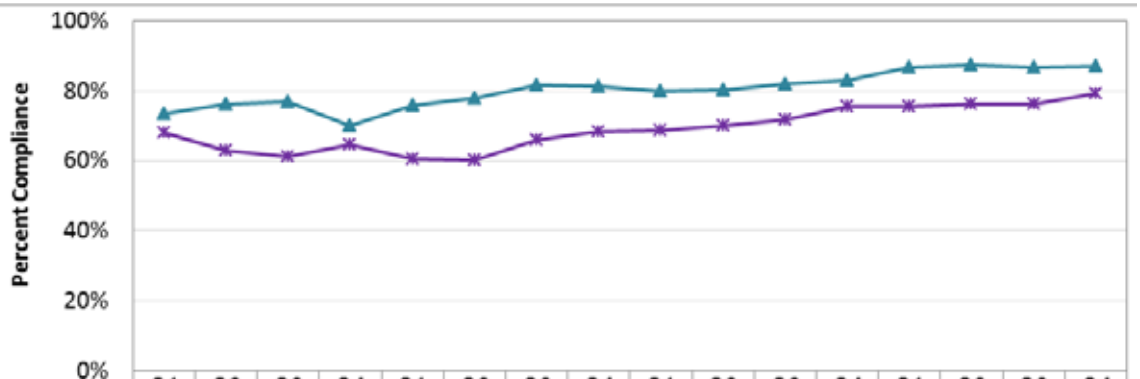
Note: FHA, VCHA, VIHA and NHA included audit results that were measured by staff from the same facility (self-audit)

*Dedicated hand hygiene auditors were brought to some large facilities in VIHA from Q1 of 2013/14

Hand cleaning compliance by moment of before or after contact

HCC has increased significantly both before and after contact over the past four years (Figure 12). However, compliance after contact was always significantly higher than compliance before contact in each quarter, indicating that healthcare workers are more vigilant with hand cleaning after contact with patients.

Figure 12. Provincial hand cleaning compliance by moment of contact, 2011/12 – 2014/15



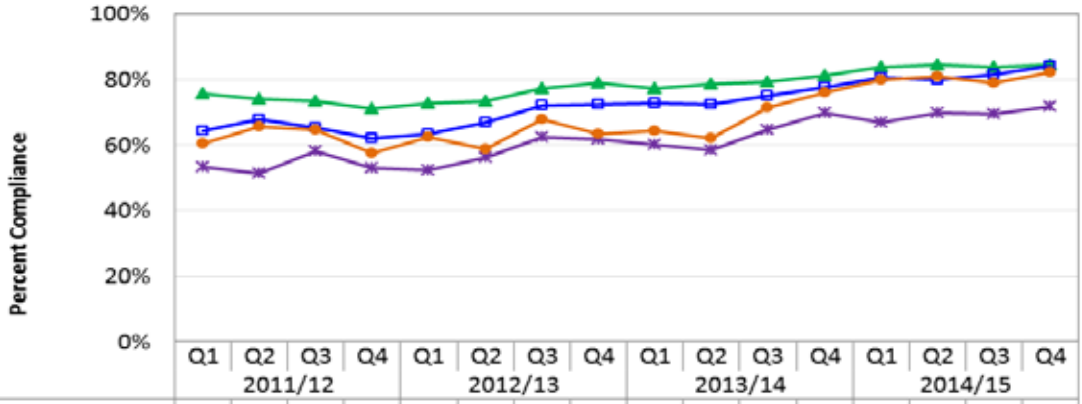
	Q1 2011/12	Q2 2011/12	Q3 2011/12	Q4 2011/12	Q1 2012/13	Q2 2012/13	Q3 2012/13	Q4 2012/13	Q1 2013/14	Q2 2013/14	Q3 2013/14	Q4 2013/14	Q1 2014/15	Q2 2014/15	Q3 2014/15	Q4 2014/15
Before contact	68%	63%	61%	65%	60%	60%	66%	68%	69%	70%	72%	75%	76%	76%	76%	79%
After contact	74%	76%	77%	70%	76%	78%	82%	81%	80%	80%	82%	83%	87%	87%	87%	87%

Note: Before contact includes the moments before contact with a patient or the patient's immediate environment (e.g., around their bedside). After contact includes the moments after contact with a patient or the patient's immediate environment (e.g., around their bedside)

Hand cleaning compliance by healthcare worker

Nursing staff consistently had the highest hand cleaning compliance among all healthcare workers and physicians had the lowest compliance (Figure 13). The HCC in each group of healthcare providers has increased significantly in the past four years.

Figure 13. Provincial hand cleaning compliance by healthcare worker, 2011/12 – 2014/15



	Q1 2011/12	Q2 2011/12	Q3 2011/12	Q4 2011/12	Q1 2012/13	Q2 2012/13	Q3 2012/13	Q4 2012/13	Q1 2013/14	Q2 2013/14	Q3 2013/14	Q4 2013/14	Q1 2014/15	Q2 2014/15	Q3 2014/15	Q4 2014/15
Nursing Staff	76%	74%	73%	71%	73%	74%	77%	79%	77%	78%	79%	81%	84%	84%	84%	84%
Physician	53%	51%	58%	53%	52%	56%	62%	62%	60%	59%	64%	70%	67%	70%	69%	72%
Clinical Support Services	64%	68%	65%	62%	63%	67%	72%	73%	73%	72%	75%	78%	80%	80%	81%	84%
Other	60%	66%	65%	57%	62%	59%	68%	63%	64%	62%	71%	76%	80%	81%	79%	82%

Discussion

It is a great achievement that the overall provincial compliance in 2014/15 surpassed the target performance set by PHHWG in 2011, which was to reach 80% of compliance by the end of 2014/15. The improvement in HCC reflected the success of collaborative efforts by HAs, healthcare workers, and PHHWG to enhance patient safety and care quality. Over the past four years, HAs have launched numerous campaigns and educational initiatives to improve awareness of hand cleaning compliance. These include: 1) encouraging all HCW to incorporate hand cleaning into their practice routines before and after direct patient care; 2) ensuring that hand cleaning products are readily available for all staff and patients; 3) reporting performance back to the care units and to senior leaders, physicians, and managers across the health authorities, and to the public; 4) using a variety of communications such as posters, newsletters, and posting of results on units; 5) identifying new initiatives and opportunities to improve the compliance before patient contact and to engage physicians more effectively. The HAs and healthcare facilities also worked hard to address barriers identified by staff, such as availability of sinks and hand cleaning products, and a culture where people feel too busy to wash their hands when there is an opportunity. A perception survey on hand hygiene among healthcare workers in BC in 2012 found that about 70-80% of respondents reported empty or broken soap, alcohol rub, or paper towel dispensers. A follow-up survey in 2013 reported only 5-6% of empty or broken soap, alcohol rub, or paper towel dispensers. Together, these efforts have effectively increased HCC among the healthcare workers in BC acute care facilities.

There are still many challenges faced by HAs and PHHWG. As noted, compliance continues to vary by moments of before/after contact, by healthcare worker, and by HA. Compliance before contact with a patient or patient's environment is still below the target performance, and physicians did not perform well in hand cleaning, indicating that there is room for improvement in this healthcare provider group. This finding is consistent with the literature.

HCC in this report was based on audit data from each HA. Auditing methodology varied among facilities, even within HAs. Self-auditing, which was used in some small facilities, tends to report higher compliance than by dedicated auditors (20). However the main purpose of auditing is intended to encourage compliance with and improve awareness of hand hygiene among healthcare workers, rather than comparison of percent compliances between HAs.

Although hand hygiene is an important activity for the prevention and control of HAIs, HAI acquisition is complex and requires multi-faceted intervention approaches.

Conclusion

In FY 2014/15, CDI rates continued to decrease, reflecting the success of CDI prevention and control strategies in the HAs, such as antimicrobial stewardship, environmental cleaning, and hand hygiene. However, these measures did not have significant impact on the incidences of HCA MRSA, which showed an upward trend in the last five years, even though the number of MRSA associated with current admission to the reporting facility decreased in 2014/15.

Additionally, the worldwide spread of CPO is of growing concern; because of this, CPO was added to the provincial surveillance program in 2014. A great deal of effort has been put into the creation of this new program, and it will allow us to effectively monitor trends related to these organisms.

Hand hygiene compliance continued to increase, with the target performance being surpassed in all four quarters in 2014/15. We would like to congratulate BC's healthcare workers on this important achievement.

Link to Methodology Appendices

The details of the methodology for this report are provided in a separate document: http://s.picnet.ca/appendices201415.

Table of Acronyms

ARO	Antimicrobial-resistant organism
BC	British Columbia
CA	Community-associated
CI	Confidence interval
CDI	*Clostridium difficile* infection
CNISP	Canadian Nosocomial Infection Surveillance Program
FHA	Fraser Health Authority
FQ	Fiscal quarter
FY	Fiscal year
HA	Health authority
HAI	Healthcare-associated infection
HCA	Healthcare-associated
HCC	Hand cleaning compliance
HH	Hand hygiene
ICP	Infection control practitioner
IHA	Interior Health Authority
MRSA	Methicillin-resistant *Staphylococcus aureus*
NHA	Northern Health Authority
PCR	polymerase chain reaction
PHC	Providence Health Care
PHSA	Provincial Health Services Authority
PICNet	Provincial Infection Control Network of British Columbia
PHHWG	Provincial Hand Hygiene Working Group of British Columbia
SSC	PICNet's Surveillance Steering Committee
VCHA	Vancouver Coastal Health Authority
VIHA	Island Health Authority

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Surveillance Steering Committee

PICNet's Surveillance Steering Committee consists of representatives from each health authority and related organization, and provides guidance to PICNet's surveillance programs and assists the PICNet Management Office in implementation within the participating health authorities. The committee members during fiscal year 2014/15 were:

Dr. Elizabeth Bryce	Medical Microbiologist	VCHA
June Chen Collet	Epidemiologist	PHSA
Kelly Dillon	Infection control practitioner	IHA
Tara Donovan	Epidemiologist	FHA
Dr. Randall Dumont	Pathologist	NHA
Leslie Forrester	Epidemiologist	VCHA
Bruce Gamage	Manager	PICNet
Diana George	Epidemiologist	BCCDC
Dr. Guanghong Han	Epidemiologist	PICNet
Lisa Harris	Infection control practitioner	VCHA
Deanna Hembroff	Infection Control Regional Manager	NHA
Dr. Linda Hoang	Medical Microbiologist	BCCDC
Dr. Pamela Kibsey	Medical Microbiologist	VIHA
Kelsi Laporte	Infection control practitioner	PHSA
Tony Leamon	Epidemiologist	VIHA
Dr. Elisa Lloyd-Smith	Epidemiologist	PHC
Dr. Julie Mori	Epidemiologist	IHA
Dr. Manal Tadros	Medical Microbiologist	FHA
Dr. Peter Tilley	Medical Microbiologist	PHSA
Dr. Bing Wang	Medical Microbiologist	IHA
Valerie Wood	Infection Control Director	VIHA

References

1. The Chief Public Health Officer's Report on the State of Public Health in Canada, 2013: Infectious Disease - The Never-ending Threat. http://publichealth.gc.ca/CPHOReport
2. Ontario Agency for Health Protection and Promotion (Public Health Ontario), Provincial Infectious Diseases Advisory Committee. Best practices for surveillance of health care-associated infections in patient and resident populations. 3rd ed. Toronto, ON: Queen's Printer for Ontario; 2014.
3. Yokoe DS, Anderson DJ, Berenholtz SB, Calfee DP, Dubberke ER, Ellingson KD, et al. A Compendium of Strategies to Prevent Healthcare-Associated Infections in Acute Care Hospitals: 2014 Updates. Infection Control and Hospital Epidemiology 2014; 35(8): 967–977. DOI: 10.1086/677216.
4. Magill SS, Dumyati D, Ray SM, and Fridkin SK. Evaluating Epidemiology and Improving Surveillance of Infections Associated with Health Care, United States. Emerging Infectious Diseases 2015; 21: 1537-1542. DOI: http://dx.doi.org/10.3201/eid2109.150508
5. Vindigni SM and Surawicz CM. *C. difficile* Infection: Changing Epidemiology and Management Paradigms. Clinical and Translational Gastroenterology. 2015; 6, e99; doi:10.1038/ctg.2015.24
6. Lessa FC, Mu Y, Bamberg WM, Beldavs ZG, Dumyati GK, et al. Burden of *Clostridium difficile* Infection in the United States. New England Journal of Medicine 2015;372:825-834. DOI: 10.1056/NEJMoa1408913
7. Provincial Control Network of British Columbia. Clostridium difficile Infection (CDI) Surveillance Report For the Fiscal Year 2013/2014 (April 1, 2013 to March 31, 2014). 2014. https://www.picnet.ca/wp-content/uploads/PICNet-Annual-CDI-Surveillance-Report-2013-2014.pdf
8. Peebles E, Morris R, and Chafe R. Community-associated methicillin-resistant *Staphylococcus aureus* in a pediatric emergency department in Newfoundland and Labrador. Canadian Journal of Infectious Diseases & Medical Microbiology 2014;25:13-16.
9. Friedman L, Wallar LE, and Papadopoulos A. Environmental Risk Factors for Community-Acquired MRSA. 2015. http://www.ncceh.ca/documents/evidence-review/environmental-risk-factors-community-acquired-mrsa
10. Graham, P. L., S. X. Lin, and E. L. Larson. A U.S. population-based survey of *Staphylococcus aureus* colonization. Annals of Internal Medicine 2006;144:318-325.
11. Public Health Agency of Canada. Methicillin-resistant *Staphylococcus aureus* in Canadian acute-care hospitals: Surveillance Report January 1, 2008 to December 31, 2012. Centre for Communicable Diseases and Infection Control, Public Health Agency of Canada, 2014.
12. Kavanagh KT, Calderon LE, Saman DM, and Abusalem SK. The use of surveillance and preventative measures for methicillin-resistant *staphylococcus aureus* infections in surgical patients. Antimicrobial Resistance and Infection Control 2014; 3:18. http://www.aricjournal.com/content/3/1/18

13. Centers for Disease Control and Prevention. 2012. Active Bacterial Core Surveillance Report, Emerging Infections Program Network, Methicillin-Resistant *Staphylococcus aureus*, 2012. http://www.cdc.gov/abcs/reports-findings/survreports/mrsa12.pdf.

14. Jacob JT, Klein E, Laxminarayan R, Beldavs Z, Lynfield R, Kallen AJ, et al. Vital Signs: Carbapenem-Resistant Enterobacteriaceae. MMWR 2013;62:165-170

15. Savard P, Carroll K, Wilson LE and Perl TM. The Challenges of Carbapenemase-Producing *Enterobacteriaceae* and Infection Prevention: Protecting Patients in the Chaos. Infection Control and Hospital Epidemiology 2013;34:730-739

16. Hoang L. Global threat, provincial action: Carbapenemase-producing organisms in British Columbia. BC Medical Journal 2014;56:395

17. van der Bij AK and Pitout JDD. The role of international travel in the worldwide spread of multiresistant *Enterobacteriaceae*. Journal of Antimicrobial Chemotherapy 2012;67:2090–2100. DOI:10.1093/jac/dks214

18. Public Health Agency of Canada. Carbapenem-Resistant Gram-Negative Bacilli in Canadian acute-care hospitals: Surveillance Report January 1, 2010 to December 31, 2012. Centre for Communicable Diseases and Infection Control, Public Health Agency of Canada, 2014.

19. Kantele A, Lääveri T,Mero S,Vilkman K, Pakkanen SH, Ollgren J, et al. Antimicrobials Increase Travelers' Risk of Colonization by Extended-Spectrum Betalactamase-Producing *Enterobacteriaceae*. Clinical Infectious Diseases. 2015;60:837–846. DOI: 10.1093/cid/ciu957

20. Dhar S, Tansek, R, Toftey E, Dziekan B, Chevalier TC, Bohlinger CG, et al. Observer bias in hand hygiene compliance reporting. Infection Control and Hospital Epidemiology 2010; 31:869-70.

21. Schutze GE and Willoughby RE. Policy statement: *Clostridium difficile* Infection in Infants and Children. Pediatrics 2013;131:196–200

22. Nicholson MR, Thomsen IP and Edwards KM. Controversies Surrounding *Clostridium diffi*cile Infection in Infants and Young Children. Children 2014;1:40-47. doi:10.3390/children1010040

23. World Health Organization (WHO). Clean care is safer care: the first global patient safety challenge. http://www.who.int/gpsc/en/. Accessed on May 18, 2011

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