

National Laboratory Surveillance of Invasive Streptococcal Disease in Canada

Annual Summary 2016

**Streptococcus and STI Unit
Bacterial Pathogens Division
National Microbiology Laboratory
Public Health Agency of Canada**

**Vaccine Preventable Diseases
Centre for Immunization and Respiratory Infectious Diseases
Public Health Agency of Canada**

**Provincial and Territorial Public Health Microbiology
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EXECUTIVE SUMMARY

- ***Streptococcus pneumoniae***: 2,906 isolates causing invasive pneumococcal disease (IPD) were characterized in 2016.
- In 2015 (most recent data available at time of publication), **incidence of IPD** declined in children under <1 year of age to 14.5 cases per 100,000 population; and in seniors ≥60 years to 20.3 cases per 100,000 population. The overall crude incidence rate has remained stable averaging 9.0 cases per 100,000 population since 2013.
- **PCV7** serotypes increased in 2016 accounting for 11% of IPD. This increase can be attributed primarily to an increase of serotype 4 isolations among adults in Western Canada.
- **PCV13** serotypes accounted for 20% of overall IPD, continuing an overall decline from 36% in 2012. However, a troubling increase of PCV13 serotypes in children <2 years of age has been driven by the resurgence of serotypes 3 and 19A in this age group since 2014. Continued declines of PCV7 and PCV13 serotypes in seniors ≥65 years of age, as well as lower case rates in this age group, indicate indirect reduction of disease most likely through herd immunity effects.
- Overall levels of **PPV23** and non-vaccine serotypes (NVT) have remained relatively unchanged in 2016 at 39% and 31%, respectively.
- **Predominant serotypes** in 2016 were serotype 3 (9%), 22F (9%), 4 (7%), 19A (6%) and 8 (5%). **15B/C** was the most prevalent serotype in <2 year olds accounting for 16% and in 2–4 year olds with 13%. An increase of serotype **4** in adults was associated with Western regions; **23B** was predominant in 2–14 year olds, and **15A** was associated with the 2–4 year old age group in 2016.
- **Antimicrobial susceptibility:** Testing of 1,114 isolates indicated levels of resistance were again relatively stable during 2016 with the following resistance rates: clarithromycin (22%), penicillin (12%), doxycycline (9%), clindamycin (4%), trimethoprim/sulfamethoxazole (6%), meropenem (0.7%), and imipenem (0.3%). Serotypes 6A, 6C, 19A, 15A, 23A and 35B generally had the highest rates of antimicrobial resistance. **Multi-drug resistance** decreased slightly from 7% in 2015 to 6% in 2016. The highest rates of multi-drug resistance were seen in serotypes 15A (78%) and 19A (15%).
- ***S. pyogenes* (Group A *Streptococcus*)**: 1,792 isolates causing invasive disease were characterized for *emm* type.
- Overall **incidence** of invasive disease has increased from 4.0 to 5.3 cases per 100,000 population from 2009 to 2015.
- Despite a dramatic decline since 2012, *emm1* continues to be most predominant among all combined age groups (15%). Regional increases of *emm89* in the East (13%), *emm74* in Central (9%), and *emm81* in the West (17%) have been noted.
- **Antimicrobial susceptibility:** Antimicrobial resistance of *S. pyogenes* is relatively low, however small increases were seen in 2016 with chloramphenicol non-susceptibility at 4%, erythromycin resistance at 9%; and clindamycin resistance at 4%.
- ***S. agalactiae* (Group B *Streptococcus*)**: There were 228 invasive Group B *Streptococcus* submitted to NML during 2016, of which 9 isolates were from early onset cases (infants ≤7 days old) and 11 were from late onset cases (infants 8 – 31 days old). Incidence of invasive disease among infants ≤31 days has increased from 27.6 to 33.8 cases per 100,000 population from 2009 to 2015.
- **Serotypes** Ia (24%), III (19%) and IV (18%) were most predominant.

- **Antimicrobial susceptibility:** Resistance to erythromycin increased to 57% while clindamycin resistance increased to 35%.

INTRODUCTION

As of April 1, 2010, the National Microbiology Laboratory (NML), Winnipeg began offering surveillance, reference diagnostics and outbreak support on invasive *Streptococcus pneumoniae* (pneumococcus), *Streptococcus pyogenes* (Group A *Streptococcus*), and *Streptococcus agalactiae* (Group B *Streptococcus*). The Streptococcus and STI Unit also participates in a number of international, national and regional surveillance programs.

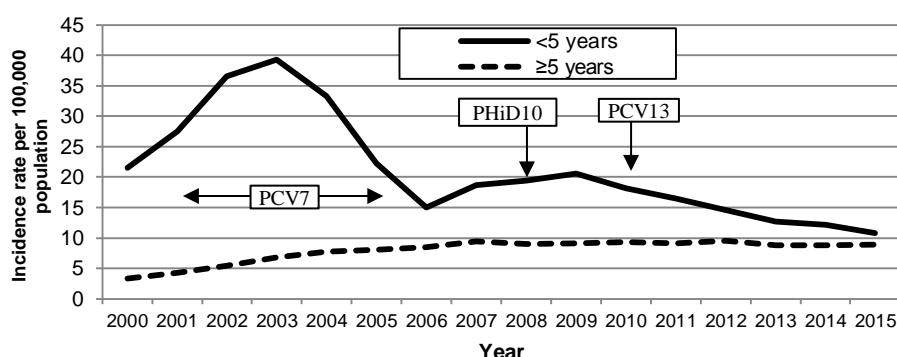
This report is intended to present the current distribution of serotypes of *S. pneumoniae*, *emm* types of *S. pyogenes*, and serotypes of *S. agalactiae* isolated from sterile sites that are forwarded from Canadian provincial and territorial public health laboratories, regional health units and reference centres to the NML. To broaden the representativeness of the data presented, the aggregated counts also include *S. pneumoniae* serotype data submitted by Laboratoire de santé publique du Québec (LSPQ), Toronto Invasive Bacterial Diseases Network (TIBDN), and the Alberta Provincial Laboratory for Public Health (ProvLab Alberta), organizations that perform their own serotyping.

Invasive pneumococcal disease (IPD, *S. pneumoniae*): IPD causes severe infections such as meningitis and bacteraemia [Marchessault, 2002; Schuchat, 1997] with children and the elderly being at greatest risk for infection [Robinson, 2001; Scott, 1996]. Of the 92 distinct pneumococcal serotypes currently recognized, the majority of disease worldwide is caused by only a few serotypes.

A 7-valent pneumococcal conjugate vaccine (**PCV7**), consisting of serotypes 4, 6B, 9V, 14, 18C, 19F, and 23F, was introduced in all provincial and territorial vaccination programs between 2002 and 2006 [Bettinger, 2010]. This led to a dramatic decrease in incidence of disease and in the constituent serotypes in children [Bettinger, 2010; Bjornson, 2007; Bruce, 2008; Demczuk, 2012; Deng, 2013; DeWals, 2012; Kellner, 2008; Kellner, 2009; Lim, 2013; Lovgren, 1998; McIntosh, 2011; NACI, 2010; Shahidi,

2008; Tyrrell, 2009; Weinberger, 2011;] (Figure 1). After the introduction of vaccination programs, paediatric IPD increased due to serotype replacement among pneumococcal infections with increases in non-PCV7 serotype infections, such as serotypes 7F and 19A [Kellner, 2009; Tyrrell, 2009]. In 2009, a 10-valent Pneumococcal conjugate vaccine (non-typable Haemophilus influenza (NTHi) protein D, diphtheria or tetanus toxoid conjugates) adsorbed (Synflorix®), (**PHiD10**); consisting of all the PCV7 serotypes plus serotypes 1, 5 and 7F; was used in Québec, Ontario, Yukon and Newfoundland and

Figure 1. Annual incidence of IPD in Canada, 2000-2015



Labrador. The 13-valent pneumococcal conjugate vaccine (**PCV13**); consisting of all PHiD10 serotypes plus serotypes 3, 6A and 19A; was recommended for use in Canada in 2010 [National Advisory Committee on Immunization (NACI), 2010] and introduced by all provinces and territories between mid-2010 and mid-2011. Immunization schedules vary by jurisdiction, however National Advisory Committee on Immunization (NACI) / Public Health Agency of Canada (PHAC) recommendations have been published [NACI, 2010; Public Health Agency of Canada (PHAC), 2017a]. The 23-valent pneumococcal polysaccharide vaccine (**PPV23**) is indicated for those over the age of 2 years with high risk of IPD and is also recommended for older adults. PPV23 is not effective in children under the age of 2 years due to a poor T-cell-independent antibody response in immature immune systems [Merck & Co. Inc.]. Surveillance of the distribution of *S. pneumoniae* serotypes is important to inform vaccine composition and monitor for possible serotype replacement [Demczuk, 2013].

Invasive Group A Streptococcus (GAS, *S. pyogenes*) is responsible for a wide range of disease including bacteraemia, toxic shock syndrome, and skin and soft tissue infections, of which necrotizing fasciitis is most notorious [Cunningham, 2000]. Surveillance of strains is important to monitor increasing virulence patterns associated with this organism [Schwartz, 1990; Siljander, 2010]. The M protein, encoded by the *emm* gene, is an important virulence factor and an epidemiological marker used to characterize *S. pyogenes* isolates.

Group B Streptococcus (GBS, *S. agalactiae*) GBS is commonly associated with neonatal disease where the highest infection risk is during childbirth. In order to decrease the risk of infection in neonates, women are swabbed late in pregnancy and if positive for GBS, they are offered prophylactic antibiotics to decrease the risk of transmission of GBS to their infants. Group B Streptococcal disease is only nationally notifiable in newborns, however, isolates submitted to NML include those that meet the case definition, as well as sterile site isolates from all age groups, since GBS is an increasing health concern among adults causing septicemia, meningitis, pneumonia, bone, joint and tissue infections. At risk adults groups include those with underlying medical conditions, pregnant women and those residing in extended health care facilities [Lamangni, 2013].

METHODS

A total of 2,906 invasive *S. pneumoniae*, 1,792 invasive *S. pyogenes* and 228 *S. agalactiae* isolates are included in this report for 2016. The data include test results for isolates submitted to the NML by provincial and territorial public health laboratories and data provided by jurisdictions including 344 IPD isolates serotyped by Laboratoire de santé publique du Québec, 431 by the Alberta Provincial Laboratory for Public Health and 341 by the Toronto Invasive Bacterial Diseases Network. Invasive GAS isolates from all provinces and territories (except Alberta) are submitted to the NML, and invasive GBS isolates are only routinely submitted by Saskatchewan, Manitoba, Newfoundland and Labrador and the Northern Territories for testing.

Data submitted with bacterial isolates included patient age, gender, clinical source and date of collection. Multiple isolates with the same serotype and collected from the same patient within 14 days were only counted once with the most invasive isolation site assigned. Meningitis related isolates were regarded as most invasive, followed by blood and then other sterile sites. The laboratory data were aggregated by age into <2, 2-4, 5-

14, 15-49, 50-64 and ≥65 year old age groups and regionally into Western (British Columbia, Alberta, Saskatchewan, Manitoba); Central (Ontario and Québec) and Eastern (New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador, Yukon Territories, Northwest Territories and Nunavut) regions of Canada. Caution should be exercised when interpreting the data presented in this report as the overall interpretation of the results is difficult due to the limitations related to the isolates available for testing. Only a subset of laboratory isolates within each province may be submitted for testing and therefore this report does not reflect true incidence or rates of disease in Canada. The representativeness of the proportions of isolates submitted to the NML for testing as compared to the Canadian Notifiable Disease Surveillance System (CNDSS) [PHAC, 2017b] are presented in the Appendix. The most recent validated disease incidence data obtained through CNDSS was for 2015 and population data obtained from Statistics Canada July 1st annual population estimates. The population of provinces and territories for whom case data were not available were excluded from the denominator. Not all provinces and territories report line list data to CNDSS and therefore only aggregated data are available at the national level. Therefore, CNDSS data and NML laboratory data were presented differently in terms of age grouping and are consistent with literature and current immunization recommendations.

All IPD isolates were screened by bile solubility and optochin (Oxoid) analyses and GAS/GBS isolates were confirmed using PYR (Pyrrolidonyl- α -naphthylamide) reaction and susceptibility to bacitracin (Oxoid) [Spellerberg, 2007] at NML. Sterile clinical isolation sites include blood, cerebrospinal fluid or other nervous tissue (CSF), peritoneal fluid, pericardial fluid, joint fluid, internal body sites and muscle including surgical or biopsy samples and aspirates. Although pleural fluid (empyema) does not currently meet the national case definition for invasive disease, these isolates are included in this report as they are widely considered as invasive in other jurisdictions [Bettinger, 2010]. Additionally for *S. pyogenes*, any isolation site was tested if a case of toxic shock syndrome or necrotizing fasciitis was associated with the infection [Canadian Communicable Disease Report, 2009; Minnesota Department of Health].

National case definitions for IPD, GAS and GBS can be found at the following:

<https://www.canada.ca/en/public-health/services/reports-publications/canada-communicable-disease-report-ccdr/monthly-issue/2009-35/definitions-communicable-diseases-national-surveillance.html>

Serotyping of IPD at NML is performed by observing the Quellung reaction using pool, group, type and factor commercial antisera (SSI Diagnostica; Statens Serum Institute, Copenhagen, Denmark) [Austrian, 1976; Lovgren, 1998]. Isolates for which a Quellung reaction is not observed are confirmed by *rpoB* gene sequencing [Drancourt, 2004; Clinical Laboratory Standards Institute (CLSI), 2008].

In 2011, the NML began a collaboration with the University of Manitoba – Health Sciences Centre - Canadian Antimicrobial Resistance Alliance (CARA) to provide antimicrobial susceptibility testing (AST) for *S. pneumoniae* isolates submitted to the NML. All sterile-site IPD isolates (n=1,114) submitted to the NML by 8 participating jurisdictions (Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, Prince Edward Island, New Brunswick, Newfoundland and Labrador) are included in the study. A panel of 18 antimicrobials are tested, including: penicillin, amoxicillin/clavulanate, cefuroxime, ceftriaxone, clarithromycin, ertapenem, meropenem, clindamycin, vancomycin, ciprofloxacin, levofloxacin, moxifloxacin, linezolid, tigecycline, trimethoprim/sulfamethoxazole and doxycycline. MICs of these antimicrobials are

determined by the CLSI broth microdilution method using 96-well custom designed microtitre plates [CLSI, 2017]. MIC interpretive standards were defined according to CLSI breakpoints [CLSI, 2017] for all antibiotics except ciprofloxacin for which EUCAST interpretative breakpoints were used [EUCAST, 2015]. Antimicrobial susceptibilities for GAS (n=1,734) and GBS (n=226) were determined at NML using Kirby-Bauer Disc diffusion for chloramphenicol (CHL, 30 µg), erythromycin (ERY, 15 µg), clindamycin (CLI, 2 µg), penicillin (PEN, 10 µg) and vancomycin (VAN, 30, µg) according to CLSI guidelines [CLSI, 2015].

The *emm* types were determined for all invasive Group A *Streptococcus* isolates submitted to the NML. Isolates were characterized using the *emm* sequencing CDC protocol available at: <http://www.cdc.gov/streplab/M-ProteinGene-typing.html>. The *emm* sequences obtained are compared with the CDC (Atlanta) data bank and results reported to the type level, not the subtype level (*emm*4.4 is reported as *emm*4).

Serotypes of Group B *Streptococcus* were determined using commercial latex agglutinating antisera (SSI Diagnostica; Statens Serum Institute, Copenhagen, Denmark).

RESULTS AND DISCUSSION

Streptococcus pneumoniae

Based on 2015 data from CNDSS (the most recent available at the time of publication), IPD has continued to decline primarily in children and seniors. Incidence rates among infants under 1 year of age have declined from 17.4 to 14.5 cases per 100,000 population from 2014 to 2015 and a smaller annual decline was seen in children aged 1 – 4 years from 11.0 to 9.9 cases per 100,000 population. Among the 40 – 59 age group rates have increased since 2013 from 8.6 to 9.0 cases per 100,000 population in 2015. Incidence of IPD in the remaining age groups have remained relatively constant since 2013 with an overall IPD rate in Canada of approximately 9 cases per 100,000 population

Figure 2. Annual incidence of IPD cases in Canada by age group, 2009–2015

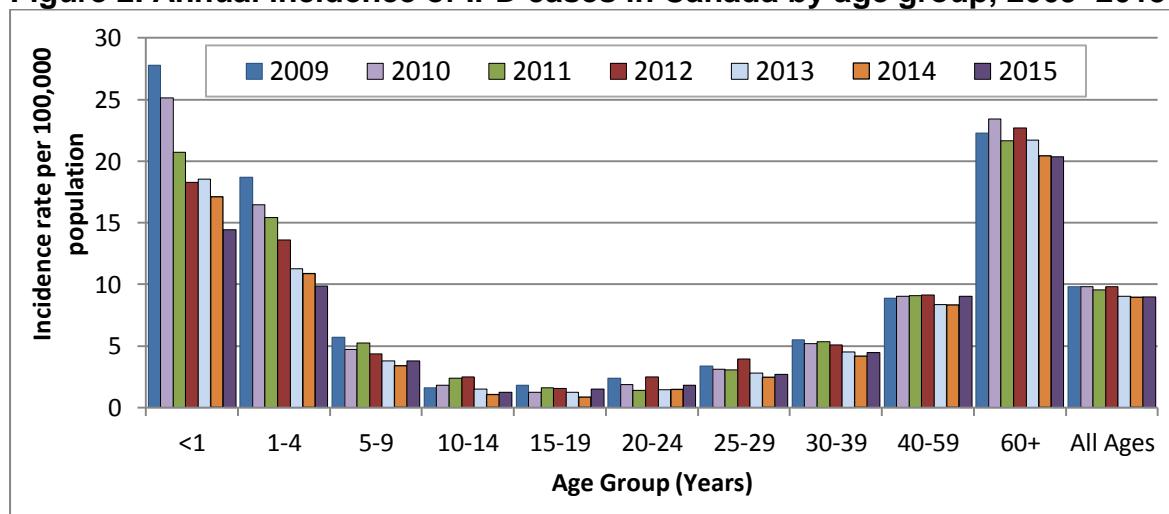


Table 1. Annual incidence of IPD cases in Canada by age group, 2009–2015

Year	Age Group (Years)										
	<1	1-4	5-9	10-14	15-19	20-24	25-29	30-39	40-59	60+	All Ages
2009	27.8	18.7	5.7	1.6	1.8	2.4	3.4	5.5	8.9	22.3	9.8
2010	25.1	16.4	4.7	1.8	1.2	1.9	3.1	5.2	9.0	23.4	9.8
2011	20.7	15.4	5.2	2.4	1.6	1.4	3.0	5.3	9.1	21.6	9.6
2012	18.3	13.6	4.3	2.5	1.6	2.5	4.0	5.1	9.1	22.7	9.8
2013	18.6	11.3	3.8	1.5	1.2	1.5	2.8	4.5	8.4	21.7	9.1
2014	17.4	11.0	3.7	1.1	1.0	1.6	2.6	4.4	8.6	21.1	8.9
2015	14.5	9.9	3.8	1.2	1.5	1.8	2.7	4.5	9.0	20.3	9.0

Distribution of *Streptococcus pneumoniae* serotypes

Of the 2,906 IPD isolates serotyped in 2016, 2,893 had patient ages and infants <2 years of age accounted for 5.8% (n=168), toddlers aged 2-4 years for 3.2% (n=92), children aged 5-14 years for 3.2% (n=92), adults aged 15-49 years for 23.4% (n=677), adults aged 50-64 years for 27.0% (n=782) and seniors aged ≥65 years for 37.4% (n=1082). Of the 2,837 isolates with gender information specified 55.5%, (n=1,575) were from male patients.

The overall most common serotype in 2016 was serotype 3, increasing from 8.1% (n=228) to 9.2% (n=268) since 2012. From 2012 to 2016, serotype 22F continued to predominate, declining from 10.5% (n=298) to 8.8% (n=257); and serotype 4 has increased dramatically from 2.6% (n=74) to 6.9% (n=200).

Blood was the most frequent clinical isolation site accounting for 91.4% (n=2,656) of all isolates. Serotype 3 was prevalent in all clinical sources representing 8.8% (n=235) of all blood, 10.9% (n=11) of CSF, 28.9% (n=11) of pleural fluid and 9.9% (n=11) of other sterile isolation site isolates. Serotype 22F was also prevalent among blood isolates with 9.0% (n=239), 8.9% (n=9) of CSF and 7.2% (n=8) of other sterile site isolates. Among CSF and other sterile site isolates serotype 15B/C accounted for 8.9% (n=9) and 7.2% (n=8), and serotype 23B for 10.9% (n=11) and 7.2% (n=8), respectively.

Serotypes associated with Western Canada included serotypes 4 (13.8%, n=165), 22F (8.0%, n=96) and 3 (7.3%, n=87); whereas in Central regions, serotype 3 was most prevalent (10.7%, n=163), followed by 22F (9.1%, n=138) and 19A (7.7% (n=117); and serotypes 22F (12.6%, n=23), 9N (10.4%, n=19) and 15A (6.6%, n=12) were predominant in Eastern Canada.

Serotype 3: In infants <2 years of age, after a decline from 7.6% (n=13) to 1.7% (n=3) from 2012 to 2014, serotype 3 has increased once again to now account for 6.0% (n=10) of the isolates of this age group in 2016. In the 2–4 year olds, serotype 3 has steadily declined between 2012–2016 from 10.4% (n=15) to 6.5% (n=6), and a smaller decline was also observed in the ≥65 year old age group from 9.7% (n=95) to 8.9% (n=96). In contrast, increases were seen among 5–14 year olds from 2% (n=2) to 10.9% (n=10), in 15–49 year olds from 6.3% (n=42) to 8.6% (n=58) and in 50 – 64 year olds from 8.2% (n=61) to 11.1% (n=87).

Serotype 22F: Continued declines in the relative proportion of serotype 22F isolates have been seen in most age groups with decreases between 2013 – 2016 in <2 year old isolates from 14.0% (n=24) to 9.5% (n=16), from 10.4% (n=58) to 6.8% (n=46) in the 15 – 49 year olds, from 11.0% (n=80) to 8.8% (n=69) in those aged 50 – 64 years, and from 12.5% (n=135) to 9.8% (n=106) in seniors ≥65 years of age. Proportions of 22F in the 2 – 4 year olds remained relatively constant over the 5 year period at around 11% (n=9 to 16), whereas in the 5 – 14 year old levels increased from 4.9% (n=5) in 2012 to 13.4% (n=11) in 2014, then decreased slightly to 8.7% (n=8) in 2016.

Serotype 4: Increases of serotype 4 can be attributed to a pneumococcal outbreak among the homeless population in Western Canada. Large increases from 2013 to 2016 have been seen in the 15 – 49 year old age group from 3.4% (n=19) to 16.0% (n=108) and in 50 – 64 year olds from 1.7% (n=12) to 8.2% (n=64).

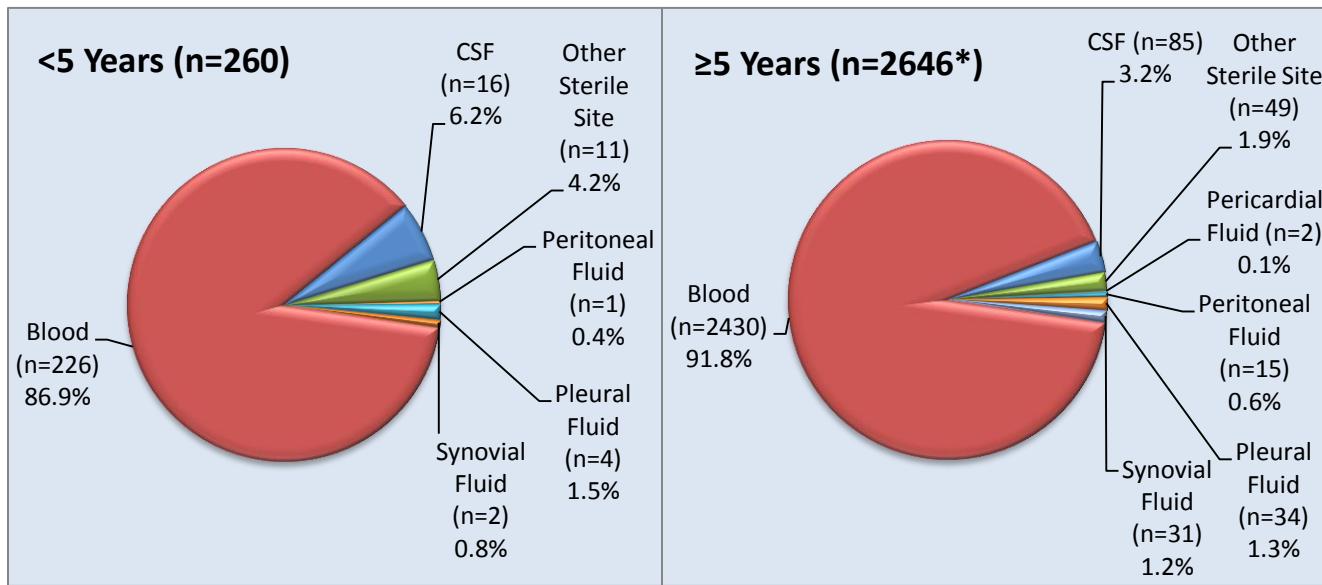
Serotype 19A: After dramatic decreases in <2 year olds from 18.2% (n=31) in 2012 to 2.8% (n=5) in 2014, serotype 19A has increased once again to account for 8.9% (n=15) of isolates in this age group. Sustained declines have been seen from 2012 – 2016 in 2 – 4 year olds from 25.0% (n=36) to 7.6% (n=7), in the 5 – 14 year olds from 22.5% (n=23) to 4.3% (n=4), the 15 – 49 year olds from 10.9% (n=72) to 4.3% (n=29), the 50 – 64 year olds from 11.8% (n=88) to 7.4% (n=58), and in ≥65 year olds from 12.2% (n=120) to 6.0% (n=65).

Serotype 7F: In 2016, serotype 7F has remained at very low levels in <2 year olds (n=1) and 2 – 4 year olds (n=0). In all other age groups declines from 2012 to 2016 have continued with 7F decreasing in the 5 – 14 year olds from 22.5% (n=23) to 4.3% (n=4), the 15 – 49 year olds from 20.8% (n=138) to 6.8% (n=46), the 50 – 64 year olds from 13.6% (n=101) to 4.5% (n=35), and in the ≥65 year old age group from 7.5% (n=74) to 2.1% (n=23).

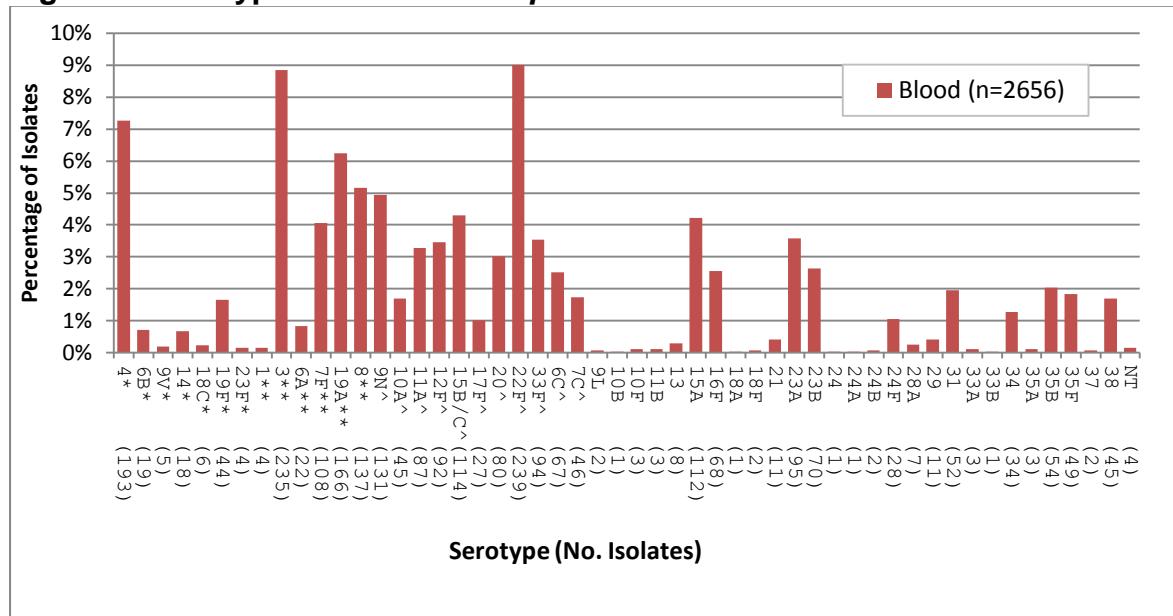
Other Serotypes: Serotype **15B/C** is the most prevalent serotype among the younger age groups accounting for 16.1% (n=27) of isolates in <2 year olds and 13.0% (n=12) of both 2 – 4 year olds and 5 – 14 year olds. Serotype **23B** was predominant in 2 – 4 year olds in 2016 representing 10.9% (n=10) and in the 5 – 14 year olds with 8.7% (n=8), while serotype **15A** was associated with the 2 – 4 year old age group increasing from 2.8% (n=4) in 2012 to 6.5% (n=6) in 2016, and in the ≥65 year old age group remaining relatively stable at around 6.5% (n=55 to 75) over the 5 year period.

Table 2. Number of invasive *S. pneumoniae* in 2016

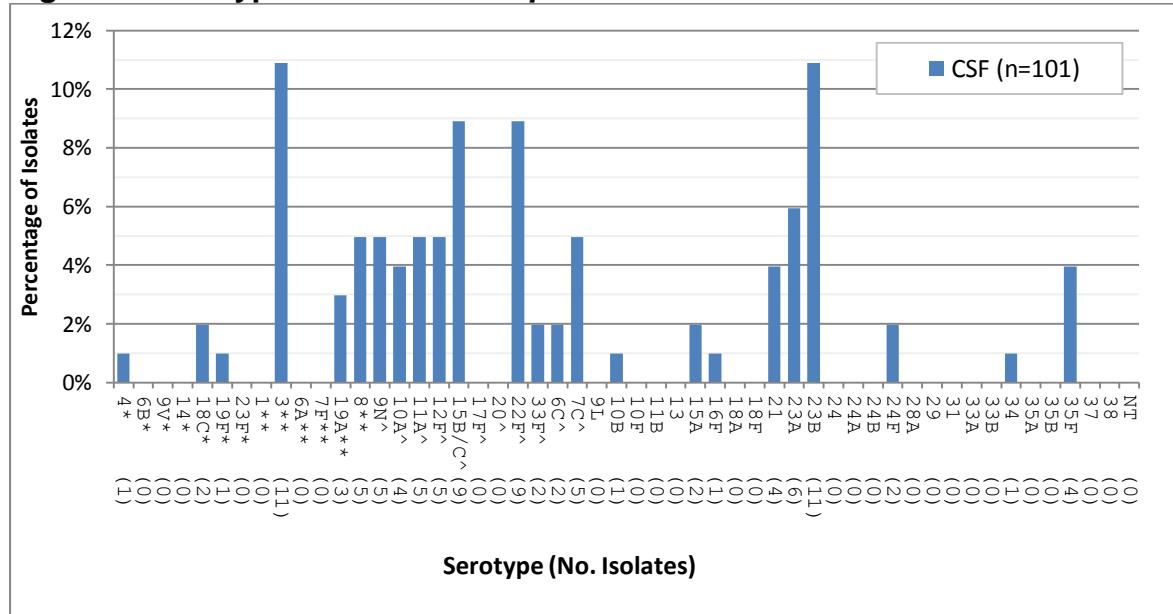
Province	Age Groups (Years)						Not Given	Total
	< 2	2 – 4	5 – 14	15 – 49	50 – 64	≥ 65		
British Columbia	18	10	16	142	132	163	0	481
Alberta	18	18	7	151	125	125	4	448
Saskatchewan	8	4	6	48	48	32	0	146
Manitoba	14	6	5	32	28	39	1	125
Ontario	39	40	32	209	297	456	4	1077
Québec	61	9	20	56	93	208	0	447
New Brunswick	3	1	3	9	23	25	1	64
Nova Scotia	2	3	2	19	21	16	1	64
Prince Edward Island	0	0	0	2	2	8	0	12
Newfoundland and Labrador	1	1	0	3	11	9	0	25
Yukon	0	0	0	0	1	1	0	2
Northwest Territories	1	0	0	3	1	0	0	5
Nunavut	3	0	1	3	0	0	0	7
Canada	168	92	92	677	782	1082	13	2906

Figure 3. Clinical isolation sites in 2016

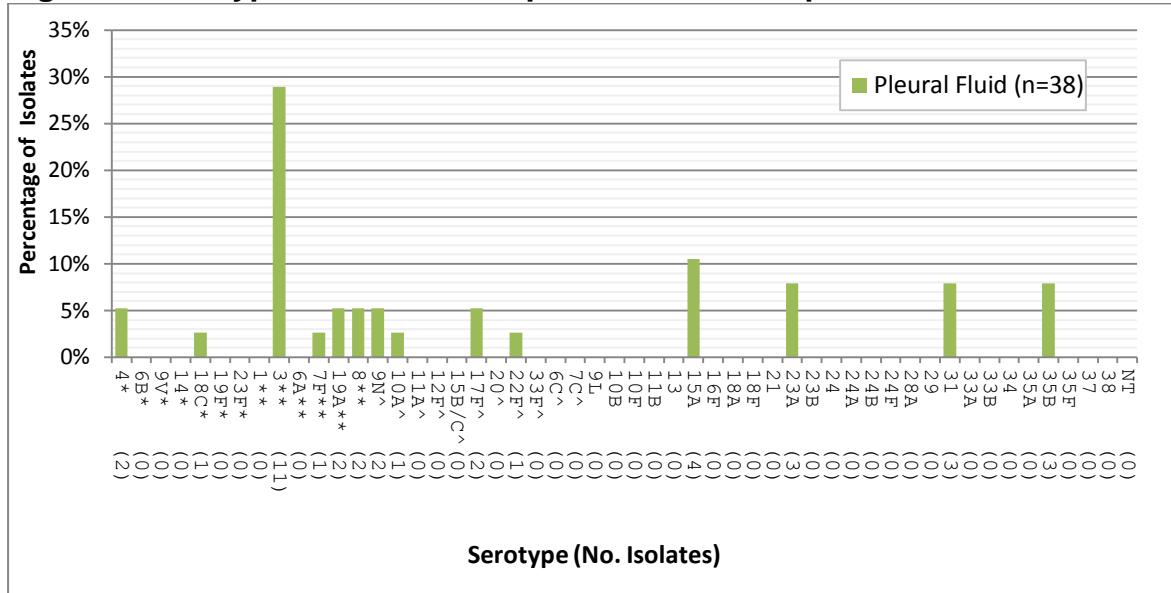
*Includes 13 isolates with age not available.

Figure 4. Serotypes of invasive *S. pneumoniae* from blood in 2016

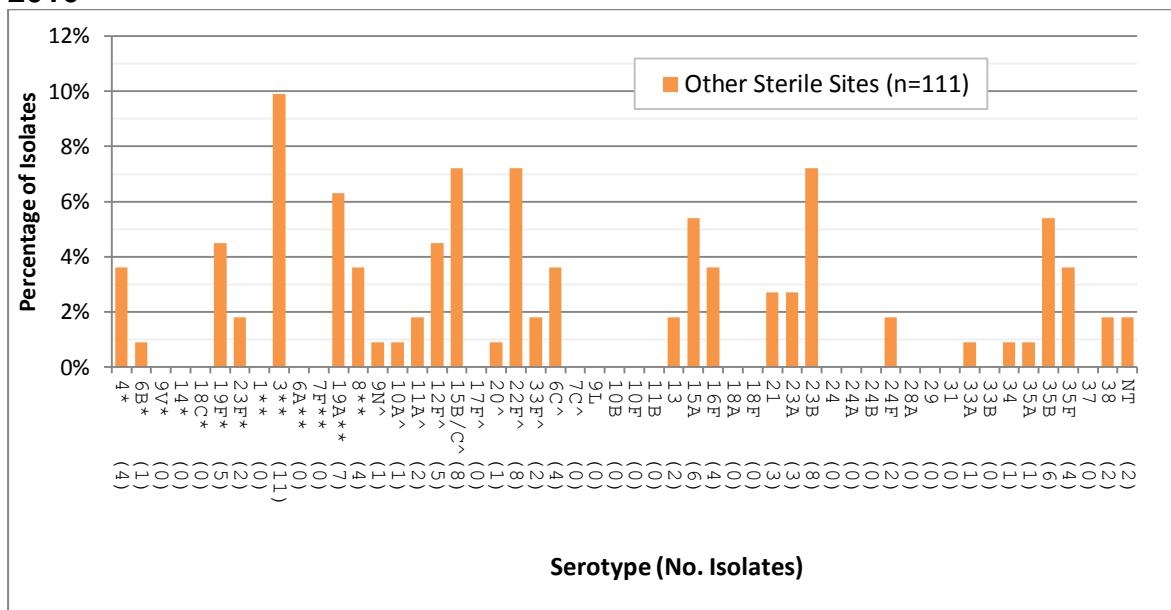
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23.

Figure 5. Serotypes of invasive *S. pneumoniae* from CSF in 2016

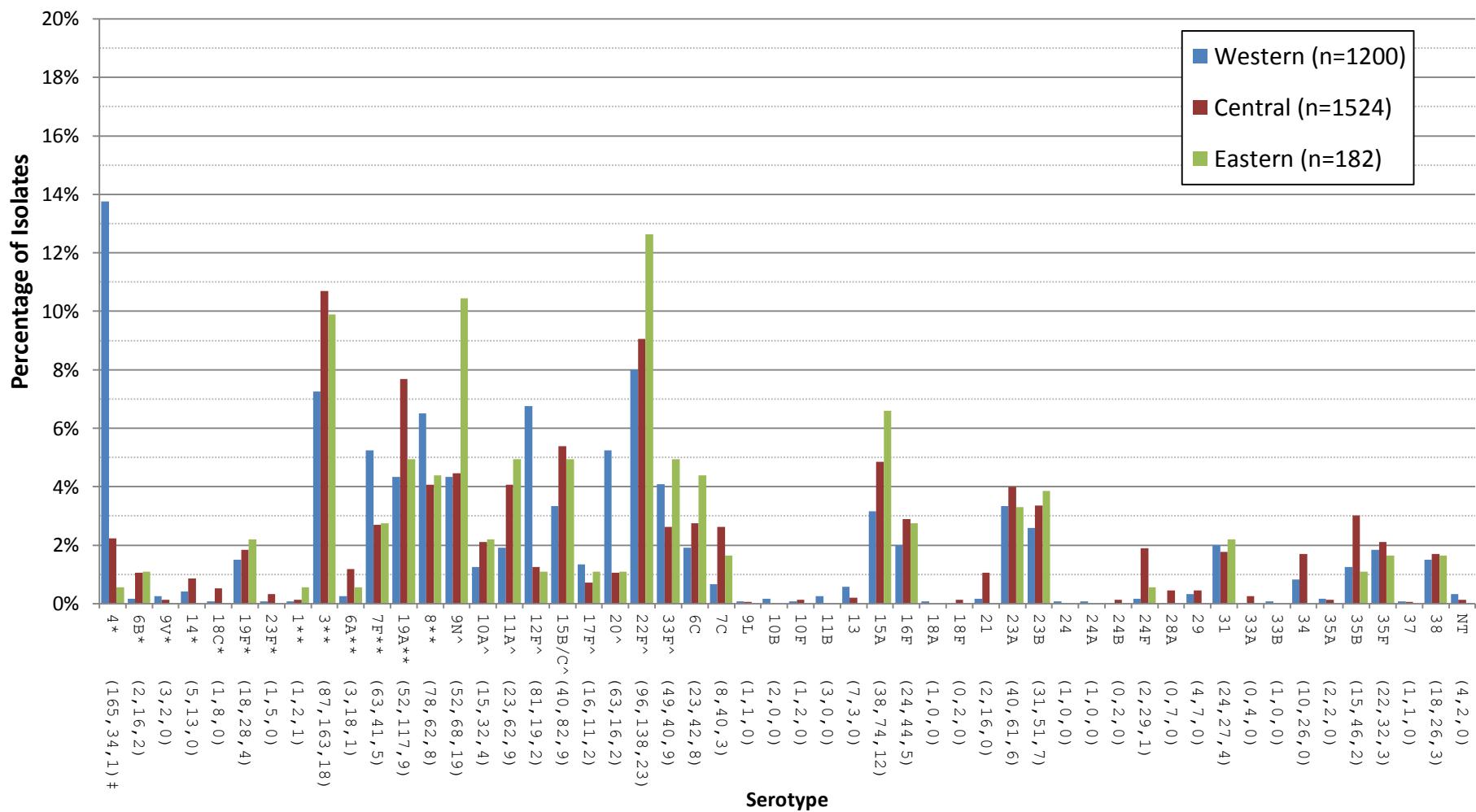
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23.

Figure 6. Serotypes of invasive *S. pneumoniae* from pleural fluid in 2016

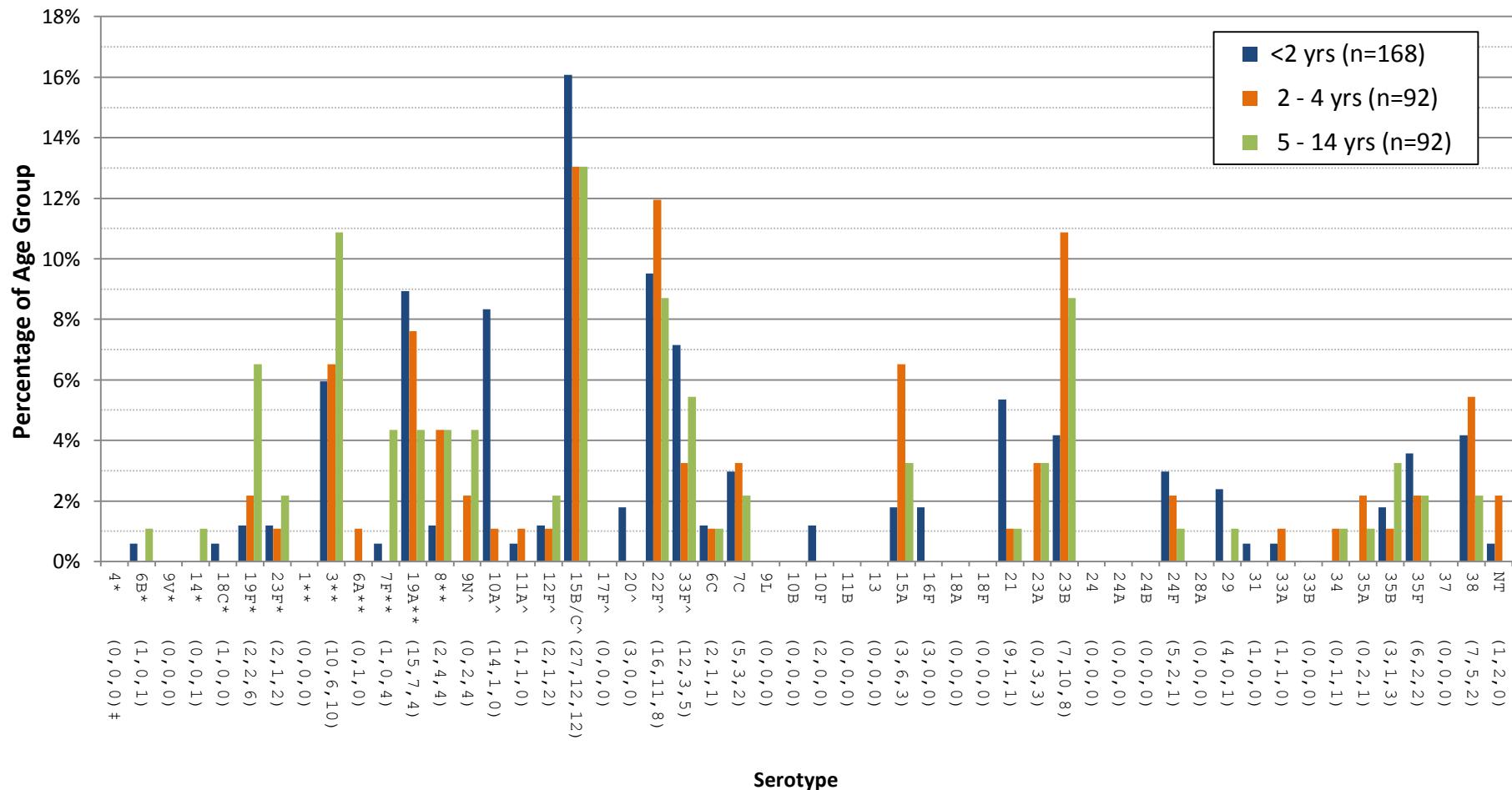
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23.

Figure 7. Serotypes of invasive *S. pneumoniae* from other sterile sites in 2016

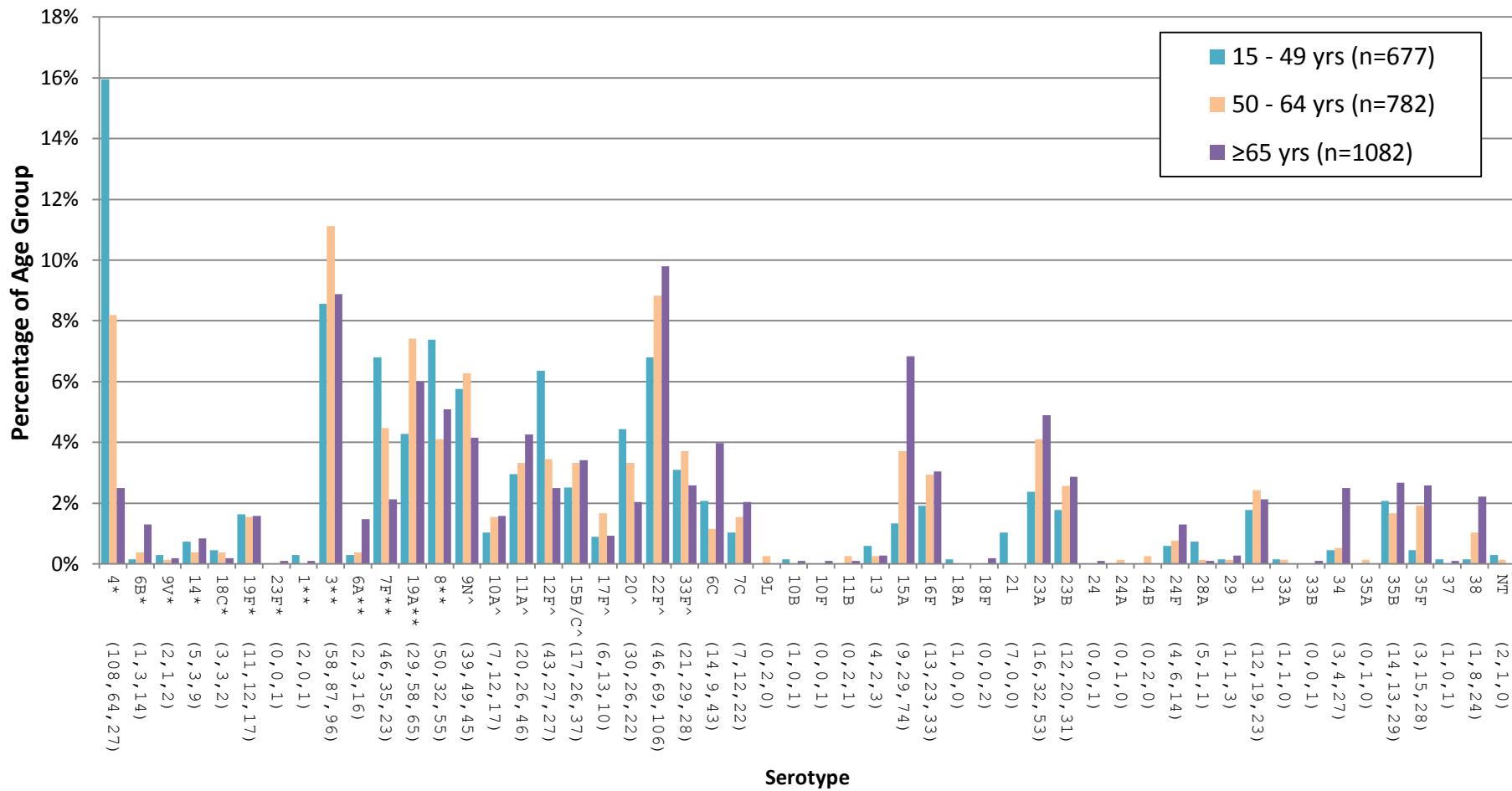
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23.

Figure 8. Regional Distribution of Invasive *S. pneumoniae* serotypes in 2016

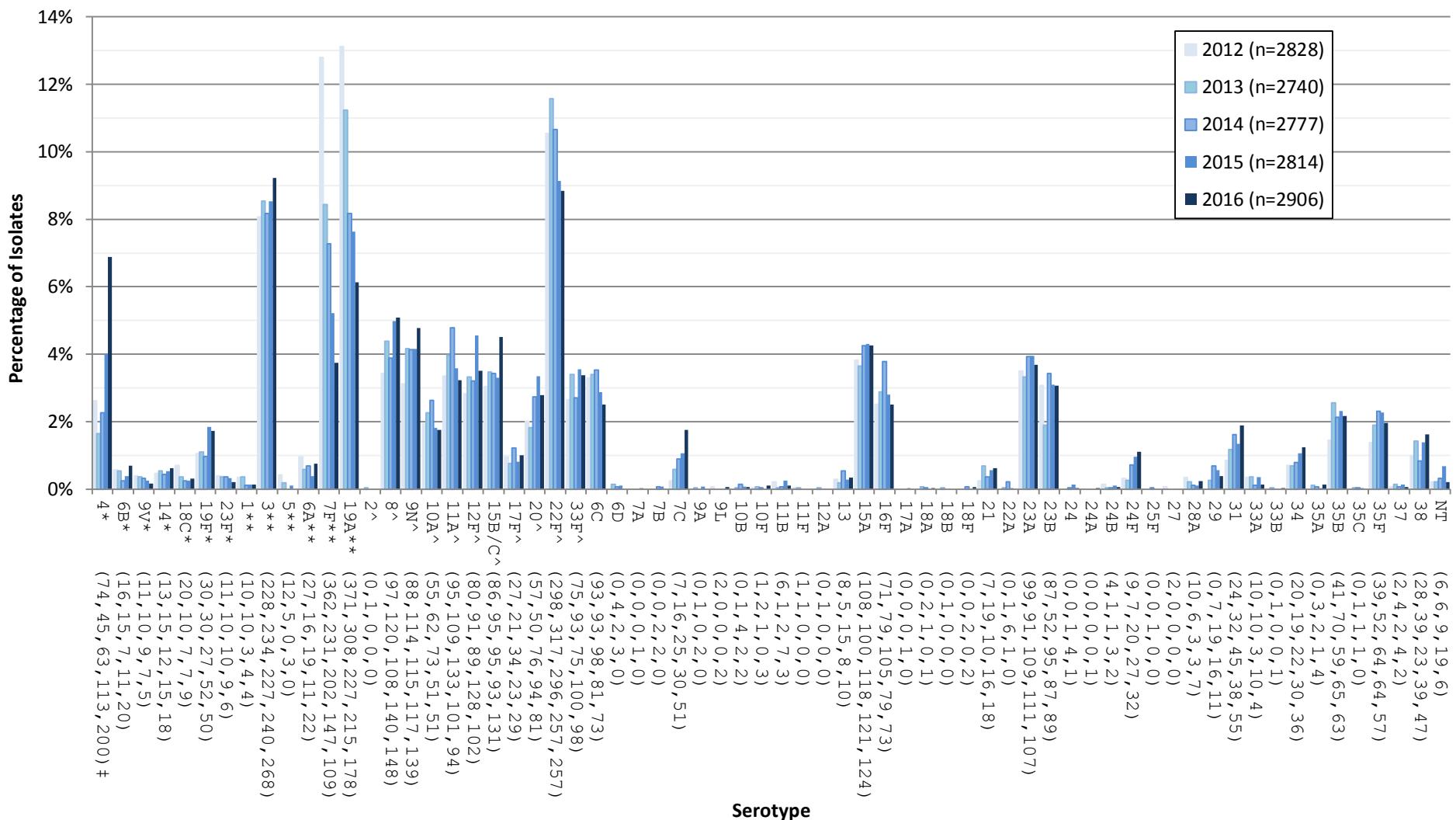
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡Number of isolates from Western, Central and Eastern Canada, respectively.

Figure 9. Invasive *S. pneumoniae* serotypes isolated in 2016: <2, 2-4 and 5-14 year old age groups

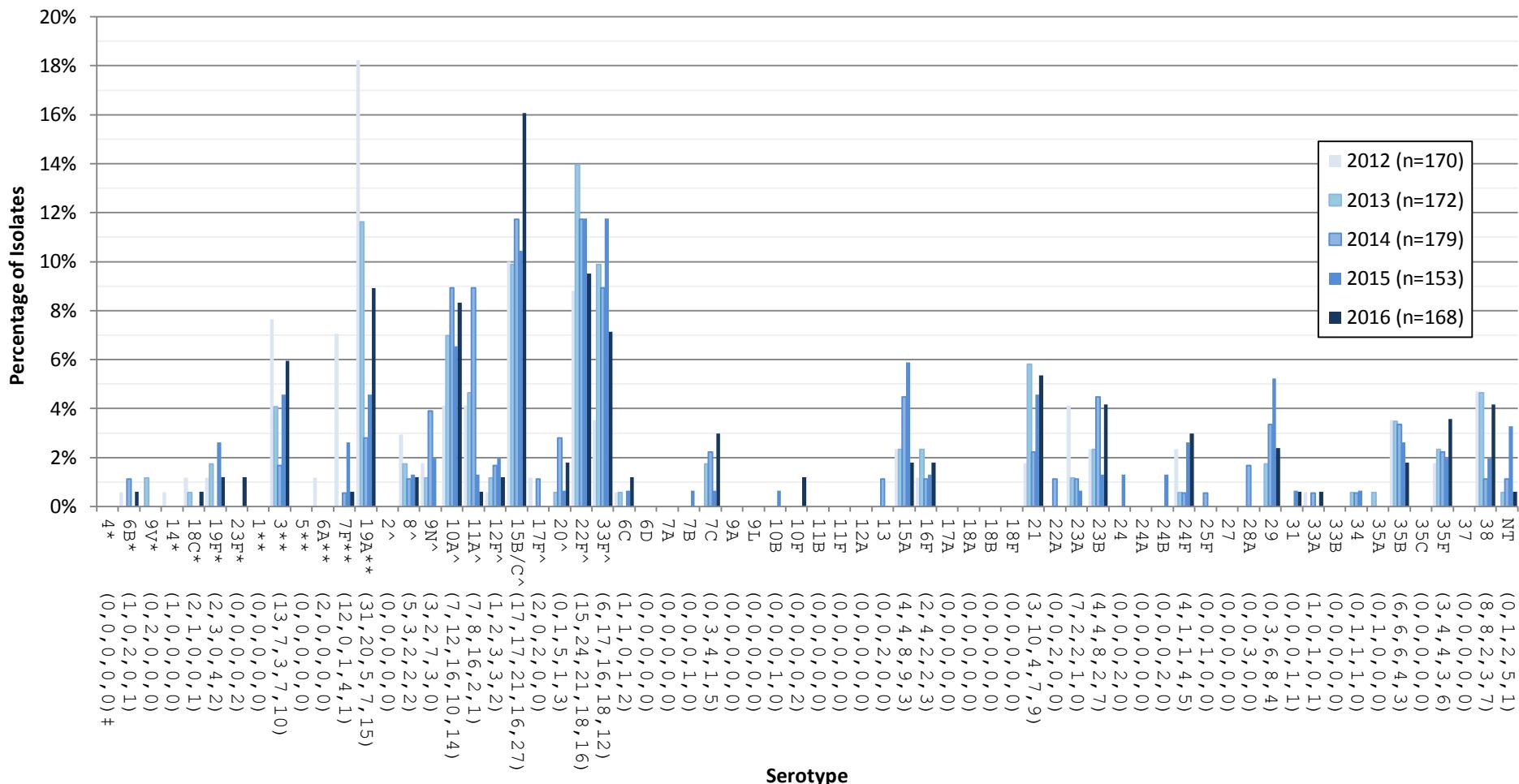
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; †Number of isolates from <2, 2-4, 5-14 year olds, respectively.

Figure 10. Invasive *S. pneumoniae* serotypes isolated in 2016: 15-49, 50-64, and ≥65 year old age groups

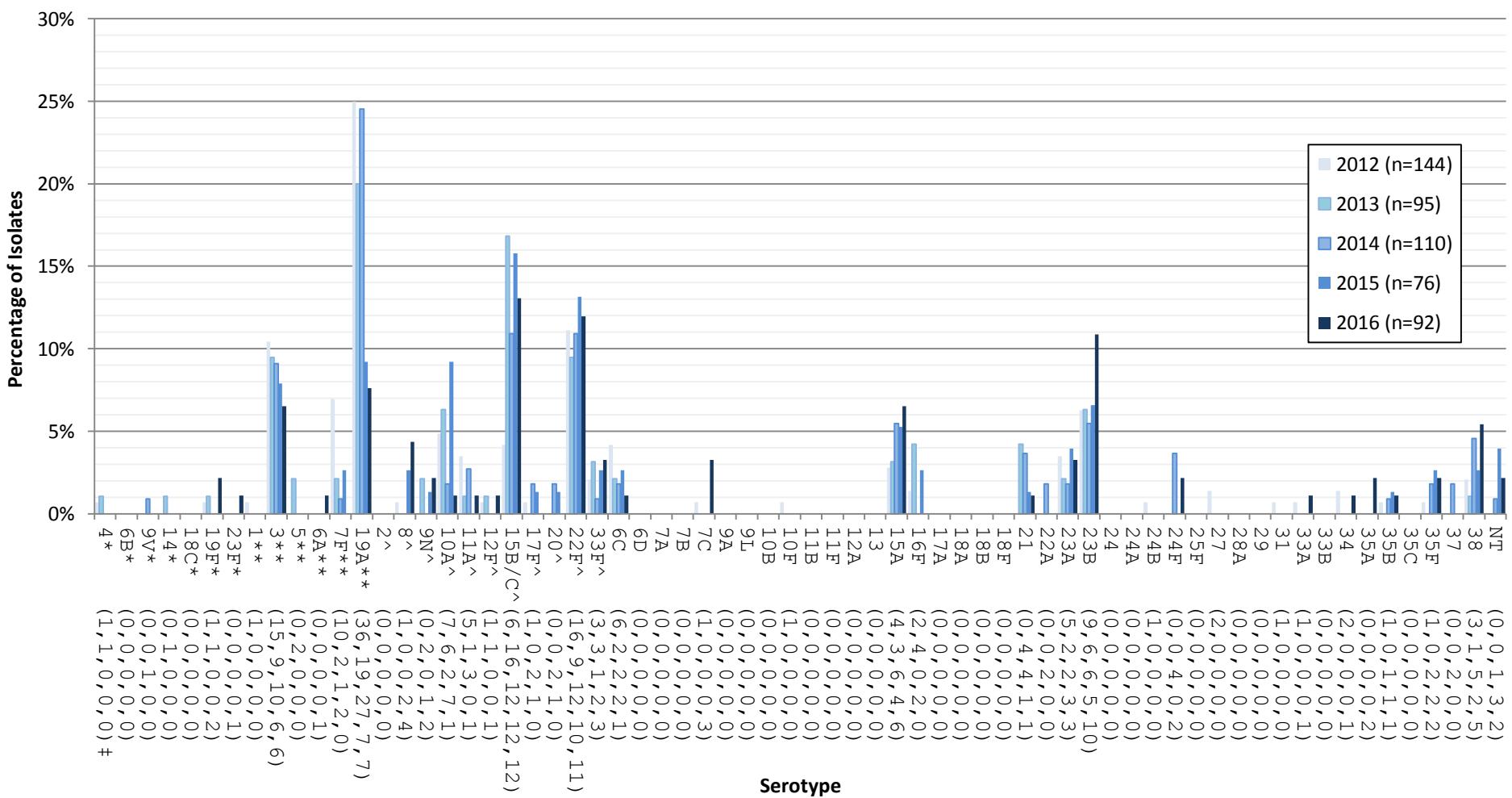
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23. ‡Number of isolates from 15-49, 50-64, ≥65 year olds, respectively.

Figure 11. Invasive *S. pneumoniae* serotypes in all combined age group

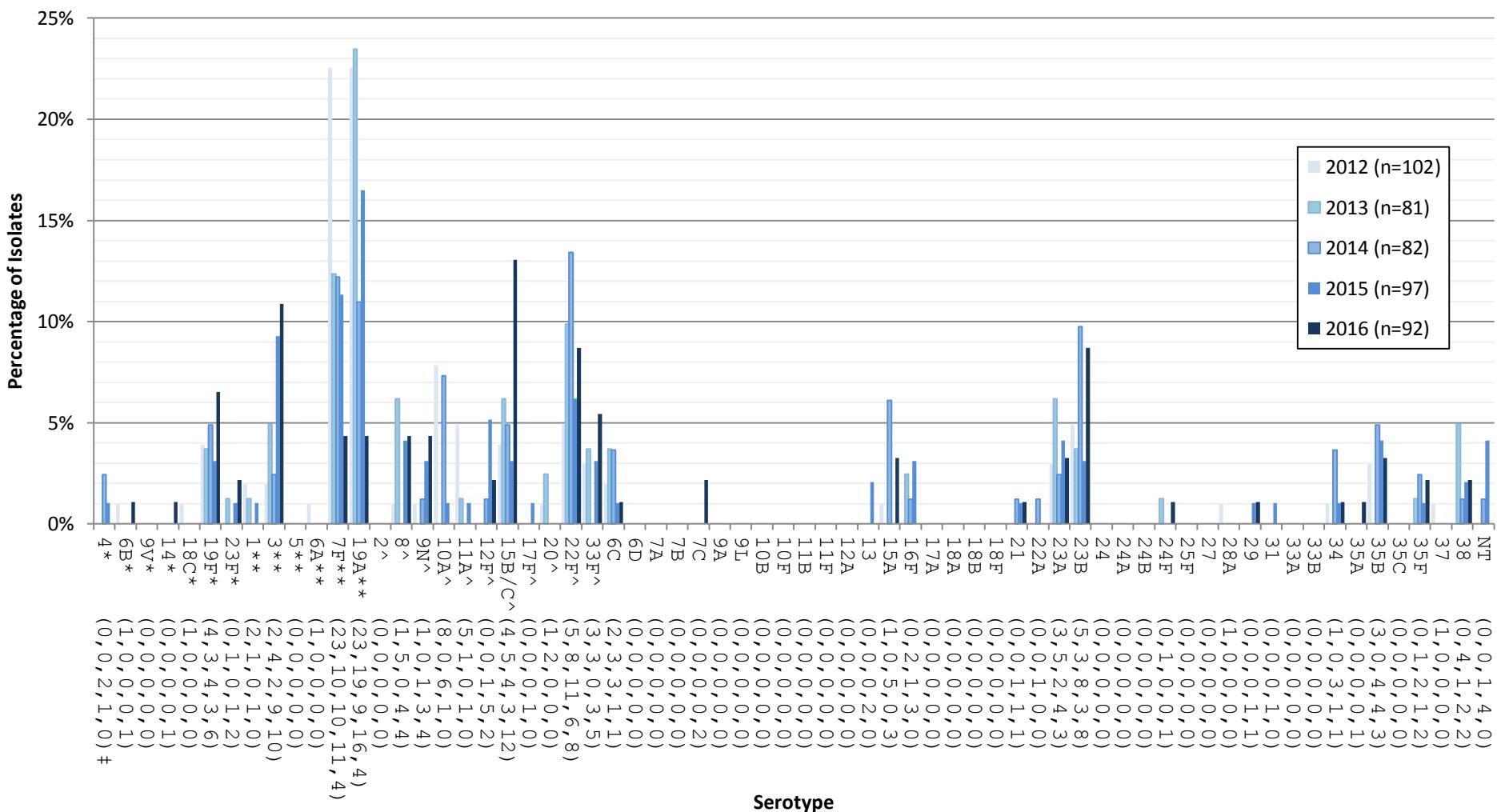
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of isolates for 2012, 2013, 2014, 2015 and 2016 respectively.

Figure 12. Invasive *S. pneumoniae* serotypes in <2 year olds

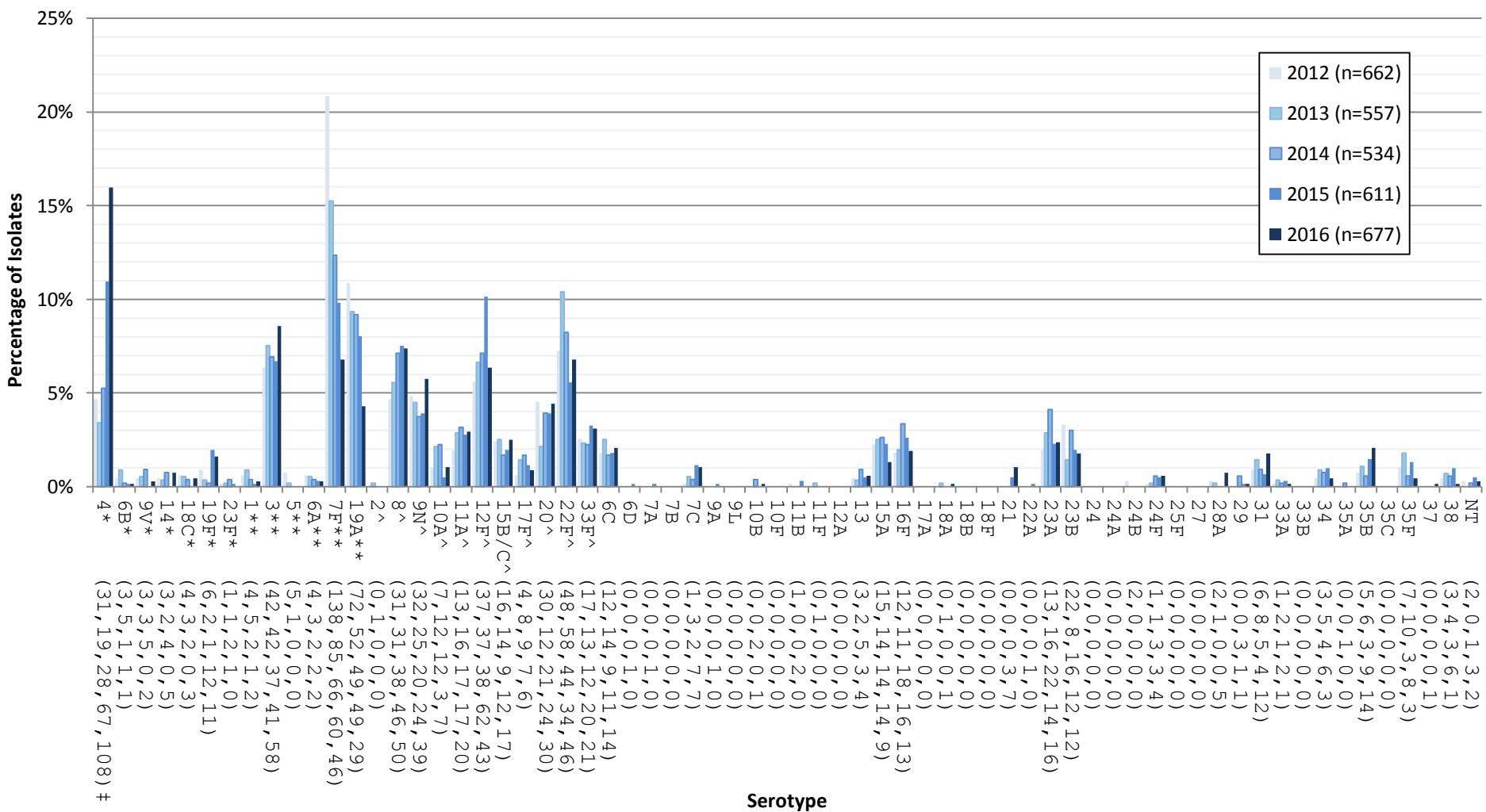
* Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of isolates for 2012, 2013, 2014, 2015 and 2016 respectively.

Figure 13. Invasive *S. pneumoniae* serotypes in 2-4 year olds

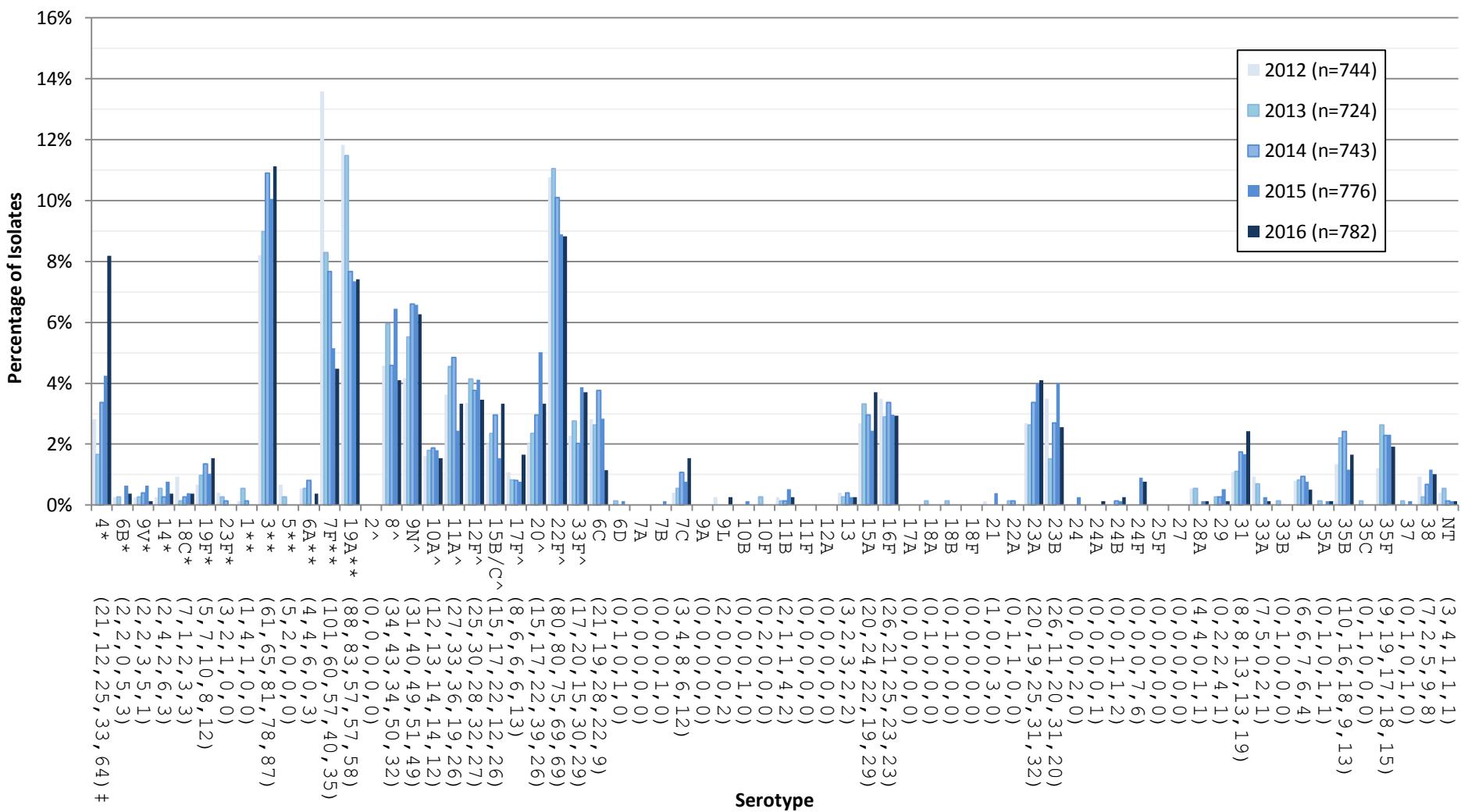
* Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of isolates for 2012, 2013, 2014, 2015 and 2016 respectively.

Figure 14. Invasive *S. pneumoniae* serotypes in 5-14 year olds

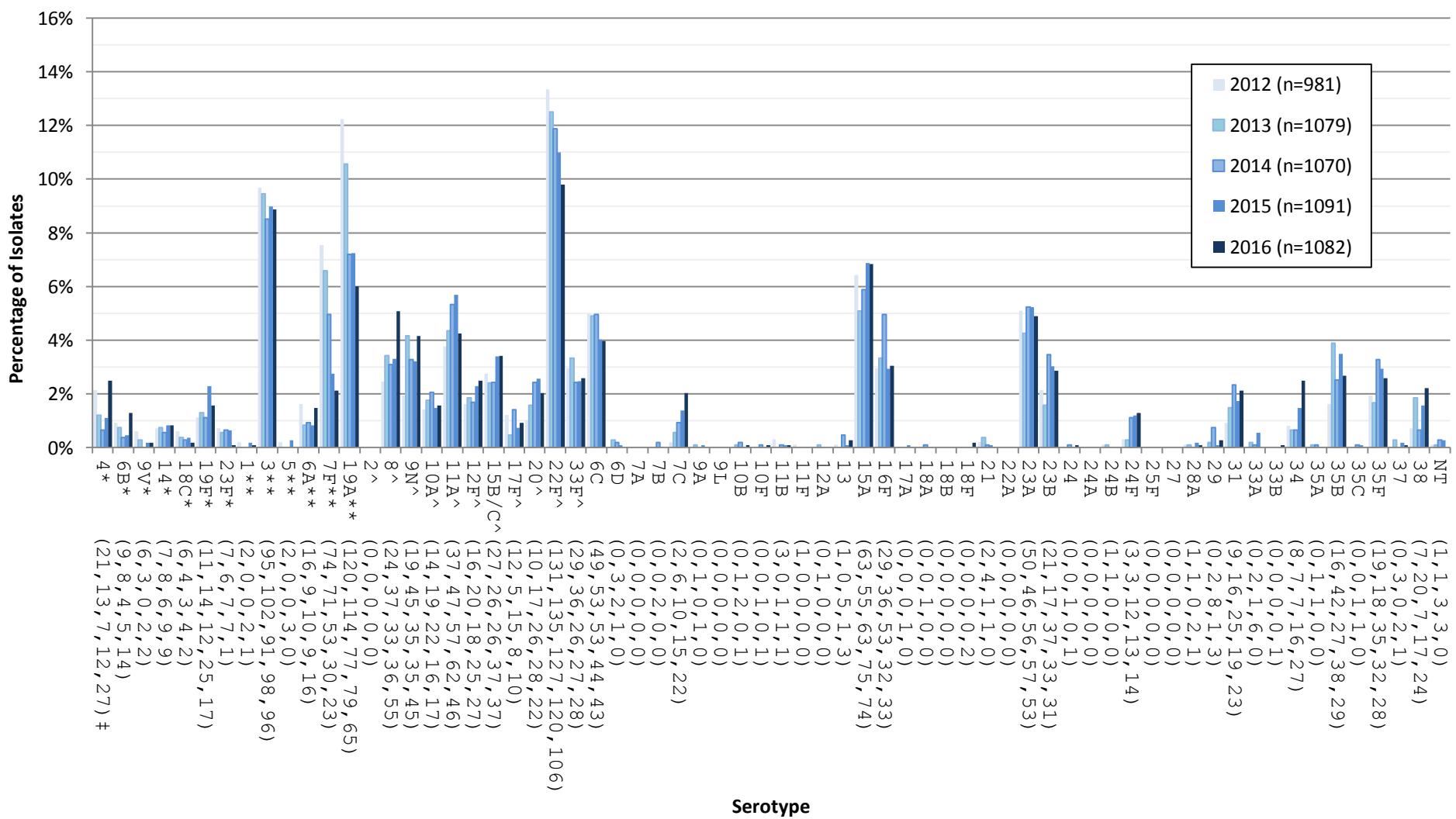
* Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of isolates for 2012, 2013, 2014, 2015 and 2016 respectively.

Figure 15. Invasive *S. pneumoniae* serotypes in 15-49 year olds

* Component of PCV7; ** Component of PCV13; ^ Component of PPV23; † Number of isolates for 2012, 2013, 2014, 2015 and 2016 respectively.

Figure 16. Invasive *S. pneumoniae* serotypes in 50-64 year olds

* Component of PCV7; ** Component of PCV13; ^ Component of PPV23; † Number of isolates for 2012, 2013, 2014, 2015 and 2016, respectively.

Figure 17. Invasive *S. pneumoniae* serotypes in ≥65 year olds

* Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of isolates for 2012, 2013, 2014, 2015 and 2016 respectively.

Pneumococcal Vaccine Serotypes

PCV7 serotypes (4, 6B, 9V, 14, 18C, 19F, 23F) continue to represent a small number of isolates in the <15 year old age groups during 2016 with only 6 isolates in the <2 year olds, 3 isolates from 2 – 4 year olds, and 10 isolates in the 5-14 year old age group. Increases in the older age groups may be attributed to increases of serotype 4 among homeless population in Western Canada. Large increases from 2012 to 2016 have been seen in the 15 – 49 year olds from 7.7% (n=51) to 19.2% (n=130); and in the 50 - 64 year olds from 5.6% (n=42) to 11.0% (n=86).

After decreases in the proportions of PCV13-specific serotypes (1, 3, 5, 6A, 7F and 19A) among <2 year olds from 2012 to 2014, levels have increased from 5.0% (n=9) in 2014 to 15.5% (n=26) in 2016, mainly attributable to resurgences of serotypes 3 and 19A. In all the other age groups, the proportion of PCV13-specific serotypes has continued a general overall decline, which now represent 20.0% (n=581) of isolates overall.

The proportion of isolates representing PPV23 serotypes (2, 8, 9N, 10A, 11A, 12F, 15B, 17F, 20, 22F, 33F) have remained relatively unchanged in all groups in 2016, representing 45.8% (n=77) of isolates from <2 year olds, 38.0% (n=35) of 2 – 4 year olds, 38.0% (n=35) of 5 – 14 year olds, 41.0% (n=279) of 15 – 49 year olds, 39.5% (n=309) of 50 – 64 year olds and 36.3% (n=393) of those ≥65 years old.

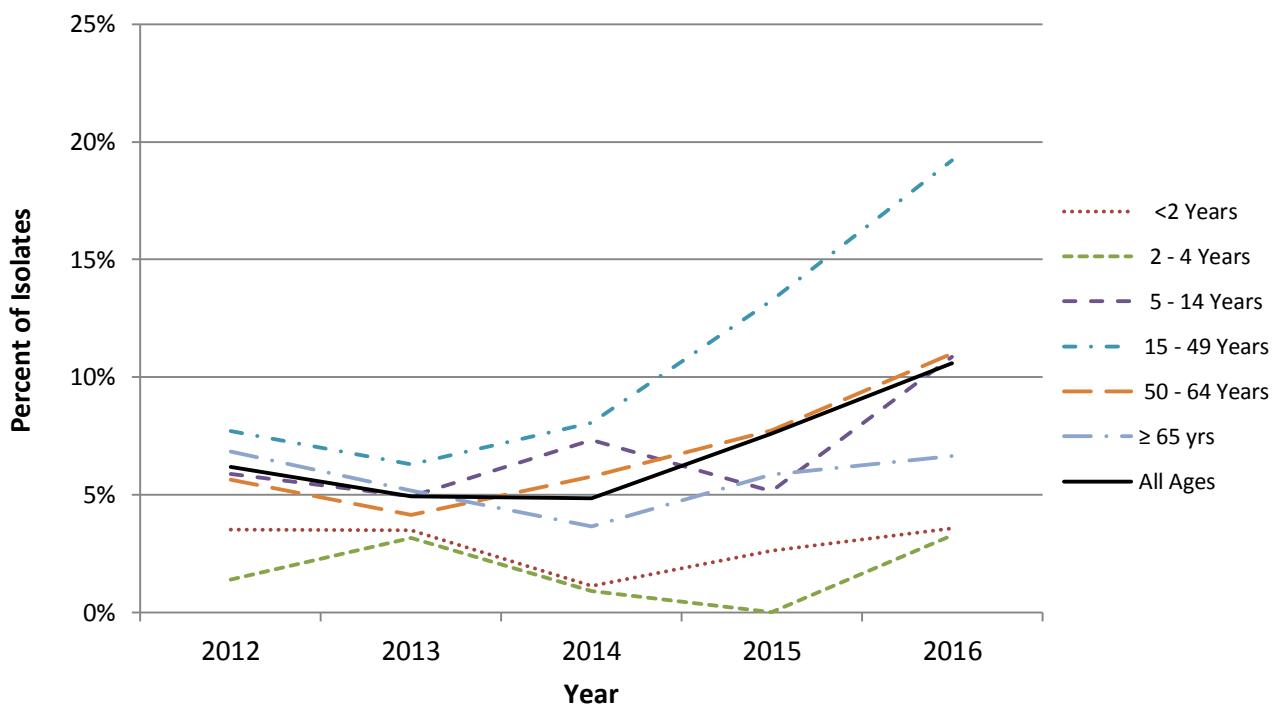
After a general increase of non-vaccine serotypes (NVT) during 2012 – 2014 among all age groups, an increase has only been observed in the 2 – 4 year olds from 33.6% (n=37) in 2014 to 43.5% (n=40). Proportions of NVTs during 2016 in the other age groups have remained relatively stable at 2014/2015 levels with 35.1% (n=59) in <2 year olds, 31.5% (n=29) in 5 – 14 year olds, 19.4% (n=131) in 15 – 49 year olds, 26.1% (n=204) in 50 – 64 year olds and 38.4% (n=416) in ≥65 year olds.

Vaccine uptake for pneumococcal disease was 80.3% at 2 years of age among survey participants for the childhood national immunization coverage survey in 2015 [PHAC, 2015].

Table 3. Pneumococcal Vaccine Serotypes 2016

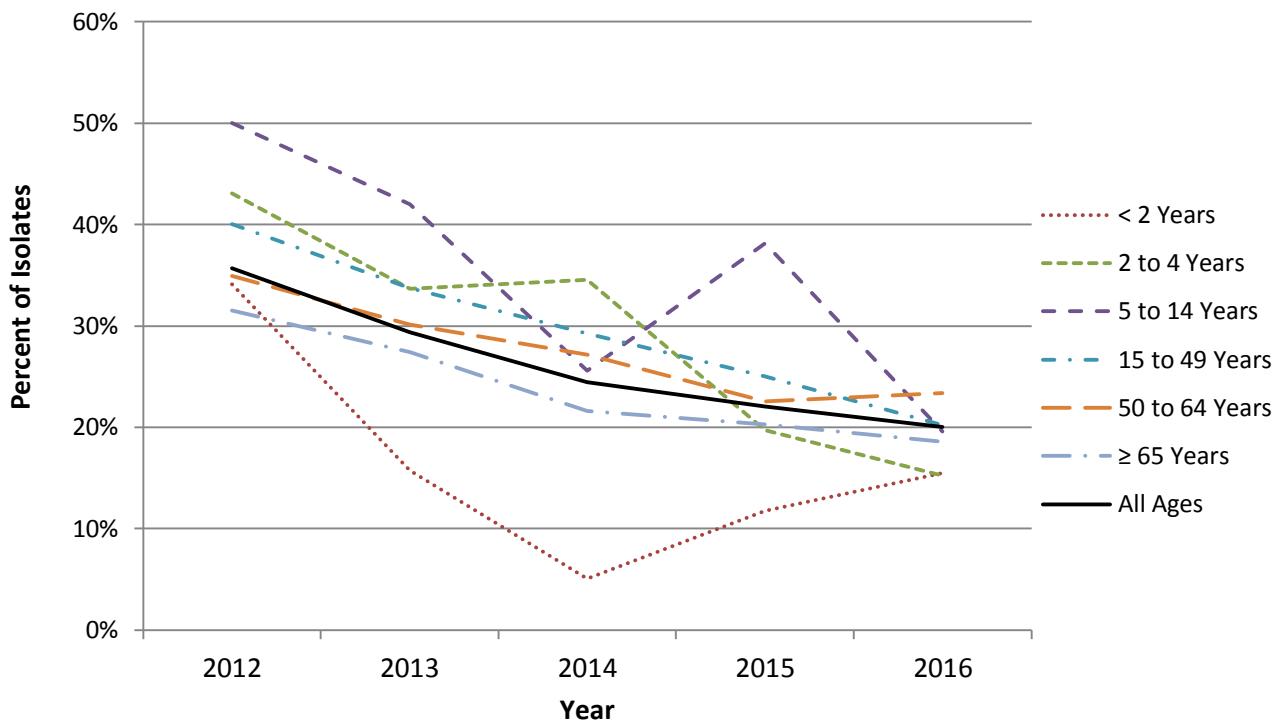
Vaccine*	Age Group						
	<2 years	2-4 years	5-14 years	15-49 years	50-64 years	≥65 years	All Ages**
PCV7	3.6%(6)***	3.3%(3)	10.9%(10)	19.2%(130)	11.0%(86)	6.7%(72)	10.6%(308)
PCV13	15.5%(26)	15.2%(14)	19.6%(18)	20.2%(137)	23.4%(183)	18.6%(201)	20.0%(581)
PCV13 All	19.0%(32)	18.5%(17)	30.4%(28)	39.4%(267)	34.4%(269)	25.2%(273)	30.6%(889)
PPV23	45.8%(77)	38.0%(35)	38.0%(35)	41.2%(279)	39.5%(309)	36.3%(393)	38.9%(1130)
PPV23 All	64.9%(109)	55.4%(51)	68.5%(63)	80.4%(544)	73.5%(575)	60.1%(650)	68.7%(1997)
NVT	35.1%(59)	43.5%(40)	31.5%(29)	19.4%(131)	26.1%(204)	38.4%(416)	30.5%(887)
Total	(168)	(92)	(92)	(677)	(782)	(1082)	(2906)

*PCV7 includes serotypes 4, 6B, 9V, 14, 18C, 19F and 23F. PCV13 serotypes include 1, 5, 7F, 3, 6A, and 19A; and PCV13 All serotypes include all PCV7 and PCV13 serotypes. PPV23 serotypes include 2, 8, 9N, 10A, 11A, 12F, 15B, 17F, 20, 22F and 33F and PPV23 All includes all PCV7, PCV13 (except 6A) and PPV23 serotypes. NVT includes all other non-vaccine serotypes. ** Includes isolates for which an age was not available: PCV13 = 1, PPV23 = 1 and NVT = 4. *** Percentage of isolates (number of isolates).

Figure 18. Trends of PCV7 serotypes (4, 6B, 9V, 14, 18C, 19F, 23F)**Table 4. PCV7 serotypes by age group**

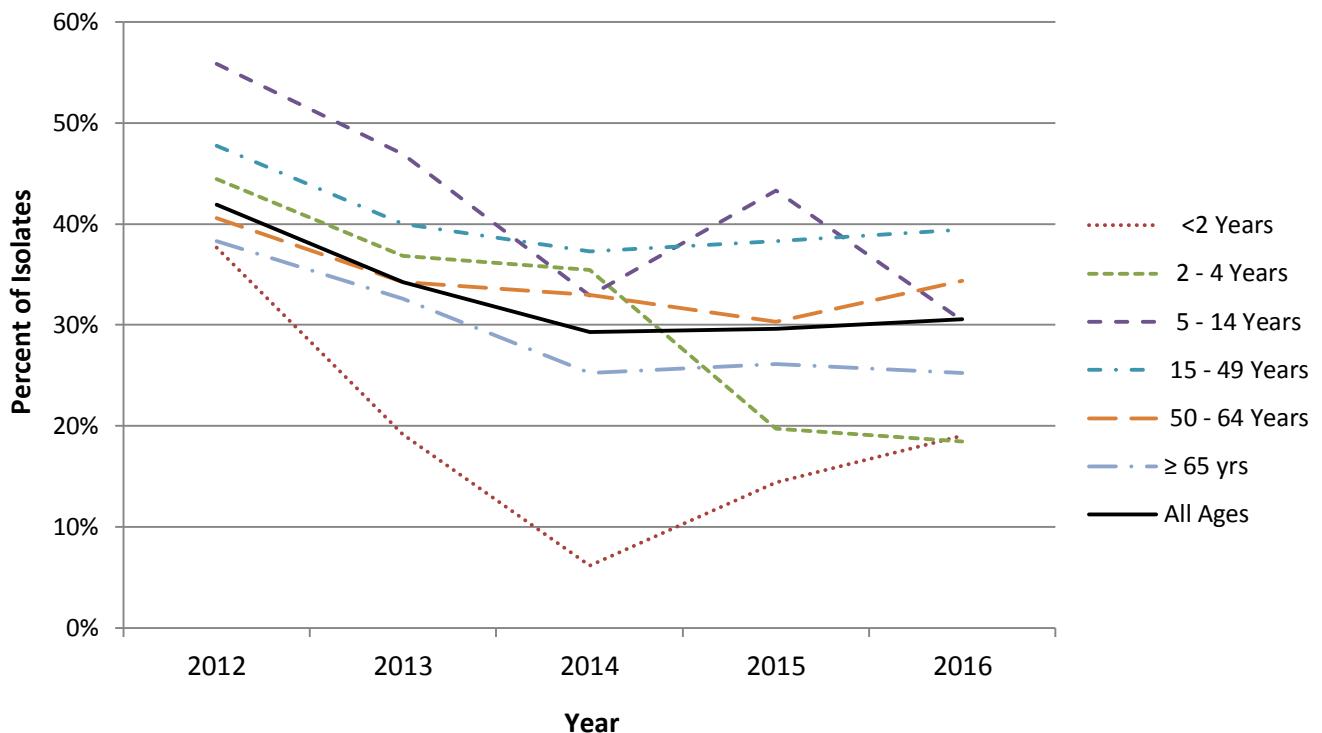
Year	Age Group						
	<2 years	2-4 years	5-14 years	15-49 years	50-64 years	≥65 years	All Ages**
2012	3.5% (6)*	1.4% (2)	5.9% (6)	7.7% (51)	5.6% (42)	6.8% (67)	6.2% (175)
2013	3.5% (6)	3.2% (3)	4.9% (4)	6.3% (35)	4.1% (30)	5.2% (56)	4.9% (135)
2014	1.1% (2)	0.9% (1)	7.3% (6)	8.1% (43)	5.8% (43)	3.6% (39)	4.9% (135)
2015	2.6% (4)	0.0% ()	5.2% (5)	13.3% (81)	7.7% (60)	5.9% (64)	7.6% (214)
2016	3.6% (6)	3.3% (3)	10.9% (10)	19.2% (130)	11.0% (86)	6.7% (72)	10.6% (308)

* Percentage of isolates (number of isolates). ** Includes isolates for which an age was not available.

Figure 19. Trends of PCV13 serotypes (1, 5, 7F, 3, 6A, 19A)**Table 5. PCV13 serotypes by age group**

Year	Age Group						
	<2 years	2-4 years	5-14 years	15-49 years	50-64 years	≥65 years	All Ages**
2012	34.1% (58)*	43.1% (62)	50.0% (51)	40.0% (265)	34.9% (260)	31.5% (309)	35.7% (1010)
2013	15.7% (27)	33.7% (32)	42.0% (34)	33.8% (188)	30.1% (218)	27.4% (296)	29.3% (804)
2014	5.0% (9)	34.5% (38)	25.6% (21)	29.2% (156)	27.2% (202)	21.6% (231)	24.4% (678)
2015	11.8% (18)	19.7% (15)	38.1% (37)	25.0% (153)	22.6% (175)	20.3% (221)	22.0% (620)
2016	15.5% (26)	15.2% (14)	19.6% (18)	20.2% (137)	23.4% (183)	18.6% (201)	20.0% (581)

* Percentage of isolates (number of isolates). ** Includes isolates for which an age was not available.

Figure 20. Trends of all PCV13 serotypes (4, 6B, 9V, 14, 18C, 19F, 23F; and 1, 5, 7F, 3, 6A, 19A)**Table 6. Combined PCV7 and PCV13 serotypes by age group**

Year	Age Group						
	<2 years	2-4 years	5-14 years	15-49 years	50-64 years	≥65 years	All Ages**
2012	37.6% (64)*	44.4% (64)	55.9% (57)	47.7% (316)	40.6% (302)	38.3% (376)	41.9% (1185)
2013	19.2% (33)	36.8% (35)	46.9% (38)	40.0% (223)	34.3% (248)	32.6% (352)	34.3% (939)
2014	6.1% (11)	35.5% (39)	32.9% (27)	37.3% (199)	33.0% (245)	25.2% (270)	29.3% (813)
2015	14.4% (22)	19.7% (15)	43.3% (42)	38.3% (234)	30.3% (235)	26.1% (285)	29.6% (834)
2016	19.0% (32)	18.5% (17)	30.4% (28)	39.4% (267)	34.4% (269)	25.2% (273)	30.6% (889)

* Percentage of isolates (number of isolates). ** Includes isolates for which an age was not available.

Figure 21. Trends of PPV23 serotypes (2, 8, 9N, 10A, 11A, 12F, 15B, 17F, 20, 22F, 33F)

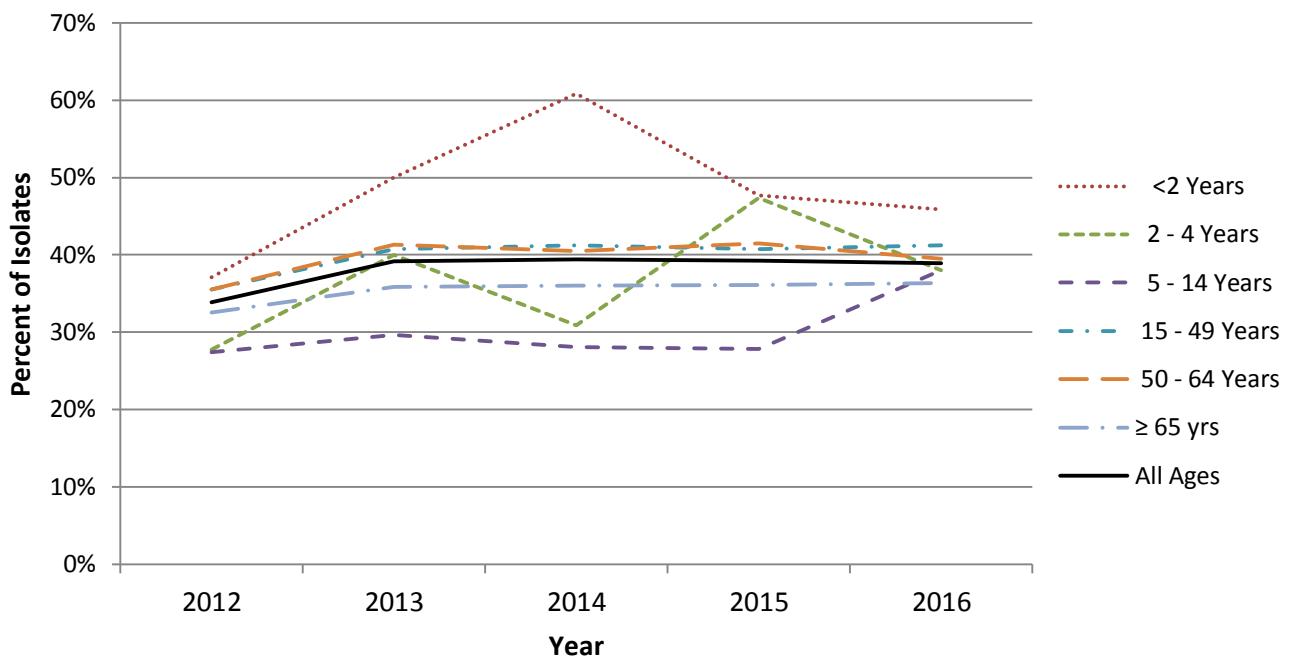
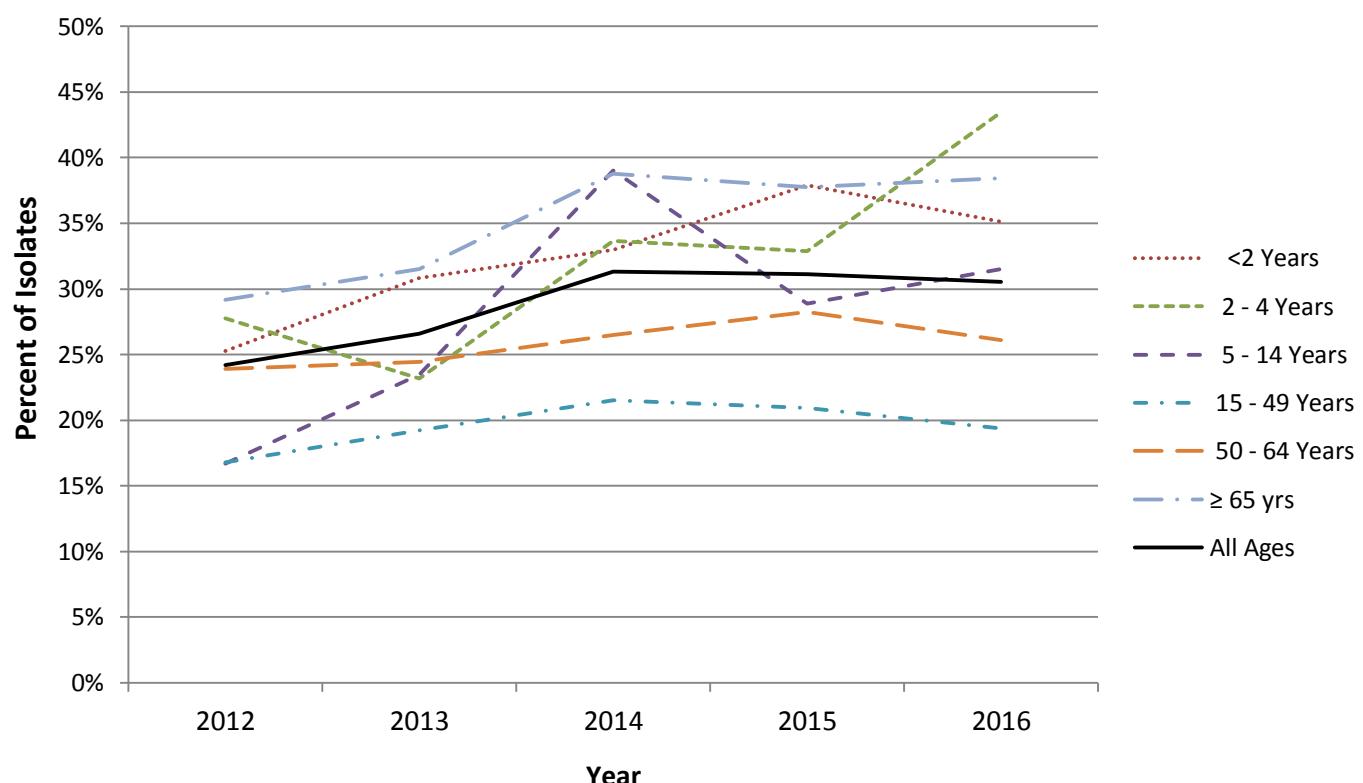


Table 7. PPV23 serotypes by age group

Year	Age Group						
	<2 years	2-4 years	5-14 years	15-49 years	50-64 years	≥65 years	All Ages**
2012	37.1% (63)*	27.8% (40)	27.5% (28)	35.5% (235)	35.5% (264)	32.5% (319)	33.9% (958)
2013	50.0% (86)	40.0% (38)	29.6% (24)	40.8% (227)	41.3% (299)	35.9% (387)	39.2% (1073)
2014	60.9% (109)	30.9% (34)	28.0% (23)	41.2% (220)	40.5% (301)	36.0% (385)	39.4% (1094)
2015	47.7% (73)	47.4% (36)	27.8% (27)	40.8% (249)	41.5% (322)	36.1% (394)	39.2% (1104)
2016	45.8% (77)	38.0% (35)	38.0% (35)	41.2% (279)	39.5% (309)	36.3% (393)	38.9% (1130)

* Percentage of isolates (number of isolates). ** Includes isolates for which an age was not available.

Figure 22. Trends of non-vaccine serotypes (NVT)**Table 8. Non-vaccine serotype (NVT) isolates**

Year	Age Group							All Ages**
	<2 years	2-4 years	5-14 years	15-49 years	50-64 years	≥65 years		
2012	25.3% (43)*	27.8% (40)	16.7% (17)	16.8% (111)	23.9% (178)	29.2% (286)	24.2%	(685)
2013	30.8% (53)	23.2% (22)	23.5% (19)	19.2% (107)	24.4% (177)	31.5% (340)	26.6%	(728)
2014	33.0% (59)	33.6% (37)	39.0% (32)	21.5% (115)	26.5% (197)	38.8% (415)	31.3%	(870)
2015	37.9% (58)	32.9% (25)	28.9% (28)	20.9% (128)	28.2% (219)	37.8% (412)	31.1%	(876)
2016	35.1% (59)	43.5% (40)	31.5% (29)	19.4% (131)	26.1% (204)	38.4% (416)	30.5%	(887)

* Percentage of isolates (number of isolates). ** Includes isolates for which an age was not available.

Antimicrobial Resistance of *S. pneumoniae*

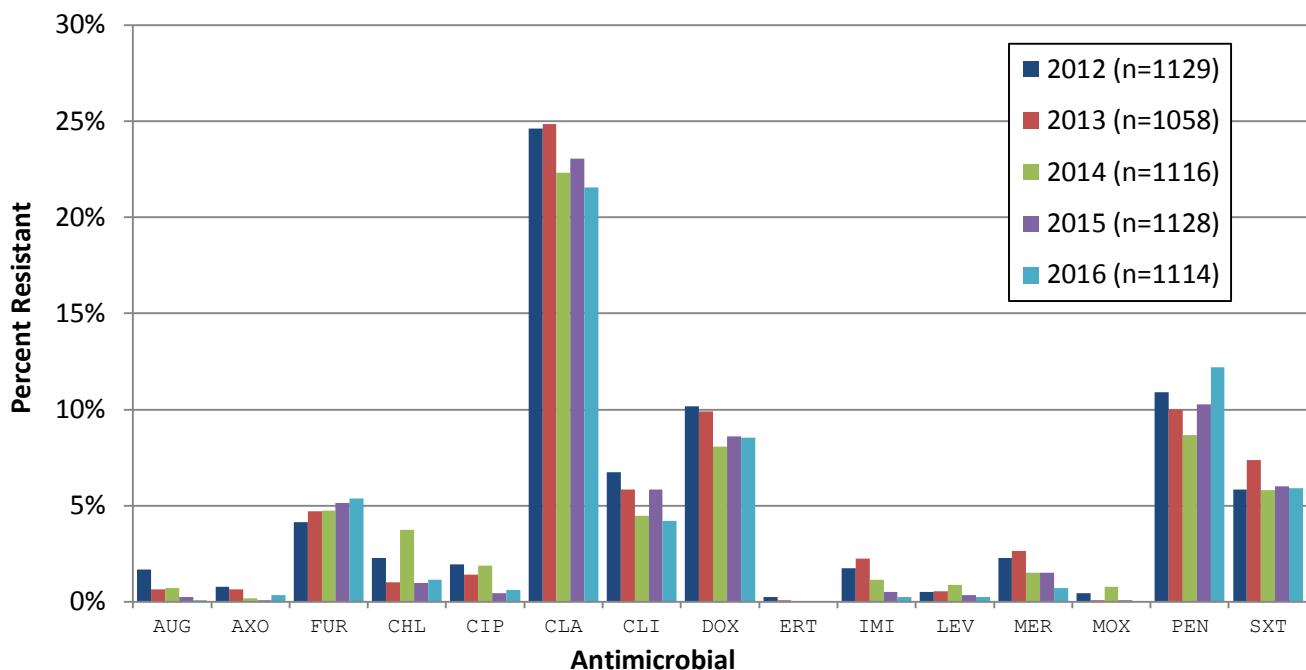
Antimicrobial susceptibility testing was performed on 1,114 *S. pneumoniae* isolates collected in 2016 that were submitted to the NML from 8 participating jurisdictions (Saskatchewan, Manitoba, Ontario, Québec, Nova Scotia, Prince Edward Island, New Brunswick and Newfoundland and Labrador).

Antimicrobial resistance rates among invasive *S. pneumoniae* in Canada have remained relatively stable in 2016. The highest rate of resistance during 2016 was observed for clarithromycin at 21.5% (n=240), a small decline from 24.6% (n=278) in 2012. Penicillin resistance (using meningitis breakpoints) was identified in 12.2% (n=136), doxycycline in 8.5% (n=95), trimethoprim-sulfamethoxazole in 5.9% (n=66), and clindamycin in 4.2% (n=47) of the isolates tested. All isolates were susceptible to ertapenem, daptomycin, linezolid, moxifloxacin, tigecycline and vancomycin.

Serotypes 6A, 6C, 19A, 15A, 23A and 35B generally had the highest rates of antimicrobial resistance. **Clarithromycin** resistance was associated with serotypes 33F (81.3%, n=39), 15A (78.3%, n=18), 6A (71.4% (n=5), 19A (53.0%, n=35), 22F (40.2%, n=43) and 35B (36.4% (n=8).

High rates of **penicillin** resistance was predominant in serotypes 6A (85.7%, n=6), 15A (78.3%, n=18), 35B (72.7%, n=16), 23A (40.0%, n=16), 6C (35.3%, n=12) and 23B (33.3%, n=13). **Cefuroxime** resistance was associated with serotypes 35B (68.2%, n=15) and 15A (43.5%, n=10). A relatively high proportion of isolate with **clindamycin** resistance was seen in serotypes 15A (78.3%, n=16) and **doxycycline** resistance in serotypes 15A (73.9%, n=17), 24F (33.3%, n=5) and 23A (27.5%, n=11). Resistance to **trimethoprim-sulfamethoxazole** was mainly associated with serotype 7C and 6C isolates (45.5%, n=10; and 23.5%, n=8; respectively).

Multidrug resistance (MDR) to 3 or more classes of antimicrobials among *S. pneumoniae* decreased slightly from 6.7% (n=76) of the isolates tested in 2015 to 6.2% (n=69) in 2016. The highest rates of MDR were seen in serotype 15A with 78.3% (n=18) and 19A with 15.2% (n=10) resistant to 3 or more antimicrobial classes. The major MDR pattern among serotype 15A isolates was β-lactam-macrolide-clindamycin-tetracycline (n=14); and for serotype 19A β-lactam-macrolide-clindamycin-tetracycline-trimethoprim/sulfamethoxazole (n=5).

Figure 23. Antimicrobial resistance of *S. pneumoniae* isolates**Table 9. Antimicrobial resistant *S. pneumoniae* isolates**

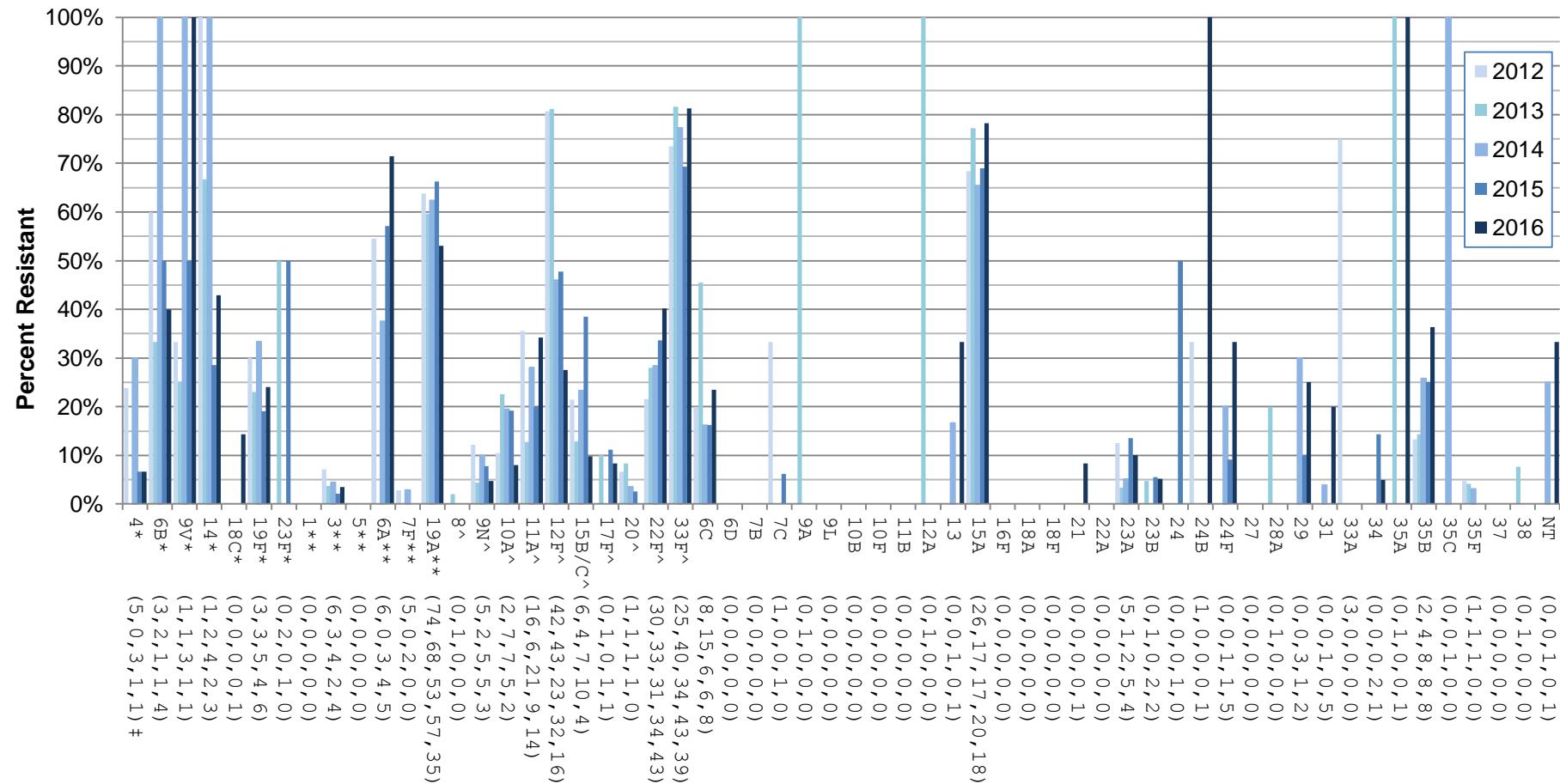
Antimicrobial	Year				
	2012	2013	2014	2015	2016
AUG*	1.7% (19)**	0.7% (7)	0.7% (8)	0.3% (3)	0.1% (1)
AXO	0.8% (9)	0.7% (7)	0.2% (2)	0.1% (1)	0.4% (4)
FUR	4.2% (47)	4.7% (50)	4.7% (53)	5.1% (58)	5.4% (60)
CHL	2.3% (26)	1.0% (11)	3.8% (42)	1.0% (11)	1.2% (13)
CIP	1.9% (22)	1.4% (15)	1.9% (21)	0.4% (5)	0.6% (7)
CLA	24.6% (278)	24.9% (263)	22.3% (249)	23.0% (260)	21.5% (240)
CLI	6.7% (76)	5.9% (62)	4.5% (50)	5.9% (66)	4.2% (47)
DOX	10.2% (115)	9.9% (105)	8.1% (90)	8.6% (97)	8.5% (95)
ERT	0.3% (3)	0.1% (1)	0.0% (0)	0.0% (0)	0.0% (0)
IMI	1.8% (20)	2.3% (24)	1.2% (13)	0.5% (6)	0.3% (3)
LEV	0.5% (6)	0.6% (6)	0.9% (10)	0.4% (4)	0.3% (3)
MER	2.3% (26)	2.6% (28)	1.5% (17)	1.5% (17)	0.7% (8)
MOX	0.4% (5)	0.1% (1)	0.8% (9)	0.1% (1)	0.0% (0)
PEN	10.9% (123)	10.0% (106)	8.7% (97)	10.3% (116)	12.2% (136)
SXT	5.8% (66)	7.4% (78)	5.8% (65)	6.0% (68)	5.9% (66)
Total Tested	(1129)	(1058)	(1116)	(1128)	(1114)

*AUG = amoxicillin/clavulanic acid; PEN = penicillin using the parenteral meningitis CLSI interpretive standard; LEV = levofloxacin; MOX = moxifloxacin; AXO = ceftriaxone using the parenteral meningitis interpretive standard; FUR = cefuroxime using the parenteral interpretative standard; ETP = ertapenem; IMI = imipenem; MER = meropenem; CIP = ciprofloxacin; CLA = clarithromycin; CLI = clindamycin; CHL = chloramphenicol; DOX = doxycycline; SXT = trimethoprim/sulfamethoxazole. Non susceptibility was not observed for daptomycin (no interpretative standard), linezolid, tigecycline (no interpretative standard), or vancomycin. EUCAST[EUCAST, 2017] interpretative breakpoints were used for CIP, all other according to CLSI[CLSI, 2017]. ** Percentage of isolates (number of isolates).

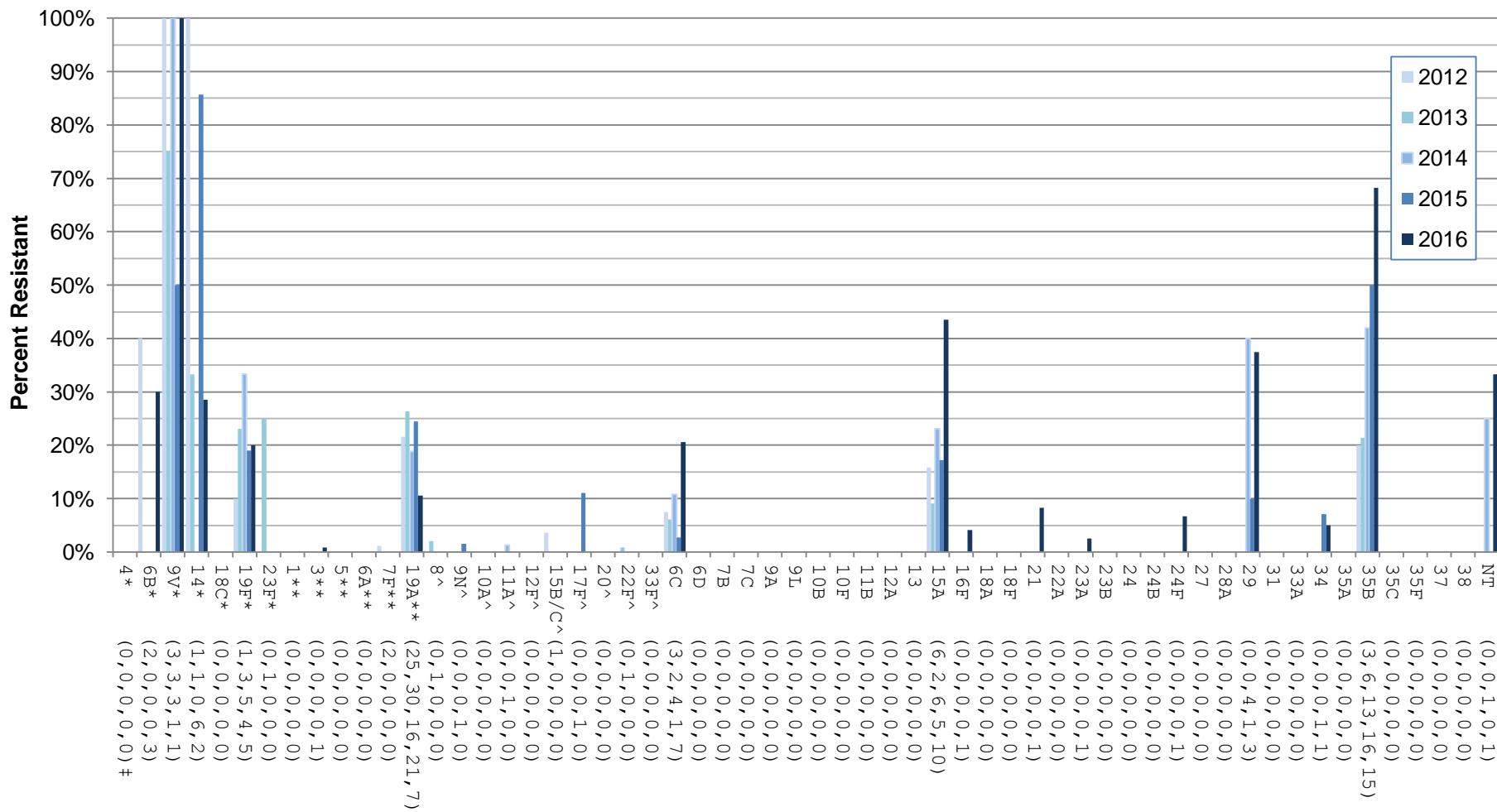
Table 10. Percentage Antimicrobial resistance[†] of *S. pneumoniae* serotypes, 2016

Serotype	PEN	AXO	FUR	ERT	IMI	MER	CIP	LEV	MOX	CLA	CLI	CHL	DOX	SXT
4* (n=15)	-	-	-	-	-	-	-	-	-	6.7	-	-	6.7	-
6B* (n=10)	60.0	-	30.0	-	-	-	10.0	10.0	-	40.0	30.0	-	60.0	30.0
9V* (n=1)	100.0	-	100.0	-	-	-	-	-	-	100.0	-	-	100.0	100.0
14* (n=7)	42.9	-	28.6	-	-	-	-	-	-	42.9	14.3	-	28.6	28.6
18C* (n=7)	42.9	-	-	-	-	-	-	-	-	14.3	-	-	28.6	28.6
19F* (n=25)	24.0	4.0	20.0	-	-	-	-	-	-	24.0	20.0	-	24.0	8.0
23F* (n=2)	50.0	-	-	-	-	-	-	-	-	-	-	-	-	50.0
1** (n=2)	50.0	-	-	-	-	-	-	-	-	-	-	-	-	-
3** (n=116)	0.9	-	0.9	-	-	-	-	-	-	3.4	2.6	6.9	12.1	0.9
6A** (n=7)	85.7	-	-	-	-	-	-	-	-	71.4	-	-	-	14.3
7F** (n=26)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19A** (n=66)	16.7	-	10.6	-	3.0	6.1	1.5	-	-	53.0	12.1	-	15.2	13.6
8^ (n=72)	-	-	-	-	-	-	-	-	-	-	-	1.4	2.8	1.4
9N^ (n=63)	1.6	-	-	-	-	-	-	-	-	4.8	-	-	-	-
10A^ (n=25)	8.0	-	-	-	-	-	-	-	-	8.0	-	-	8.0	4.0
11A^ (n=41)	-	-	-	-	-	-	-	-	-	34.1	2.4	-	2.4	12.2
12F^ (n=58)	1.7	-	-	-	-	-	1.7	1.7	-	27.6	-	1.7	1.7	1.7
15B/C^ (n=41)	4.9	-	-	-	-	-	-	-	-	9.8	2.4	-	4.9	-
17F^ (n=12)	-	-	-	-	-	-	-	-	-	8.3	8.3	-	-	-
20^ (n=24)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22F^ (n=107)	-	-	-	-	-	-	0.9	-	-	40.2	-	-	-	0.9
33F^ (n=48)	-	-	-	-	-	-	-	-	-	81.3	4.2	-	-	14.6
6C (n=34)	35.3	-	20.6	-	-	-	5.9	2.9	-	23.5	5.9	-	5.9	23.5
7C (n=22)	4.5	-	-	-	-	-	-	-	-	-	-	-	-	45.5
9L (n=1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10B (n=1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10F (n=1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13 (n=3)	-	-	-	-	-	-	-	-	-	33.3	-	-	-	-
15A (n=23)	78.3	-	43.5	-	-	-	-	-	-	78.3	69.6	4.3	73.9	-
16F (n=24)	16.7	-	4.2	-	4.2	4.2	-	-	-	4.2	-	4.2	-	-
18F (n=1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21 (n=12)	8.3	-	8.3	-	-	-	-	-	-	8.3	-	-	-	8.3
23A (n=40)	40.0	-	2.5	-	-	-	-	-	-	10.0	-	-	27.5	-
23B (n=39)	33.3	-	-	-	-	-	-	-	-	5.1	-	-	7.7	2.6
24B (n=1)	-	-	-	-	-	-	-	-	-	100.0	100.0	-	-	-
24F (n=15)	33.3	6.7	6.7	-	-	-	-	-	-	33.3	-	-	33.3	6.7
28A (n=5)	-	-	-	-	-	-	-	-	-	-	-	40.0	40.0	40.0
29 (n=8)	37.5	-	37.5	-	-	-	-	-	-	25.0	-	-	-	-
31 (n=25)	-	-	-	-	-	-	-	-	-	20.0	-	-	-	-
34 (n=20)	5.0	5.0	5.0	-	-	-	-	-	-	5.0	5.0	-	10.0	10.0
35A (n=1)	-	-	-	-	-	-	-	-	-	100.0	-	-	100.0	100.0
35B (n=22)	72.7	4.5	68.2	-	-	9.1	4.5	-	-	36.4	4.5	-	4.5	4.5
35F (n=18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37 (n=1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38 (n=19)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NT (n=3)	33.3	-	33.3	-	-	33.3	-	-	-	33.3	-	-	-	33.3
All (n=1114)	12.2	0.4	5.4	-	0.3	0.7	0.6	0.3	-	21.5	4.2	1.2	8.5	5.9

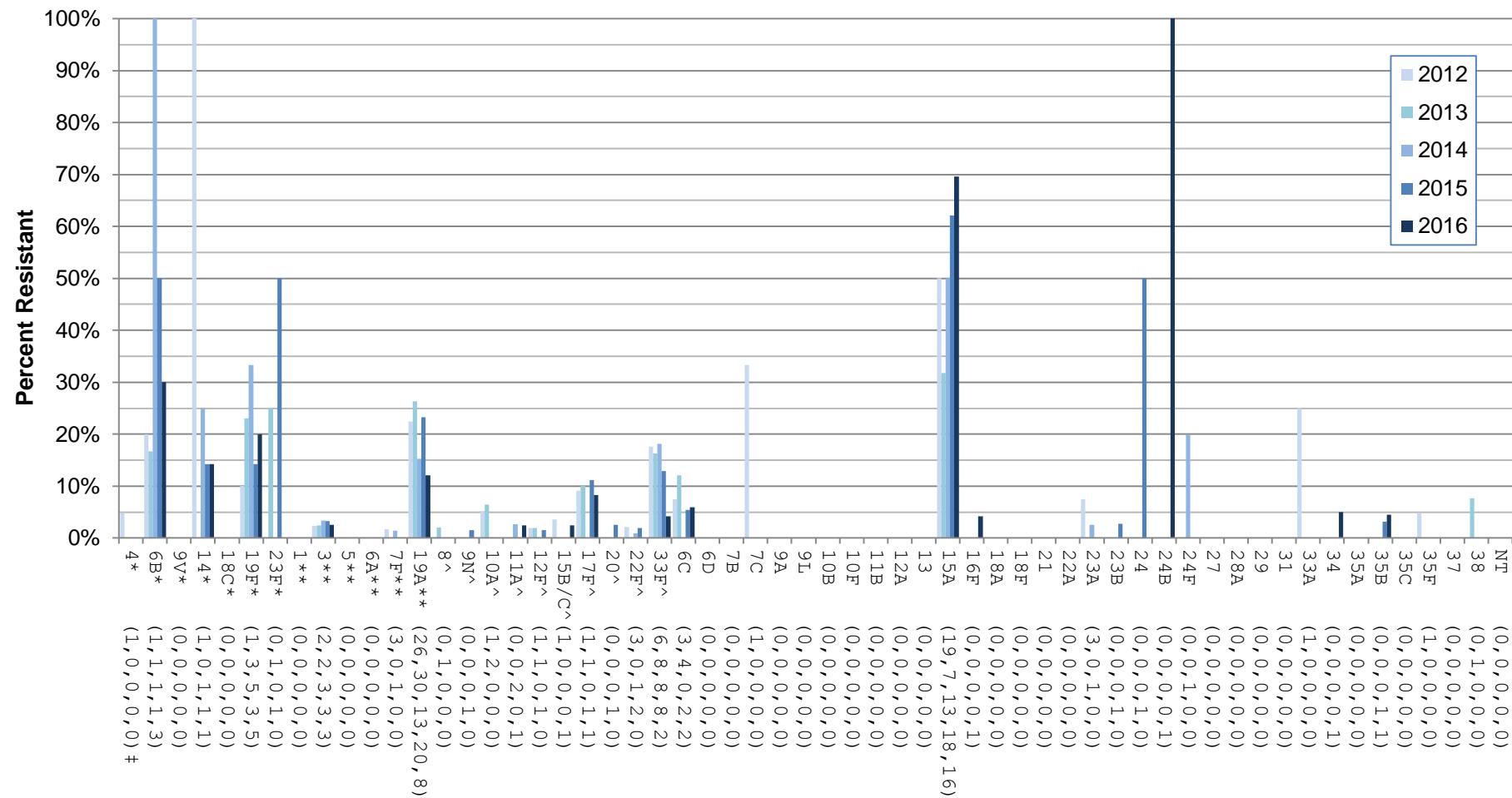
[†]Percentage of serotype total interpreted as resistant to the antimicrobial agent; “-” denotes no resistance (0%) to the antimicrobial. PEN = penicillin using the parenteral meningitis CLSI interpretive standard; AXO = ceftriaxone using the parenteral meningitis interpretive standard; FUR = cefuroxime using the parenteral interpretative standard; ERT = ertapenem; IMI = imipenem; MER = meropenem; CIP = ciprofloxacin; LEV = levofloxacin; MOX = moxifloxacin; CLA = clarithromycin; CLI = clindamycin; CHL = chloramphenicol; DOX = doxycycline; SXT = trimethoprim/sulfamethoxazole. Non susceptibility was not observed for daptomycin (no interpretative standard), linezolid, tigecycline (no interpretative standard), or vancomycin. EUCAST [EUCAST, 2015] interpretative breakpoints were used for CIP, all other according to CLSI [CLSI, 2017]. * represent PCV7 serotypes, ** represent PCV13 serotypes, and ^ represent PPV23.

Figure 24. Clarithromycin resistance of *S. pneumoniae* serotypes

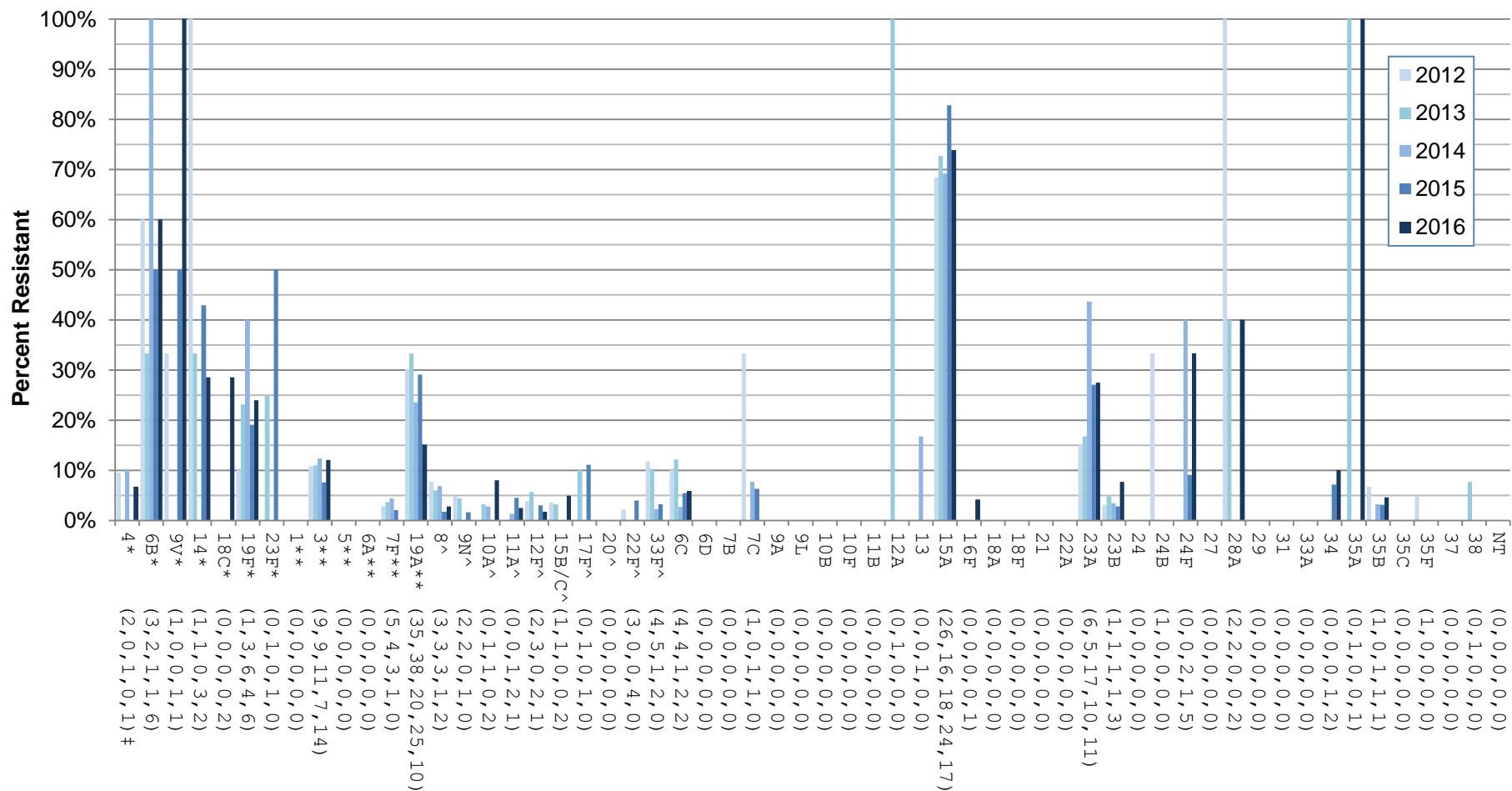
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2012, 2013, 2014, 2015 and 2016, respectively.

Figure 25. Cefuroxime resistance of *S. pneumoniae* serotypes

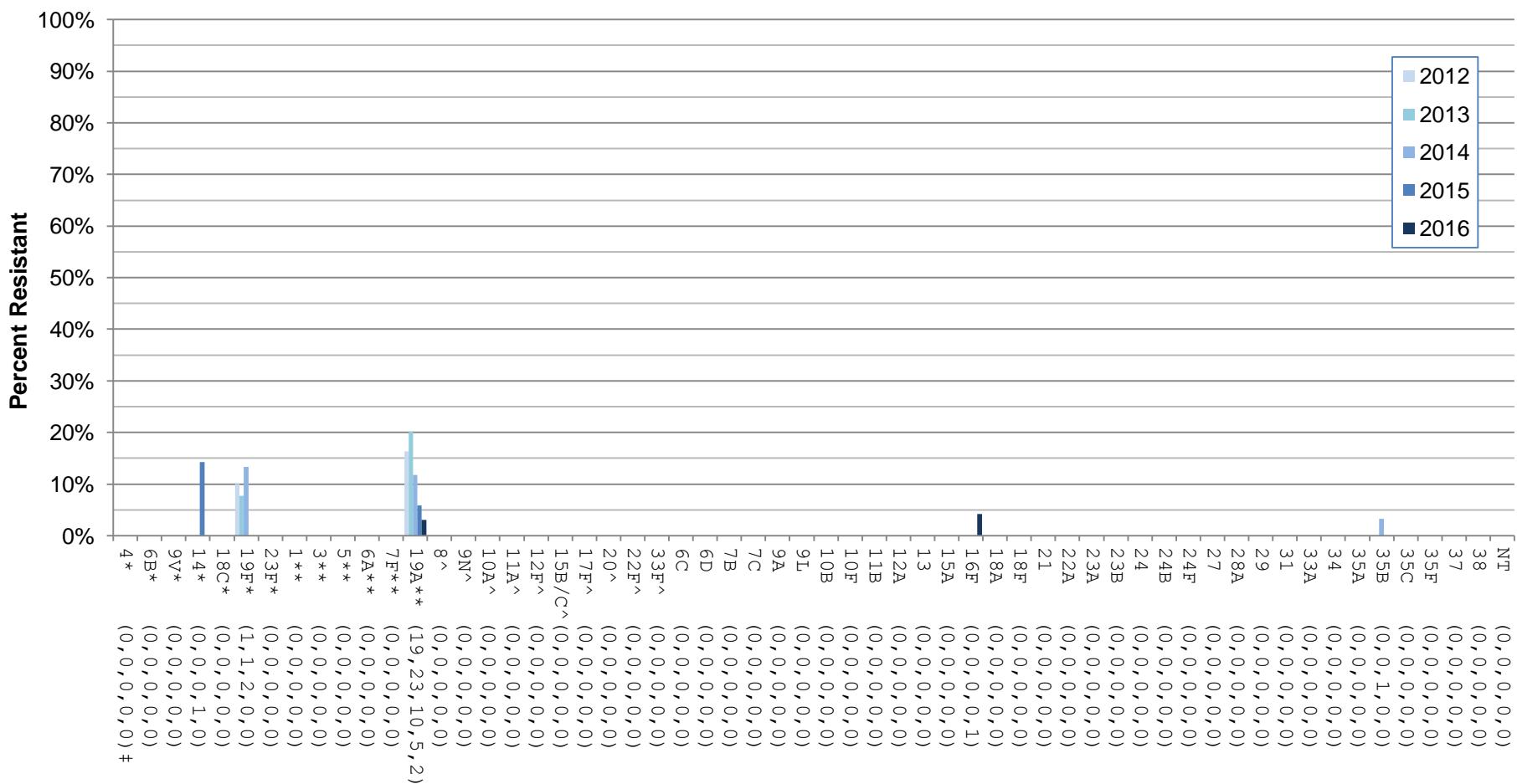
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2012, 2013, 2014, 2015 and 2016, respectively.

Figure 26. Clindamycin resistance of *S. pneumoniae* serotypes

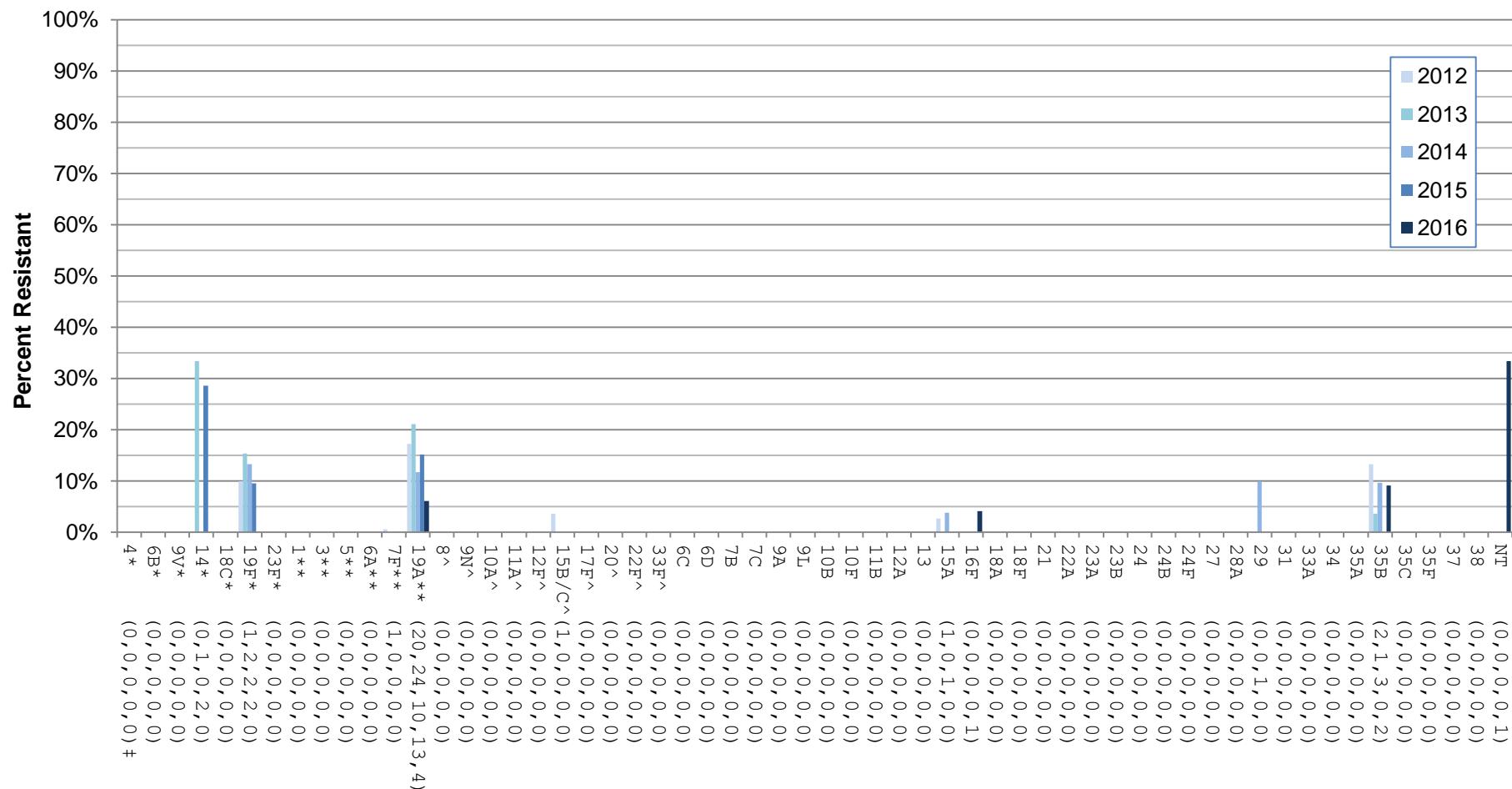
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2012, 2013, 2014, 2015 and 2016, respectively.

Figure 27. Doxycycline resistance of *S. pneumoniae* serotypes

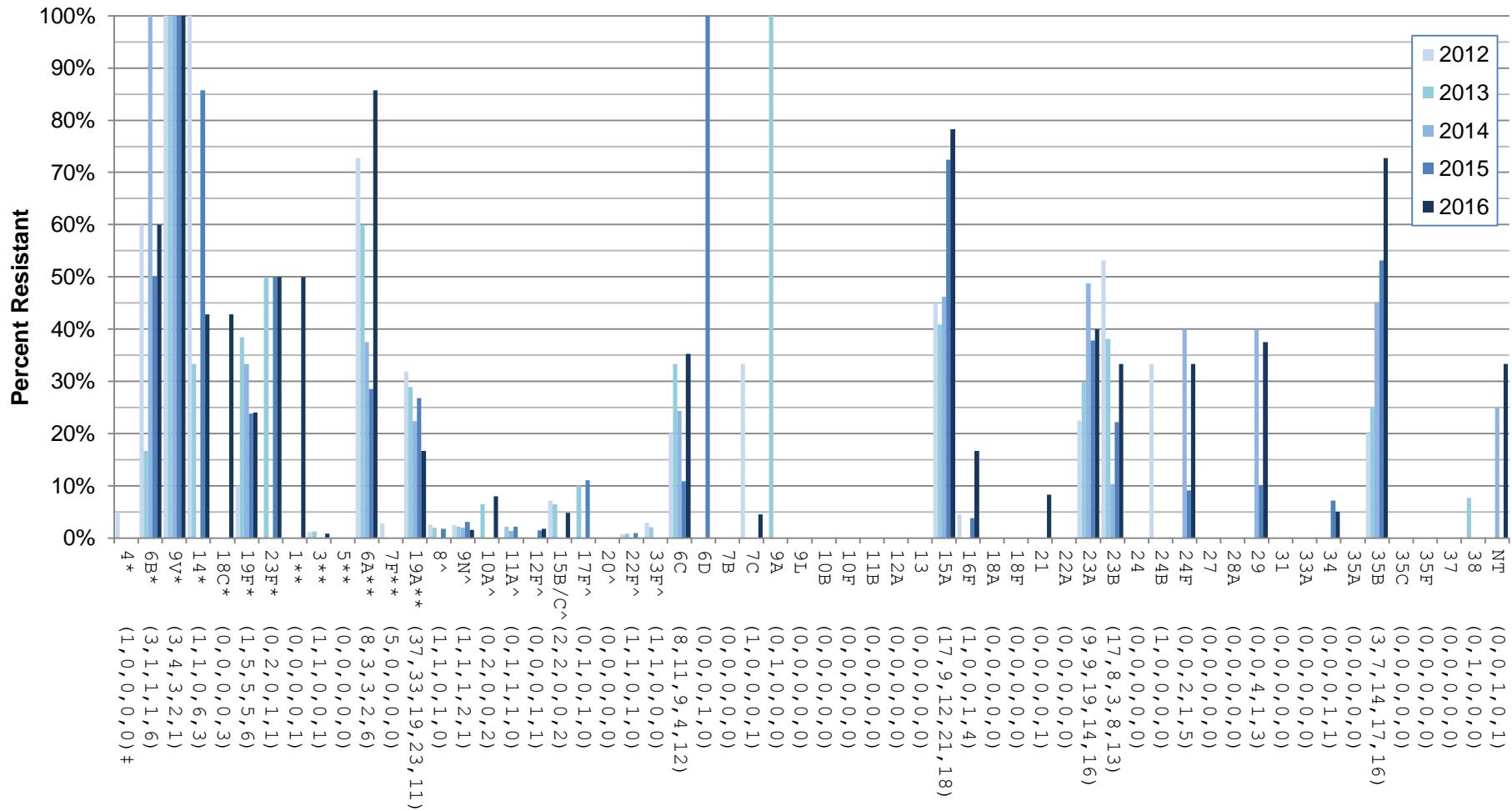
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2012, 2013, 2014, 2015 and 2016, respectively.

Figure 28. Imipenem resistance of *S. pneumoniae* serotypes

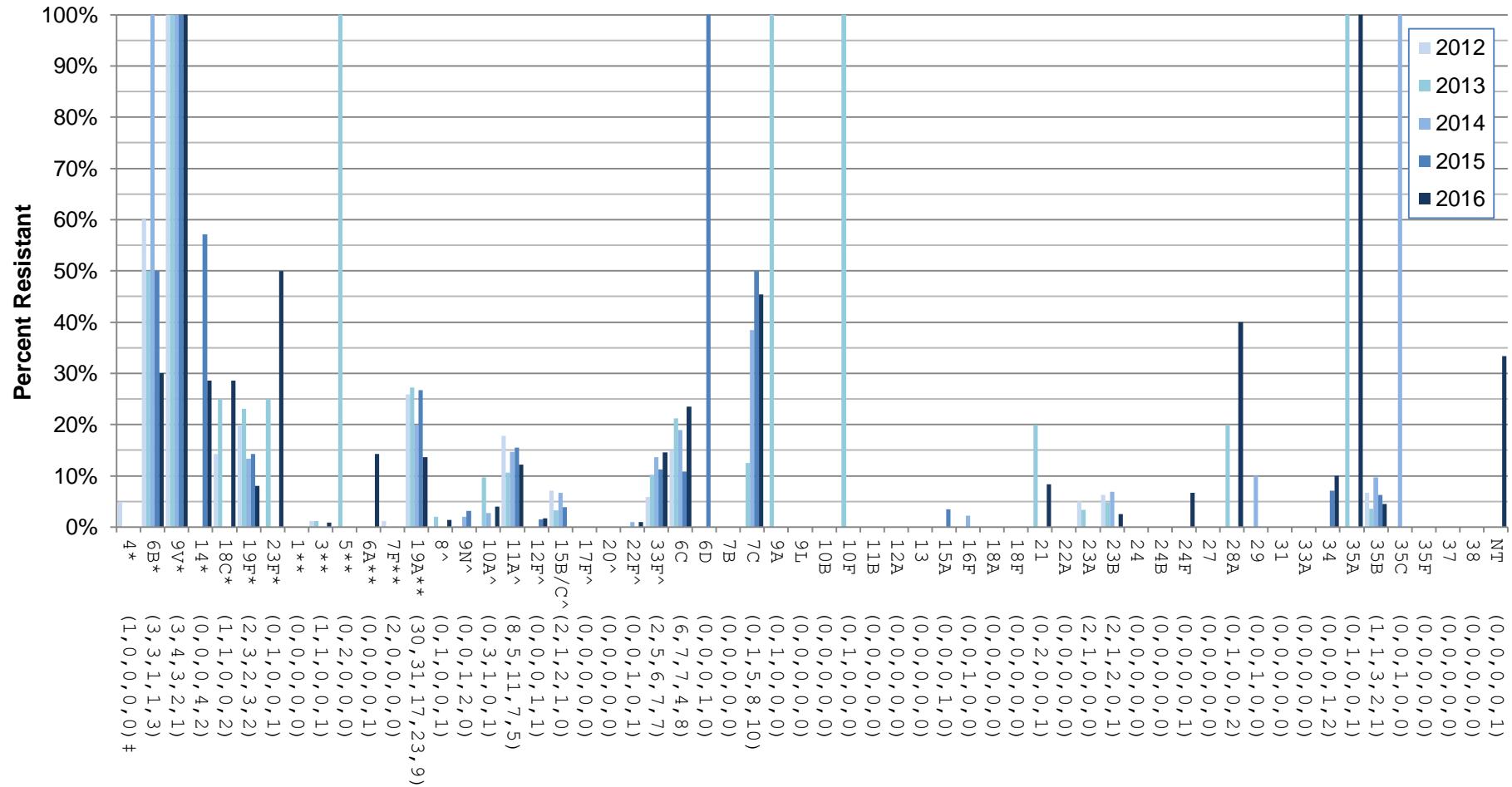
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; † Number of resistant isolates for 2012, 2013, 2014, 2015 and 2016, respectively.

Figure 29. Meropenem resistance of *S. pneumoniae* serotypes

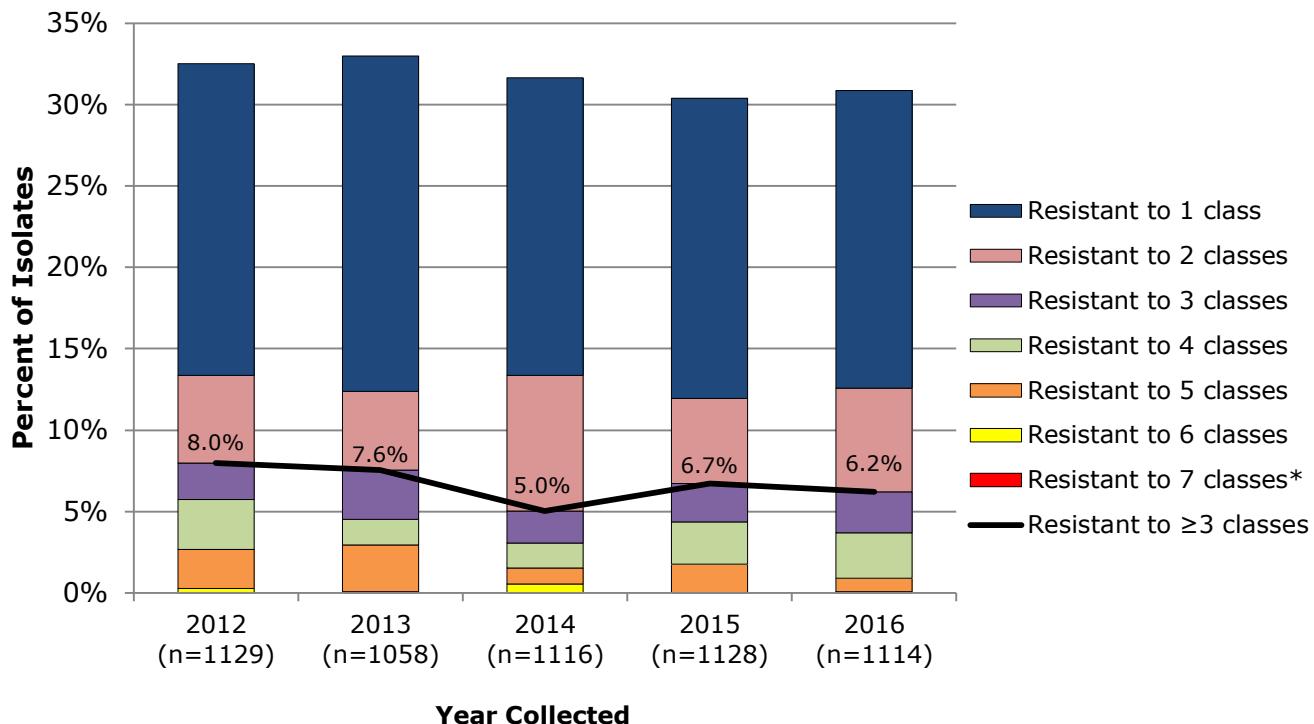
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2012, 2013, 2014, 2015 and 2016, respectively.

Figure 30. Penicillin resistance of *S. pneumoniae* serotypes

*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2012, 2013, 2014, 2015 and 2016, respectively.

Figure 31. Trimethoprim/Sulfamethoxazole resistance of *S. pneumoniae* serotypes

*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; † Number of resistant isolates for 2012, 2013, 2014, 2015 and 2016, respectively.

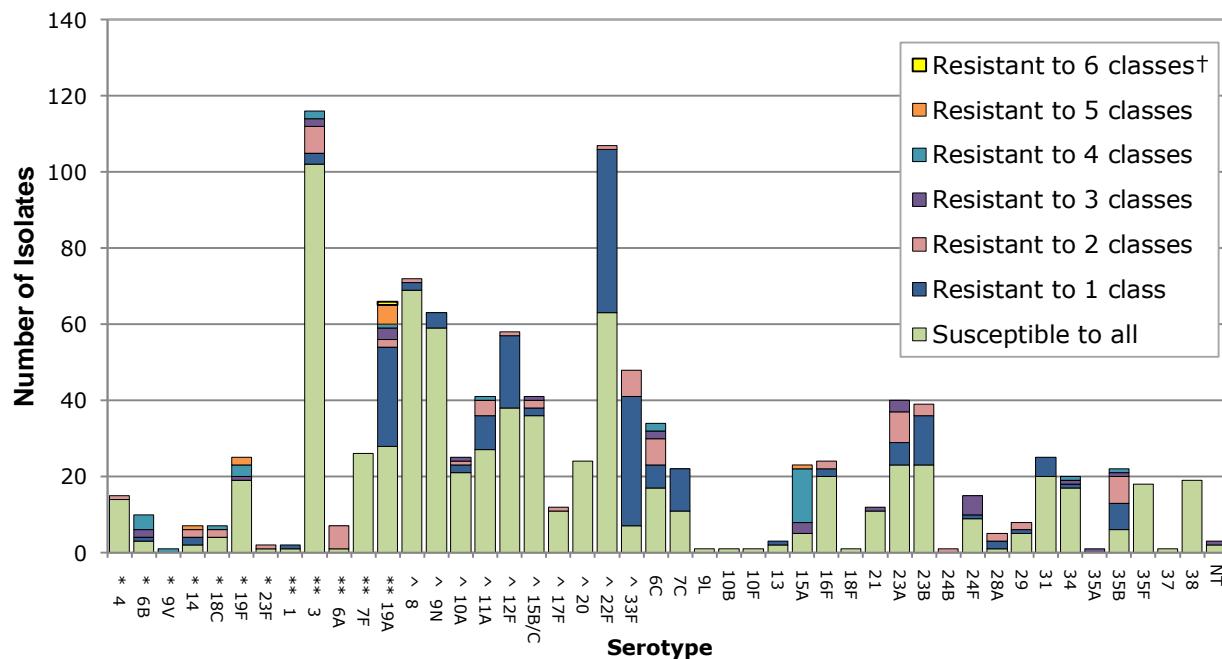
Figure 32. Annual trend of multi-drug resistance of *S. pneumoniae*

*Antimicrobial classes include: β-lactams (amoxicillin/clavulanic acid, penicillin using meningitis breakpoints, ceftriaxone using meningitis breakpoints, cefuroxime using parenteral breakpoint, ertapenem, imipenem and meropenem); macrolides (clarithromycin); fluoroquinolones (levofloxacin and moxifloxacin); tetracyclines (doxycycline); folate pathway inhibitors (trimethoprim-sulfamethoxazole); phenicols (chloramphenicol); lincosamides (clindamycin); oxazolidinones (linezolid).

Table 11: Multi-drug resistance of *S. pneumoniae*

Year	Number of Antimicrobial Classes Resistant							
	1	2	3	4	5	6	7	≥3
2012	19.1%(216)*	5.4%(61)	2.2%(25)	3.1%(35)	2.4%(27)	0.3%(3)	0.0%(0)	8.0%(90)
2013	20.6%(218)	4.8%(51)	3.0%(32)	1.6%(17)	2.8%(30)	0.0%(0)	0.1%(1)	7.6%(80)
2014	18.3%(204)	8.3%(93)	2.0%(22)	1.5%(17)	1.0%(11)	0.5%(6)	0.0%(0)	5.0%(56)
2015	18.4%(208)	5.2%(59)	2.4%(27)	2.6%(29)	1.8%(20)	0.0%(0)	0.0%(0)	6.7%(76)
2016	18.3%(204)	6.4%(71)	2.5%(28)	2.8%(31)	0.8%(9)	0.1%(1)	0.0%(0)	6.2%(69)

* Percentage of isolates (number of isolates).

Figure 33. Multi-drug resistance of *S. pneumoniae* serotypes in 2016

†Antimicrobial classes include: β-lactams (amoxicillin/clavulanic acid, penicillin using meningitis breakpoints, ceftriaxone using meningitis breakpoints, cefuroxime using parenteral breakpoint, ertapenem, imipenem and meropenem); macrolides (clarithromycin); fluoroquinolones (levofloxacin and moxifloxacin); tetracyclines (doxycycline); folate pathway inhibitors (trimethoprim-sulfamethoxazole); phenolics (chloramphenicol); lincosamides (clindamycin); oxazolidinones (linezolid).

*Component of PCV7; ** Component of PCV13; ^ Component of PPV23

Table 12. Multi-drug resistant profiles of *S. pneumoniae* serotypes in 2016

Serotype	BLA*	BLA-CLI	BLA-CLI-TET-SXT	BLA-FQN	BLA-MAC	BLA-MAC-CLI	BLA-MAC-CLI-TET	BLA-MAC-CLI-TET-CHL	BLA-MAC-CLI-TET-SXT	BLA-MAC-FQN-CLI-TET-SXT	BLA-MAC-SXT	BLA-MAC-TET	BLA-MAC-TET-SXT	BLA-SXT	BLA-TET	BLA-TET-SXT	CHL	FQN	FQN-SXT	MAC	MAC-CLI	MAC-CLI-TET	MAC-CLI-TET-CHL	MAC-CLI-TET-SXT	MAC-SXT	MAC-TET	MAC-TET-SXT	SXT	TET	TET-CHL	TET-SXT				
1	1																																		
3																																			
4																																			
6A			5												1																				
6B			1			2						1	1			1	1																		
6C	1			2	2						2		5				2	2											1						
7C	1																												10						
7F																																			
8																													1	1	1				
9L																																			
9N	1																																		
9V															1																				
NT															1																				
10A																			1	1				2											
10B																																			
10F																																			
11A																													1	4					
12F	1																		1	1				16							1				
13																															1				
14															1				1	1				2											
15A					1	14	1								2																				
15B/C																			1					2	1										
16F	2	1																																	
17F																															1				
18C																			1	1	1														
18F																																			
19A	1														1	5	1	1	1	1	1			25	1		1								
19F															3	2		1																	
20																																			
21																1																			
22F																																			
23A	5														1																	1			
23B	11														1																	1	1		
23F																		1																	
24B																																1			
24F																		5																1	
28A																																2	2		
29	1														2																				
31																																			
33F																																			
34	1																	1															1		
35A																																			
35B	7														1	6	1		1																
35F																																			
37																																			
38																																			
All	33	1	1	1	1	17	1	23	1	8	1	5	14	3	10	13	5	1	4	1	143	5	2	2	2	10	2	1	17	6	9	2			

*Antimicrobial classes: BLA= β -lactams (amoxicillin/clavulanic acid, penicillin and ceftriaxone (meningitis breakpoints), cefuroxime (parenteral breakpoint), ertapenem, imipenem and meropenem); MAC=macrolides (clarithromycin); FQN=fluoroquinolones (levofloxacin and moxifloxacin); TET=tetracyclines (doxycycline); SXT=folate pathway inhibitors (trimethoprim-sulfamethoxazole); CLI=lincosamides (clindamycin); CHL=phenicols (chloramphenicol).

Invasive *Streptococcus pyogenes* (Group A Streptococcus)

The overall incidence of disease from invasive GAS in Canada as reported to the CNDSS has continued to increase in 2015 to 5.3 cases per 100,000 population, an increase from 5.1 cases per 100,000 population in 2014. The highest average annual incidence rate per 100,000 population was in infants <1 year of age with 13.6 cases followed by seniors ≥60 years old with 8.3 cases, and lowest among the 10-14 age group with 1.1 cases.

Figure 34. Annual incidence of invasive *S. pyogenes* cases

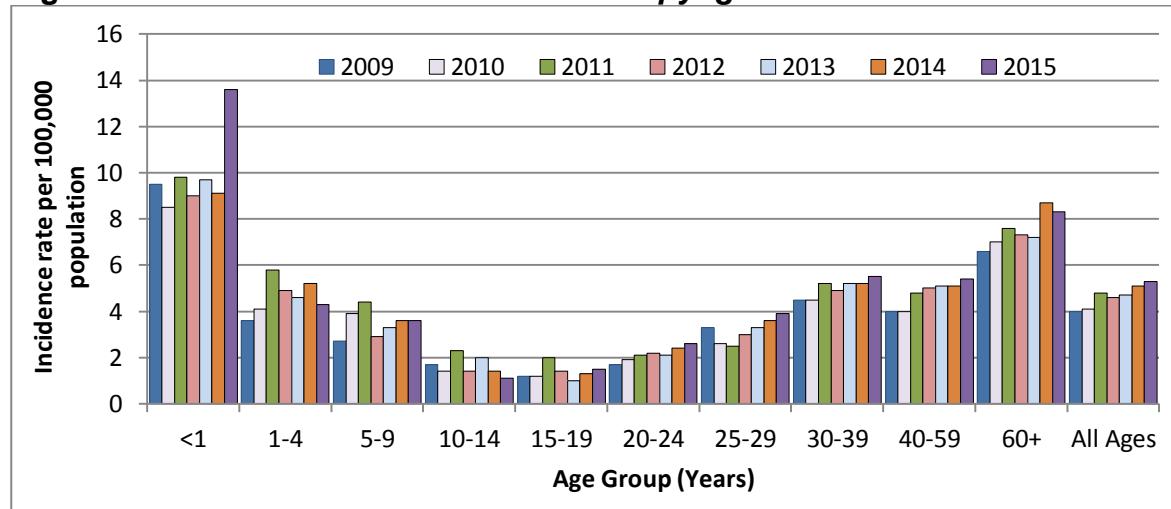


Table 13. Annual incidence rates of invasive *S. pyogenes*

Year	Age Group (Years)										
	<1	1-4	5-9	10-14	15-19	20-24	25-29	30-39	40-59	60+	All Ages
2009	9.5*	3.6	2.7	1.7	1.2	1.7	3.3	4.5	4.0	6.6	4.0
2010	8.5	4.1	3.9	1.4	1.2	1.9	2.6	4.5	4.0	7.0	4.1
2011	9.8	5.8	4.4	2.3	2.0	2.1	2.5	5.2	4.8	7.6	4.8
2012	9.0	4.9	2.9	1.4	1.4	2.2	3.0	4.9	5.0	7.3	4.6
2013	9.7	4.6	3.3	2.0	1.0	2.1	3.3	5.2	5.1	7.2	4.7
2014	8.3	5.0	3.5	1.3	1.2	2.2	3.5	4.9	4.7	8.2	5.1
2015	13.6	4.3	3.6	1.1	1.5	2.6	3.9	5.5	5.4	8.3	5.3

* Cases per 100,000 population

Of the 1,792 invasive *Streptococcus pyogenes* isolates tested at the NML by *emm* typing, 10.7% (n=191) were isolated from children <15 years of age and 1,598 (89.3%) were from adults ≥15 years of age. Isolates from male patients represented 56.5% (n=994) of the isolates for which gender information was available.

There were no major differences observed in the relative proportions of clinical isolation sites between adults and children other than more CSF and pleural fluid isolations sites were observed among pediatric isolates (2.6%, n=5; and 7.9%, n=15; respectively) than in the adults (0.1%, n=2; and 1.7%, n=27; respectively). There was generally an even distribution of *emm* types among the major clinical isolation sites except for *emm74*, which accounted for 15.6% (n=61) of isolates from other sterile sites such as deep wounds and abscesses with only 3.6% (n=45) of blood and 3.0% (n=5) of synovial fluid isolates.

In Western regions *emm81* (16.7%, n=112), *emm82* (10.0%, n=67), and *emm101* (8.8%, n=59) were predominant; in Central regions *emm1* (19.7%, n=206), *emm74* (9.4%, n=99), *emm3* (8.0%, n=84), and *emm12* (7.9%, n=83) were predominant; and in Eastern Canada *emm* types *emm1* (15.3%, n=11), *emm89* (12.5%, n=9), *emm4* (9.7%, n=7), and *emm2* (8.3%, n=6) were predominant.

Although *emm1* continues to be most prevalent in Canada, it has decreased dramatically from 25.9% (n=293) in 2012 to 14.7% (n=264) in 2016. *Emm89* continues to decline from 9.9% (n=113) in 2012 to 5.6% (n=100) in 2016. Large increases of *emm74* from none in 2012 to 6.2% (n=111) and *emm81* from 0.4% (n=5) to 8.8% (n=157) were observed.

Table 14. Number of invasive *S. pyogenes* (GAS) isolates by province

Province	Age Group (Years)						Not Given	Total
	< 2	2 – 4	5 – 14	15 – 49	50 – 64	≥ 65		
British Columbia	1	1	16	142	58	71	-	289
Saskatchewan	3	5	6	92	36	26	-	168
Manitoba	11	7	9	83	54	50	1	215
Ontario	9	15	31	238	153	202	1	649
Québec	22	21	24	142	86	104	-	399
New Brunswick	-	1	1	9	4	12	-	27
Nova Scotia	1	-	3	8	4	3	-	19
Prince Edward Island	-	-	-	1	-	3	1	5
Newfoundland and Labrador	-	-	1	2	-	-	-	3
Yukon	-	1	-	3	2	-	-	6
Northwest Territories	-	1	1	3	3	3	-	11
Nunavut	-	-	-	-	1	-	-	1
Canada	47	52	92	723	401	474	3	1792

Figure 35a. Clinical isolation sites of *S. pyogenes* from children <15 years of age in 2016 (n=191)

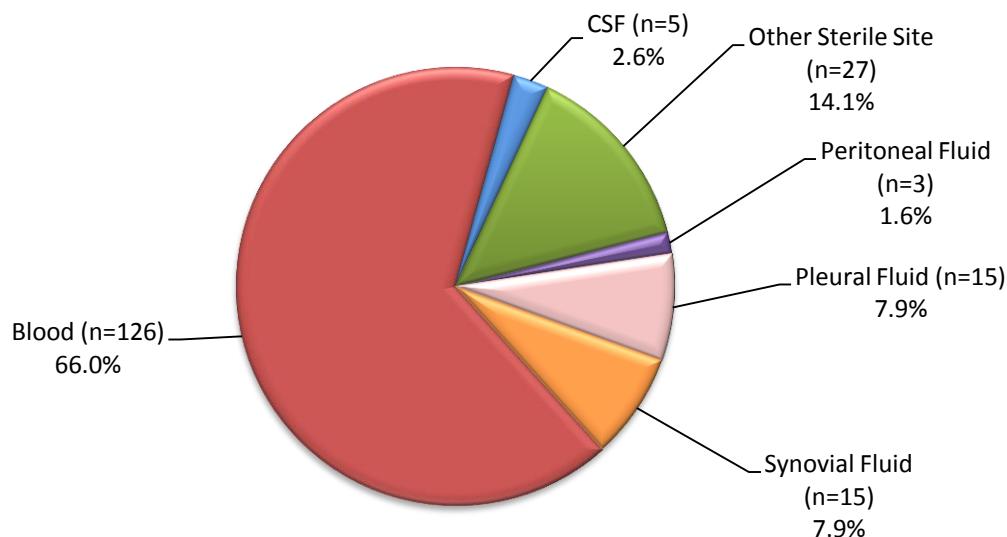
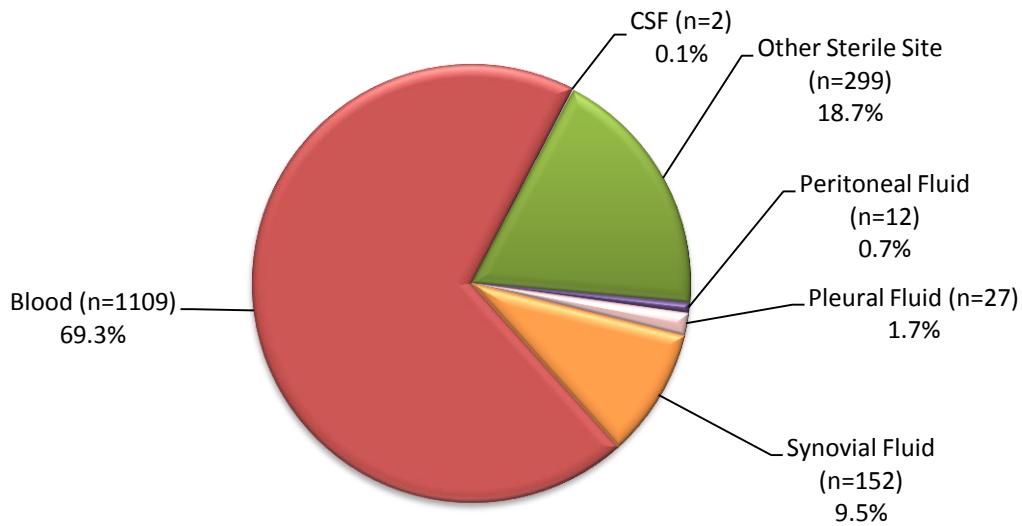
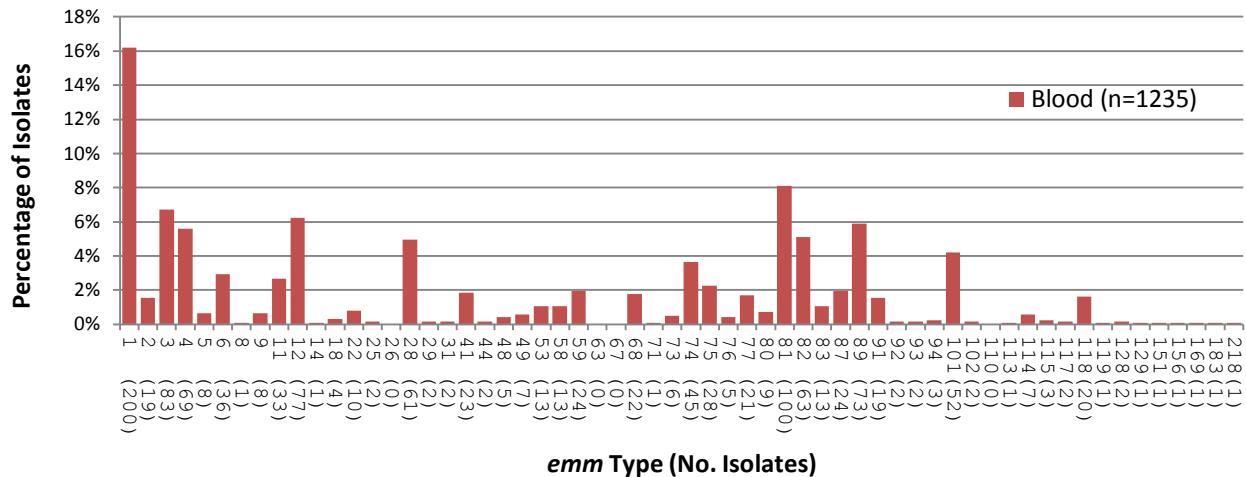
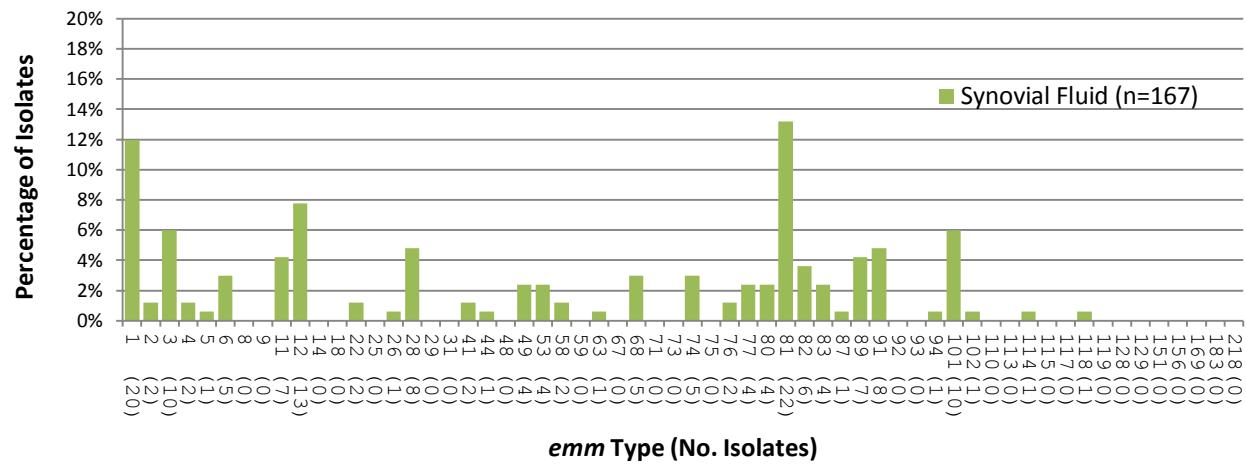
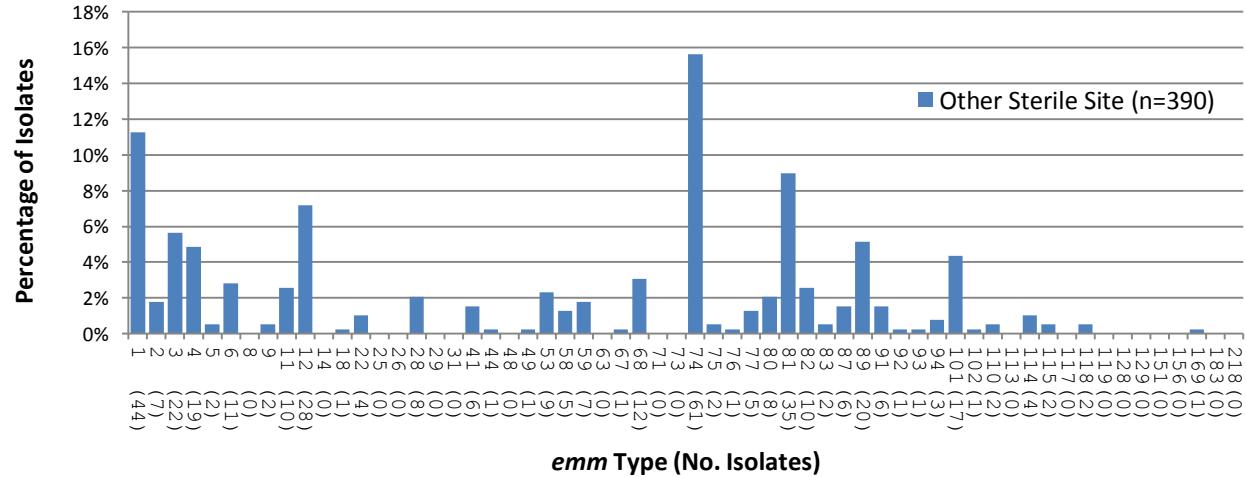


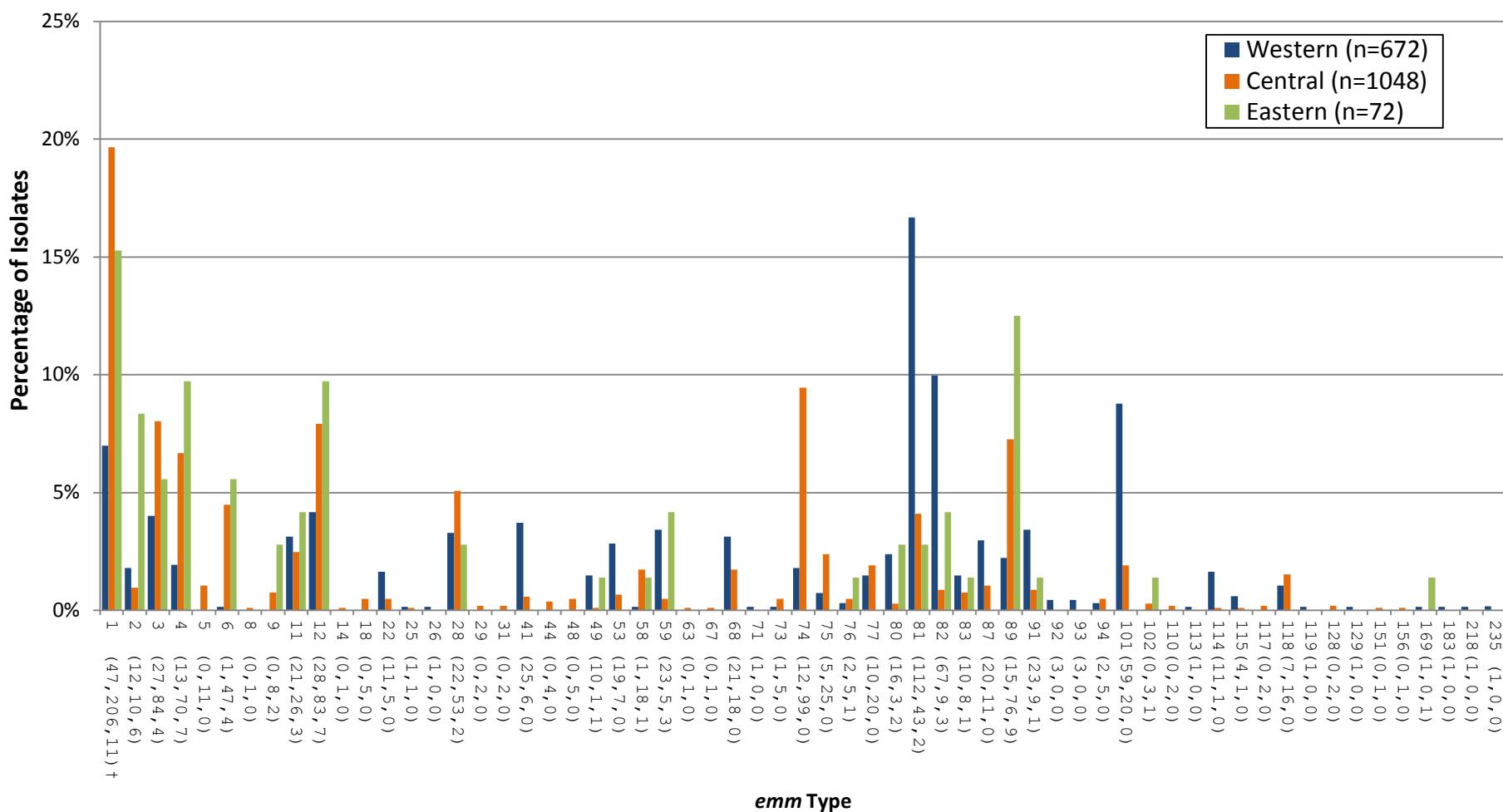
Figure 35b. Clinical isolation sites of *S. pyogenes* from adults ≥15 years of age in 2016 (n=1,601)



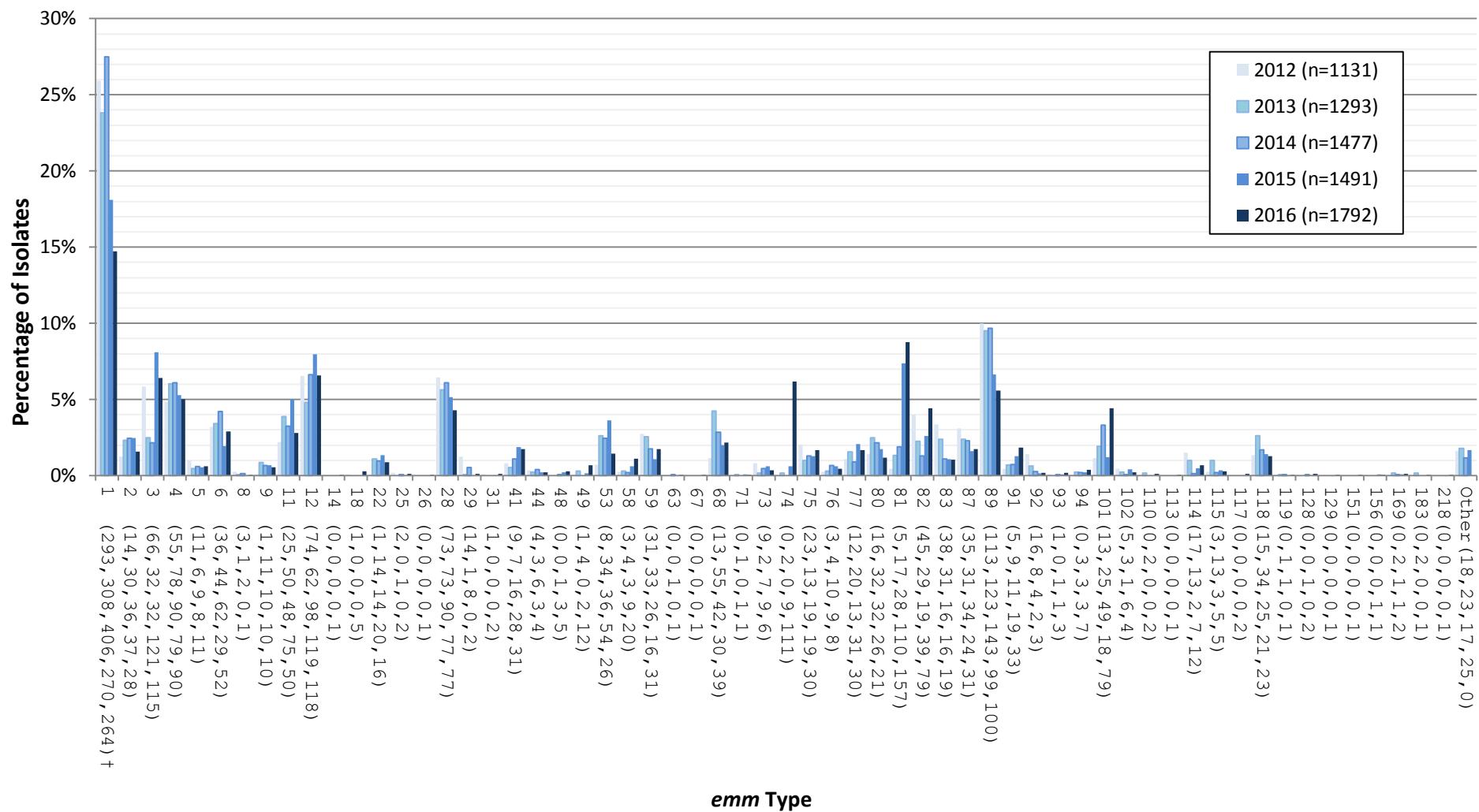
Other sterile sites include: deep tissue, biopsy and surgical samples, bone, mastoid and any clinical sources associated with necrotizing fasciitis or toxic shock syndrome. *Includes 3 isolates with no age available.

Figure 36a. Invasive *S. pyogenes* *emm* types from blood in 2016**Figure 36b. Invasive *S. pyogenes* *emm* types from synovial fluid in 2016****Figure 36c. Invasive *S. pyogenes* *emm* types from other clinical sources in 2016**

Other sterile sites include: CSF, pericardial fluid, peritoneal fluid, deep tissue, biopsy and surgical samples, bone, mastoid and any clinical sources associated with necrotizing fasciitis.

Figure 37. Regional distribution of Invasive *S. pyogenes* *emm* types in 2016

† Number of isolates in the Western, Central and Eastern regions of Canada, respectively.

Figure 38. Invasive *S. pyogenes* emm types

†Number of isolates from 2012, 2013, 2014, 2015 and 2016, respectively.

Antimicrobial Resistance of *Streptococcus pyogenes*

Antimicrobial resistance among Group A Streptococcus isolates continued to increase in 2016. **Chloramphenicol** non-susceptible isolates increased from 1.5% (n=22) in 2015 to 4.1% (n=71) in 2016; **erythromycin** resistance from 8.2% (n=118) in 2015 to 9.0% (n=156) in 2016; and resistance to **clindamycin** from 3.1% (n=45) in 2015 to 4.0% (n=69) in 2016. Relatively high macrolide (erythromycin) resistance was observed among *emm114* (91.7%, n=11), *emm11* (88.5%, n=23), *emm77* (63.3%, n=19), *emm83* (55.6%, n=10) and *emm101* (40.0%, n=30). All isolates of *emm8* (n=1), *emm48* (n=5), *emm119* (n=1), and *emm129* (n=1) were erythromycin resistant. There was no resistance observed to penicillin or vancomycin.

Figure 39. Antimicrobial resistance of invasive *S. pyogenes*

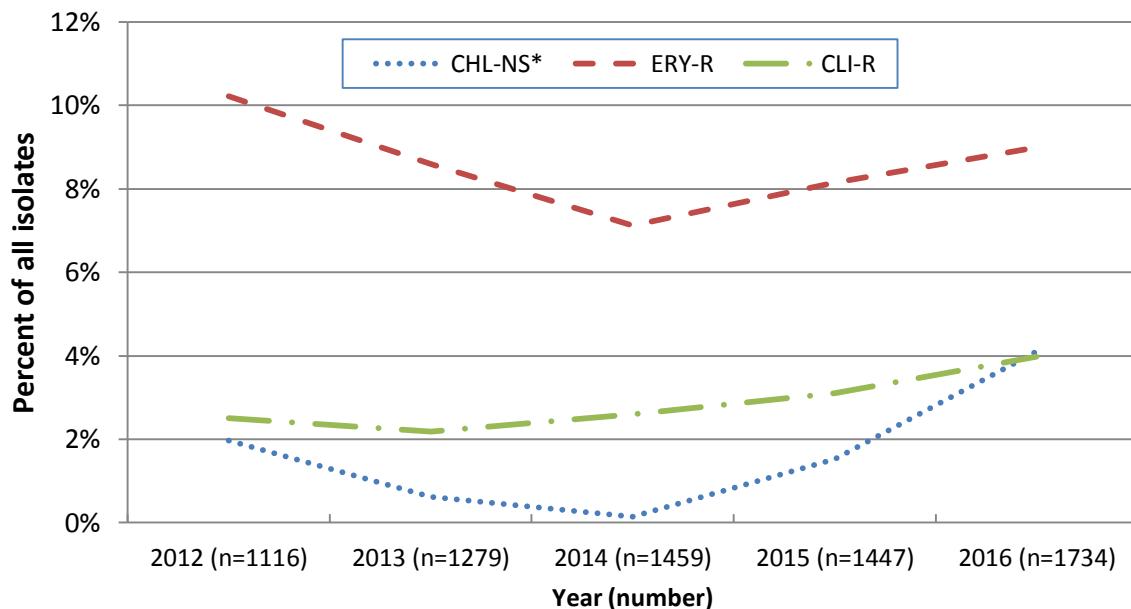
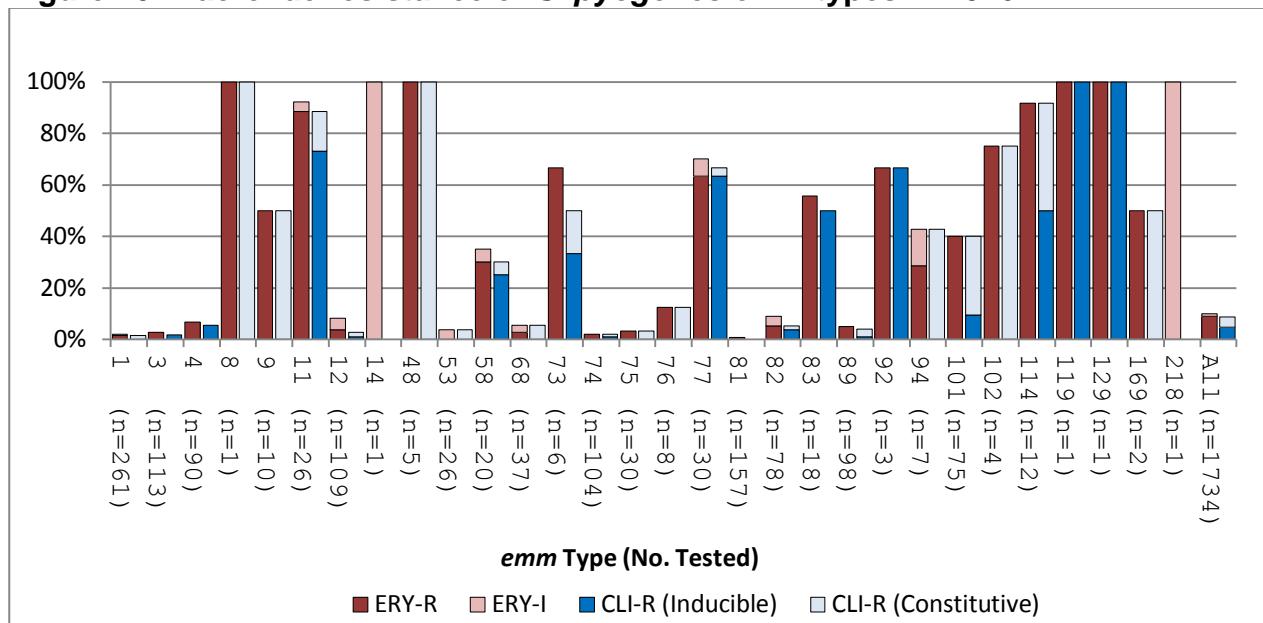


Table 15. Antimicrobial resistance of invasive *S. pyogenes* isolates

Antimicrobial	Year				
	2012	2013	2014	2015	2016
CHL-NS*	2.0% (22)	0.6% (8)	0.1% (2)	1.5% (22)	4.1% (71)
ERY-R	10.2% (114)	8.6% (110)	7.1% (104)	8.2% (118)	9.0% (156)
CLI-R	2.5% (28)	2.2% (28)	2.6% (38)	3.1% (45)	4.0% (69)
Total Tested	(1116)	(1279)	(1459)	(1447)	(1734)

*CHL-NS = Chloramphenicol non-susceptible (resistant or intermediate); ERY-R = Erythromycin resistant; CLI-R = constitutively clindamycin resistant.

Figure 40. Macrolide resistance of *S. pyogenes* *emm* types in 2016

*ERY-R = erythromycin resistant; ERY-I = erythromycin intermediately resistant; CLI-R = clindamycin resistant (constitutive or inducible).

Table 16. Macrolide resistance of *S. pyogenes* *emm* types in 2016

<i>emm</i> (Tested)	ERY-R		ERY-I		CLI-R (Constitutive)		CLI-R (Inducible)	
1 (n=261)	1.5%	(4)	0.4%	(1)	1.5%	(4)	0.0%	(0)
3 (n=113)	2.7%	(3)	0.0%	(0)	0.0%	(0)	1.8%	(2)
4 (n=90)	6.7%	(6)	0.0%	(0)	0.0%	(0)	5.6%	(5)
8 (n=1)	100.0%	(1)	0.0%	(0)	100.0%	(1)	0.0%	(0)
9 (n=10)	50.0%	(5)	0.0%	(0)	50.0%	(5)	0.0%	(0)
11 (n=26)	88.5%	(23)	3.8%	(1)	15.4%	(4)	73.1%	(19)
12 (n=109)	3.7%	(4)	4.6%	(5)	1.8%	(2)	0.9%	(1)
14 (n=1)	0.0%	(0)	100.0%	(1)	0.0%	(0)	0.0%	(0)
48 (n=5)	100.0%	(5)	0.0%	(0)	100.0%	(5)	0.0%	(0)
53 (n=26)	0.0%	(0)	3.8%	(1)	3.8%	(1)	0.0%	(0)
58 (n=20)	30.0%	(6)	5.0%	(1)	5.0%	(1)	25.0%	(5)
68 (n=37)	2.7%	(1)	2.7%	(1)	5.4%	(2)	0.0%	(0)
73 (n=6)	66.7%	(4)	0.0%	(0)	16.7%	(1)	33.3%	(2)
74 (n=104)	1.9%	(2)	0.0%	(0)	1.0%	(1)	1.0%	(1)
75 (n=30)	3.3%	(1)	0.0%	(0)	3.3%	(1)	0.0%	(0)
76 (n=8)	12.5%	(1)	0.0%	(0)	12.5%	(1)	0.0%	(0)
77 (n=30)	63.3%	(19)	6.7%	(2)	3.3%	(1)	63.3%	(19)
81 (n=157)	0.6%	(1)	0.0%	(0)	0.0%	(0)	0.0%	(0)
82 (n=78)	5.1%	(4)	3.8%	(3)	1.3%	(1)	3.8%	(3)
83 (n=18)	55.6%	(10)	0.0%	(0)	0.0%	(0)	50.0%	(9)
89 (n=98)	5.1%	(5)	0.0%	(0)	3.1%	(3)	1.0%	(1)
92 (n=3)	66.7%	(2)	0.0%	(0)	0.0%	(0)	66.7%	(2)
94 (n=7)	28.6%	(2)	14.3%	(1)	42.9%	(3)	0.0%	(0)
101(n=75)	40.0%	(30)	0.0%	(0)	30.7%	(23)	9.3%	(7)
102(n=4)	75.0%	(3)	0.0%	(0)	75.0%	(3)	0.0%	(0)
114(n=12)	91.7%	(11)	0.0%	(0)	41.7%	(5)	50.0%	(6)
119(n=1)	100.0%	(1)	0.0%	(0)	0.0%	(0)	100.0%	(1)
129(n=1)	100.0%	(1)	0.0%	(0)	0.0%	(0)	100.0%	(1)
169(n=2)	50.0%	(1)	0.0%	(0)	50.0%	(1)	0.0%	(0)
218(n=1)	0.0%	(0)	100.0%	(1)	0.0%	(0)	0.0%	(0)
All(n=1734)	9.0%	(156)	1.0%	(18)	4.0%	(69)	4.8%	(84)

*ERY-R = erythromycin resistant; ERY-I = erythromycin intermediately resistant; CLI-R = clindamycin resistant (constitutive or inducible).

Invasive *Streptococcus agalactiae* (Group B Streptococcus)

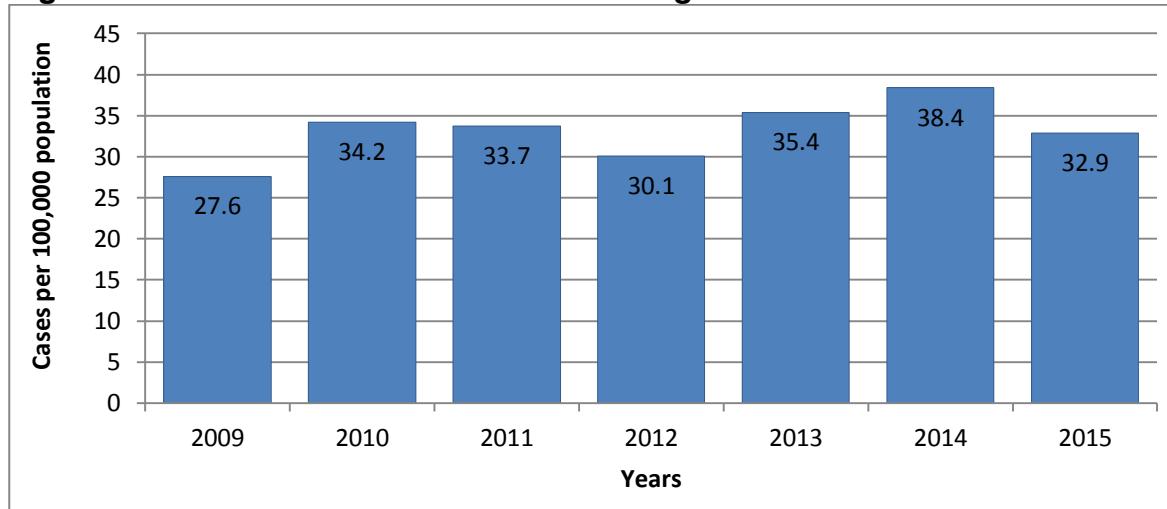
The incidence of disease within newborns as reported to the CNDSS has steadily increased from 27.6 to 36.6 cases per 100,000 population from 2009 to 2014, and decreased to 33.8 in 2015.

Of the 228 *Streptococcus agalactiae* isolates tested at the NML during 2016, 3.9% (n=9) were early onset isolates from infants <8 days old; 4.8% (n=11) were late onset from infants 8-31 days old; 5.3% (n=12) were from children 1 month to 14 years old; 54.8% (n=125) were from adults 15-64 years old; and 31.1% (n=71) were from seniors ≥65 years of age. Isolates from male patients accounted for 57.0% (n=130) of the isolates for which gender information was available (n=226).

Serotype III was most prevalent among late onset and child age groups (90.9%, n=10; and 66.7%, n=8; respectively), whereas serotype Ia was most prevalent in adults and seniors (24.8%, n=31; and 28.2%, n=20; respectively).

The overall proportion of serotype Ia has increased from 12.9% (n=22) in 2015 to 24.1% (n=55) in 2016, whereas serotype V decreased from 22.9% (n=39) to 11.8% (n=27) over the same time period.

Figure 41. Annual incidence of invasive *S. agalactiae*

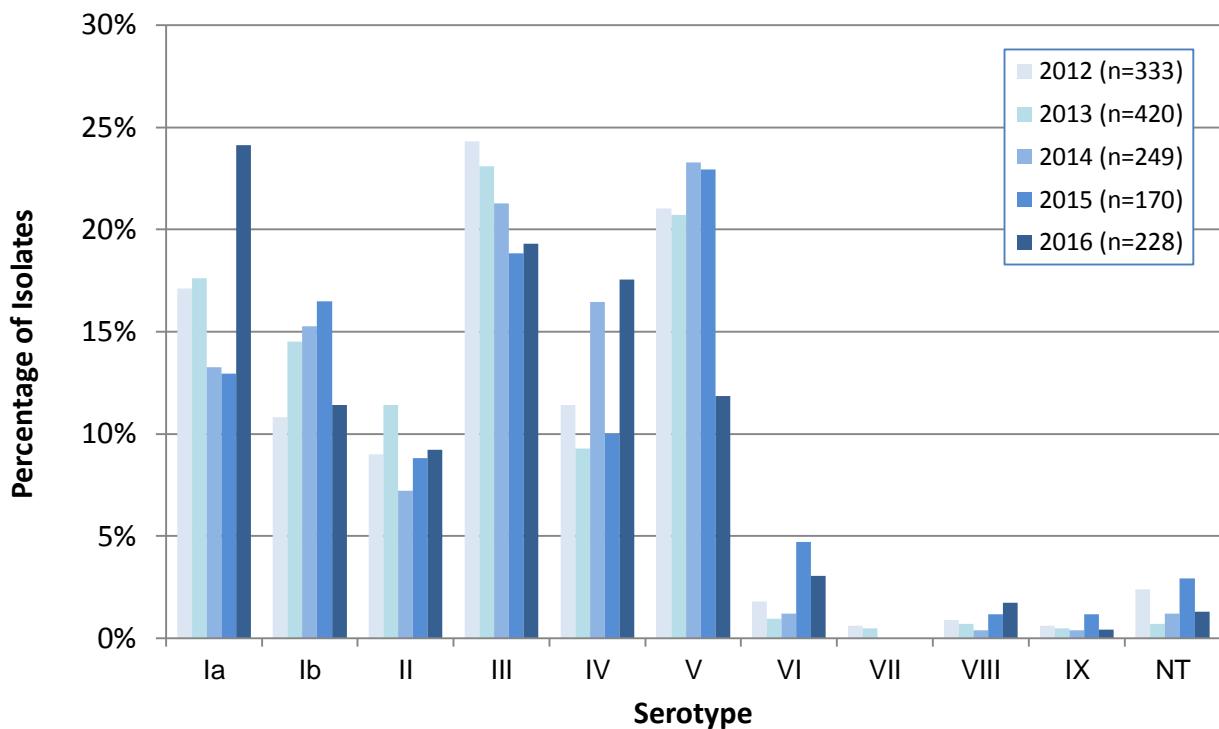


*Case data from 2009 to 2015 was obtained from CNDSS. Case data doesn't include Alberta (2000-2011), Manitoba (2000-2014) and Québec (2000-2014). Case data started in 2000 for Nunavut.

Table 17. Invasive *S. agalactiae* serotypes by age group in 2016

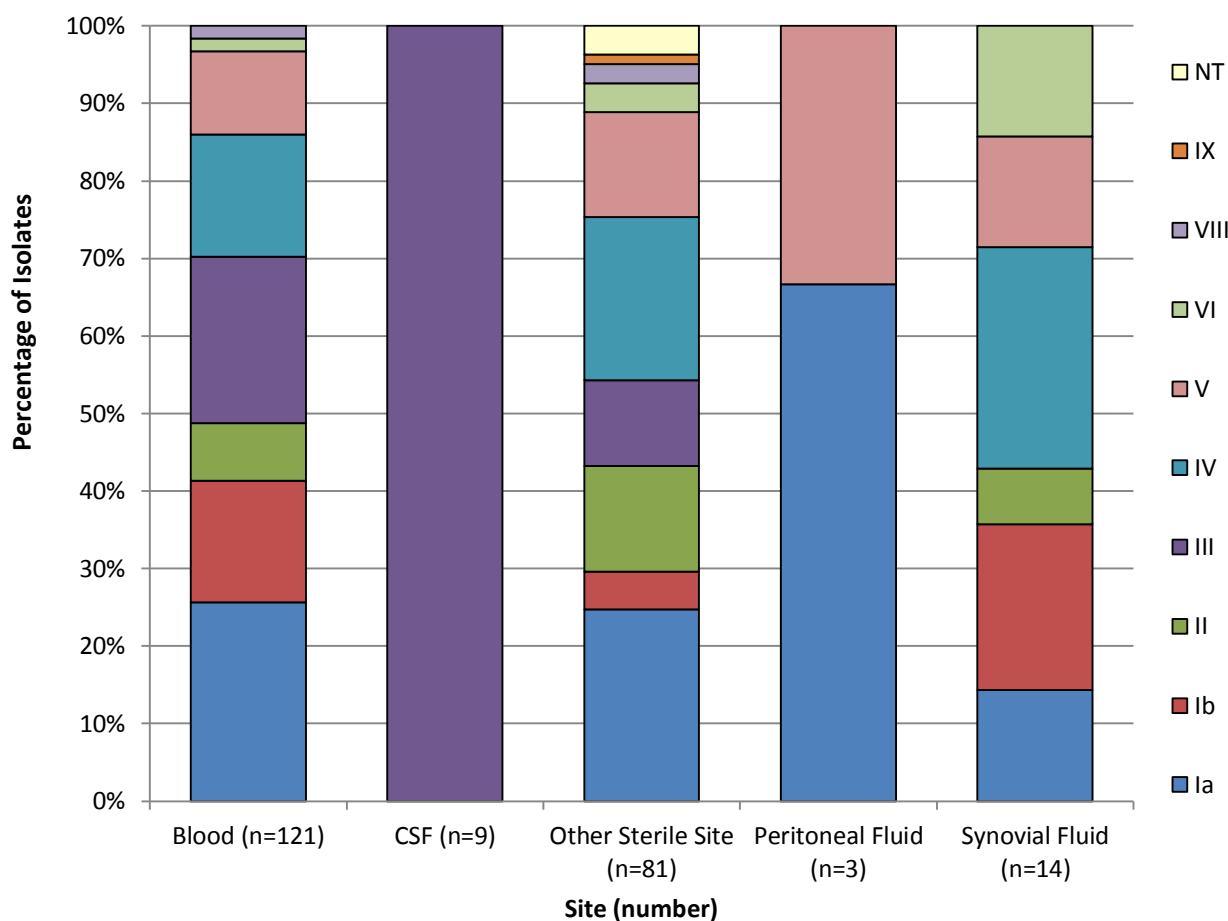
Serotype	Age Group*					Total
	Infant Early Onset	Infant Late Onset	Child	Adult	Senior	
Ia	22.2%(2)**	9.1%(1)	8.3%(1)	24.8%(31)	28.2%(20)	24.1%(55)
Ib	11.1%(1)	0.0%	16.7%(2)	9.6%(12)	15.5%(11)	11.4%(26)
II	11.1%(1)	0.0%	0.0%	12.0%(15)	7.0%(5)	9.2%(21)
III	22.2%(2)	90.9%(10)	66.7%(8)	9.6%(12)	16.9%(12)	19.3%(44)
IV	22.2%(2)	0.0%	8.3%(1)	21.6%(27)	14.1%(10)	17.5%(40)
V	11.1%(1)	0.0%	0.0%	12.8%(16)	14.1%(10)	11.8%(27)
VI	0.0%	0.0%	0.0%	4.8%(6)	1.4%(1)	3.1%(7)
VIII	0.0%	0.0%	0.0%	1.6%(2)	2.8%(2)	1.8%(4)
IX	0.0%	0.0%	0.0%	0.8%(1)	0.0%	0.4%(1)
NT	0.0%	0.0%	0.0%	2.4%(3)	0.0%	1.3%(3)
Total	(9)	(11)	(12)	(125)	(71)	(228)

*Infant Early Onset ≤ 7 days, Infant Late Onset = 8-30 days, Child = 1 month-14 years, Adult = 15-64 years, Senior ≥ 65 years, NT = Non-typeable. **Percentage of age group isolates (number of isolates).

Figure 42. Invasive *S. agalactiae* serotypes**Table 18. Invasive *S. agalactiae* serotypes**

Serotype	Year				
	2012	2013	2014	2015	2016
Ia	17.1% (57)*	17.6% (74)	13.3% (33)	12.9% (22)	24.1% (55)
Ib	10.8% (36)	14.5% (61)	15.3% (38)	16.5% (28)	11.4% (26)
II	9.0% (30)	11.4% (48)	7.2% (18)	8.8% (15)	9.2% (21)
III	24.3% (81)	23.1% (97)	21.3% (53)	18.8% (32)	19.3% (44)
IV	11.4% (38)	9.3% (39)	16.5% (41)	10.0% (17)	17.5% (40)
V	21.0% (70)	20.7% (87)	23.3% (58)	22.9% (39)	11.8% (27)
VI	1.8% (6)	1.0% (4)	1.2% (3)	4.7% (8)	3.1% (7)
VII	0.6% (2)	0.5% (2)	0.0%	0.0%	0.0%
VIII	0.9% (3)	0.7% (3)	0.4% (1)	1.2% (2)	1.8% (4)
IX	0.6% (2)	0.5% (2)	0.4% (1)	1.2% (2)	0.4% (1)
NT	2.4% (8)	0.7% (3)	1.2% (3)	2.9% (5)	1.3% (3)
Total	(333)	(420)	(249)	(170)	(228)

*Percentage of age group isolates (number of isolates)

Figure 43. Invasive *S. agalactiae* serotypes by clinical isolation site in 2016**Table 19. Invasive *S. agalactiae* isolates by clinical isolation site in 2016**

	Clinical Isolation Site					Total
	Blood	CSF	Other Sterile Site	Peritoneal Fluid	Synovial Fluid	
Ia	25.6%(31)*	0.0%	24.7%(20)	66.7%(2)	14.3%(2)	24.1%(55)
Ib	15.7%(19)	0.0%	4.9%(4)	0.0%	21.4%(3)	11.4%(26)
II	7.4%(9)	0.0%	13.6%(11)	0.0%	7.1%(1)	9.2%(21)
III	21.5%(26)	100.0%(9)	11.1%(9)	0.0%	0.0%	19.3%(44)
IV	15.7%(19)	0.0%	21.0%(17)	0.0%	28.6%(4)	17.5%(40)
V	10.7%(13)	0.0%	13.6%(11)	33.3%(1)	14.3%(2)	11.8%(27)
VI	1.7%(2)	0.0%	3.7%(3)	0.0%	14.3%(2)	3.1%(7)
VIII	1.7%(2)	0.0%	2.5%(2)	0.0%	0.0%	1.8%(4)
IX	0.0%	0.0%	1.2%(1)	0.0%	0.0%	0.4%(1)
NT	0.0%	0.0%	3.7%(3)	0.0%	0.0%	1.3%(3)
Total	(121)	(9)	(81)	(3)	(14)	(228)

*Percentage of age group isolates (number of isolates)

Antimicrobial Resistance of *Streptococcus agalactiae*

Of the 226 invasive *S. agalactiae* isolates tested for antimicrobial resistance by the disc diffusion method in 2016, the proportion of isolates resistant to **erythromycin** increased from 45.5% (n=75) to 56.6% (n=128) from 2015 to 2016, while **clindamycin** resistance has increased from 27.5% (n=46) in 2015 to 35.4% (n=80) in 2016. One isolate was resistant to chloramphenicol during 2016.

Relatively high macrolide (erythromycin) resistance was observed among serotypes IV (90.0%, n=36), III (59.1%, n=26), Ib (53.8%, n=14) and V (53.8%, n=14).

Figure 44. Antimicrobial resistance of invasive *S. agalactiae*

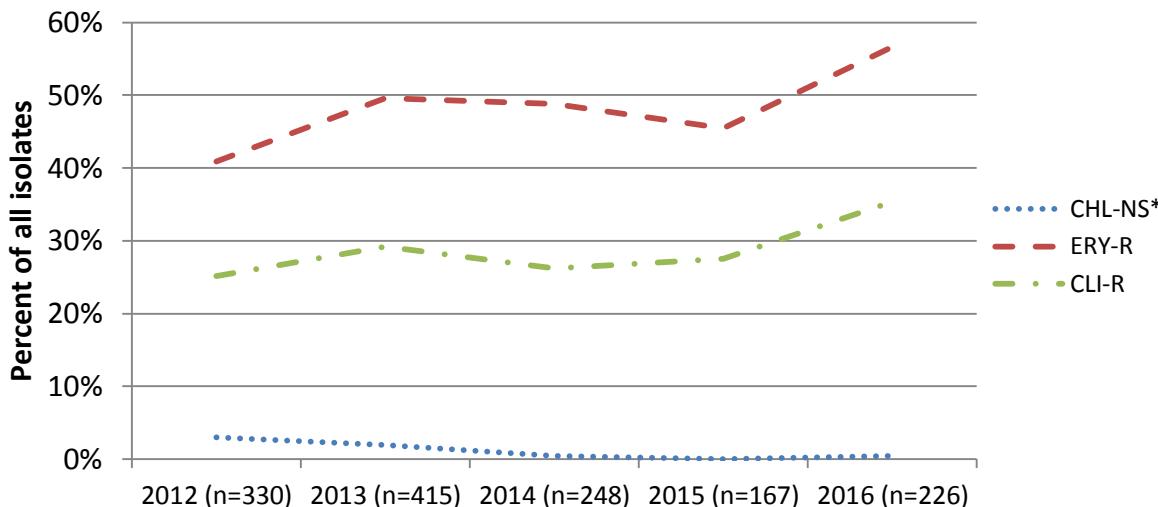
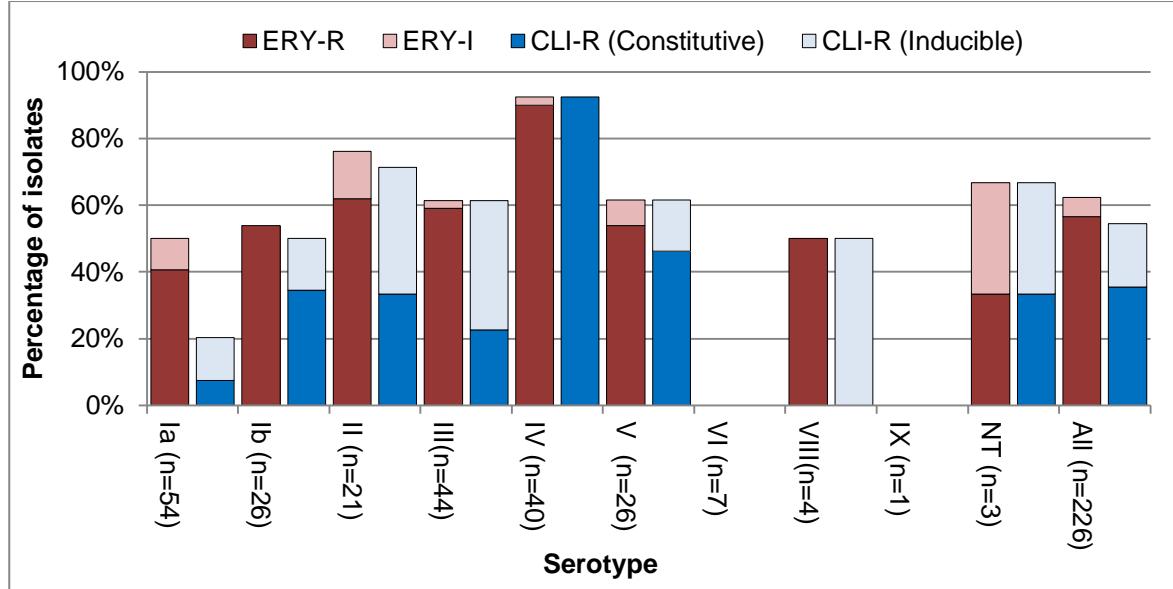


Table 20. Antimicrobial resistance of invasive *S. agalactiae*

Antimicrobial	Year				
	2012	2013	2014	2015	2016
CHL-NS*	3.0% (10)**	1.9% (8)	0.4% (1)	0.0% (0)	0.4% (1)
ERY-R	40.9% (135)	49.6% (206)	48.8% (121)	45.5% (76)	56.6% (128)
CLI-R	25.2% (83)	29.2% (121)	26.2% (65)	27.5% (46)	35.4% (80)
Total Tested	(330)	(415)	(248)	(167)	(226)

*CHL-NS = Chloramphenicol non susceptible (resistant or intermediate); ERY-R = Erythromycin resistant; CLI-R = constitutively clindamycin resistant. ** Percent resistant (number of isolates).

Figure 45. Macrolide resistance of *S. agalactiae* serotypes in 2016

*ERY-R = erythromycin resistant; ERY-I = erythromycin intermediately resistant; CLI-R = clindamycin resistant (constitutive or inducible).

Table 21. Macrolide resistance of *S. agalactiae* serotypes in 2016

Serotype (Tested)	ERY-R	ERY-I	CLI-R (Constitutive)	CLI-R (Inducible)
Ia (n=54)	40.7% (22)	9.3% (5)	7.4% (4)	13.0% (7)
Ib (n=26)	53.8% (14)	0.0% (0)	34.6% (9)	15.4% (4)
II (n=21)	61.9% (13)	14.3% (3)	33.3% (7)	38.1% (8)
III (n=44)	59.1% (26)	2.3% (1)	22.7% (10)	38.6% (17)
IV (n=40)	90.0% (36)	2.5% (1)	92.5% (37)	0.0% (0)
V (n=26)	53.8% (14)	7.7% (2)	46.2% (12)	15.4% (4)
VI (n=7)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)
VII (n=4)	50.0% (2)	0.0% (0)	0.0% (0)	50.0% (2)
VIII (n=1)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)
NT (n=3)	33.3% (1)	33.3% (1)	33.3% (1)	33.3% (1)
All (n=226)	56.6% (128)	5.8% (13)	35.4% (80)	19.0% (43)

CONCLUSIONS

In 2016, IPD caused by PCV7 serotypes of *S. pneumoniae* in Canada remains low and sustained overall decreases of PCV13 serotypes have been observed. Together with continued declines in the incidence of disease in both child and senior age groups provide evidence of the effectiveness of the childhood PCV vaccination programs in Canada in reducing the burden of disease directly in children, as well as indirectly through herd immunity effects in seniors. Further surveillance is critical to identify potential threats in the future such as increases of non-vaccine replacement serotypes such as serotypes 15A, 23A, 23B and 35B; and the resurgence of some PCV serotypes such as 19A in children <2 years of age. Close monitoring of serotype levels can also alert health authorities to sudden increases of disease in various at risk populations. Despite the success of the PCV vaccination programs in lowering disease attributed to the component serotypes, little change has been observed in the levels of serotype 3, raising concerns of the virulence and the effectiveness of the current vaccine against this serotype. The continued monitoring of the relative frequency of serotypes circulating in Canada will help inform and guide the evaluation and development of vaccines which will lower the total burden of disease.

Antimicrobial resistance among isolates of *S. pneumoniae* continues to generally decline in 2016, mainly due to the decline of highly resistant serotypes contained in the conjugate vaccines; however, concern of serotype-specific increases of resistant serotypes 15A and 35B are warranted.

The incidence of disease attributed to **invasive *S. pyogenes*** has continued to increase in most age groups from 2012 to 2016. Dominant strains in Canada tended to be regionally distributed with *emm81*, *emm82*, and *emm101* prevalent in Western Canada; *emm1* and *emm74* in Central Canada; and *emm4*, *emm12*, and *emm89* predominant in Eastern Canada. **Antimicrobial resistance** in Group A *Streptococcus* has increased again in 2016. Although overall resistance is low and Group A Streptococcal disease is readily treated with penicillin, due to the severity, high risk of infection and heightened public awareness of Group A *Streptococci*, the continued monitoring and surveillance of circulating strains and antimicrobial resistance levels are important to help identify outbreaks of disease and to inform and guide public health interventions.

S. agalactiae serotypes Ia, III and IV were the predominate strains in Canada during 2016. Macrolide resistance has been relatively high among Group B *Streptococci* and an increase of macrolide resistance has been observed in 2016 after being relatively stable in previous years. Although Group B *Streptococci* generally causes severe outcomes in neonatal groups, there is an increasing burden of disease among adults. Monitoring shifts in the distribution of serotypes, levels of antimicrobial resistance as well as collecting additional enhanced epidemiological information, is important to help identify potential risk factors, spread of invasive strains, and to raise awareness of future prevention and treatment options.

APPENDIX

Table A. Proportion of invasive *Streptococcus pneumoniae* cases serotyped in Canada, 2015

Age group	Total number of isolates serotyped*	Total number of illnesses reported to CNDSS**	Percent serotyped
<1 years	49	55	89.1%
1 - 4 years	140	153	91.5%
5 – 39 years	377	459	82.1%
40 – 59 years	726	916	79.3%
≥60 years	1,256	1,631	77.0%
All Ages***	2,557	3,216	79.5%

* Pleural fluid isolates excluded. ** Data from Canadian Notifiable Diseases Surveillance System, PHAC.

***All Ages total includes isolates with no patient age.

Table B. Proportion of invasive *Streptococcus pyogenes* cases typed in Canada, 2015

Age group	Total number of isolates tested	Total number of illnesses reported to CNDSS**	Percent serotyped
<1 years	41	53	77.4%
1 - 4 years	54	67	80.6%
5 – 39 years	438	554	79.1%
40 – 59 years	419	548	76.5%
≥60 years	533	667	79.9%
All Ages***	1,492	1,893	78.8%

** Canadian Notifiable Diseases Surveillance System, PHAC. *** All Ages total includes isolates with no patient age.

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