PUBLIC HEALTH AGENCY OF CANADA

National Laboratory Surveillance of Invasive Streptococcal Disease in Canada

Annual Summary 2018

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 Laboratories

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Également disponible en français sous le titre :
Surveillance nationale en laboratoire de la maladie invasive due au streptocoque au Canada, Rapport sommaire annuel de 2018

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This publication can be made available in alternative formats upon request.

Publication date:

Cat.: HP57-4E-PDF
ISSN: 2368-9846
Pub.: 200203

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This report has been reviewed by Canadian Public Health Laboratory Network (CPHLN) Provincial and Territorial laboratory Directors.

ACKNOWLEDGEMENTS

The results presented in this report represent streptococcal isolates kindly submitted to the NML from the following hospitals or provincial public health laboratories: **British Columbia Centre for Disease Control**, Vancouver, British Columbia – Dr. Mel Krajden, Dr. Linda Hoang, Ana Paccagnella, Robert Azana, Vincent Tang; **Saskatchewan Disease Control Laboratory**, Regina, Saskatchewan - Dr. Jessica Minion; **Cadham Provincial Laboratory,** Winnipeg, Manitoba - Dr. Jared Bullard, Dr. Paul Van Caeseele, Denise Sitter; **Public Health Ontario**, Toronto, Ontario – Dr. Vanessa Allen, Dr. Julianne Kus; **Queen Elizabeth II Health Science Centre**, Halifax, Nova Scotia - Dr. David Haldane; **New Brunswick Regional Hospitals** – Dr. Rita Gad, Maryse Thibeault, Nadine Bosse-Beaulieu, Eric Brisson, Dr. L. Thibault, Shelley Dupuis, Dr. Ian Stuart, Melanie Stace, Linda Turgeon, Tammy Mahaney; **Queen Elizabeth Hospital, Charlottetown, Prince Edward Island** – Dr. G. German; **Newfoundland Public Health Laboratory**, St. John's, Newfoundland - Dr. George Zahariadis; **Stanton Territorial Hospital Laboratory**, Yellowknife, Northwest Territories – Laura Steven; **Whitehorse General Hospital**, Whitehorse, Yukon - Becky Nash, Chris Cash.

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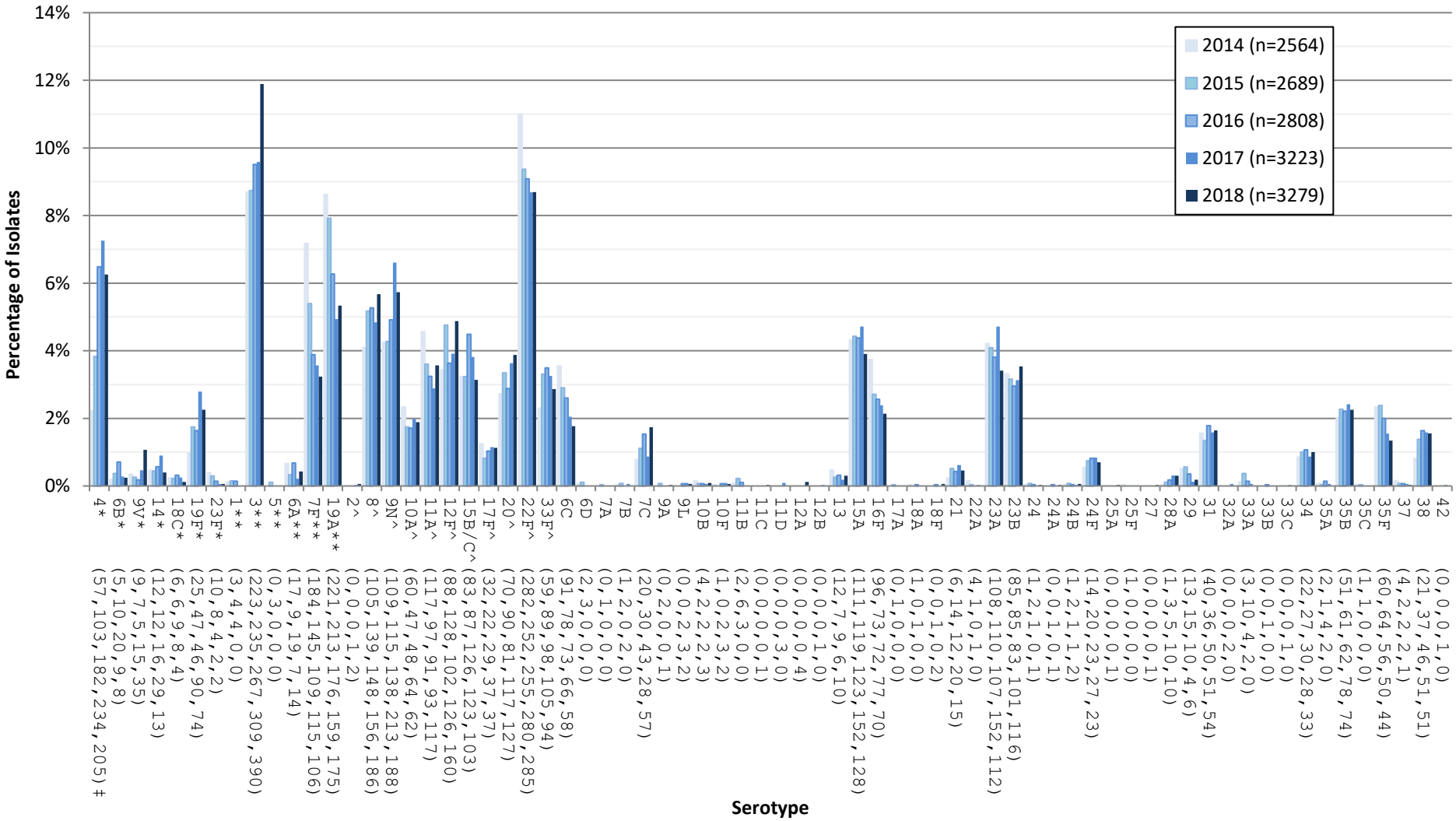
EXECUTIVE SUMMARY

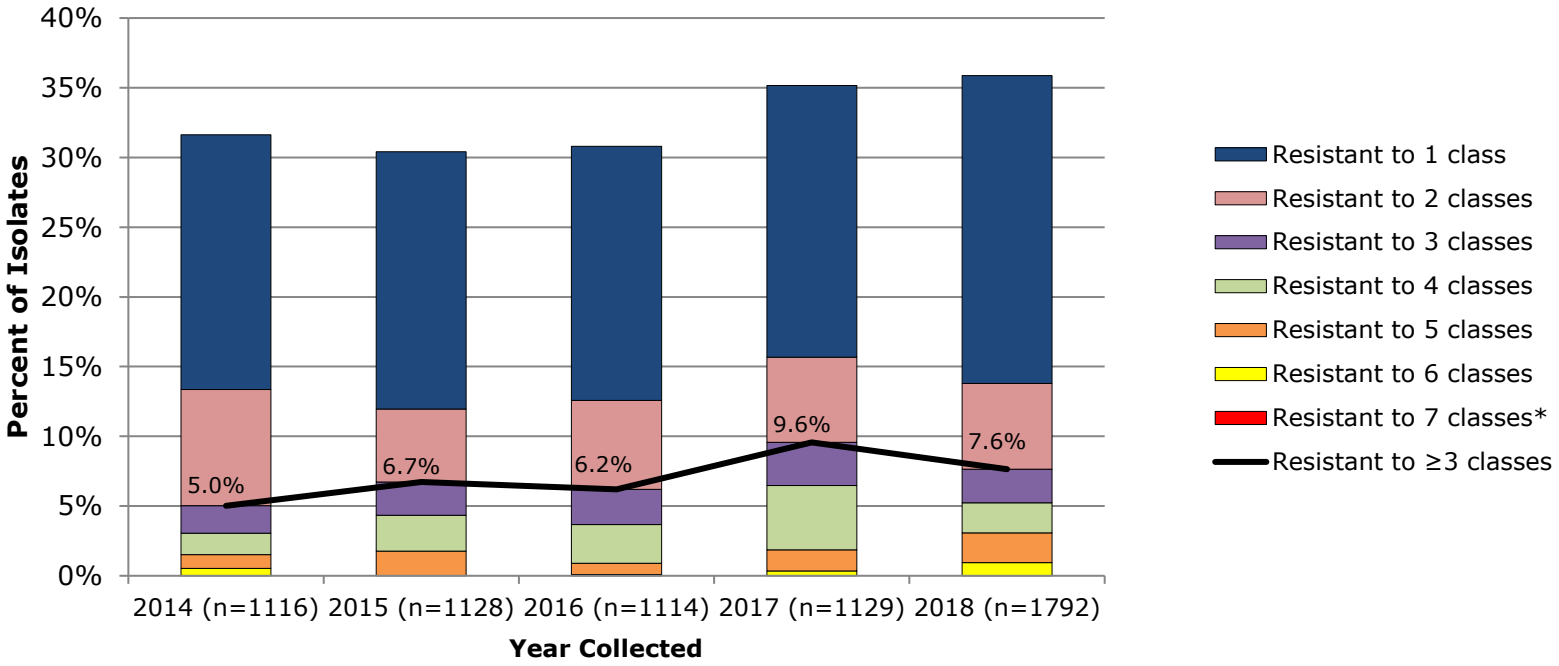
- ***Streptococcus pneumoniae:*** 3,279 isolates causing invasive pneumococcal disease (IPD) were characterized in 2018.
- **Incidence rate of IPD** declined in children under <1 year of age to 11.9 cases per 100,000 population and increased in seniors ≥60 years to 23.4 cases per 100,000 population compared to 2017. The overall crude incidence rate has remained stable averaging 9.6 cases per 100,000 population since 2009.
- **PCV7** serotypes decreased slightly in 2018 from 2017 in most age groups accounting for 10% of IPD, except for the 5-14 year olds which increased by 3%.
- **PCV13** (not including PCV7) serotypes accounted for 21% of overall IPD, showing a slight increase from 2017 levels. Rates of serotype 3 increased in all age groups except infants where numbers are very low (n=3 for 2018).
- Overall proportions of **PPV23** have increased slightly, by 2%, in the last five years and non-vaccine serotypes (NVT) have decreased by 3.5% in the same time frame.
- **Predominant serotypes** in 2018 were **3** (12%), **22F** (9%), **4** (6%), **9N** (6%) and **8** (6%).
- **Antimicrobial susceptibility:** Testing of 1,792 isolates indicated levels of resistance were again relatively stable during 2018 with the following resistance rates: clarithromycin (26%), penicillin (11%), doxycycline (8%), trimethoprim/sulfamethoxazole (8%), clindamycin (7%), chloramphenicol (6%), meropenem (2%), and imipenem (1%). Serotypes 6A/C, 19A/F, 23A/F, 15A, 9V, 14 and 35B generally had the highest rates of antimicrobial resistance. **Multi-drug resistance** decreased from 10% in 2017 to 8% in 2018. The highest rates of multi-drug resistance were seen in serotypes 15A (57%) and 19A (30%).
- ***S. pyogenes* (Group A *Streptococcus*):** 3,202 isolates causing invasive disease were characterized for *emm* type.
- Overall, the annual **incidence** rate of invasive disease has increased from 4.0 to 7.9 cases per 100,000 population from 2009 to 2018.
- ***emm1*** continues to be the most predominant type among all combined age groups and regions (17%) (Figure C). Regional increases of *emm6* in the East (15%) and *emm76* (13%) and *emm74* (16%) in the West have been noted. 60
- **Antimicrobial susceptibility:** Antimicrobial resistance of *S. pyogenes* is relatively low, decreases were seen in 2018 with chloramphenicol non-susceptibility at 2.6% and clindamycin resistance at 3.5%. Erythromycin resistance remained constant at 10%.
- ***S. agalactiae* (Group B *Streptococcus*):** There were 290 invasive Group B *Streptococcus* submitted to NML during 2018, of which 7 isolates were from early onset cases (infants ≤7 days old) and 8 were from late onset cases (infants 8 – 31 days old). Annual incidence of invasive disease in newborns has fluctuated from a low of 25.0 per 100,000 live births in 2009 to a high of 38.1 in 2016; the incidence rate in 2018 was 24.7.
- **Serotypes** V (25%), III (17%) and Ib and IV (16% each) were most predominant.
- **Antimicrobial susceptibility**: Resistance of *S.agalactiae* to erythromycin decreased to 42% while clindamycin resistance decreased to 31%.

Figure A. Invasive *S. pneumoniae* serotypes in all ages, 2014-2018



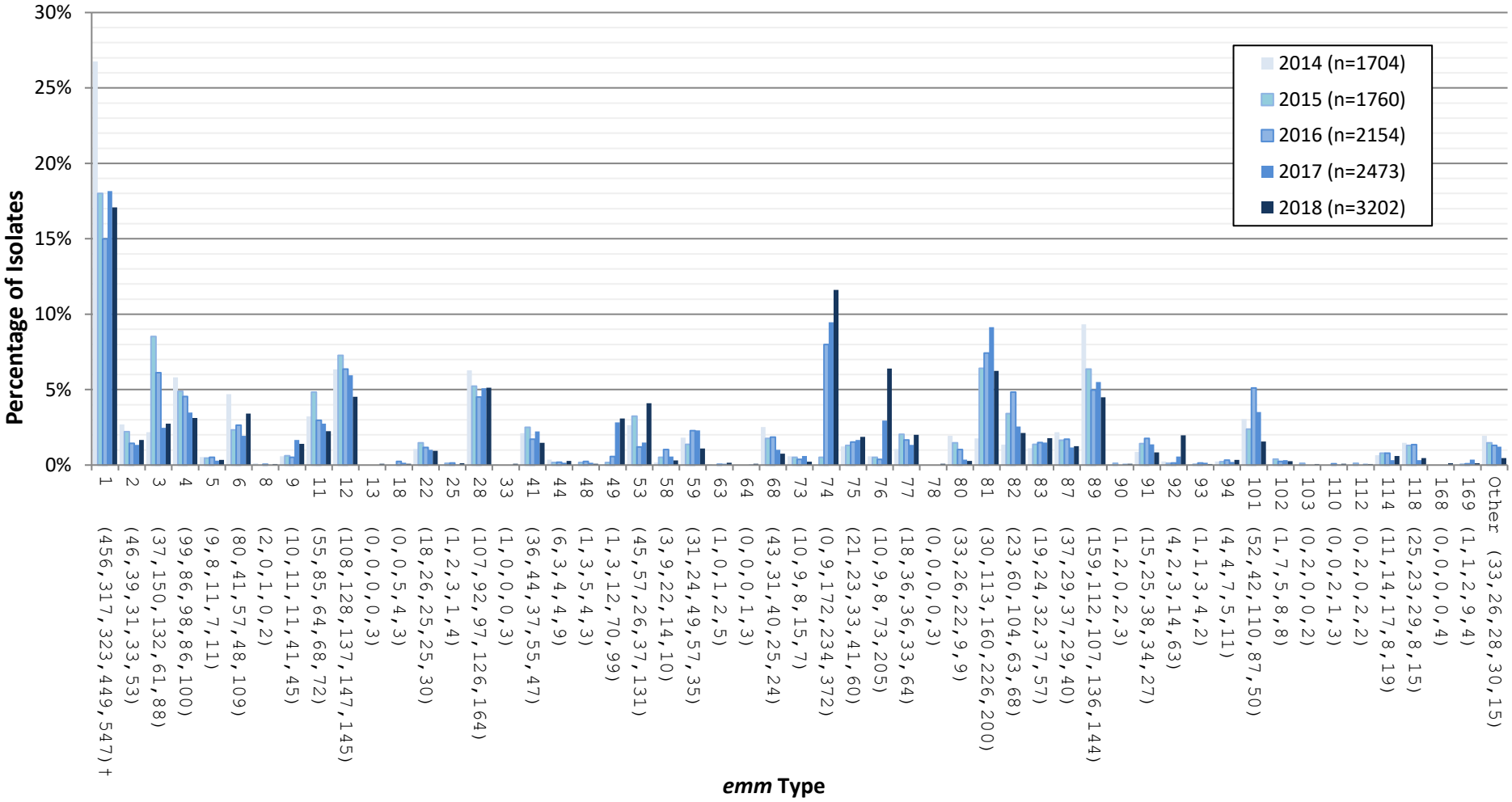
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of isolates for 2014, 2015, 2016, 2017 and 2018 respectively.

Figure B. Annual trend of multi-drug resistance of *S. pneumoniae*, 2014-2018



*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).

Figure C. Invasive *S. pyogenes emm* types, 2014-2018



†Number of isolates from 2014, 2015, 2016, 2017 and 2018, respectively.

INTRODUCTION

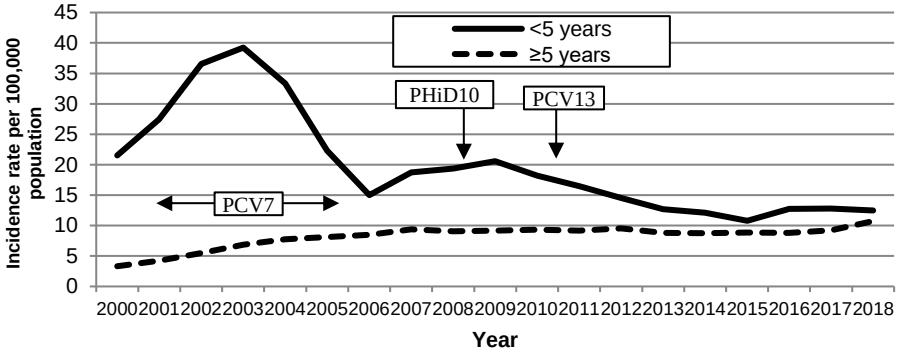
On April 1, 2010 the National Microbiology Laboratory (NML), Winnipeg began offering surveillance, reference diagnostics and outbreak support on invasive *Streptococcus pneumoniae* (pneumococcus), *Streptococcus pyogenes* (Group A *Streptococcus,* iGAS), and *Streptococcus agalactiae* (Group B *Streptococcus,* GBS). 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-typeable 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 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

Figure 1. Annual incidence of IPD in Canada, 2000-2018



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]. Overcrowded and disadvantaged populations have been reported to be at particular risk of disease [Teatero, 2018; Hammond-Collins, 2018]. The M protein, encoded by the *emm* gene, is an important virulence factor and an epidemiological marker used to characterize *S. pyogenes* isolates.

Invasive Group B *Streptococcus* (GBS, *S. agalactiae*) GBS is commonly associated with neo-natal 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 adult groups include those with underlying medical conditions, pregnant women and those residing in extended health care facilities [Lamangni, 2013].

METHODS

A total of 3,279 invasive *S. pneumoniae,* 3,202 invasive *S. pyogenes* and 290 *S. agalactiae* isolates are included in this report for 2018. The data includes test results for isolates submitted to the NML by provincial and territorial public health laboratories and data provided by jurisdictions including 436 IPD isolates serotyped by Laboratoire de santé publique du Québec, 445 IPD and 410 iGAS by the Alberta Provincial Laboratory for Public Health and 341 IPD by the TIBDN (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 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), Eastern (New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador), and Northern (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 limited to only

isolates available for testing. 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. Preliminary disease data for 2018 were obtained through CNDSS, population data for incidence rate calculations were obtained from Statistics Canada's July 1st annual population estimates, and live births data for the 2018 incidence rate calculation of invasive GBS in newborns were obtained from Statistics Canada, Table 13-10-04140-01 Live births, by place of residence of mother. 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 are 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) MM18, 2018].

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=1,792) 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 M07, 2018]. MIC interpretive standards were defined according to CLSI breakpoints [CLSI M100, 2019] for all antibiotics except ciprofloxacin for which EUCAST interpretative breakpoints were used [EUCAST, 2015]. Antimicrobial susceptibilities for GAS (n=2,760) and GBS (n=288) 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), ceftriaxone(CRO, 30 µg) and vancomycin (VAN, 30 µg) according to CLSI guidelines [CLSI M02, 2018].

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 if possible.

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 2018 data from CNDSS, the overall IPD incidence rate in Canada increased slightly from 9.5 cases per 100,000 population in 2017 to 10.9 cases per 100,000 in 2018. (Figure 2, Table 1) Since 2009, IPD incidence rates have remained stable over time. IPD incidence rates increased or remained similar in all age groups in 2018 compared to 2017, except among infants <1 year of age where the rate decreased from 15.4 in 2017 to 11.9 in 2018.

Figure 2. Annual incidence of IPD cases in Canada by age group, 2009–2018

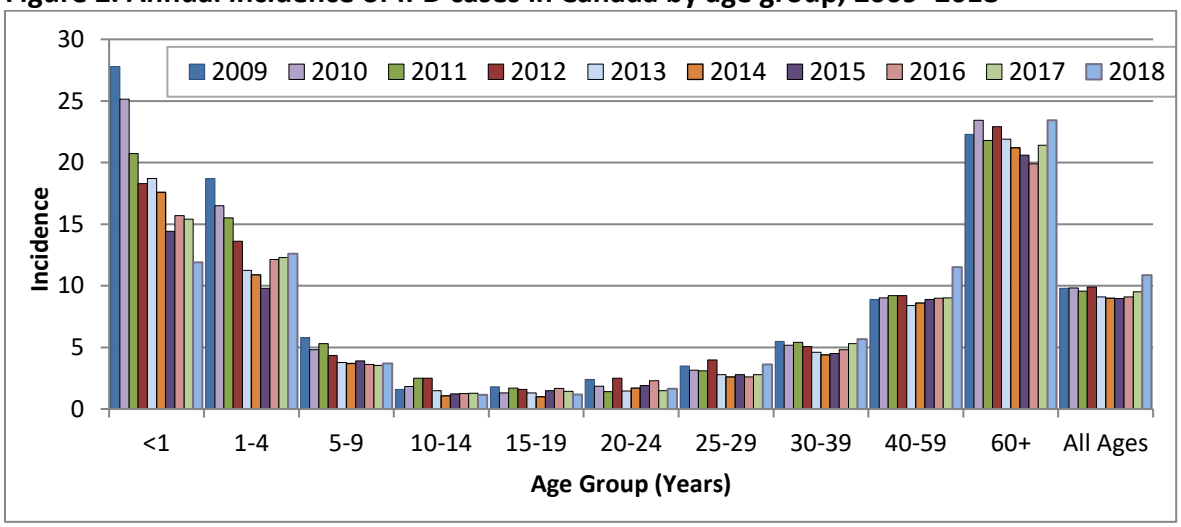


Table 1. Annual incidence of IPD cases in Canada by age group, 2009–2018

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	5.8	1.6	1.8	2.4	3.5	5.5	8.9	22.3	9.8
2010	25.1	16.5	4.8	1.8	1.3	1.9	3.1	5.2	9.0	23.4	9.8
2011	20.7	15.5	5.3	2.5	1.7	1.4	3.1	5.4	9.2	21.8	9.6
2012	18.3	13.6	4.3	2.5	1.6	2.5	4.0	5.1	9.2	22.9	9.9
2013	18.7	11.2	3.8	1.5	1.3	1.5	2.8	4.6	8.4	21.9	9.1
2014	17.6	10.9	3.7	1.1	1.0	1.7	2.6	4.4	8.6	21.2	9.0
2015	14.4	9.8	3.9	1.2	1.5	1.9	2.8	4.5	8.9	20.6	9.0
2016	15.7	12.1	3.6	1.3	1.7	2.3	2.6	4.8	9.0	19.9	9.1
2017	15.4	12.3	3.5	1.3	1.4	1.5	2.8	5.3	9.0	21.4	9.5
2018	11.9	12.6	3.7	1.2	1.2	1.6	3.6	5.7	11.5	23.4	10.9

Distribution of Streptococcus pneumoniae serotypes

Of the 3,279 IPD isolates serotyped in 2018, 3,244 had patient ages and infants <2 years of age accounted for 2.8% (n=92), toddlers aged 2-4 years for 2.7% (n=86), children aged 5-14 years for 2.2% (n=71), adults aged 15-49 years for 23.4% (n=760), adults aged 50-64 years for 29.7% (n=962) and seniors aged ≥65 years for 39.2% (n=1273). Of the 3,184 isolates with gender information specified 57.7%, (n=1,836) were from male patients.

The overall most prevalent serotype in 2018 was serotype 3, increasing from 8.7% (n=223) to 11.9% (n=390) since 2014. From 2014 to 2018, serotype 22F continued to dominate, declining from 11.0% (n=282) to 8.7% (n=285); and serotype 4 has increased dramatically from 2.2% (n=57) to 6.3% (n=205). Serotype 9N accounted for 5.7% (n=188) of the isolates in 2018, a decrease from 6.6% (n=213) in 2017, and serotype 8 has increased over the last year from 4.8% (n=156) to 5.7% (n=186).

Blood was the most frequent clinical isolation site accounting for 92.1% (n=3,021) of all isolates. Serotype 3 was prevalent in all clinical sources representing 11.6% (n=349) of all blood, 14.5% (n=12) of CSF, 25.0% (n=19) of pleural fluid and 10.1% (n=10) of other sterile isolation site isolates. Serotype 22F and 4 were also prevalent among blood isolates with 8.9% (n=269) and 6.7% (n=201) respectively. Among CSF isolates, serotypes 15A and 23B predominated, accounting for 9.6% (n=8) and 8.4% (n=7).

Serotypes associated with **Western Canada** during 2018 included serotypes 3 (10.5%, n=143), 4 (9.8%, n=134), 12F (8.6%, n=117), 20 (7.1%, n=97) and 22F (6.9%, n=95). In **Central** regions, serotype 3 was most prevalent (13.4%, n=231), followed by 22F (9.5%, n=163), 19A (6.7% (n=115) and 9N (5.8%, n=100). Serotypes 22F (12.8%, n=21) and 9N (9.8%, n=16) were predominant in **Eastern Canada**. **Northern Canada** had very small sample numbers overall with 22.2% (n=6) being 22F and 18.5% being serotype 8 (n=5).

In 2018 the most predominant serotypes for the **<2 year olds** included 15B/C (21.7%, n=20), and 22F and 38 both with 8.7% (n=8). Common in the **2 – 4 year olds** were serotypes 3 and 15B/C (both at 17.4%, n=15), and 22F and 23B (both at 12.8%, n=11). Serotypes 3 (16.9%, n=12), 19A (12.7%, n=9) and22F (11.3%, n=8) were the most common in 5 **– 14 year olds**. Serotype 4 was the most prevalent serotype in **15 – 49 year olds** (11.7%, n=89), serotype 3 in **50 – 64 year olds** (13.2%, n=127), and serotypes 3 (12.3%, n=157) and 22F (11.0%, n=140) in those **65 years of age** and older.

Serotype 3: There has been a steady overall increase of serotype 3 from 2014 (8.7%, n=223) to 2018 (11.9%, n=390). In infants <2 years of age, serotype 3 increased slightly since 2014 from 2.4% (n=3) to account for 3.3% (n=3) of the isolates in 2018. Among the 2–4 year olds serotype 3 showed the largest increase from 9.5% (n=8) in 2014 to 17.4% (n=15) in 2018. Serotype 3 increased in all other age groups from 3.1% (n=2) to 16.9% (n=12) in 5–14 year olds; from 7.1% (n=37) to 9.9% (n=75) in 15–49 year olds; from 11.1% (n=80) to 13.2% (n=127) in 50 – 64 year olds and from 8.8% (n=91) to 12.3% (n=157) in the ≥65 year old age group.

Serotype 22F: Continued declines in the relative proportion of serotype 22F isolates have been seen overall with decreases from 2014 to 2018 for <2 year olds from 12.7% (n=16) to 8.7% (n=8), from 8.5% (n=44) to 6.1% (n=46) in the 15 – 49 year olds, and from 10.4% (n=75) to 7.3% (n=70) in those aged 50 – 64 years. The 2 – 4 year olds saw an increase from 10.7% (n=9) in 2014 to 12.7% (n=11) in 2018. Proportions of 22F in the remaining age groups have fluctuated over the five year study period but show an overall

decrease from 2014 to 2018; the 5 – 14 year old age group from 15.3% (n=10) to 11.2% (n=8) and the ≥65 year old age group from 12.4% (n=128) to 10.9% (n=140).

Serotype 4: Increases of serotype 4, attributed to a pneumococcal outbreak among the homeless population in Western Canada seem to be waning. Large increases from 2014 to 2017 with a decrease in 2018 have been seen in the 15 – 49 year old age group; 4.6% (n=24) in 2014 to 16.4% (n=108) in 2017 then down to 11.7% (n=89) in 2018. Similarly for the 50 – 64 year olds, 3.1% (n=23) in 2014 to 9.8% (n=88) then down to 7.8% (n=75) in 2018. In the ≥65 year old group an increase was seen from 2014 to 2018 from 0.5% (n=7) to 3.2% (n=41). There were no serotype 4 samples submitted to the NML for children ≤14 years old in 2018.

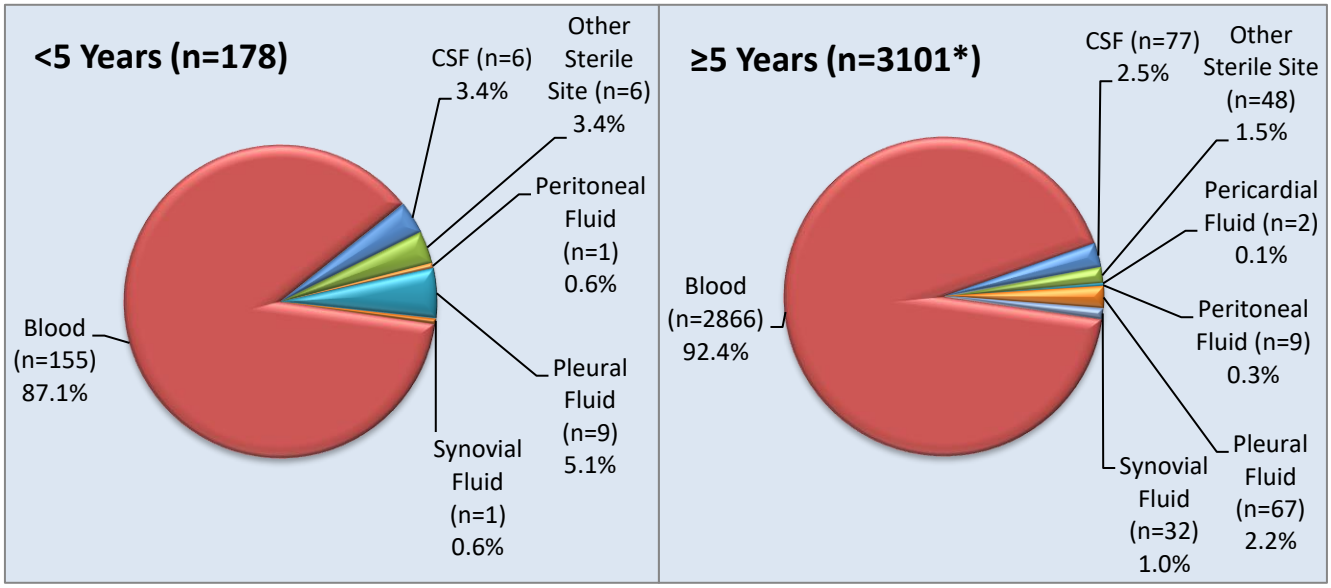
Serotype 19A: Overall from 2014 to 2018, 19A has shown a steady decrease from 8.6% (n=221) to 5.3% (n=175); for 2 – 4 year olds from 26.1% (n=22) to 5.8% (n=5), for 15 – 49 year olds from 9.4% (n=49) to 4.5% (n=34), for 50 – 64 year olds from 7.9% (n=57) to 5.6% (n=54), and for ≥65 year olds from 7.5% (n=77) to 5.0% (n=64). The proportion of 19A in the <2 year olds and 5 – 14 year olds increased from 4.0% (n=5) to 6.5% (n=6) and 12.3% (n=8) to 12.7% (n=9) respectively.

Serotype 7F: In 2018, there was only one isolation of serotype 7F in children under 15 years of age. In all other age groups, declines from 2014 to 2018 have continued with 7F decreasing in the 15 – 49 year olds from 12.5% (n=65) to 6.6% (n=50), in the 50 – 64 year olds from 7.9% (n=57) to 4.2% (n=40), and in the ≥65 year old age group from 5.0% (n=52) to 1.2% (n=15).

Table 2. Number of invasive *S. pneumoniae* submitted by Province in 2018

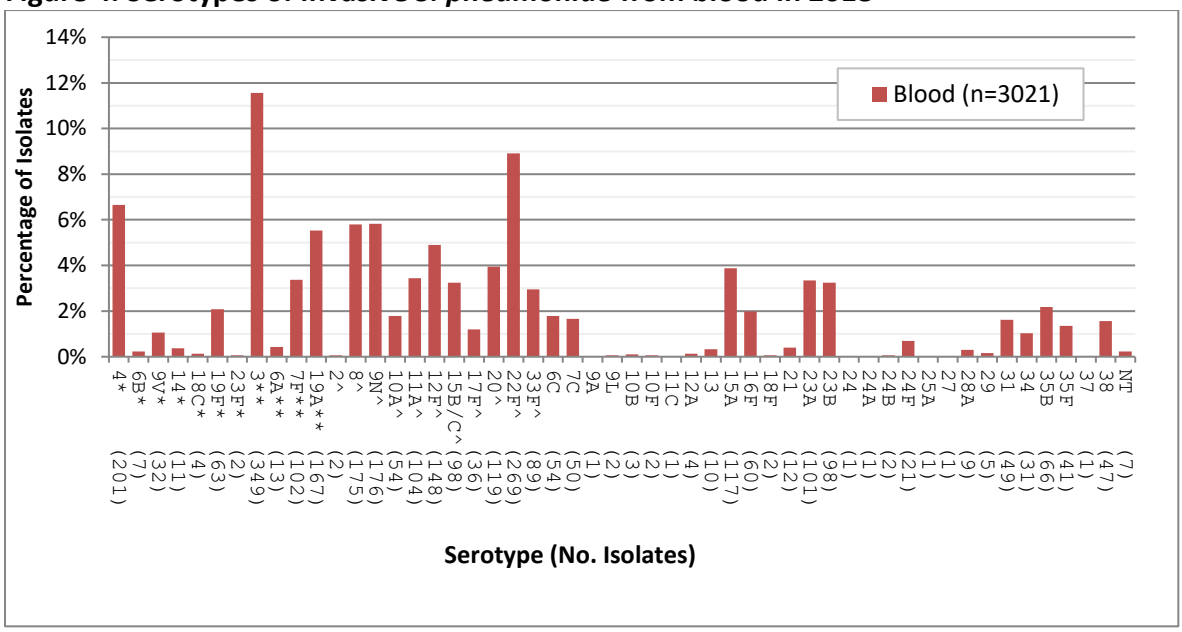
Province	Age Groups (Years)						Not Given	Total
	< 2	2 – 4	5 – 14	15 – 49	50 – 64	≥ 65		
British Columbia	6	9	5	170	185	177	2	554
Alberta	9	8	8	138	141	126	10	440
Saskatchewan	3	2	4	36	34	52		131
Manitoba	12	5	6	85	72	62		242
Ontario	39	38	24	219	358	529	14	1221
Quebec	20	18	21	77	116	239	9	500
New Brunswick	1	3	1	18	27	35		85
Prince Edward Island	1	1		2	7	10		21
Nova Scotia		1	1	3	5	19		29
Newfoundland		1		4	14	10		29
Yukon				2		5		7
Northwest Territories			1	5	3	8		17
Nunavut	1			1		1		3
Total	**92**	**86**	**71**	**760**	**962**	**1273**	**35**	**3279**

Figure 3. Clinical isolation sites in 2018



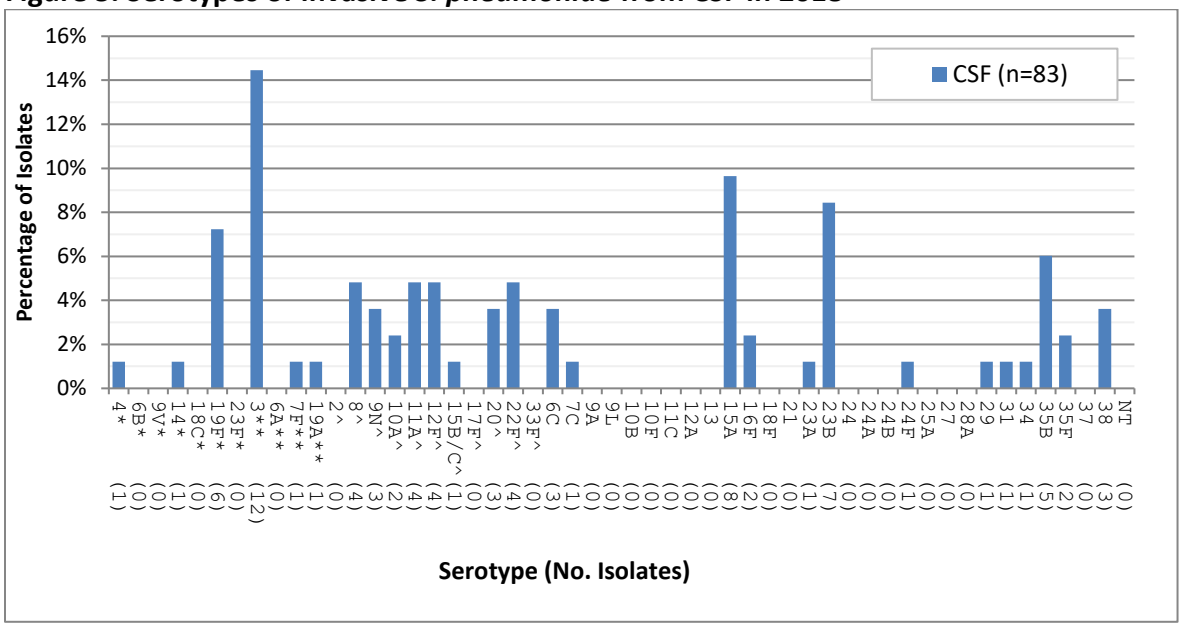
*Includes 35 isolates with age not available. Other sterile sites include deep tissue, abscess or fluid, vitreous humor, biopsy and unknown clinical sources.

Figure 4. Serotypes of invasive *S. pneumoniae* from blood in 2018



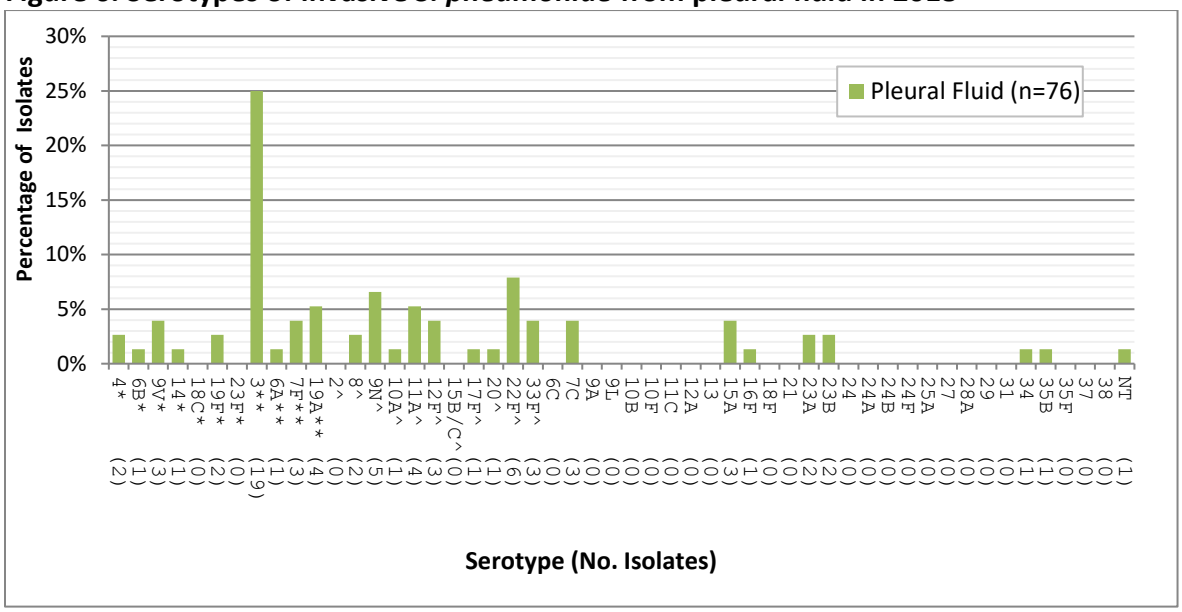
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23.

Figure 5. Serotypes of invasive *S. pneumoniae* from CSF in 2018



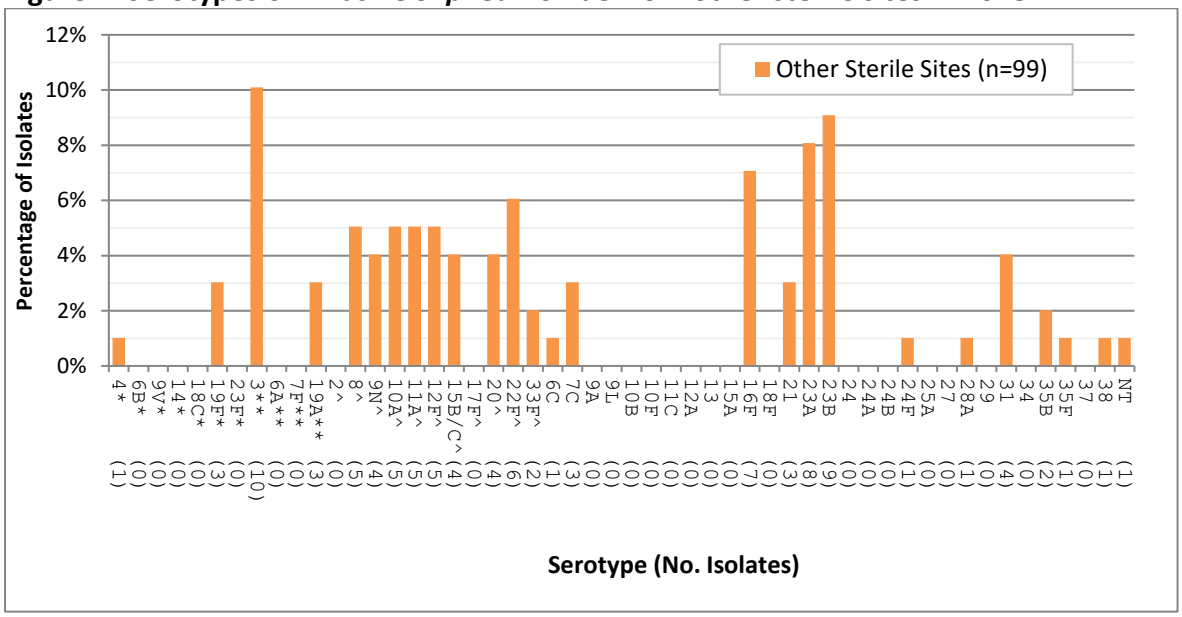
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23.

Figure 6. Serotypes of invasive *S. pneumoniae* from pleural fluid in 2018



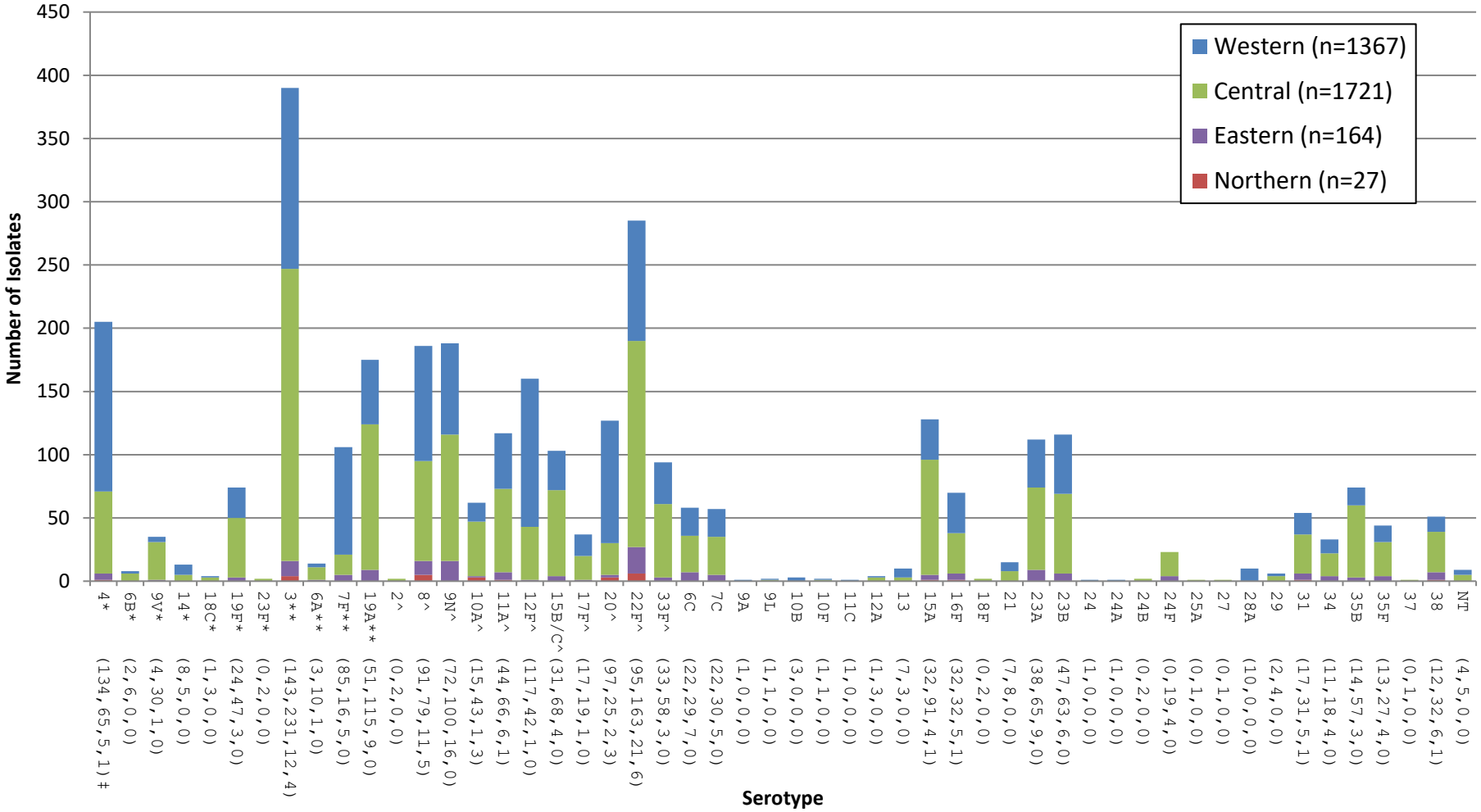
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23.

Figure 7. Serotypes of invasive *S. pneumoniae* from other sterile sites in 2018



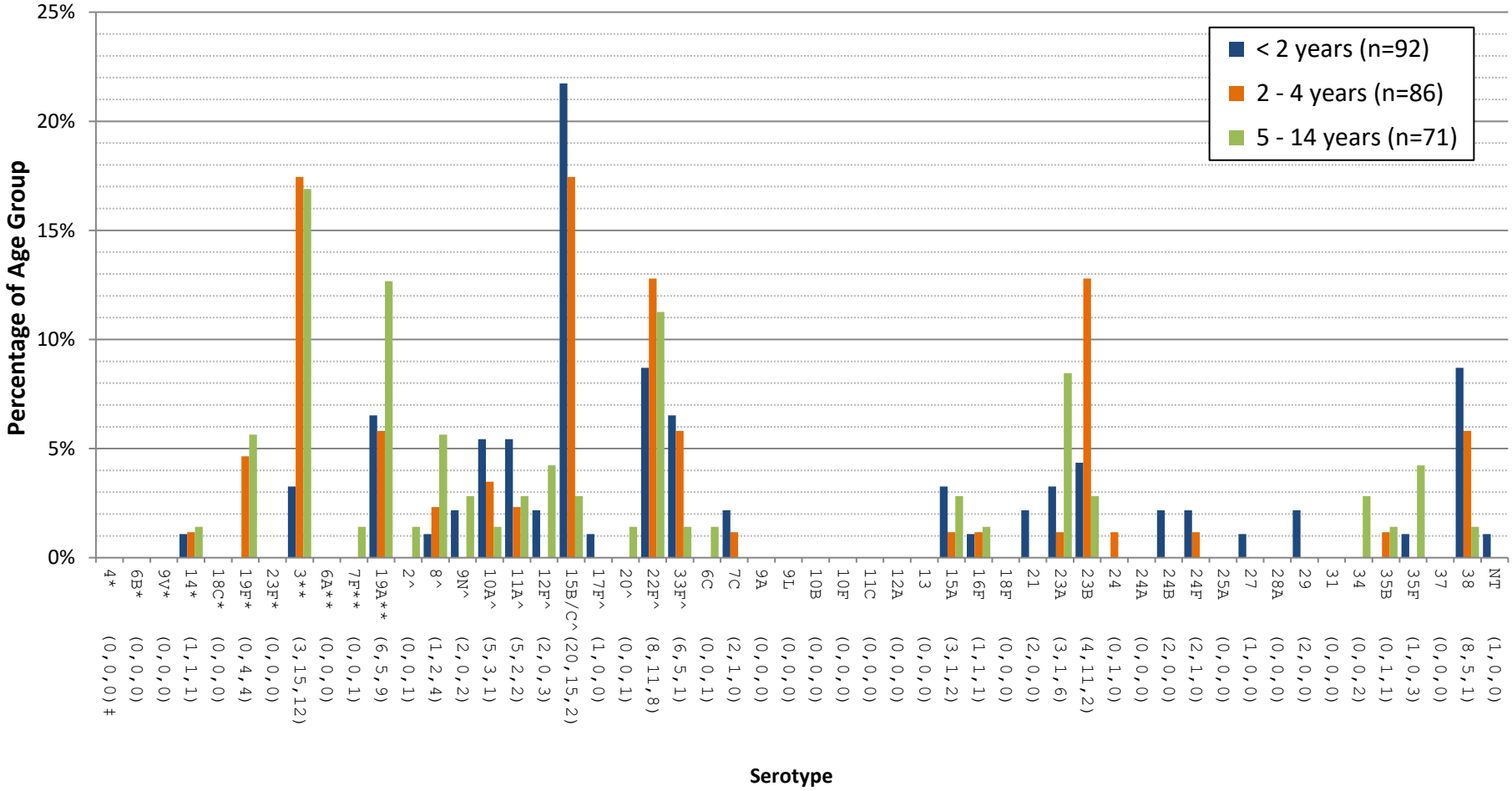
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23.

Figure 8. Regional Distribution of Invasive *S. pneumoniae* serotypes in 2018



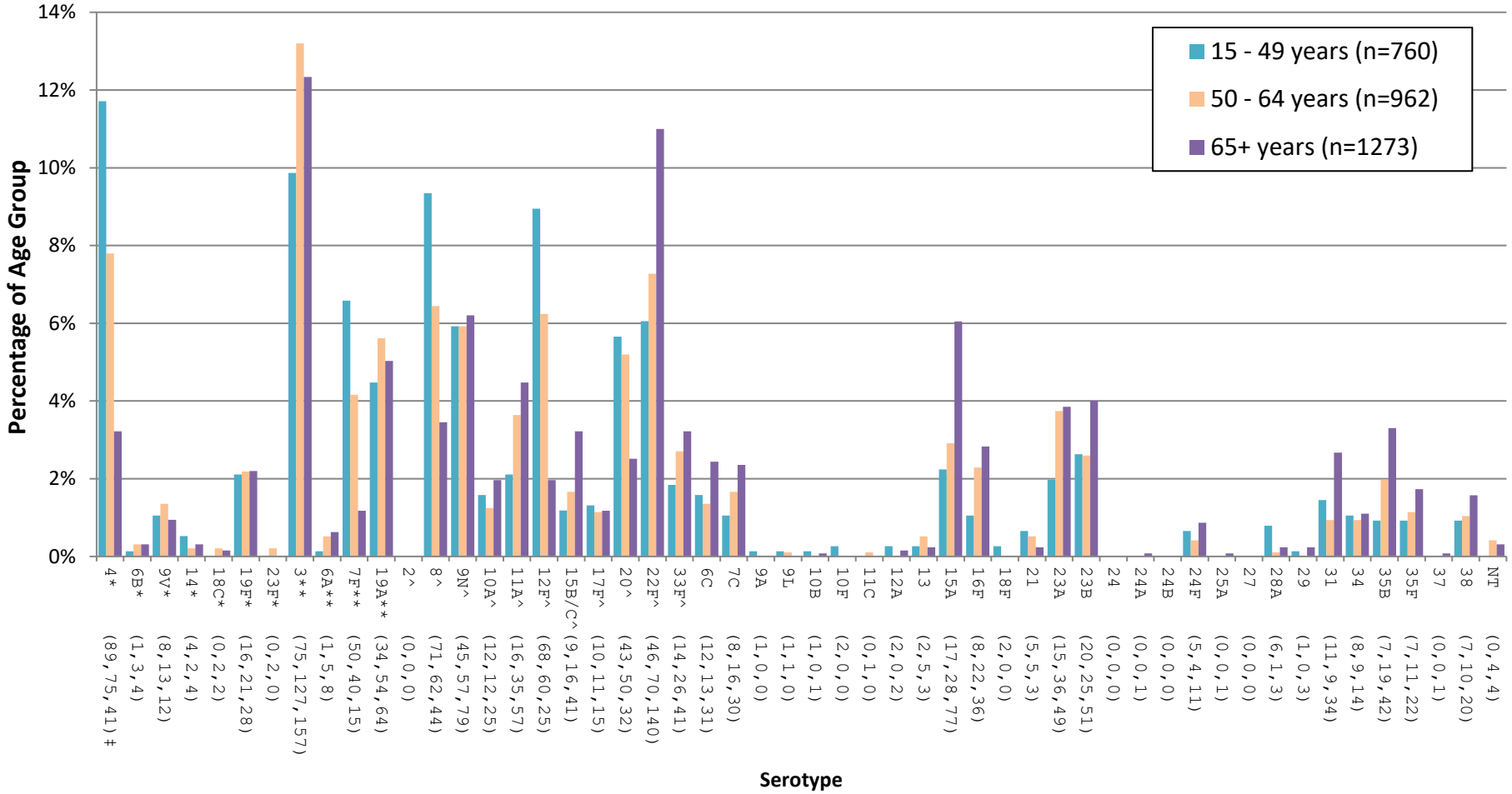
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡Number of isolates from Western, Central, Eastern and Northern Canada, respectively.

Figure 9. Invasive *S. pneumoniae* serotypes isolated in 2018: <2, 2-4 and 5-14 year old age groups



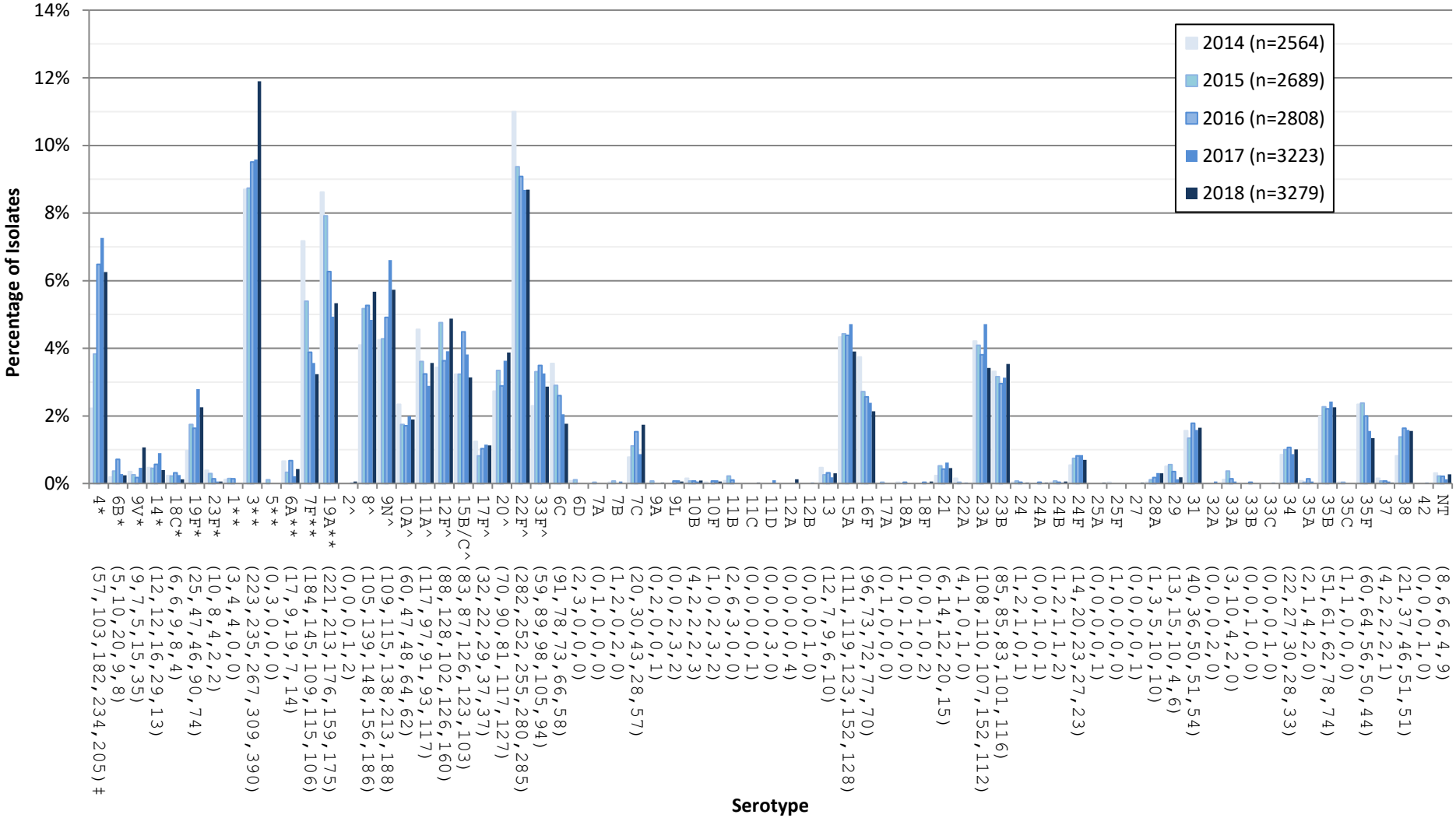
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡Number of isolates from <2, 2-4, 5-14 year olds, respectively.

Figure 10. Invasive *S. pneumoniae* serotypes isolated in 2018: 15-49, 50-64, and ≥65 year old age groups



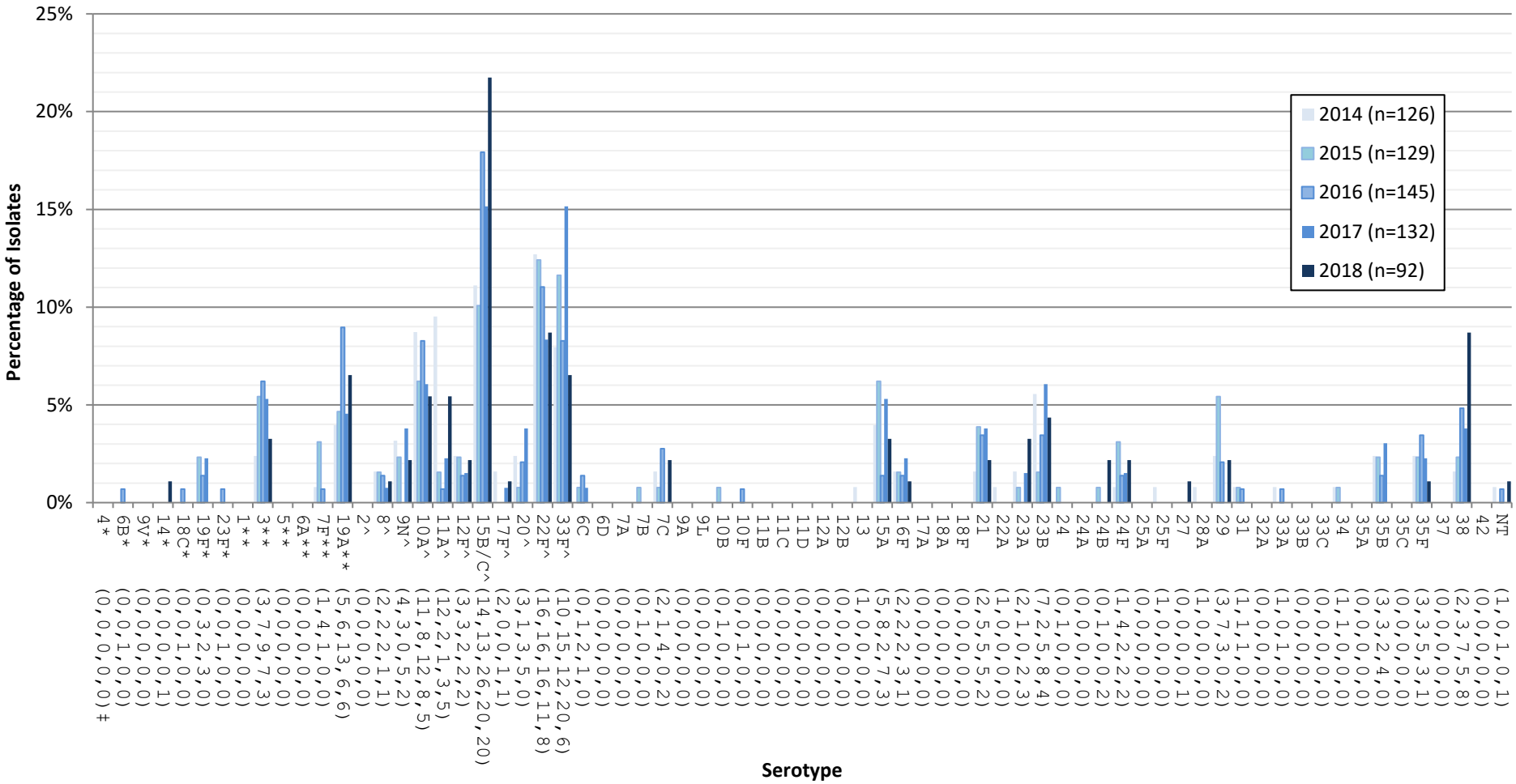
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23. ‡Number of isolates from 15-49, 50-64, ≥65 year olds, respectively.

Figure 11. Invasive *S. pneumoniae* serotypes in all combined age groups, 2014-2018



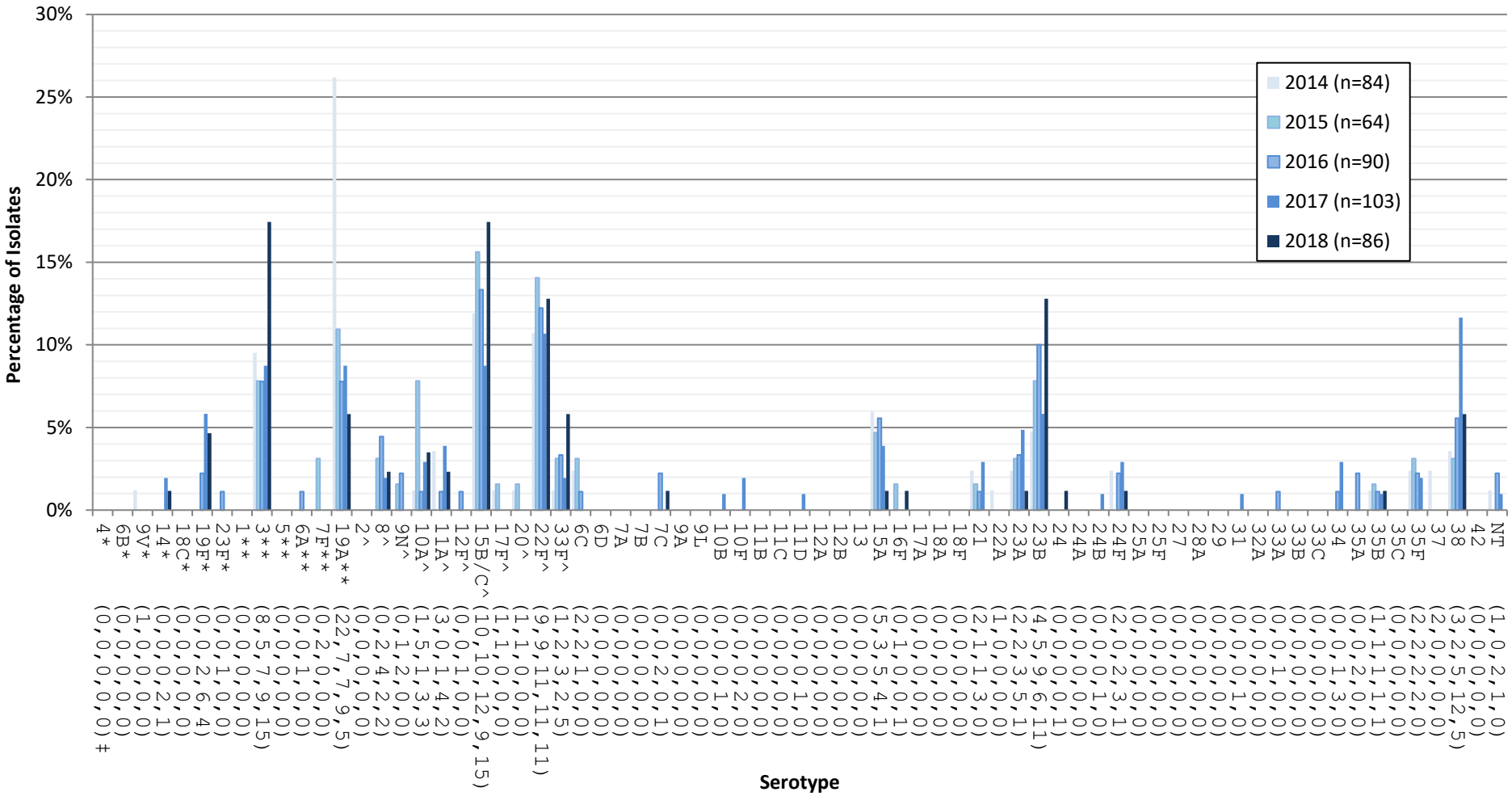
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of isolates for 2014, 2015, 2016, 2017 and 2018 respectively.

Figure 12. Invasive *S. pneumoniae* serotypes in <2 year olds, 2014-2018



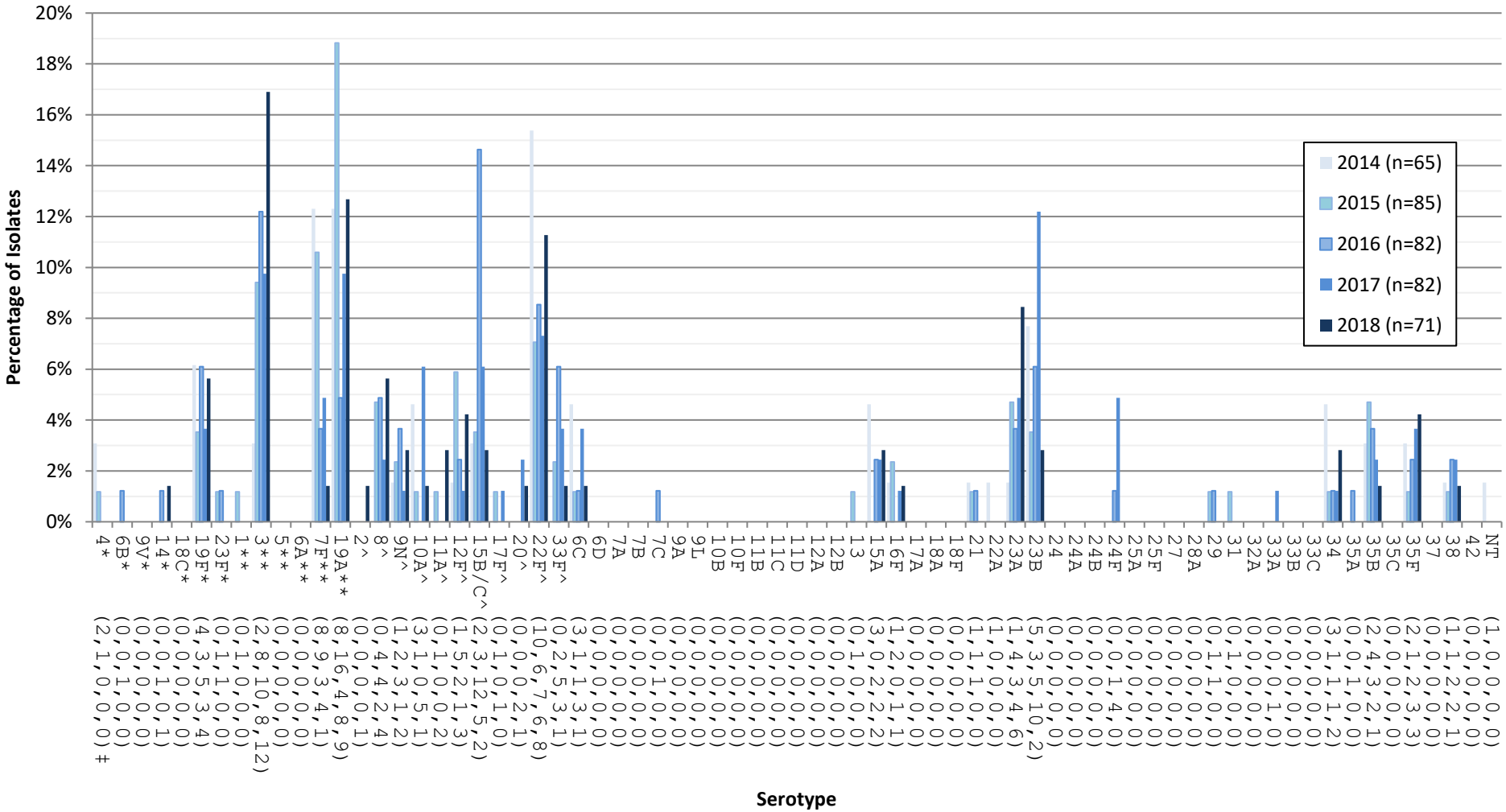
* Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of isolates for 2014, 2015, 2016, 2017 and 2018 respectively.

Figure 13. Invasive *S. pneumoniae* serotypes in 2-4 year olds, 2014-2018



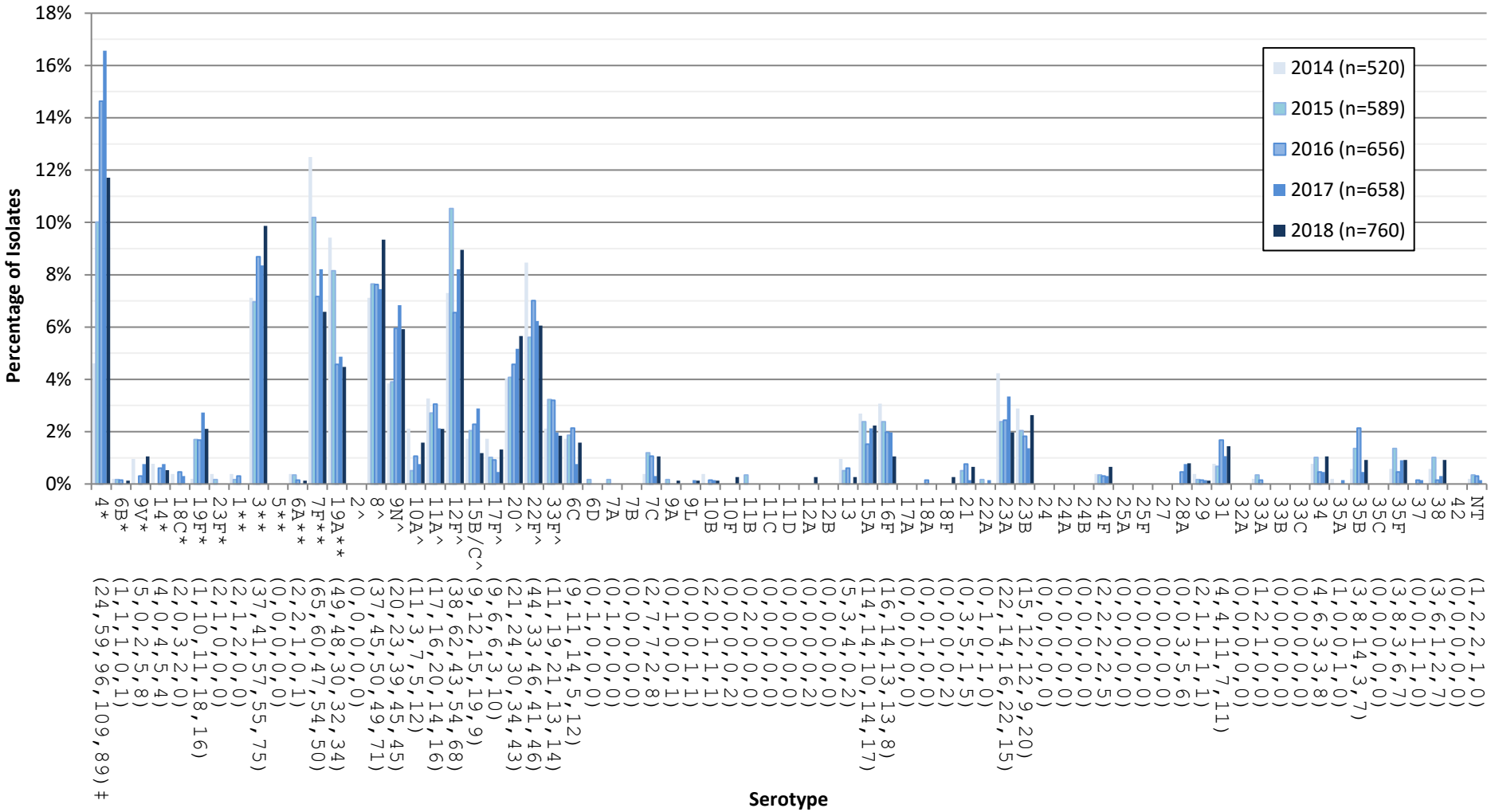
* Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of isolates for 2014, 2015, 2016, 2017 and 2018 respectively.

Figure 14. Invasive *S. pneumoniae* serotypes in 5-14 year olds, 2014-2018



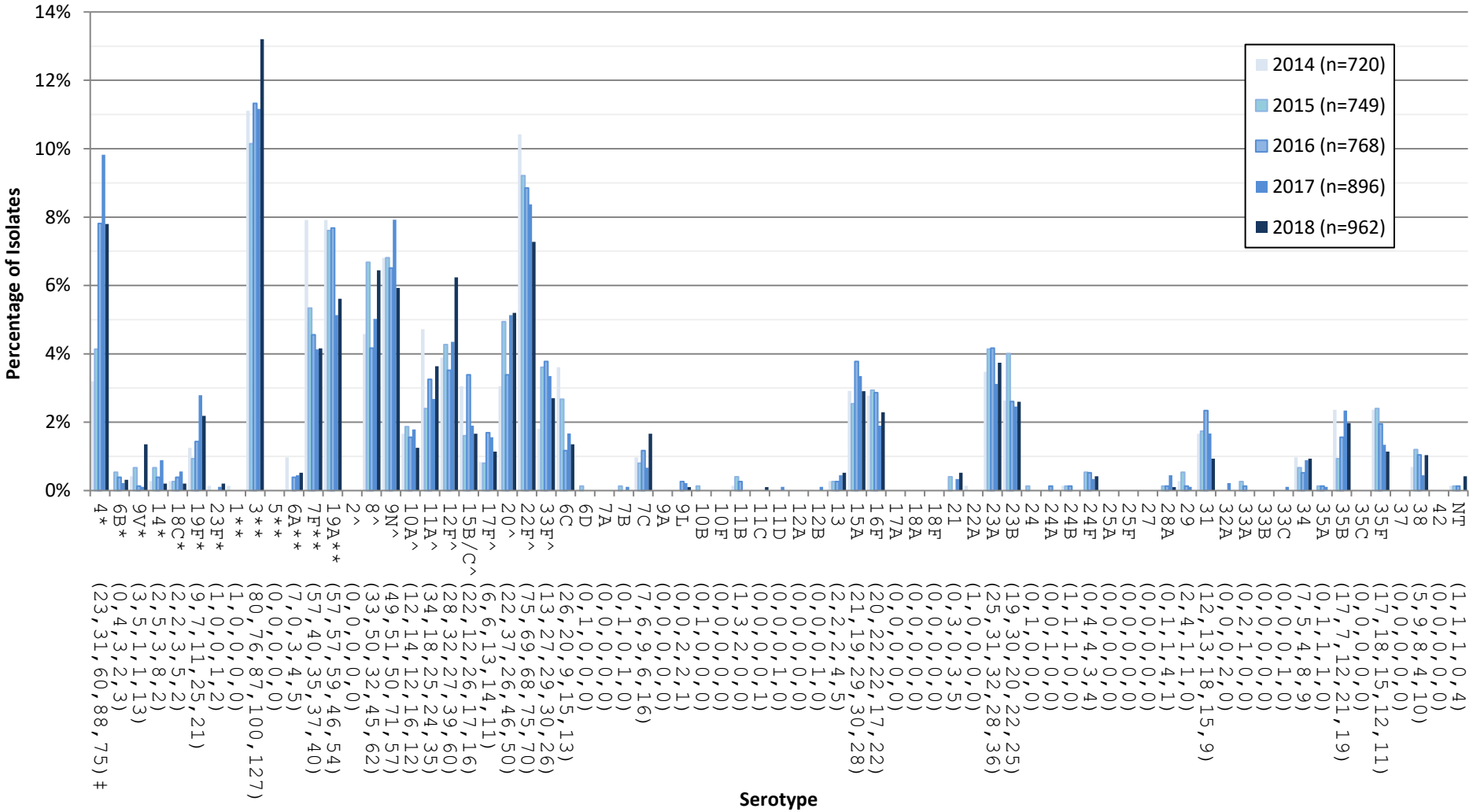
* Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of isolates for 2014, 2015, 2016, 2017 and 2018 respectively.

Figure 15. Invasive *S. pneumoniae* serotypes in 15-49 year olds, 2014-2018



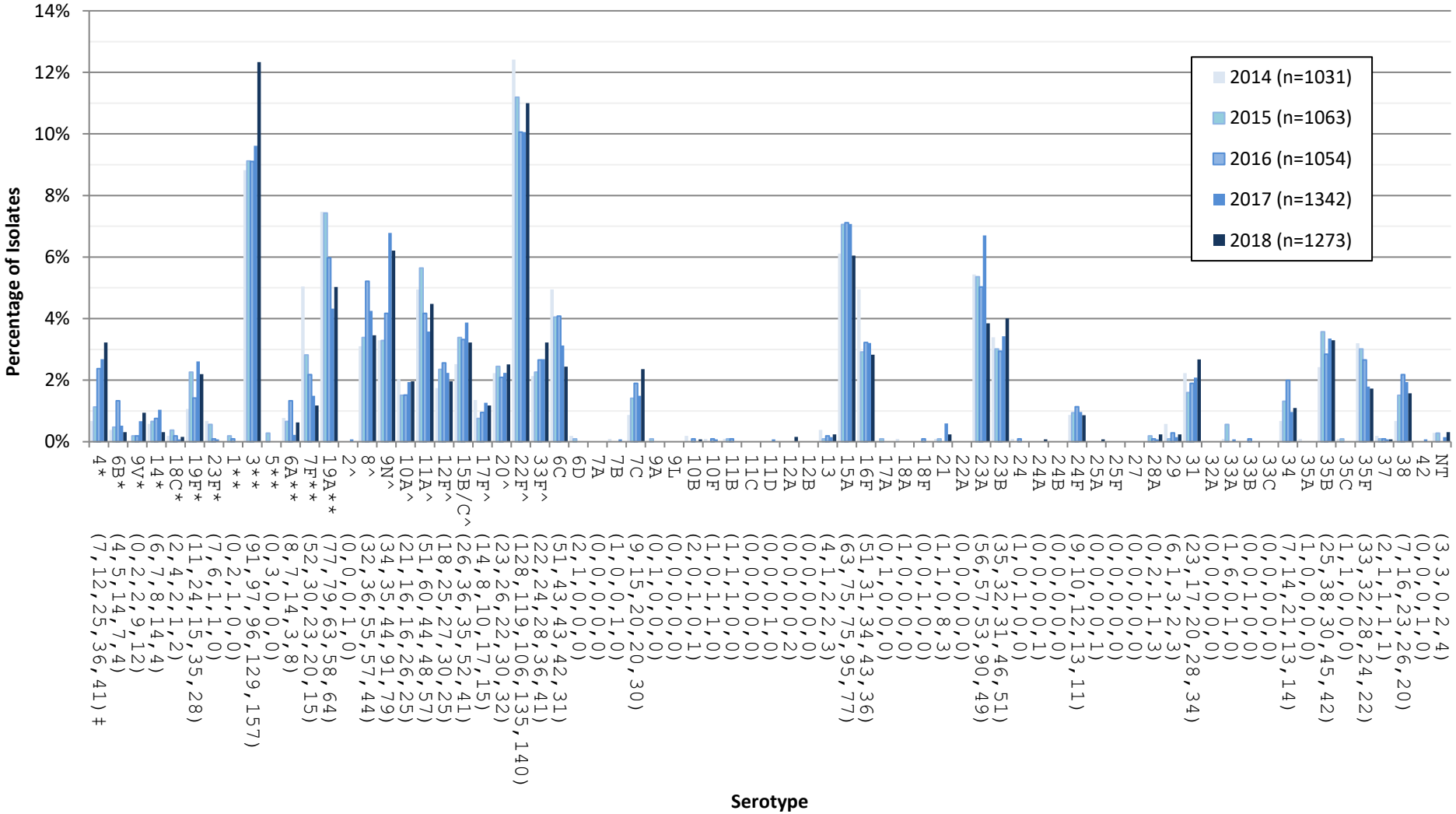
* Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of isolates for 2014, 2015, 2016, 2017 and 2018 respectively.

Figure 16. Invasive *S. pneumoniae* serotypes in 50-64 year olds, 2014-2018



* Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of isolates for 2014, 2015, 2016, 2017 and 2018 respectively.

Figure 17. Invasive *S. pneumoniae* serotypes in ≥65 year olds, 2014-2018



* Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of isolates for 2014, 2015, 2016, 2017 and 2018 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 2018 with only 1 isolate in the <2 year olds, 5 isolates from 2 – 4 year olds, and 5 isolates in the 5-14 year old age group. Overall PCV7 serotypes accounted for 10.4% (n=341) of the isolates in 2018 down from 12.0% (n=387) in 2017.

Proportions of PCV13-specific serotypes (1, 3, 5, 6A, 7F and 19A) have increased across most age groups from 2017 to 2018. There was no changes noted in the <2 year olds and the 15-49 year olds, the rates remained constant at 9.8% and 21% respectively from 2017 to 2018. The level of PCV13 specific serotypes for 2-4 year olds increased from 17.5% (n=18) to 23.3% (n=20); the 5-14 year olds from 24.4% (n=20) to 31.0% (n=22); the 50-64 year olds from 20.9% (n=187) to 23.5% (n=226) and ≥65 year olds increased from 15.6% (n=210) to 19.2% (n=244). This increase is mainly attributable to resurgences of serotype 3.

The proportion of isolates representing PPV23 serotypes (2, 8, 9N, 10A, 11A, 12F, 15B/C, 17F, 20, 22F, 33F) has remained consistent overall, increasing only slightly from 40.8% (n=1315) in 2017 to 41.5% (n=1361) in 2018. For seniors ≥65 year olds, the rate remains at 39% while decreases were seen for <2 year olds from 57.6% (n=76) to 54.3% (n=50); and 50-64 year olds from 42.1% (n=377) to 41.5% (n=399). A significant increase in the proportion of PPV23 serotypes in 2-4 year olds, 30.1% (n=31) to 44.2% (n=38) can be attributed to a rise in serotype 15B/C. Increases were also seen in the 5-14 year olds from 31.7% (n=26) to 35.2% (n=25) and the 15-49 year olds from 42.1% (n=277) to 43.9% (n=334).

The number of non-vaccine serotypes (NVTs) in 2018 has decreased slightly overall from 2017, 28.9% (n=931) to 27.2% (n=892). Levels have remained relatively unchanged at 22% for 50 – 64 year olds. Decreases were seen for 2-4 year olds from 44.7% (n=46) to 26.7% (n=23), for 5-14 year olds from 40.2% (n=33) to 26.8% (n=19) and for ≥65 year olds from 37.7% (n=506) to 34.5% (n=439). Increases in the proportion of NVT serotypes occurred in the <2 year olds from 30.3% (n=40) to 34.8% (n=32) and in the 15-49 year olds from 15.3% (n=101) to 19.5% (n=148).
According to the 2017 childhood National Immunization Coverage Survey, vaccine uptake for pneumococcal vaccine was 81.4% among those less than 2 years of age [PHAC, 2019].

Table 3. Pneumococcal Vaccine Serotypes 2018

	Age Group						
Vaccine*	<2 years	2-4 years	5-14 years	15-49 years	50-64 years	≥65 years	All Ages**
PCV7	1.1%(1)***	5.8%(5)	7.0%(5)	15.5%(118)	12.3%(118)	7.1%(91)	10.4%(341)
PCV13	9.8%(9)	23.3%(20)	31.0%(22)	21.1%(160)	23.5%(226)	19.2%(244)	20.9%(685)
PCV13 All	10.9%(10)	29.1%(25)	38.0%(27)	36.6%(278)	35.8%(344)	26.3%(335)	31.3%(1026)
PPV23	54.3%(50)	44.2%(38)	35.2%(25)	43.9%(334)	41.5%(399)	39.2%(499)	41.5%(1361)
PPV23 All	64.1%(59)	67.4%(58)	66.2%(47)	64.9%(493)	64.7%(622)	58.1%(739)	62.2%(2038)
NVT	34.8%(32)	26.7%(23)	26.8%(19)	19.5%(148)	22.8%(219)	34.5%(439)	27.2%(892)
Total	(92)	(86)	(71)	(760)	(962)	(1273)	(3279)

*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. *** Percentage of isolates (number of isolates).

Figure 18. Trends of PCV7 serotypes (4, 6B, 9V, 14, 18C, 19F, 23F), 2014-2018

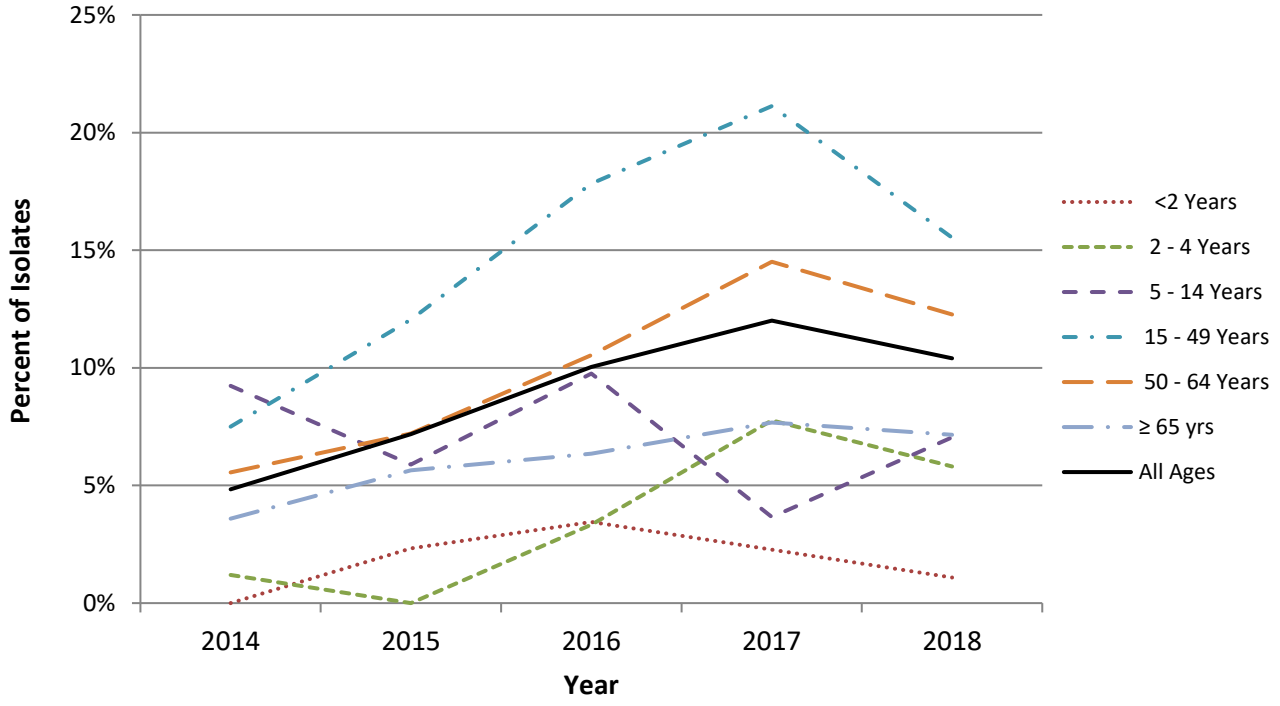


Table 4. PCV7 serotypes by age group, 2014-2018

	Age Group						
Year	<2 years	2-4 years	5-14 years	15-49 years	50-64 years	≥65 years	All Ages**
2014	0.0% (0)	1.2% (1)	9.2% (6)	7.5% (39)	5.6% (40)	3.6% (37)	4.8% (124)
2015	2.3% (3)	0.0% (0)	5.9% (5)	12.1% (71)	7.2% (54)	5.6% (60)	7.2% (193)
2016	3.4% (5)	3.3% (3)	9.8% (8)	17.8% (117)	10.5% (81)	6.4% (67)	10.0% (282)
2017	2.3% (3)	7.8% (8)	3.7% (3)	21.1% (139)	14.5% (130)	7.7% (103)	12.0% (387)
2018	1.1% (1)	5.8% (5)	7.0% (5)	15.5% (118)	12.3% (118)	7.1% (91)	10.4% (341)

* 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), 2014-2018

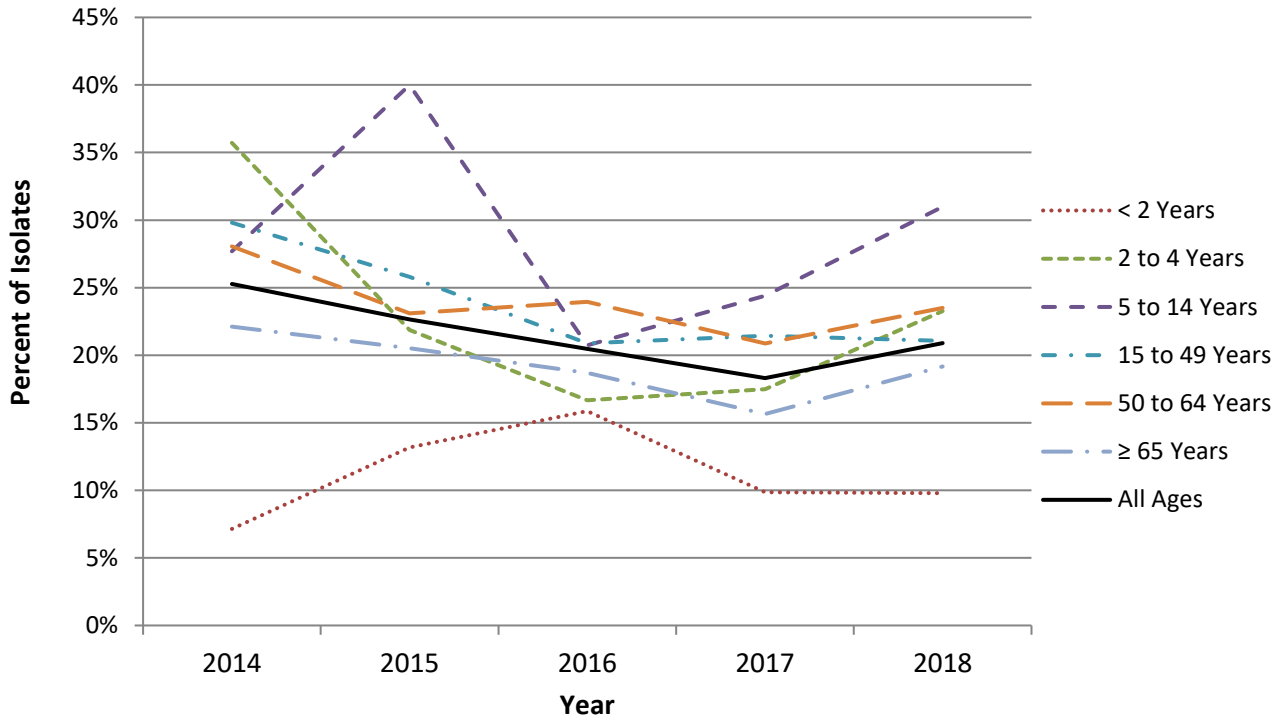


Table 5. PCV13 serotypes by age group, 2014-2018

	Age Group						
Year	<2 years	2-4 years	5-14 years	15-49 years	50-64 years	≥65 years	All Ages**
2014	7.1% (9)	35.7% (30)	27.7% (18)	29.8% (155)	28.1% (202)	22.1% (228)	25.3% (648)
2015	13.2% (17)	21.9% (14)	40.0% (34)	25.8% (152)	23.1% (173)	20.5% (218)	22.6% (609)
2016	15.9% (23)	16.7% (15)	20.7% (17)	20.9% (137)	24.0% (184)	18.7% (197)	20.5% (575)
2017	9.8% (13)	17.5% (18)	24.4% (20)	21.4% (141)	20.9% (187)	15.6% (210)	18.3% (590)
2018	9.8% (9)	23.3% (20)	31.0% (22)	21.1% (160)	23.5% (226)	19.2% (244)	20.9% (685)

* 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), 2014-2018

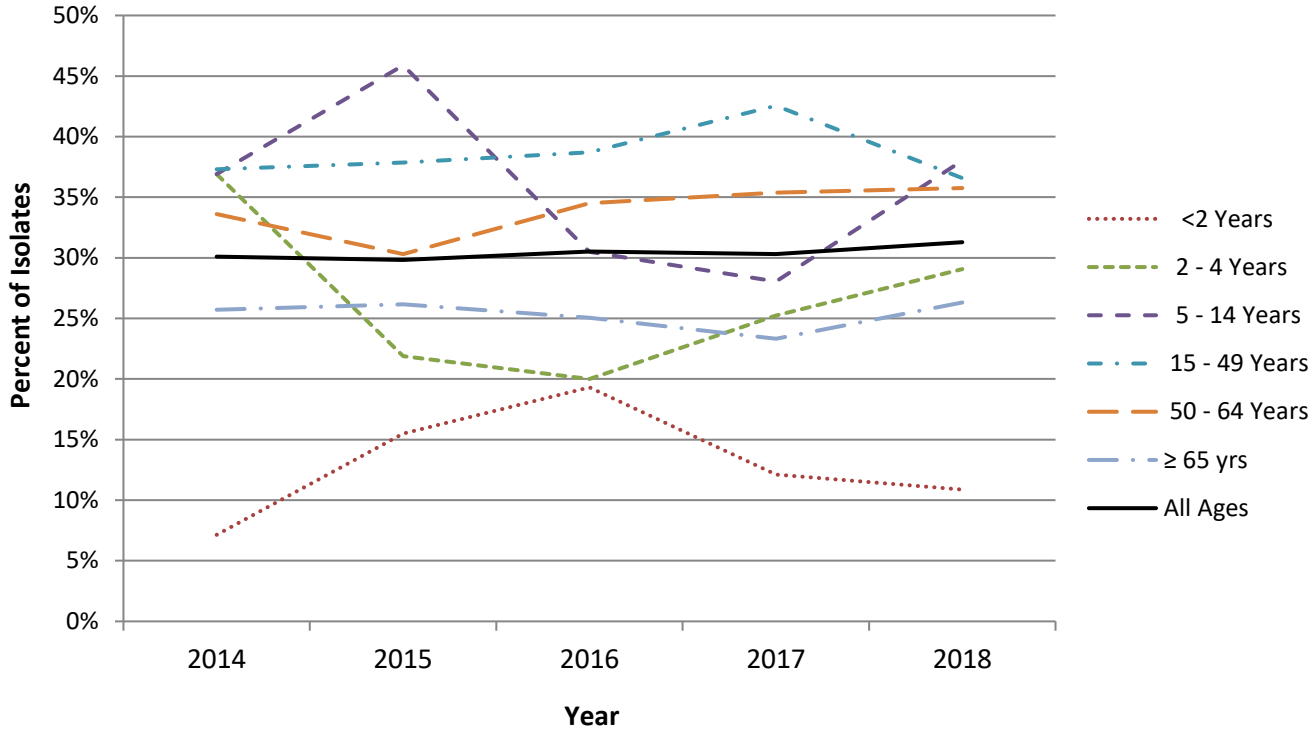


Table 6. Combined PCV7 and PCV13 serotypes by age group, 2014-2018

	Age Group (Years)*						
Year	<2 years	2-4 years	5-14 years	15-49 years	50-64 years	≥65 years	All Ages**
2014	7.1% (9)	36.9% (31)	36.9% (24)	37.3% (194)	33.6% (242)	25.7% (265)	30.1% (772)
2015	15.5% (20)	21.9% (14)	45.9% (39)	37.9% (223)	30.3% (227)	26.2% (278)	29.8% (802)
2016	19.3% (28)	20.0% (18)	30.5% (25)	38.7% (254)	34.5% (265)	25.0% (264)	30.5% (857)
2017	12.1% (16)	25.2% (26)	28.0% (23)	42.6% (280)	35.4% (317)	23.3% (313)	30.3% (977)
2018	10.9% (10)	29.1% (25)	38.0% (27)	36.6% (278)	35.8% (344)	26.3% (335)	31.3% (1026)

* 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/C, 17F, 20, 22F, 33F), 2014-2018

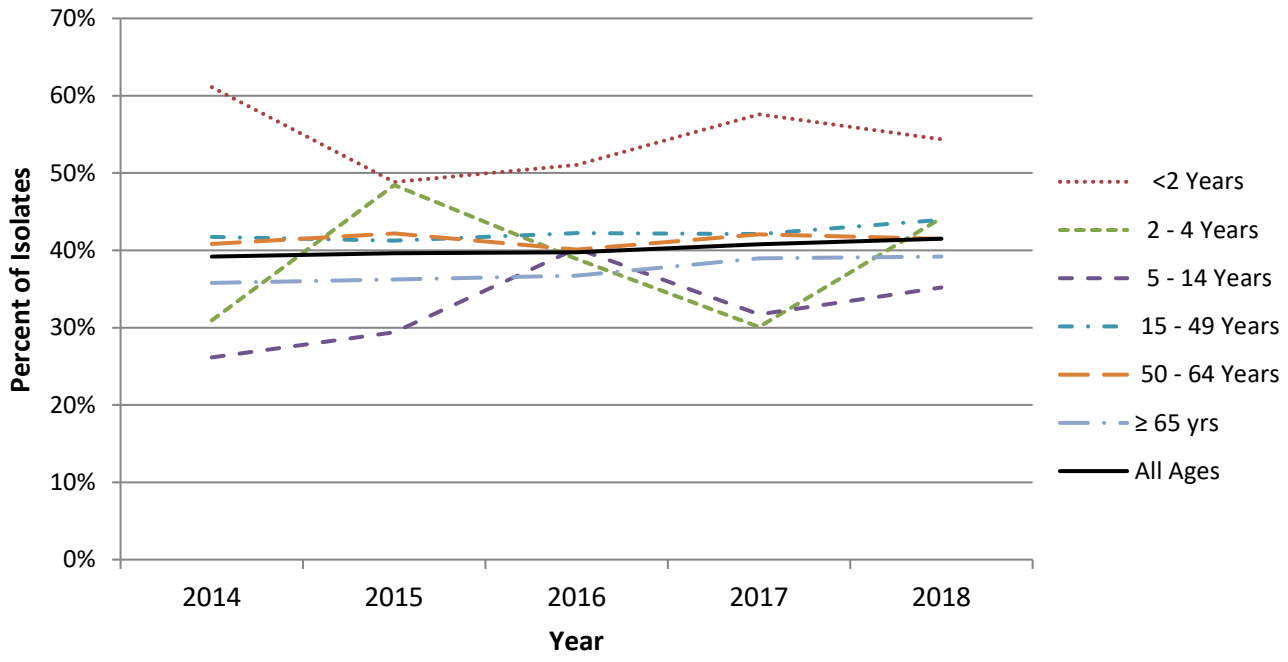


Table 7. PPV23 serotypes by age group, 2014-2018

	Age Group						
Year	<2 years	2-4 years	5-14 years	15-49 years	50-64 years	≥65 years	All Ages**
2014	61.1% (77)	31.0% (26)	26.2% (17)	41.7% (217)	40.8% (294)	35.8% (369)	39.2% (1005)
2015	48.8% (63)	48.4% (31)	29.4% (25)	41.3% (243)	42.2% (316)	36.2% (385)	39.6% (1066)
2016	51.0% (74)	38.9% (35)	40.2% (33)	42.2% (277)	40.1% (308)	36.7% (387)	39.7% (1116)
2017	57.6% (76)	30.1% (31)	31.7% (26)	42.1% (277)	42.1% (377)	39.0% (523)	40.8% (1315)
2018	54.3% (50)	44.2% (38)	35.2% (25)	43.9% (334)	41.5% (399)	39.2% (499)	41.5% (1361)

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

Figure 22. Trends of non-vaccine serotypes (NVT), 2014-2018

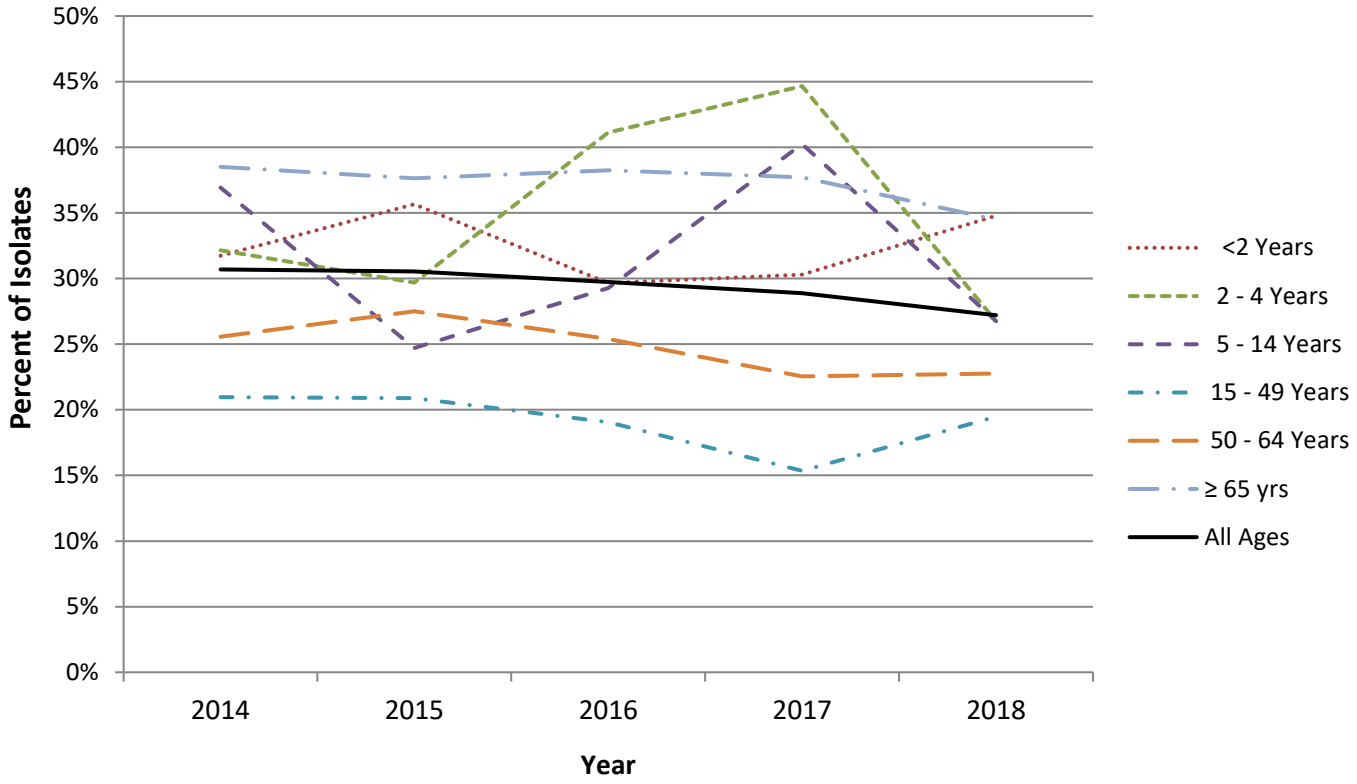


Table 8. Non-vaccine serotype (NVT) isolates, 2014-2018

	Age Group						
Year	<2 years	2-4 years	5-14 years	15-49 years	50-64 years	≥65 years	All Ages**
2014	31.7% (40)	32.1% (27)	36.9% (24)	21.0% (109)	25.6% (184)	38.5% (397)	30.7% (787)
2015	35.7% (46)	29.7% (19)	24.7% (21)	20.9% (123)	27.5% (206)	37.6% (400)	30.5% (821)
2016	29.7% (43)	41.1% (37)	29.3% (24)	19.1% (125)	25.4% (195)	38.2% (403)	29.7% (835)
2017	30.3% (40)	44.7% (46)	40.2% (33)	15.3% (101)	22.5% (202)	37.7% (506)	28.9% (931)
2018	34.8% (32)	26.7% (23)	26.8% (19)	19.5% (148)	22.8% (219)	34.5% (439)	27.2% (892)

* 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 1,792 *S. pneumoniae* isolates collected in 2018 that were submitted to the NML from eight 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 increased slightly in 2018. The highest rate of resistance during 2018 was observed for clarithromycin at 25.8% (n=462), an increase from 22.3% (n=249) in 2014. Resistance was identified in penicillin (using meningitis breakpoints) (11.1%, n=199), in doxycycline (8.4%, n=151), in trimethoprim-sulfamethoxazole (7.6%, n=137), and in clindamycin (6.8%, n=122). All isolates were susceptible to daptomycin, linezolid, tigecycline and vancomycin.

Serotypes 19F, 6C, 19A, 15A, 23A, 23B and 35B generally had the highest rates of antimicrobial resistance. **Clarithromycin** resistance was associated with serotypes 33F (87.9%, n=58), 19A (80.4%, n=74), 12F (59.8%, n=52) and 22F (46.4%, n=78). High rates of **penicillin** resistance were predominant in serotypes 15A (55.0%, n=22), 23B (43.9%, n=29), 23A (37.7%, n=23), and 6C (28.6%, n=10). **Cefuroxime** resistance was associated with serotypes 35B (48.8%, n=20) and 19A (21.7%, n=20). A relatively high proportion of isolates with **clindamycin** resistance were seen in serotype 19A (34.8%, n=32). **Doxycycline** resistance in serotypes 15A (55.0%, n=22), 23A (23.0%, n=14), 19A (25.0%, n=23) and 3 (13.3%, n=31). Resistance to **trimethoprim-sulfamethoxazole** was mainly associated with serotype 7C and 33F isolates (71.4%, n=25; and 30.3%, n=20; respectively).

Multidrug resistance (MDR) to 3 or more classes of antimicrobials among *S. pneumoniae* increased from 5.0% (n=56) of the isolates tested in 2014 to 7.6% (n=137) in 2018. The highest rates of MDR were seen in serotype 19A with 30% (n=27) and 15A with 57% (n=23) which were resistant to 3 or more antimicrobial classes. The major MDR pattern among serotype 15A isolates was β-lactam-macrolide-clindamycin-tetracycline-chloramphenicol (n=15) and the major pattern among serotype 19A was β-lactam-macrolide-clindamycin-tetracycline-trimethoprim-sulfamethoxazole (n=12).

Figure 23. Antimicrobial resistance of *S. pneumoniae* isolates, 2014-2018

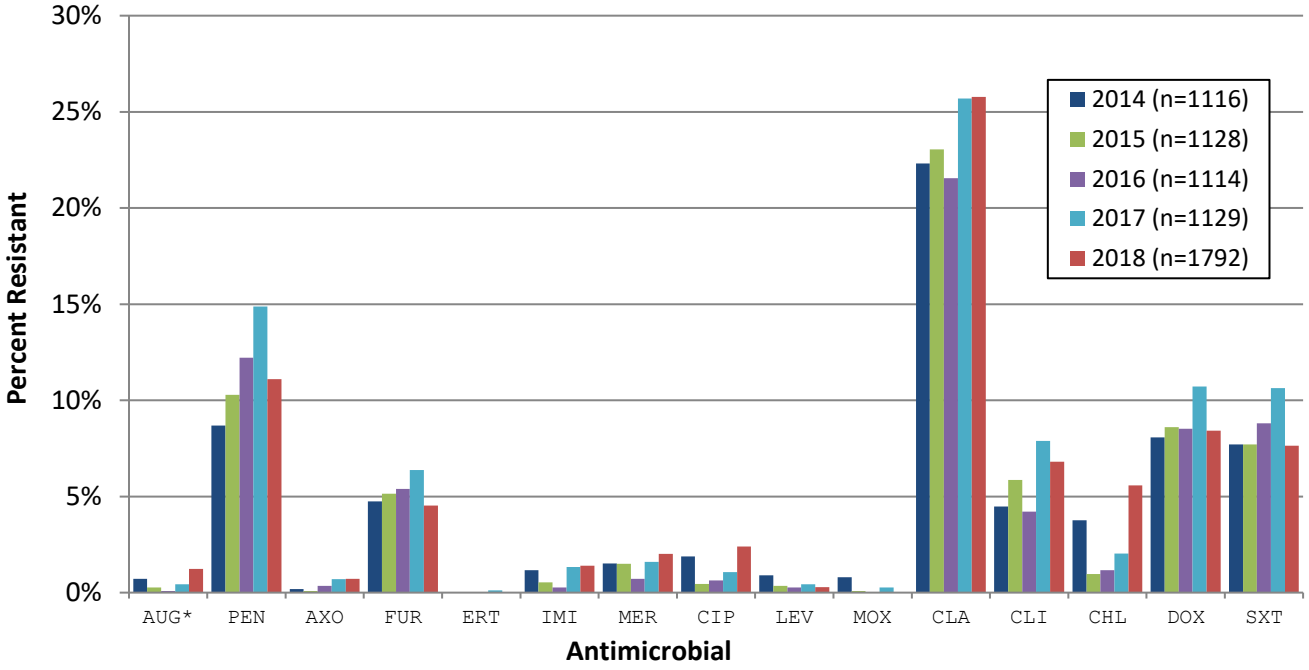


Table 9. Antimicrobial resistant *S. pneumoniae* isolates, 2014-2018

Antimicrobial	Year				
	2014	2015	2016	2017	2018
AUG	0.7% (8)**	0.3% (3)	0.1% (1)	0.4% (5)	1.2% (22)
PEN	8.7% (97)	10.3% (116)	12.2% (136)	14.9% (168)	11.1% (199)
AXO	0.2% (2)	0.1% (1)	0.4% (4)	0.7% (8)	0.7% (13)
FUR	4.7% (53)	5.1% (58)	5.4% (60)	6.4% (72)	4.5% (81)
EPT	0.0% (0)	0.0% (0)	0.0% (0)	0.1% (1)	0.0% (0)
IMI	1.2% (13)	0.5% (6)	0.3% (3)	1.3% (15)	1.4% (25)
MER	1.5% (17)	1.5% (17)	0.7% (8)	1.6% (18)	2.0% (36)
CIP	1.9% (21)	0.4% (5)	0.6% (7)	1.1% (12)	2.4% (43)
LEV	0.9% (10)	0.4% (4)	0.3% (3)	0.4% (5)	0.3% (5)
MOX	0.8% (9)	0.1% (1)	0.0% (0)	0.3% (3)	0.0% (0)
CLA	22.3% (249)	23.0% (260)	21.5% (240)	25.7% (290)	25.8% (462)
CLI	4.5% (50)	5.9% (66)	4.2% (47)	7.9% (89)	6.8% (122)
CHL	3.8% (42)	1.0% (11)	1.2% (13)	2.0% (23)	5.6% (100)
DOX	8.1% (90)	8.6% (97)	8.5% (95)	10.7% (121)	8.4% (151)
SXT	7.7% (86)	7.7% (87)	8.8% (98)	10.6% (120)	7.6% (137)
Total Tested	(1116)	(1128)	(1114)	(1129)	(1792)

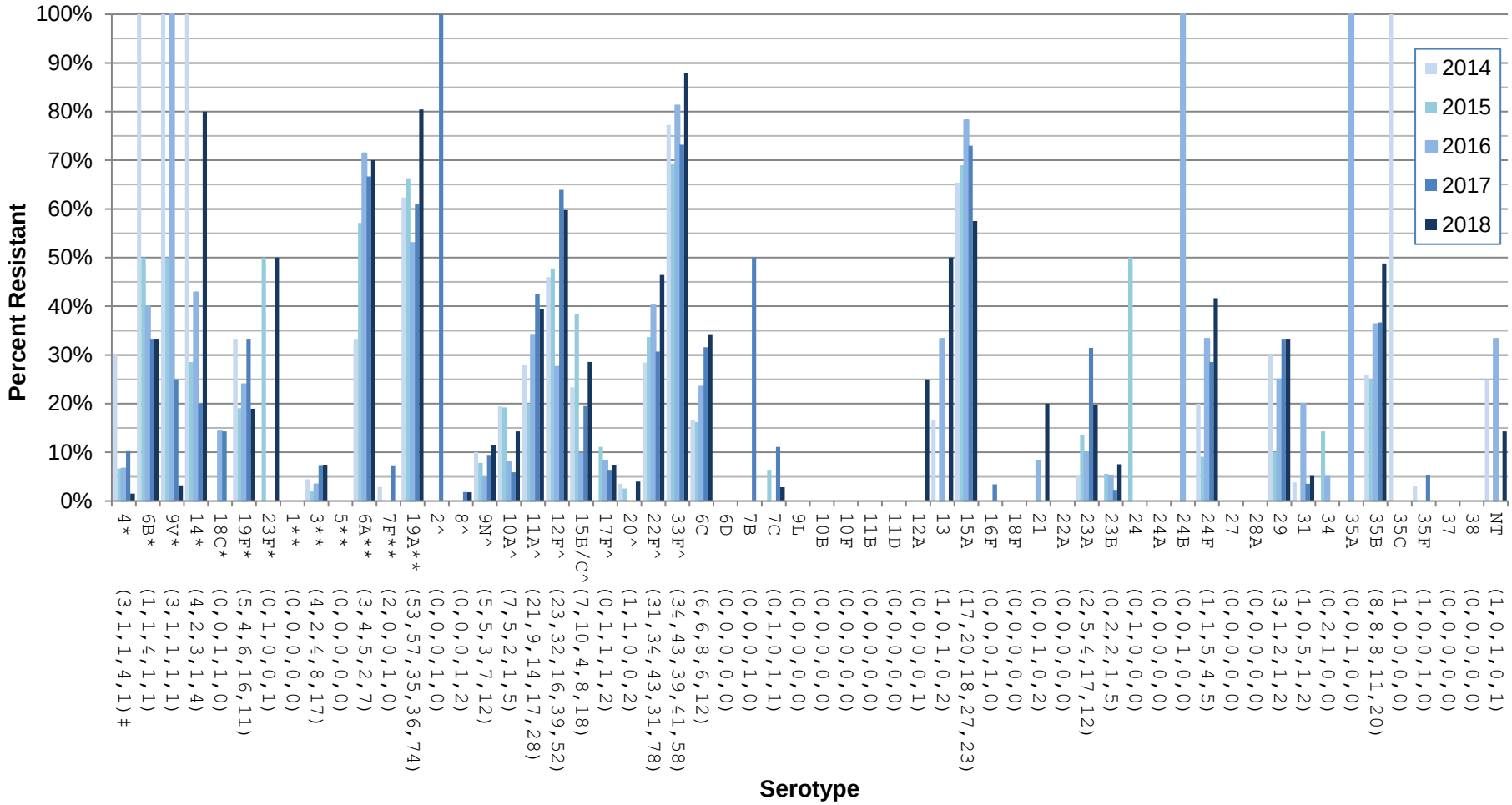
*AUG = amoxicillin/clavulanic acid; PEN = penicillin using the parenteral meningitis CLSI interpretive standard; LEV = levofloxacin; MOX = moxifloxacin; AXO = ceftriaxone using the parenteral meningitis interpretive standard; FUR = cefuroxime using the parenteral interpretative standard; ETP = ertapenem; 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, 2018

Serotype	PEN	AXO	FUR	ERT	IMI	MER	CIP	LEV	MOX	CLA	CLI	CHL	DOX	SXT
4* (n=65)	-	-	-	-	-	-	3.1	-	-	1.5	-	-	-	-
6B* (n=3)	33.3	-	33.3	-	-	-	-	-	-	33.3	33.3	33.3	33.3	33.3
9V* (n=31)	6.5	-	6.5	-	-	-	-	-	-	3.2	-	-	-	9.7
14* (n=5)	80.0	-	40.0	-	20.0	20.0	-	-	-	80.0	40.0	20.0	60.0	80.0
18C* (n=4)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19F* (n=58)	20.7	6.9	17.2	-	6.9	8.6	6.9	5.2	-	19.0	10.3	1.7	13.8	13.8
23F* (n=2)	50.0	-	50.0	-	-	50.0	-	-	-	50.0	50.0	50.0	100.0	100.0
3 (n=232)**	-	-	-	-	-	-	1.7	-	-	7.3	5.6	13.4	13.4	0.4
6A (n=10)**	80.0	-	20.0	-	-	10.0	10.0	-	-	70.0	20.0	30.0	40.0	-
7F (n=18)**	5.6	-	5.6	-	-	-	-	-	-	-	-	-	-	-
19A (n=92)**	28.3	5.4	21.7	-	17.4	16.3	4.3	1.1	-	80.4	34.8	3.3	25.0	23.9
2^ (n=3)	-	-	-	-	-	-	-	-	-	-	-	-	-	33.3
8^ (n=110)	-	-	-	-	-	-	-	-	-	1.8	-	0.9	1.8	-
9N^ (n=104)	3.8	-	1.0	-	-	-	-	-	-	11.5	1.9	-	1.9	-
10A^ (n=35)	-	-	-	-	-	-	-	-	-	14.3	-	-	-	-
11A^ (n=71)	11.3	2.8	4.2	-	2.8	2.8	11.3	-	-	39.4	9.9	5.6	8.5	18.3
12F^ (n=87)	-	-	-	-	-	-	-	-	-	59.8	-	14.9	3.4	2.3
15B/C^ (n=63)	9.5	-	1.6	-	-	-	4.8	-	-	28.6	6.3	-	9.5	4.8
17F^ (n=27)	7.4	-	-	-	-	-	11.1	-	-	7.4	11.1	-	7.4	-
20^ (n=50)	-	-	-	-	-	-	4.0	-	-	4.0	2.0	6.0	2.0	-
22F^ (n=168)	0.6	-	0.6	-	-	-	1.2	-	-	46.4	3.0	7.1	1.8	0.6
33F^ (n=66)	-	-	-	-	-	-	-	-	-	87.9	4.5	4.5	1.5	30.3
6C (n=35)	28.6	-	5.7	-	-	-	8.6	2.9	-	34.3	11.4	5.7	11.4	8.6
7C (n=35)	-	-	-	-	-	-	-	-	-	2.9	-	-	2.9	71.4
9L (n=1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10F (n=1)	100.0	-	-	-	-	-	100.0	-	-	-	-	-	-	100.0
12A (n=4)	50.0	-	-	-	-	-	-	-	-	25.0	-	-	-	75.0
13 (n=4)	-	-	-	-	-	-	-	-	-	50.0	-	-	-	-
15A (n=40)	55.0	-	20.0	-	2.5	2.5	-	-	-	57.5	57.5	37.5	55.0	-
16F (n=40)	5.0	-	-	-	-	-	-	-	-	-	-	2.5	-	-
18F (n=2)	-	-	-	-	-	-	-	-	-	-	-	-	50.0	-
21 (n=10)	-	-	-	-	-	-	-	-	-	20.0	10.0	-	-	-
23A (n=61)	37.7	1.6	1.6	-	1.6	1.6	-	-	-	19.7	13.1	1.6	23.0	9.8
23B (n=66)	43.9	-	-	-	-	-	1.5	-	-	7.6	3.0	1.5	3.0	6.1
24 (n=1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24A (n=1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24B (n=2)	50.0	-	-	-	-	-	-	-	-	-	-	-	-	-
24F (n=12)	25.0	-	-	-	-	-	-	-	-	41.7	8.3	8.3	33.3	41.7
27 (n=1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28A (n=4)	-	-	-	-	-	-	-	-	-	-	-	25.0	25.0	-
29 (n=6)	50.0	-	50.0	-	-	16.7	-	-	-	33.3	-	-	-	-
31 (n=39)	5.1	-	2.6	-	-	-	10.3	-	-	5.1	-	2.6	2.6	-
34 (n=23)	-	-	-	-	-	-	-	-	-	-	-	-	4.3	-
35B (n=41)	56.1	-	48.8	-	-	19.5	-	-	-	48.8	2.4	-	2.4	17.1
35F (n=24)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37 (n=1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38 (n=27)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NT (n=7)	28.6	14.3	14.3	-	-	-	14.3	-	-	14.3	-	-	14.3	28.6
All (n=1792)	11.1	0.7	4.5	-	1.4	2.0	2.4	0.3	-	25.8	6.8	5.6	8.4	7.6

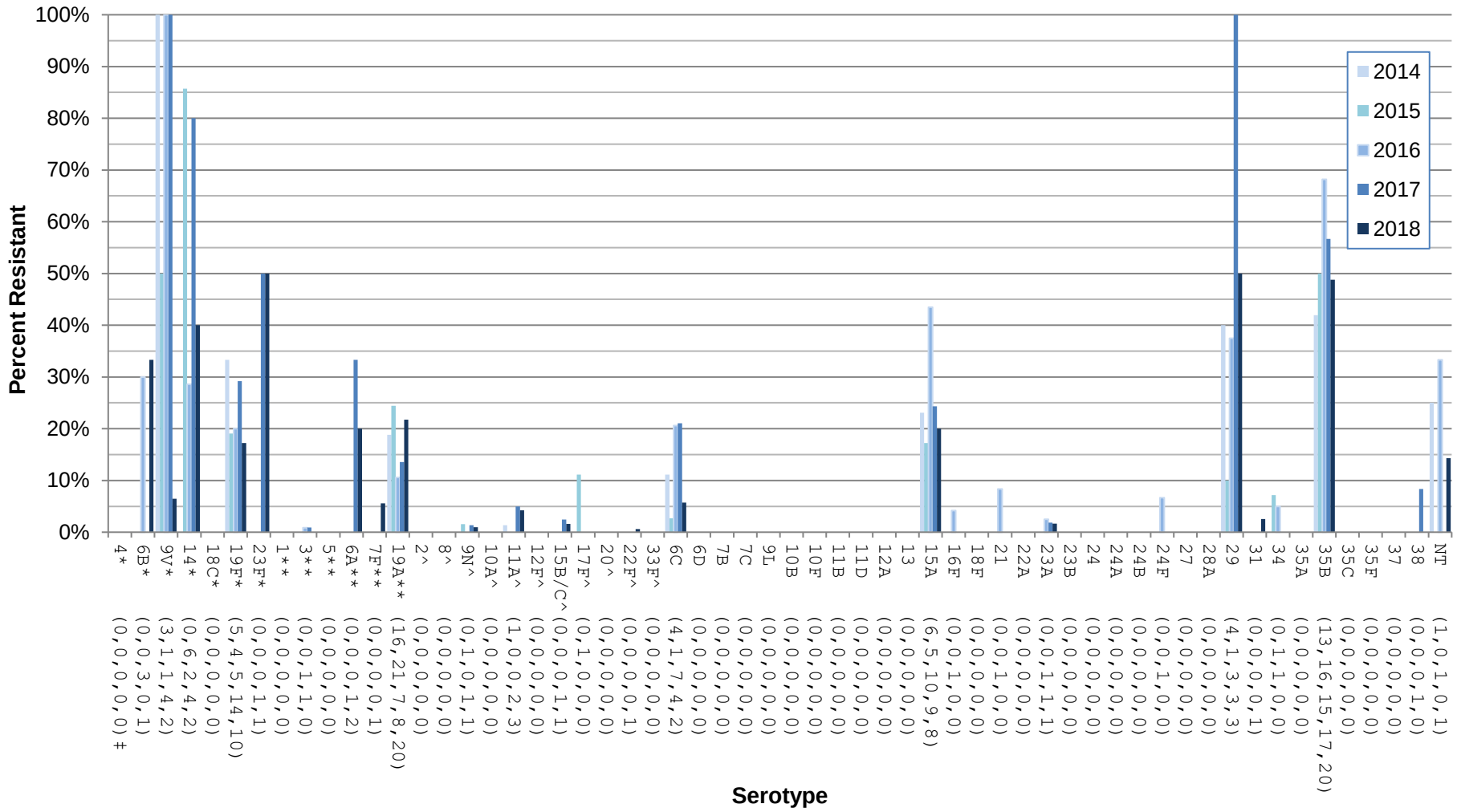
†Percentage of serotype total interpreted as resistant to the antimicrobial agent; "-" denotes no resistance (0%) to the antimicrobial. PEN = penicillin using the parenteral meningitis CLSI interpretive standard; AXO = ceftriaxone using the parenteral meningitis interpretive standard; FUR = cefuroxime 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, 2014-2018



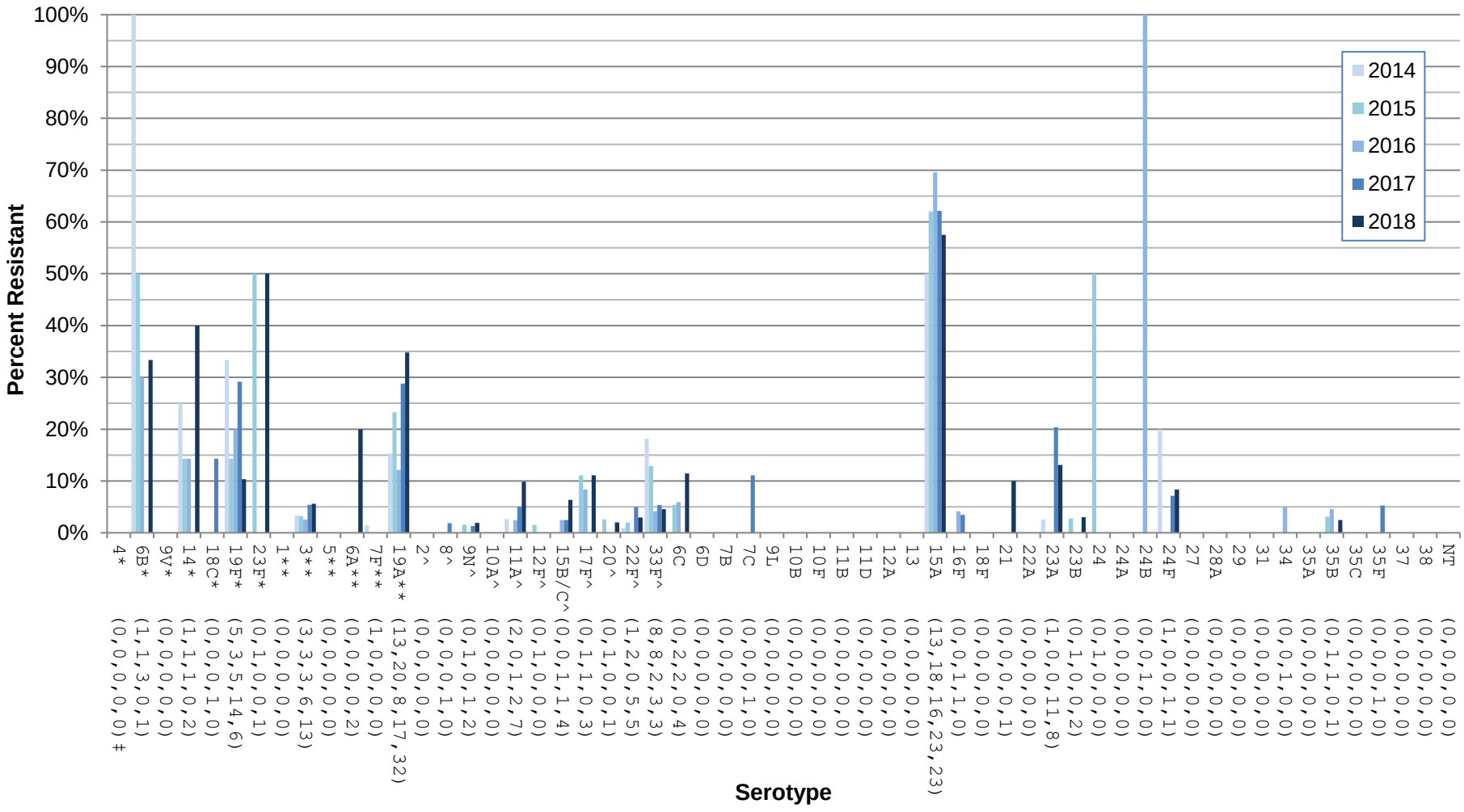
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2014, 2015, 2016, 2017 and 2018, respectively.

Figure 25. Cefuroxime resistance of *S. pneumoniae* serotypes, 2014-2018



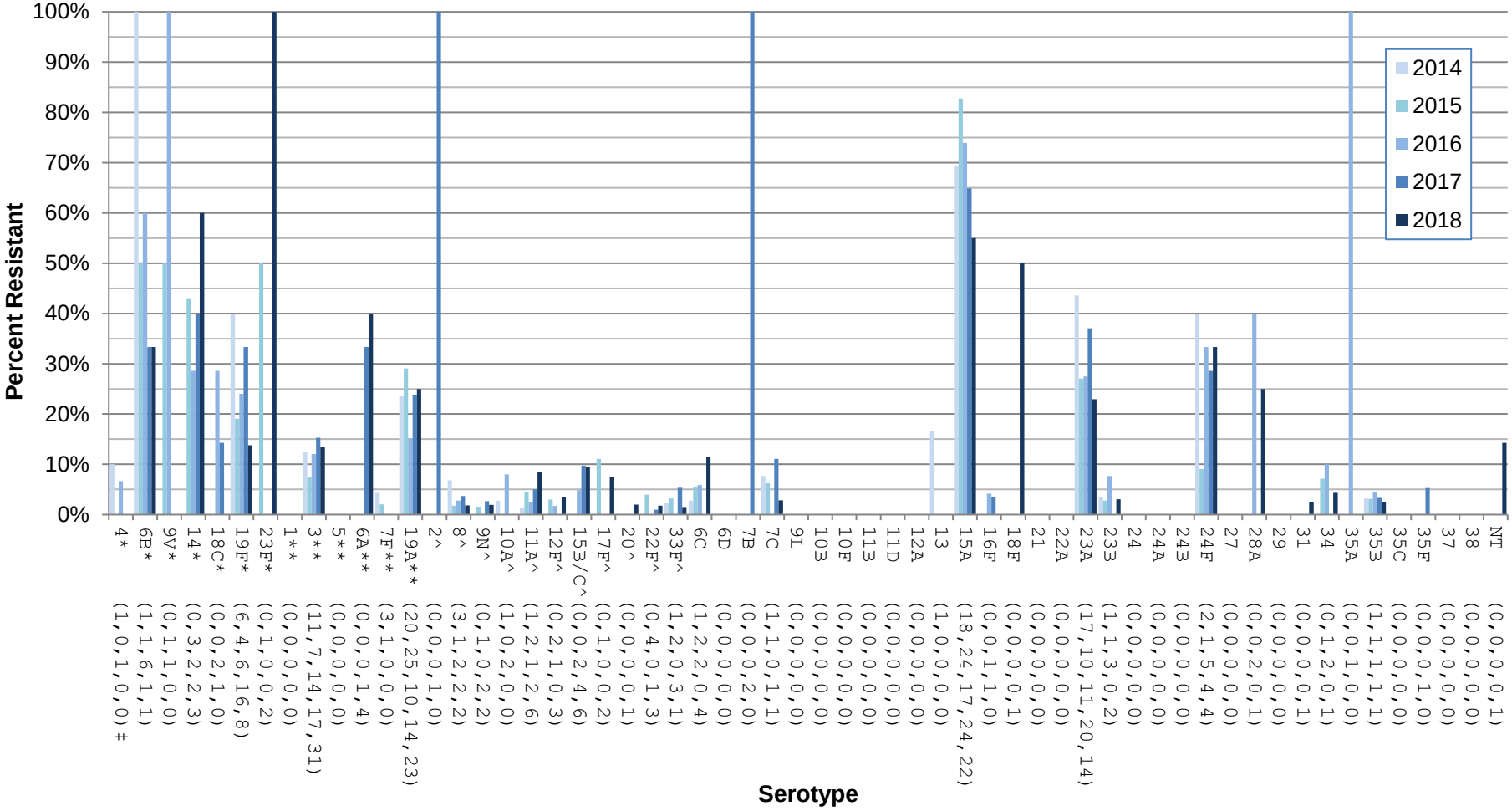
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2014, 2015, 2016, 2017 and 2018, respectively.

Figure 26. Clindamycin resistance of *S. pneumoniae* serotypes, 2014-2018



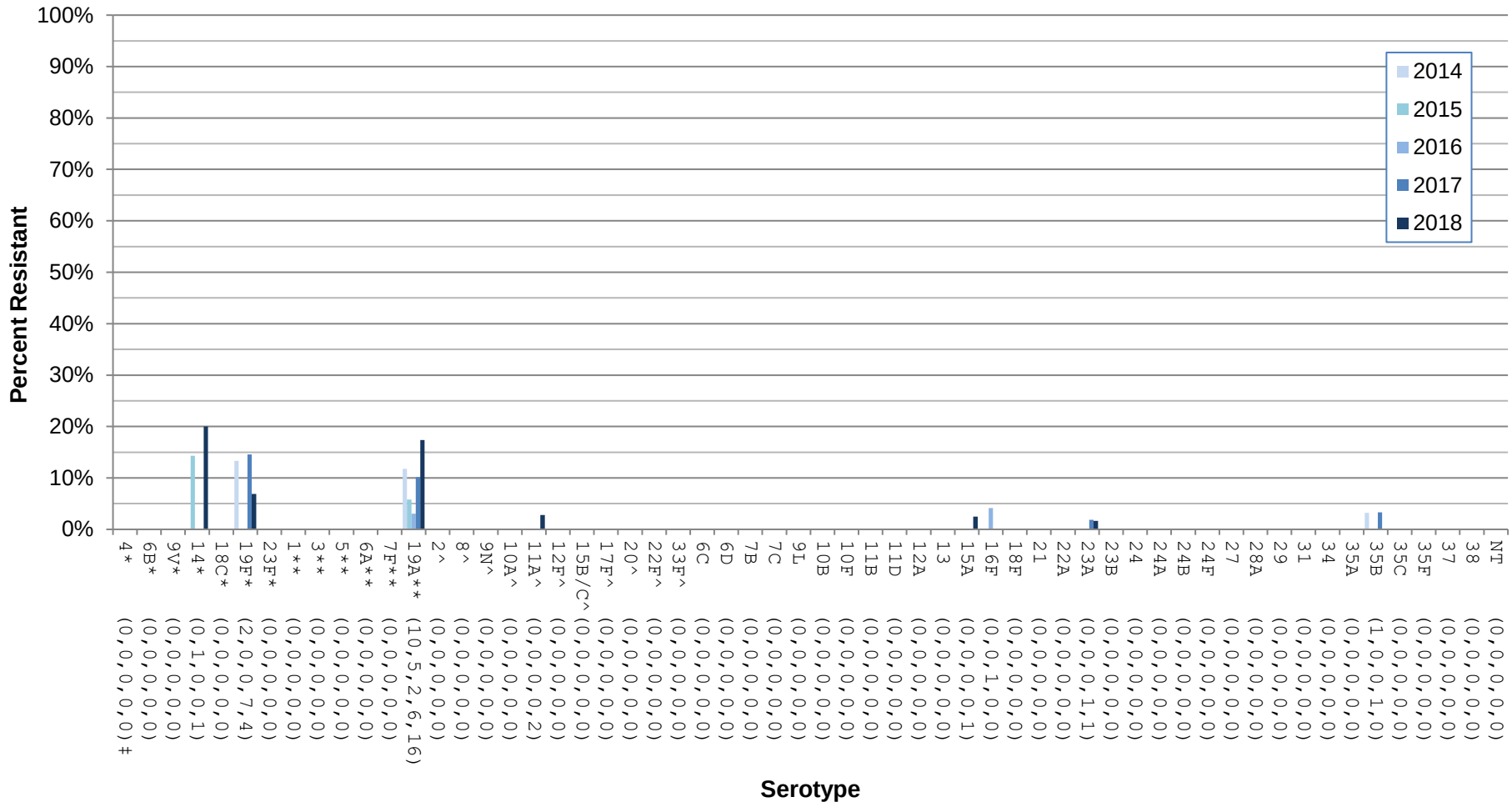
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2014, 2015, 2016, 2017 and 2018, respectively.

Figure 27. Doxycycline resistance of *S. pneumoniae* serotypes, 2014-2018



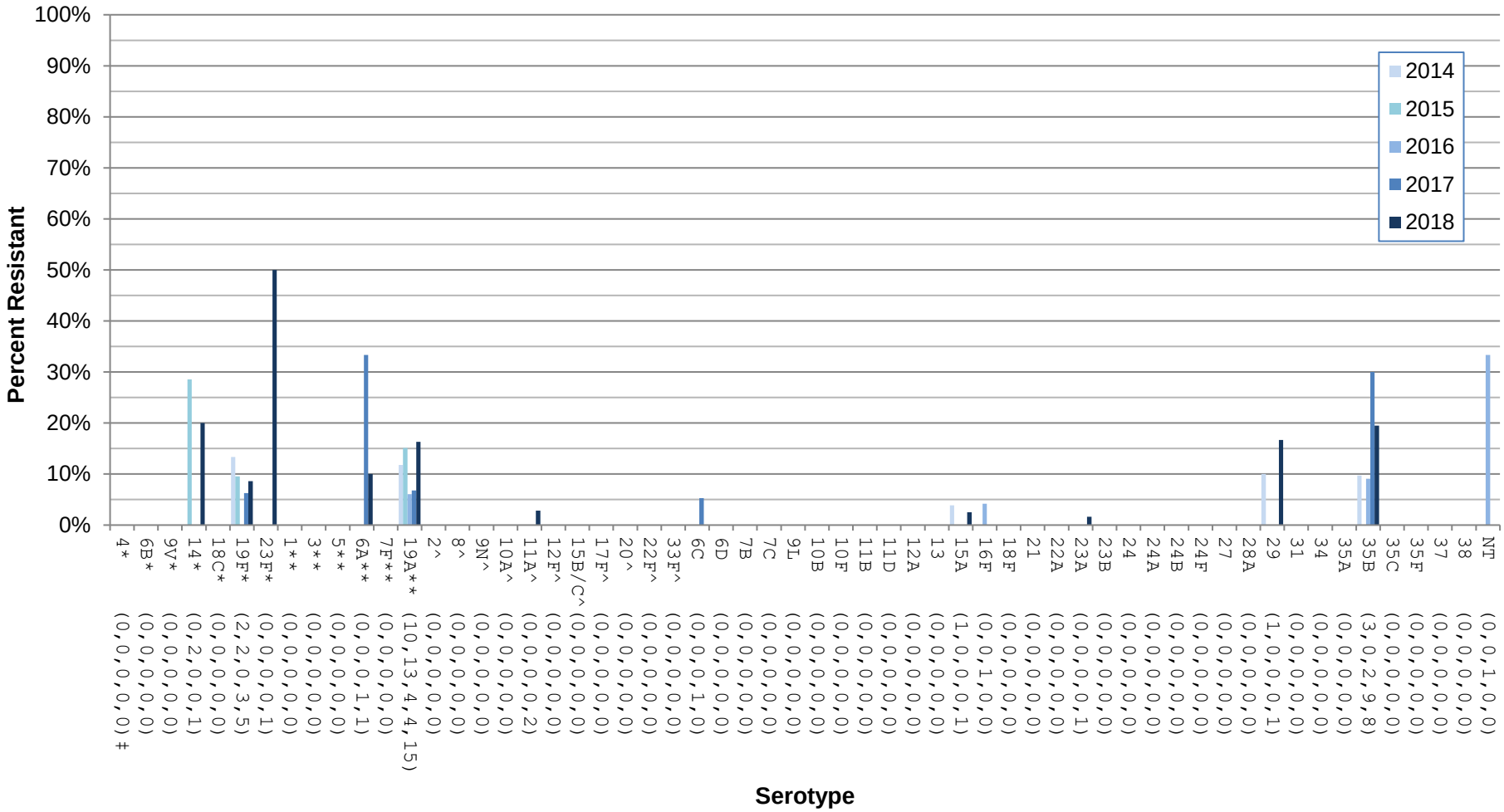
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2014, 2015, 2016, 2017 and 2018, respectively.

Figure 28. Imipenem resistance of *S. pneumoniae* serotypes, 2014-2018



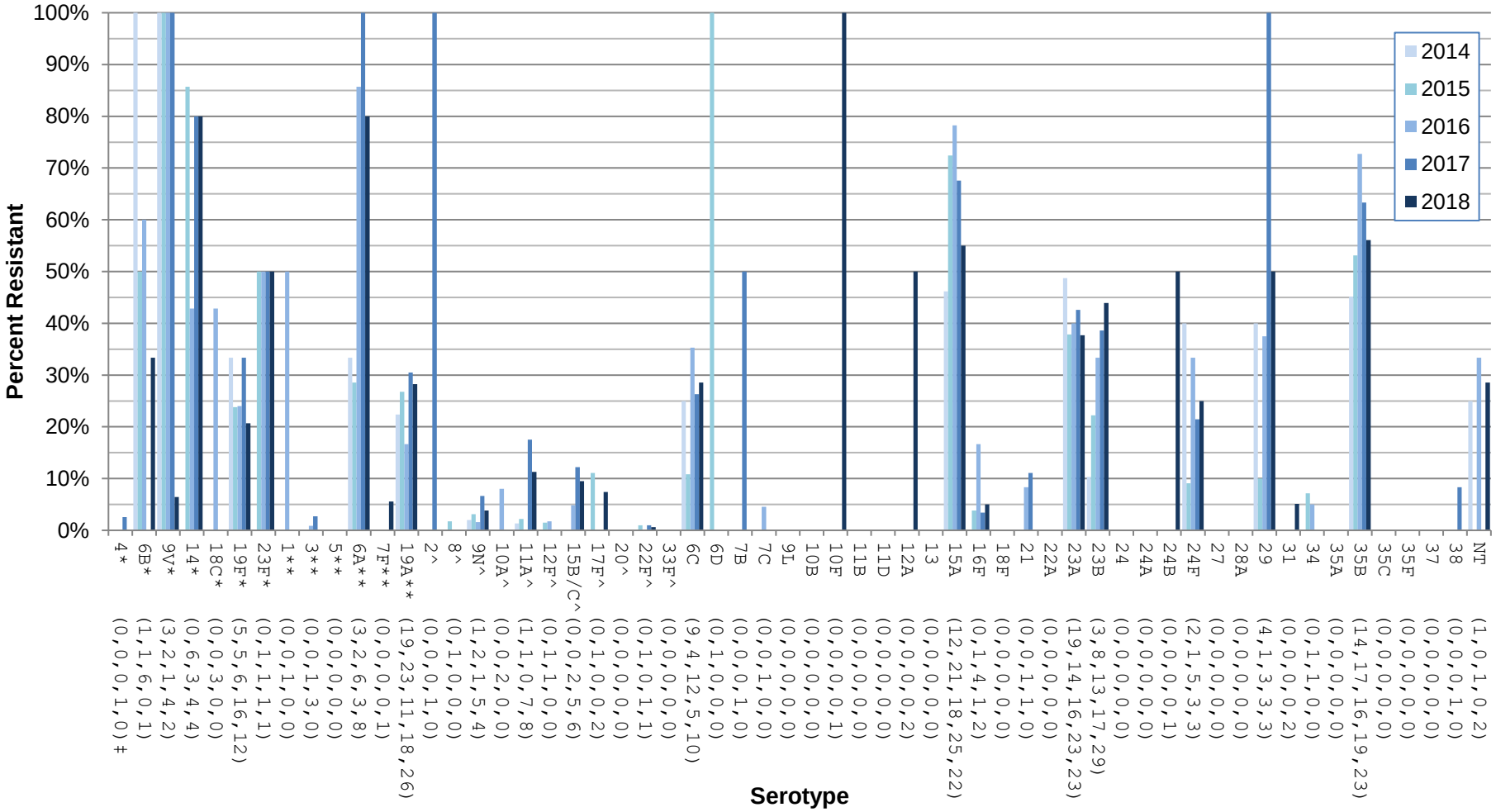
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2014, 2015, 2016, 2017 and 2018, respectively.

Figure 29. Meropenem resistance of *S. pneumoniae* serotypes, 2014-2018



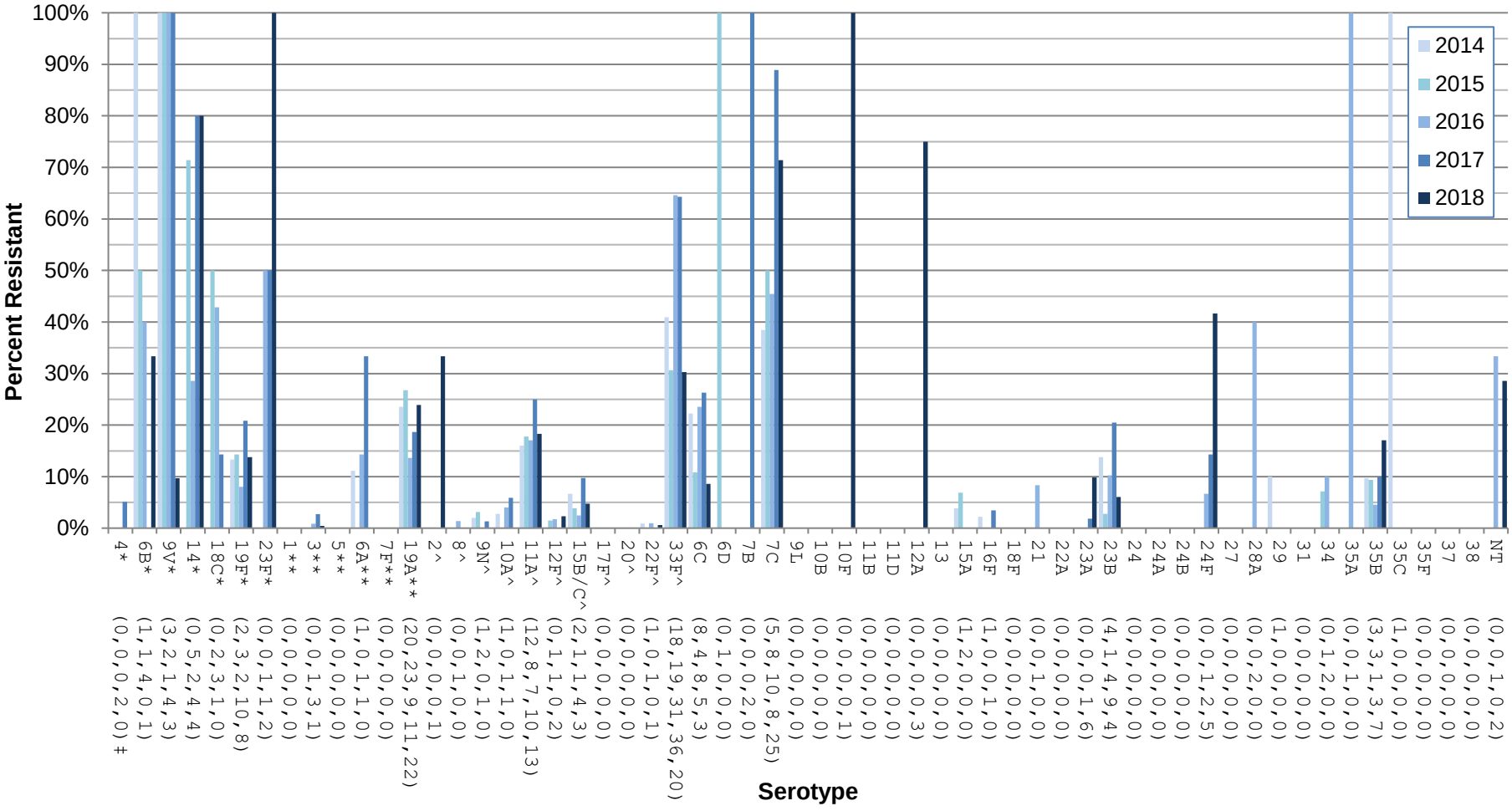
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2014, 2015, 2016, 2017 and 2018, respectively.

Figure 30. Penicillin resistance of *S. pneumoniae* serotypes, 2014-2018



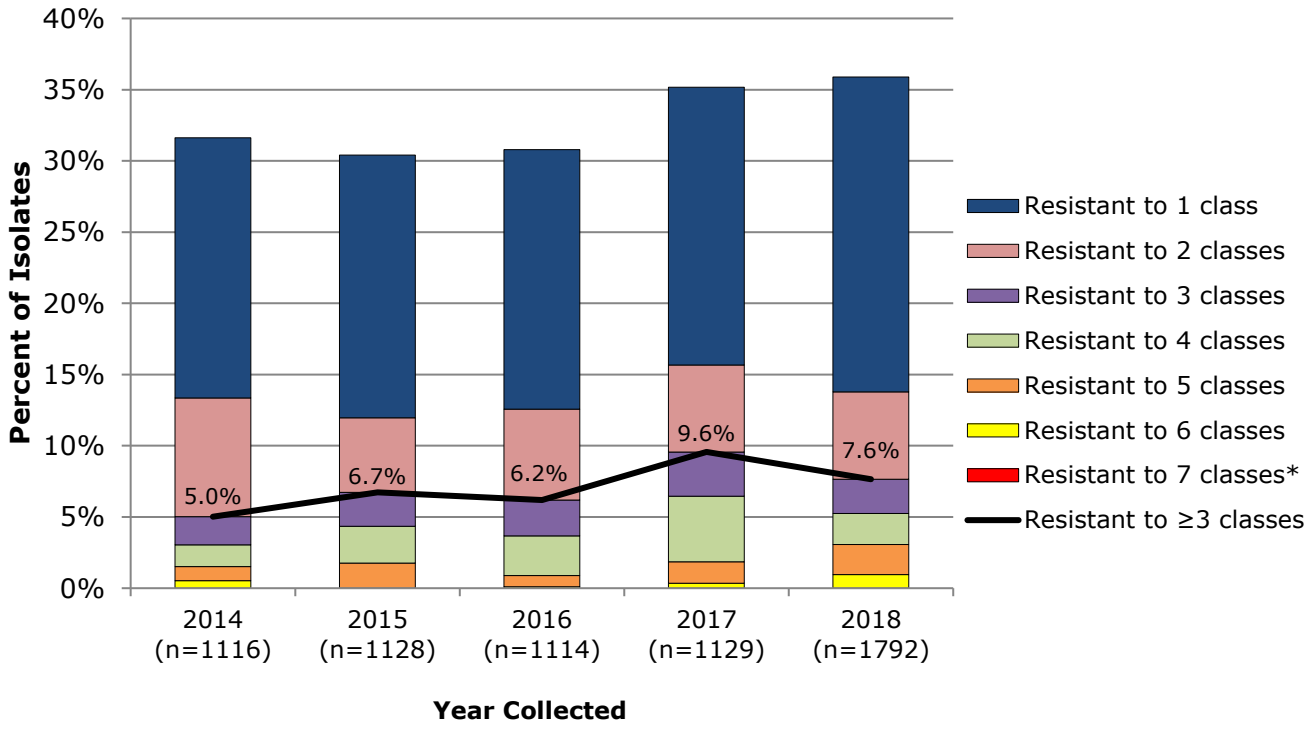
*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2014, 2015, 2016, 2017 and 2018, respectively.

Figure 31. Trimethoprim/Sulfamethoxazole resistance of *S. pneumoniae* serotypes, 2014-2018



*Component of PCV7; ** Component of PCV13; ^ Component of PPV23; ‡ Number of resistant isolates for 2014, 2015, 2016, 2017 and 2018, respectively.

Figure 32. Annual trend of multi-drug resistance of *S. pneumoniae*, 2014-2018



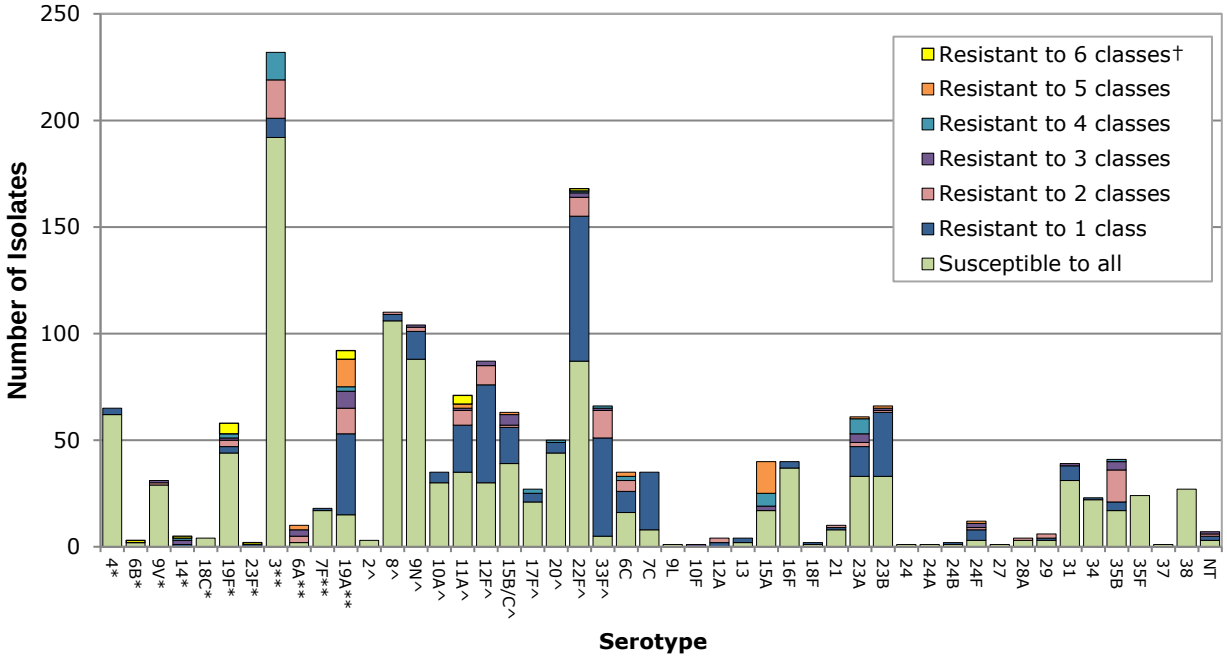
*Antimicrobial classes include: β-lactams (amoxicillin/clavulanic acid, penicillin using meningitis breakpoints, ceftriaxone using meningitis breakpoints, cefuroxime using parenteral breakpoint, ertapenem, imipenem and meropenem); macrolides (clarithromycin); fluoroquinolones (levofloxacin and moxifloxacin);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

Table 11: Multi-drug resistance of *S. pneumoniae*, 2014-2018

	Number of Antimicrobial Classes Resistant							
Year	1	2	3	4	5	6	7	≥3
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	18.2%(203)	6.4%(71)	2.5%(28)	2.8%(31)	0.8%(9)	0.1%(1)	0.0%(0)	6.2%(69)
2017	19.5%(220)	6.1%(69)	3.1%(35)	4.6%(52)	1.5%(17)	0.4%(4)	0.0%(0)	9.6%(108)
2018	22.1%(396)	6.1%(110)	2.4%(43)	2.2%(39)	2.1%(38)	0.9%(17)	0.0%(0)	7.6%(137)

* Percentage of isolates (number of isolates).

Figure 33. Multi-drug resistance of *S. pneumoniae* serotypes in 2018



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

Table 12. Multi-drug resistant profiles of *S. pneumoniae* serotypes in 2018

Serotype	BLA	BLA-FQN	BLA-FQN-SXT	BLA-FQN-TET	BLA-MAC	BLA-MAC-CLI	BLA-MAC-CLI-SXT	BLA-MAC-CLI-TET	BLA-MAC-CLI-TET-CHL	BLA-MAC-CLI-TET-SXT	BLA-MAC-CLI-TET-SXT-CHL	BLA-MAC-FQN	BLA-MAC-FQN-CLI-TET-SXT	BLA-MAC-SXT	BLA-MAC-TET	BLA-MAC-TET-SXT	CLI	BLA-SXT	BLA-TET	BLA-TET-CHL	BLA-TET-SXT	CHL	FQN	MAC	MAC-CHL	MAC-CLI	MAC-CLI-CHL	MAC-CLI-TET	MAC-CLI-TET-CHL	MAC-CLI-TET-SXT-CHL	MAC-FQN	MAC-SXT	MAC-TET	SXT	TET	TET-CHL	TET-SXT-CHL
4*																							2	1													
6B*											1																										
9V*														1				1																			
14*								1			1			1							1			1													
19F*	1				2			1			1		4		1	1		1						1										1			
23F*											1																								1		
3**																						1	4	3					13				1	1		17	
6A**					3				2			1			1					1																	
7F**	1																																				
19A**	2		1		1			1	1	12	1		3	2	1	1								36		10	1	3				1					
8^																						1		1									1		1		
9N^	3				1												1							9				1					1				
10A^																								5													
11A^	1									2	4			1			1						3	14							5	2		3			
12F^																						2		44	8											1	2
15B/C^	3									1				1	1								3	11				3					1				
17F^								2									1						3														
20^																						2	2	1					1								
22F^											1											3		65	6	1	1	1	1		2						
33F^																								43	1	1	1		1			11		3			
6C	2	1			2			2	1									2					2	6						1							
7C																								1										25	1		
10F			1																																		
12A																		2						1										1			
13																								2													
15A						1		6	15																			1									
16F	2																					1															
18F																																			1		
21																								1		1											
23A	9							7	1						4				2															5			
23B	27				1				1														1	2				1									
24B	1																																				
24F									1						2									1									1	4			
28A																																				1	
29	1				2																																
31	1			1																		1	3	2													
34																																			1		
35B	3				14		1							4					1					1													
NT															1			1					1											1			
All	57	1	2	1	26	1	1	20	22	15	10	1	7	10	11	2	3	7	3	1	1	11	24	252	15	13	3	10	16	1	7	14	5	44	5	19	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). *Component of PCV7; ** Component of PCV13; ^ Component of PPV23

Invasive Streptococcus pyogenes (Group A Streptococcus, iGAS*)*

The annual incidence rate of disease from iGAS in Canada, as reported to the CNDSS, continued to show an increasing trend over time. The incidence rate in 2018 was 7.9 cases per 100,000 population, which is twice the rate observed in 2009 (Figure 34, Table 13). In 2018, the highest incidence rates by age group were in seniors ≥60 years old with 11.8 cases per 100,000 followed by 40-59 year olds with 9.0 cases, and the lowest rates were among the 15-19 and 10-14 year age groups with 2.0 and 2.2 cases per 100,000 population respectively.

Figure 34. Annual incidence of invasive *S. pyogenes* cases, 2009-2018

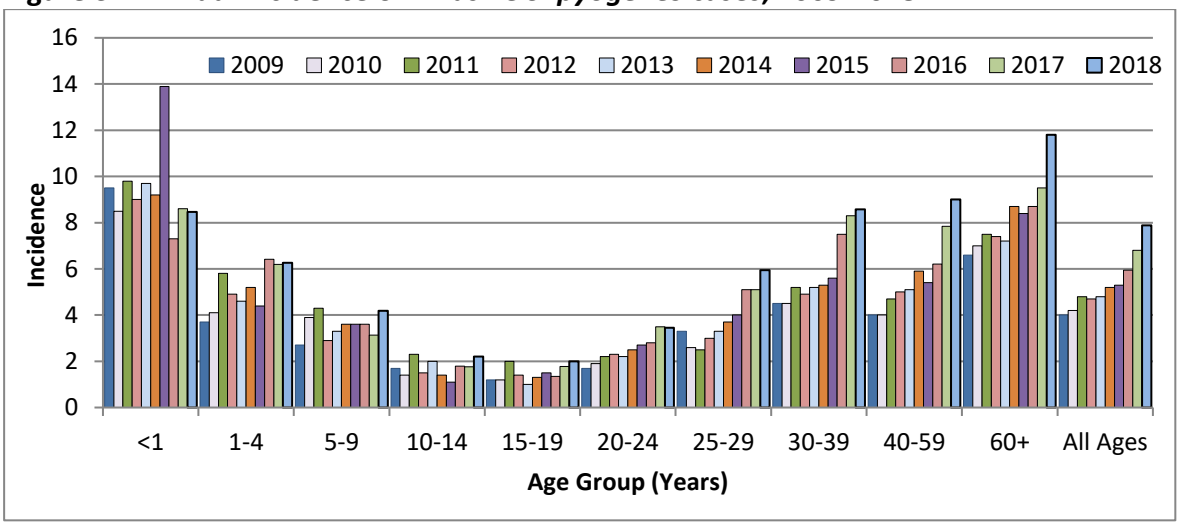


Table 13. Annual incidence rates of invasive *S. pyogenes*, 2009-2018

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*	3.7	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	4.2
2011	9.8	5.8	4.3	2.3	2.0	2.2	2.5	5.2	4.7	7.5	4.8
2012	9.0	4.9	2.9	1.5	1.4	2.3	3.0	4.9	5.0	7.4	4.7
2013	9.7	4.6	3.3	2.0	1.0	2.2	3.3	5.2	5.1	7.2	4.8
2014	9.2	5.2	3.6	1.4	1.3	2.5	3.7	5.3	5.9	8.7	5.2
2015	13.9	4.4	3.6	1.1	1.5	2.7	4.0	5.6	5.4	8.4	5.3
2016	7.3	6.4	3.6	1.8	1.3	2.8	5.1	7.5	6.2	8.7	6.0
2017	8.6	6.2	3.1	1.8	1.8	3.5	5.1	8.3	7.8	9.5	6.8
2018	8.5	6.3	4.2	2.2	2.0	3.4	5.9	8.6	9.0	11.8	7.9

* Cases per 100,000 population

Of the 3,202 invasive *Streptococcus pyogenes* isolates tested by *emm* typing, 8.2% (n=263) were isolated from children <15 years of age and 91.6% (n=2,932) were from adults ≥15 years of age. Isolates from male patients represented 56.4% (n=1775) 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 except more pleural fluid isolations sites were observed among pediatric isolates (8.9%, n=24) than in the adults (1.5%, n=45). There was a similar distribution of *emm* types among each of the major clinical isolation sites. The predominant type from blood was *emm1* with 19.2% (n=424). Synovial fluid and other sterile sites shared the majority of their strains between *emm1* (9.7%, n=23; 13.2%, n=100), *emm74* (16.5%, n=39; 17.8%, n=135) and *emm81* (8.1%, n=19; 6.7%, n=51) respectively.

In Western regions *emm74* (15.7%, n=204) and *emm76* (12.6%, n=164) were predominant; in Central regions *emm1* (20.9%, n=366) and *emm74* (9.4%, n=164) were predominant; and in Eastern Canada *emm1* (26.5%, n=36) and *emm6* (15.4%, n=21) were predominant. Northern regions were highly represented by *emm11* at 35.3% (n=6).

Although *emm1* continues to be most prevalent in Canada, it has decreased from 26.8% (n=456) in 2014 to 17.1% (n=547) in 2018. Increases from 2014 to 2018 were observed for *emm74* from 0% (n=0) to 11.6% (n=372) and *emm76* from 0.6% (n=10) to 6.4% (n=205).

Table 14. Number of invasive *S. pyogenes* (GAS) isolates by province in 2018

Province	Age Group (Years)						Not Given	Total
	< 2	2 – 4	5 – 14	15 – 49	50 – 64	≥ 65		
British Columbia	3	6	9	172	95	100		385
Alberta	4	12	13	181	96	83	11	400
Saskatchewan	7	2	8	94	33	48		192
Manitoba	13	3	6	152	82	68		324
Ontario	21	20	39	419	253	323	3	1078
Québec	17	23	40	260	154	176		670
New Brunswick	1	3	3	19	10	14	2	52
Prince Edward Island		1		2		2		5
Nova Scotia		1	5	17	19	17		59
Newfoundland and Labrador			2	5	5	8		20
Yukon				1	2			3
Northwest Territories	1			2	5	4		12
Nunavut				1	1			2
Canada	**67**	**71**	**125**	**1325**	**755**	**843**	**16**	**3202**

Figure 35a. Clinical isolation sites of *S. pyogenes* from children <15 years of age in 2018 (n=271)

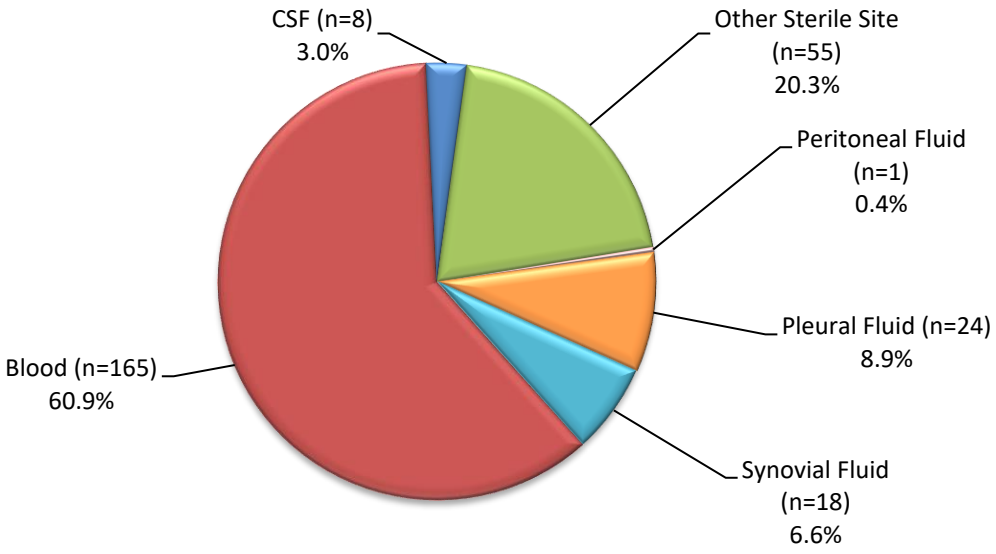
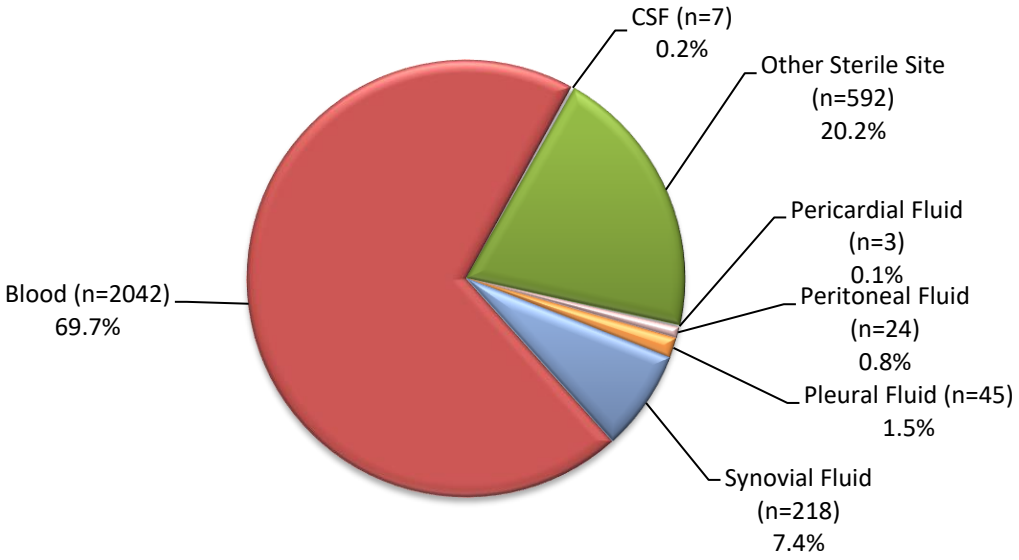


Figure 35b. Clinical isolation sites of *S. pyogenes* from adults ≥15 years in 2018 (n=2931*)



Other sterile sites include: deep tissue, biopsy and surgical samples, bone, and any clinical sources associated with necrotizing fasciitis or toxic shock syndrome. *Includes 16 isolates with no age available.

Figure 36a. Invasive *S. pyogenes emm* types from blood in 2018

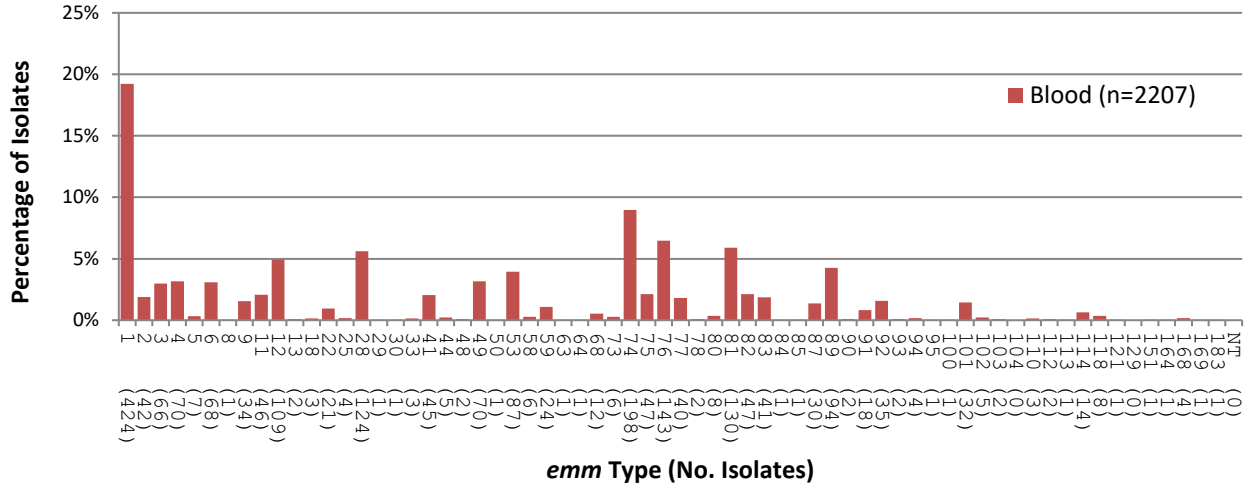


Figure 36b. Invasive *S. pyogenes emm* types from synovial fluid in 2018

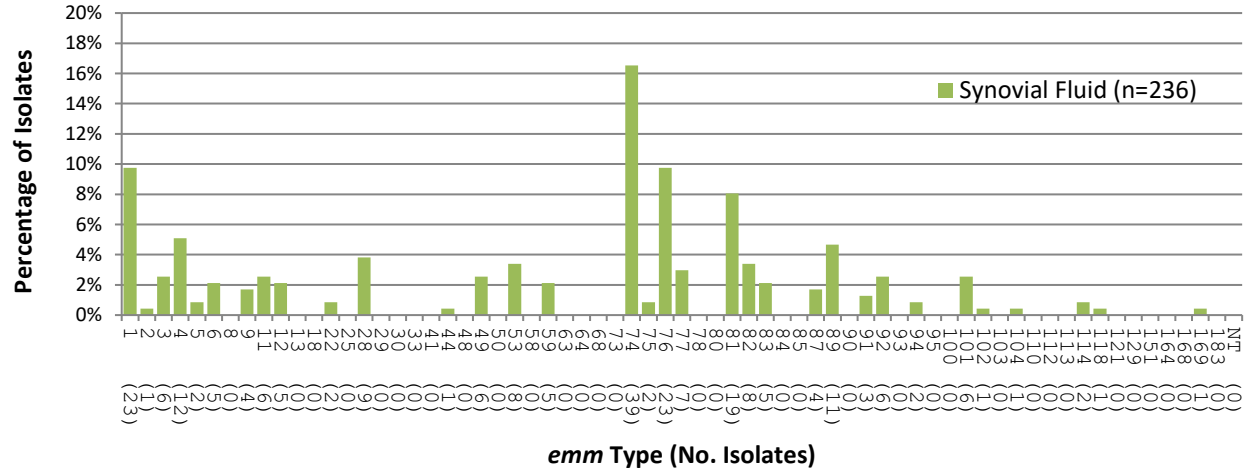
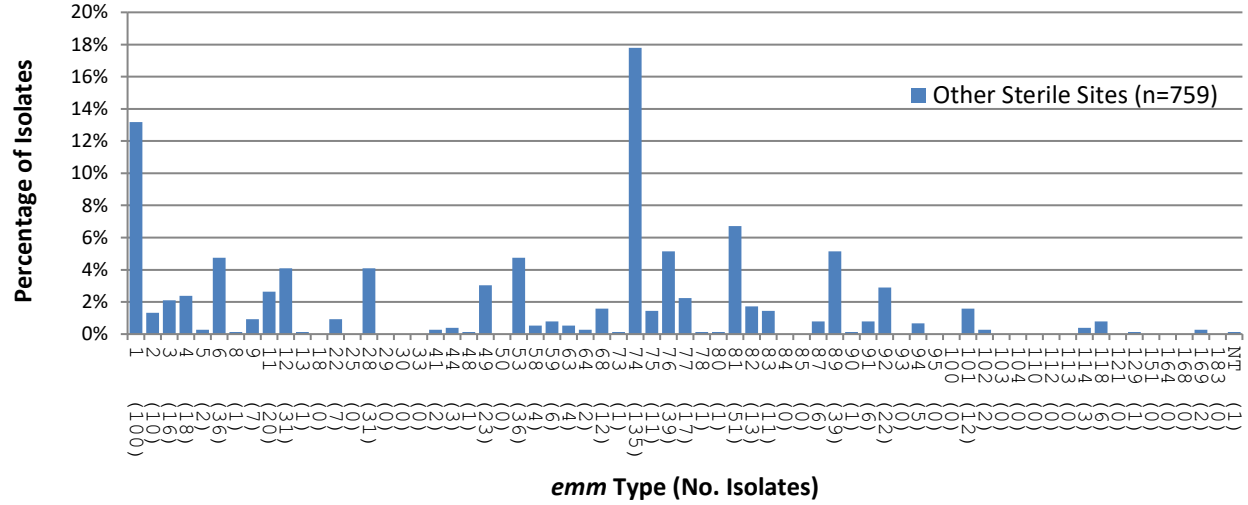
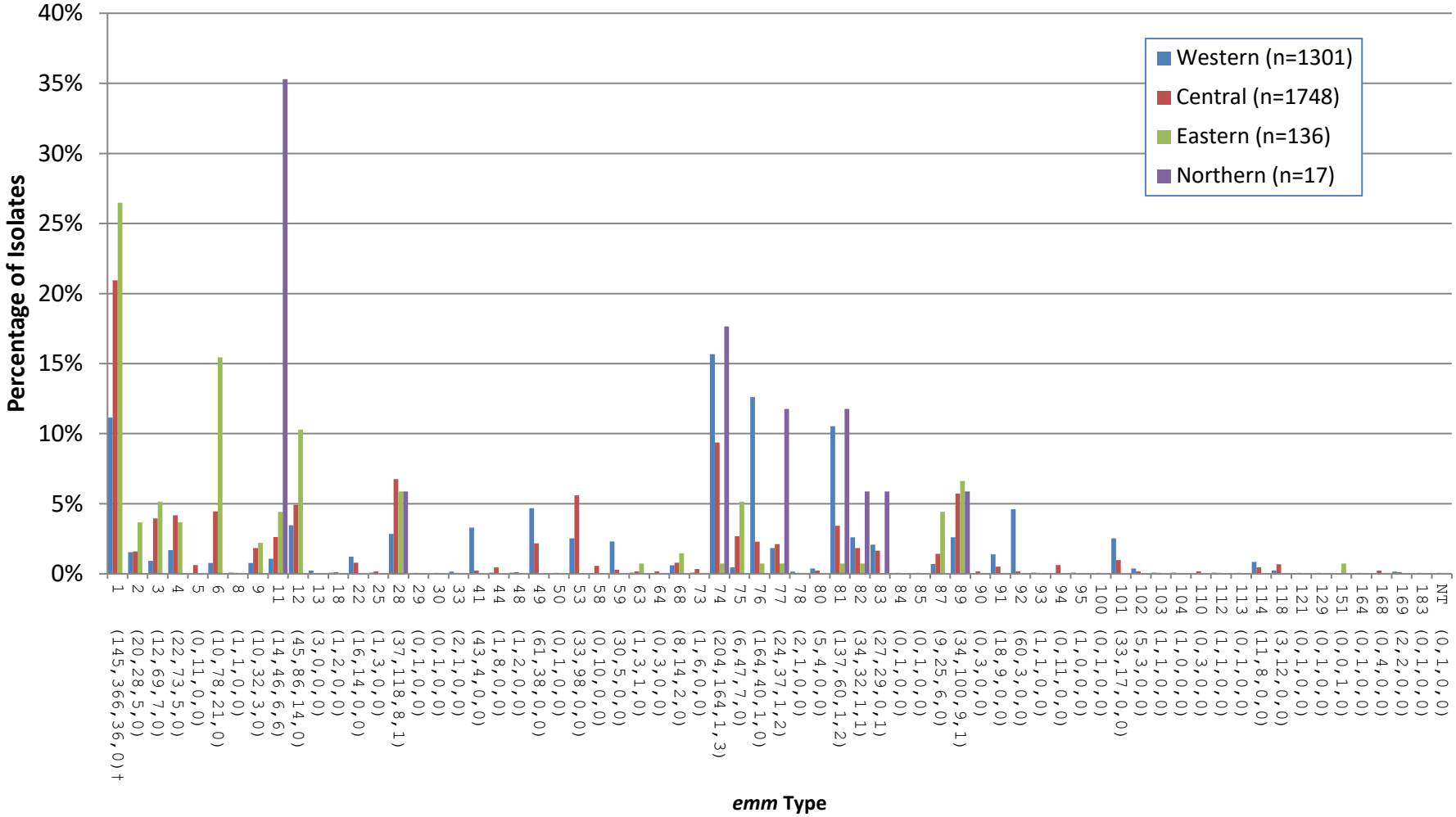


Figure 36c. Invasive *S. pyogenes emm* types from other sterile sites in 2018



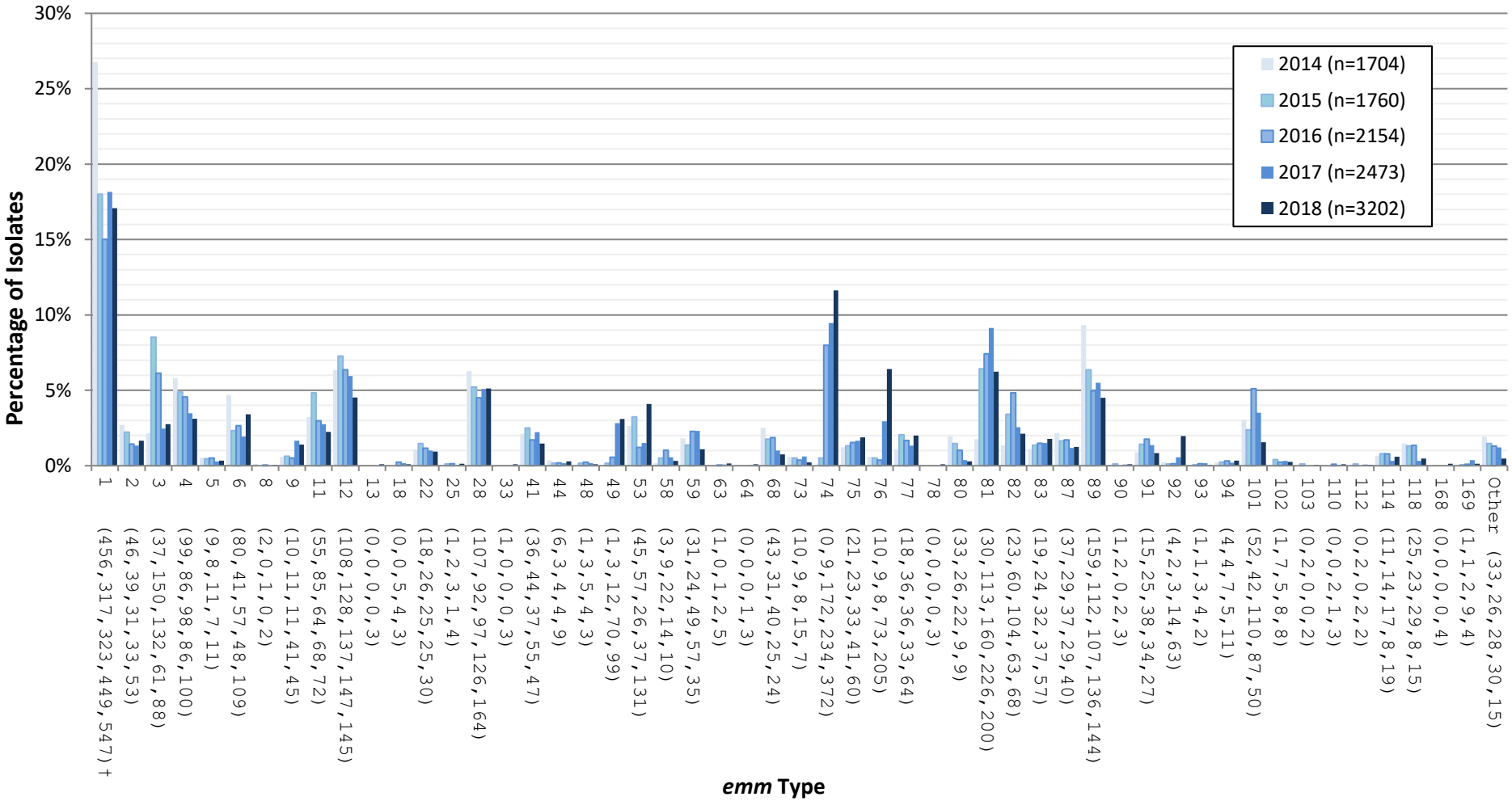
Other sterile sites include: CSF, pericardial fluid, peritoneal fluid, deep tissue, biopsy and surgical samples, bone, mastoid and any clinical sources associated with necrotizing fasciitis or toxic shock.

Figure 37. Regional distribution of invasive *S. pyogenes emm* types in 2018



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

Figure 38. Invasive *S. pyogenes emm* types, 2014-2018



†Number of isolates for 2014, 2015, 2016, 2017 and 2018, respectively.

Antimicrobial Resistance of Streptococcus pyogenes

Antimicrobial resistance among Group A Streptococcus isolates decreased in 2018. **Erythromycin** resistance remained consistent from 9.9% (n=204) in 2017 to 9.5% (n=262) in 2018. Resistance to **clindamycin** decreased from 6.8% (n=139) in 2017 to 3.5% (n=96) in 2018. **Chloramphenicol** non-susceptible isolates also decreased from 5.0% (n=102) in 2017 to 2.6% (n=72) in 2018. Relatively high macrolide (erythromycin) resistance was observed among *emm92* (98.1%, n=52), *emm83* (67.3%, n=37) and *emm9* (85.0%, n=34). There was no resistance observed to penicillin or vancomycin.

Figure 39. Antimicrobial resistance of invasive *S. pyogenes*, 2014-2018

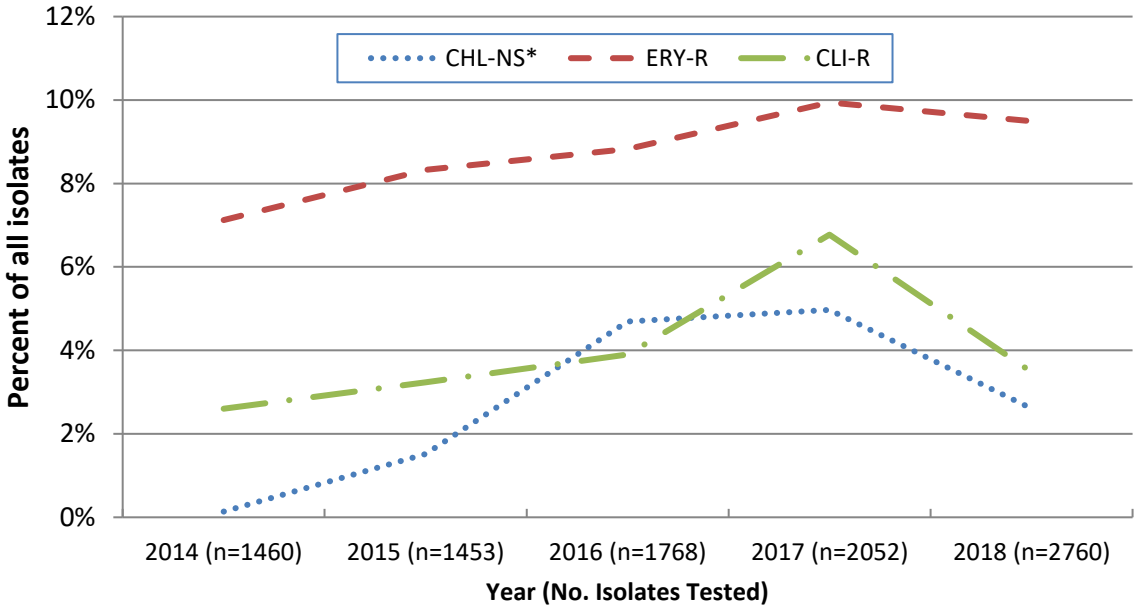
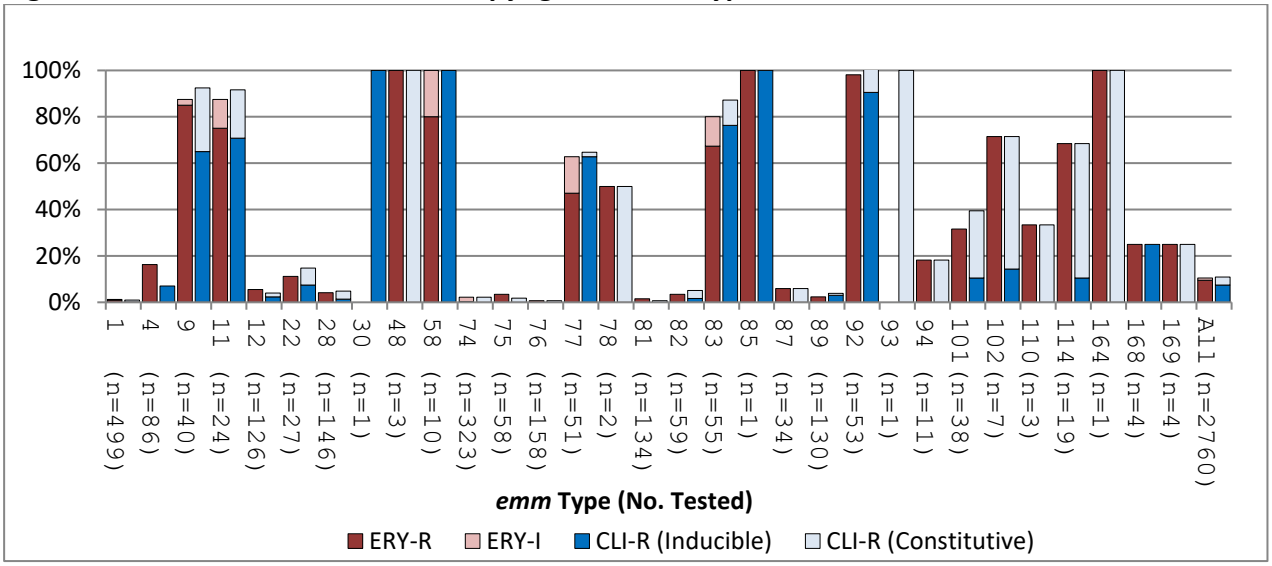


Table 15. Antimicrobial resistance of invasive *S. pyogenes* isolates, 2014-2018

Antimicrobial	Year				
	2014	2015	2016	2017	2018
CHL-NS*	0.1% (2)	1.5% (22)	4.7% (83)	5.0% (102)	2.6% (72)
ERY-R	7.1% (104)	8.3% (121)	8.8% (156)	9.9% (204)	9.5% (262)
CLI-R	2.6% (38)	3.2% (47)	3.9% (69)	6.8% (139)	3.5% (96)
No. Tested	(1460)	(1453)	(1768)	(2052)	(2760)

*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, 2018



*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, 2018

Emm (Tested)	ERY-R*		ERY-I		CLI-R (Constitutive)		CLI-R (Inducible)	
1 (n=499)	1.0%	(5)**	0.2%	(1)	0.8%	(4)	0.2%	(1)
4 (n=86)	16.3%	(14)	0.0%	(0)	0.0%	(0)	7.0%	(6)
9 (n=40)	85.0%	(34)	2.5%	(1)	27.5%	(11)	65.0%	(26)
11 (n=24)	75.0%	(18)	12.5%	(3)	20.8%	(5)	70.8%	(17)
12 (n=126)	5.6%	(7)	0.0%	(0)	1.6%	(2)	2.4%	(3)
22 (n=27)	11.1%	(3)	0.0%	(0)	7.4%	(2)	7.4%	(2)
28 (n=146)	4.1%	(6)	0.0%	(0)	3.4%	(5)	1.4%	(2)
30 (n=1)	0.0%	(0)	0.0%	(0)	0.0%	(0)	100.0%	(1)
48 (n=3)	100.0%	(3)	0.0%	(0)	100.0%	(3)	0.0%	(0)
58 (n=10)	80.0%	(8)	20.0%	(2)	0.0%	(0)	100.0%	(10)
74 (n=323)	0.3%	(1)	1.9%	(6)	2.2%	(7)	0.0%	(0)
75 (n=58)	3.4%	(2)	0.0%	(0)	1.7%	(1)	0.0%	(0)
76 (n=158)	0.6%	(1)	0.0%	(0)	0.6%	(1)	0.0%	(0)
77 (n=51)	47.1%	(24)	15.7%	(8)	2.0%	(1)	62.7%	(32)
78 (n=2)	50.0%	(1)	0.0%	(0)	50.0%	(1)	0.0%	(0)
81 (n=134)	1.5%	(2)	0.0%	(0)	0.7%	(1)	0.0%	(0)
82 (n=59)	3.4%	(2)	0.0%	(0)	3.4%	(2)	1.7%	(1)
83 (n=55)	67.3%	(37)	12.7%	(7)	10.9%	(6)	76.4%	(42)
85 (n=1)	100.0%	(1)	0.0%	(0)	100.0%	(1)	100.0%	(1)
87 (n=34)	5.9%	(2)	0.0%	(0)	5.9%	(2)	0.0%	(0)
89 (n=130)	2.3%	(3)	0.0%	(0)	0.8%	(1)	3.1%	(4)
92 (n=53)	98.1%	(52)	0.0%	(0)	15.1%	(8)	90.6%	(48)
93 (n=1)	0.0%	(0)	0.0%	(0)	100.0%	(1)	0.0%	(0)
94 (n=11)	18.2%	(2)	0.0%	(0)	18.2%	(2)	0.0%	(0)
101(n=38)	31.6%	(12)	0.0%	(0)	28.9%	(11)	10.5%	(4)
102(n=7)	71.4%	(5)	0.0%	(0)	57.1%	(4)	14.3%	(1)
110(n=3)	33.3%	(1)	0.0%	(0)	33.3%	(1)	0.0%	(0)
114(n=19)	68.4%	(13)	0.0%	(0)	57.9%	(11)	10.5%	(2)
164(n=1)	100.0%	(1)	0.0%	(0)	100.0%	(1)	0.0%	(0)
168(n=4)	25.0%	(1)	0.0%	(0)	0.0%	(0)	25.0%	(1)
169(n=4)	25.0%	(1)	0.0%	(0)	25.0%	(1)	0.0%	(0)
All(n=2760)	**9.5%**	**(262)**	**1.0%**	**(28)**	**3.5%**	**(96)**	**7.4%**	**(204)**

*ERY-R = erythromycin resistant; ERY-I = erythromycin intermediately resistant; CLI-R = clindamycin resistant (constitutive or inducible). **Percentage of *emm* type (number of isolates).

Invasive Streptococcus agalactiae (Group B Streptococcus)

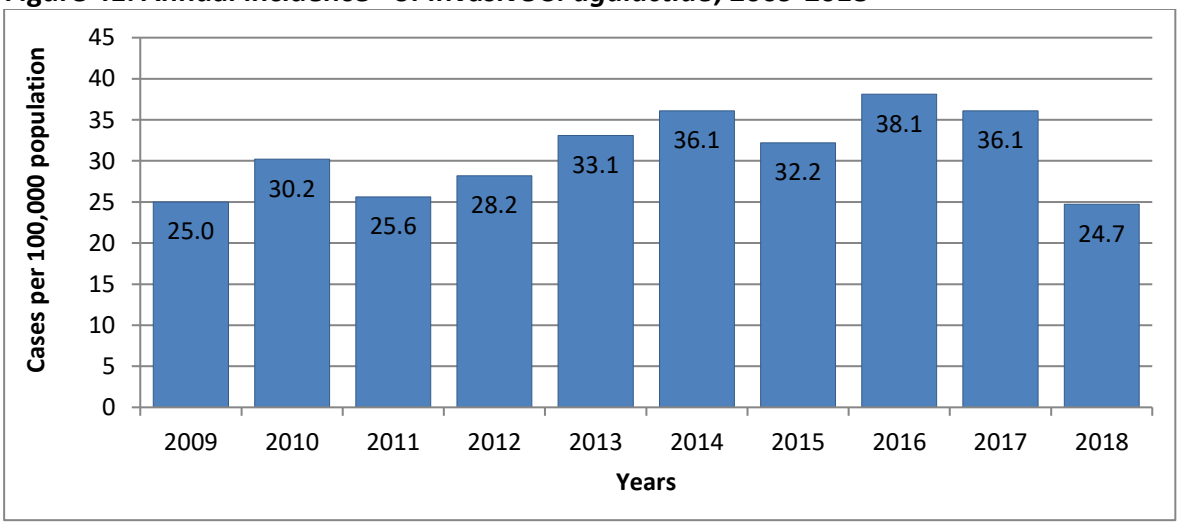
The incidence rate of disease among newborns less than one year of age as reported to the CNDSS has steadily increased from 25.0 to 38.1 cases per 100,000 population from 2009 to 2016, and has subsequently declined to 24.7 in 2018 (Figure 41).

Of the 290 *Streptococcus agalactiae* isolates tested at the NML during 2018, 2.4% (n=7) were early onset isolates from infants <8 days old; 2.8% (n=8) were late onset from infants 8-31 days old; 6.2% (n=18) were from children 1 month to 14 years old; 46.6% (n=135) were from adults 15-64 years old; and 41.7% (n=121) were from seniors ≥65 years of age. Isolates from male patients accounted for 51.8% (n=147) of the isolates for which gender information was available (n=284). The majority of isolates came from blood 55.2% n=160).

Serotype III was most prevalent among infant and child age groups (53.3%, n=8; and 72.2%, n=13; respectively), whereas serotype V was most prevalent in both adults (27.4%, n=37) and in seniors (27.3%, n=33).

Increases in serotypes from 2017 to 2018 were seen in serotype V (increased from 17.0% (n=39) in 2017 to 25.2% (n=73) in 2018) and Ib (increased from 11.8% (n=27) to 15.5% (n=45)). A notable decrease was seen in serotype Ia from 22.3% (n=51) in 2017 to 7.9% (n=23) in 2018.

Figure 41. Annual incidence* of invasive *S. agalactiae*, 2009-2018



*Incidence per 100,000 population. Case data from 2009 to 2017 was obtained from CNDSS. Case data does not include Alberta (2009-2010), Manitoba (2009-2014) and Québec (2009-2018). CNDSS only collects data on Group B *Streptococcus* in newborns < 1 year of age.

Table 17. Invasive *S. agalactiae* serotypes by age group in 2018

Serotype	Age Group*					Total
	Infant Early Onset	Infant Late Onset	Child	Adult	Senior	
Ia	0.0%	25.0%(2)	11.1%(2)	6.7%(9)	8.3%(10)	7.9%(23)
Ib	0.0%	0.0%	0.0%	14.1%(19)	21.5%(26)	15.5%(45)
II	0.0%	0.0%	5.6%(1)	9.6%(13)	1.7%(2)	5.5%(16)
III	57.1%(4)	50.0%(4)	72.2%(13)	11.9%(16)	8.3%(10)	16.6%(48)†
IV	28.6%(2)	0.0%	0.0%	17.0%(23)	16.5%(20)	15.5%(45)
V	14.3%(1)	12.5%(1)	5.6%(1)	27.4%(37)	27.3%(33)	25.2%(73)
VI	0.0%	0.0%	0.0%	5.2%(7)	3.3%(4)	3.8%(11)
VIII	0.0%	0.0%	0.0%	0.7%(1)	1.7%(2)	1.0%(3)
IX	0.0%	0.0%	0.0%	3.0%(4)	3.3%(4)	2.8%(8)
NT	0.0%	12.5%(1)	5.6%(1)	4.4%(6)	8.3%(10)	6.2%(18)
Total	(7)	(8)	(18)	(135)	(121)	(290)†

*Infant Early Onset ≤ 7days, Infant Late Onset = 8-31 days, Child = 1 month-14 years, Adult = 15-64 years, Senior ≥65 years, NT = Non-typeable. **Percentage of age group isolates (number of isolates). † Includes 1 isolate for which age was not available.

Figure 42. Invasive *S. agalactiae* serotypes, 2014-2018

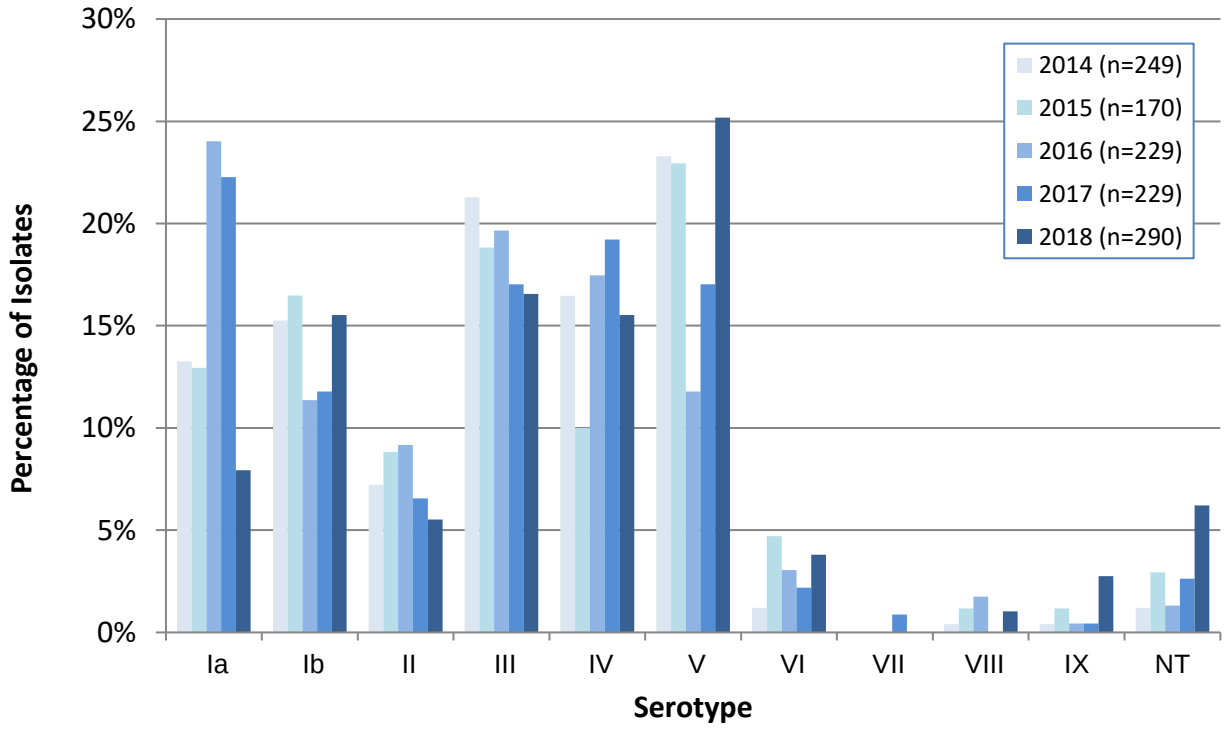


Table 18. Invasive *S. agalactiae* serotypes, 2014-2018

Serotype	Year				
	2014	2015	2016	2017	2018
Ia	13.3% (33)*	12.9% (22)	24.0% (55)	22.3% (51)	7.9% (23)
Ib	15.3% (38)	16.5% (28)	11.4% (26)	11.8% (27)	15.5% (45)
II	7.2% (18)	8.8% (15)	9.2% (21)	6.6% (15)	5.5% (16)
III	21.3% (53)	18.8% (32)	19.7% (45)	17.0% (39)	16.6% (48)
IV	16.5% (41)	10.0% (17)	17.5% (40)	19.2% (44)	15.5% (45)
V	23.3% (58)	22.9% (39)	11.8% (27)	17.0% (39)	25.2% (73)
VI	1.2% (3)	4.7% (8)	3.1% (7)	2.2% (5)	3.8% (11)
VII	0.0% (0)	0.0% (0)	0.0% (0)	0.9% (2)	0.0% (0)
VIII	0.4% (1)	1.2% (2)	1.7% (4)	0.0% (0)	1.0% (3)
IX	0.4% (1)	1.2% (2)	0.4% (1)	0.4% (1)	2.8% (8)
NT	1.2% (3)	2.9% (5)	1.3% (3)	2.6% (6)	6.2% (18)
Grand Total	(249)	(170)	(229)	(229)	(290)

*Percentage of age group isolates (number of isolates).

Figure 43. Invasive *S. agalactiae* serotypes by clinical isolation site in 2018

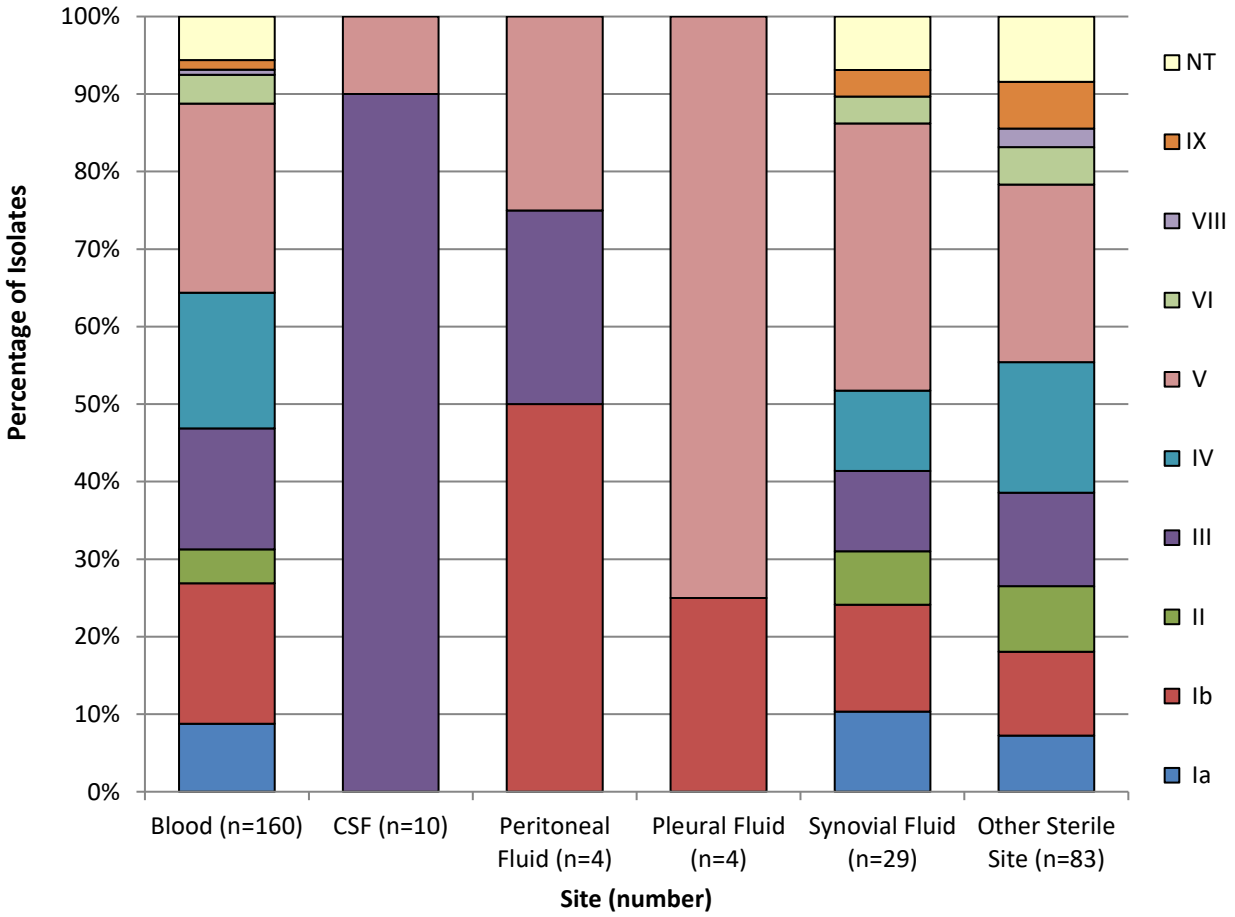


Table 19. Invasive *S. agalactiae* isolates by clinical isolation site in 2018

Serotype	Clinical Isolation Site						
	Blood	CSF	Peritoneal Fluid	Pleural Fluid	Synovial Fluid	Other Sterile Site**	Total
Ia	8.8%(14)*	0.0%(0)	0.0%(0)	0.0%(0)	10.3% (3)	7.2%(6)	7.9%(23)
Ib	18.1%(29)	0.0%(0)	50.0%(2)	25.0%(1)	13.8% (4)	10.8%(9)	15.5%(45)
II	4.4%(7)	0.0%(0)	0.0%(0)	0.0%(0)	6.9% (2)	8.4%(7)	5.5%(16)
III	15.6%(25)	90.0%(9)	25.0%(1)	0.0%(0)	10.3% (3)	12.0%(10)	16.6%(48)
IV	17.5%(28)	0.0%(0)	0.0%(0)	0.0%(0)	10.3% (3)	16.9%(14)	15.5%(45)
V	24.4%(39)	10.0%(1)	25.0%(1)	75.0%(3)	34.5% (10)	22.9%(19)	25.2%(73)
VI	3.8%(6)	0.0%(0)	0.0%(0)	0.0%(0)	3.4% (1)	4.8%(4)	3.8%(11)
VIII	0.6%(1)	0.0%(0)	0.0%(0)	0.0%(0)	0.0% (0)	2.4%(2)	1.0%(3)
IX	1.3%(2)	0.0%(0)	0.0%(0)	0.0%(0)	3.4% (1)	6.0%(5)	2.8%(8)
NT	5.6%(9)	0.0%(0)	0.0%(0)	0.0%(0)	6.9% (2)	8.4%(7)	6.2%(18)
Total	(160)	(10)	(4)	(4)	(29)	(83)	(290)

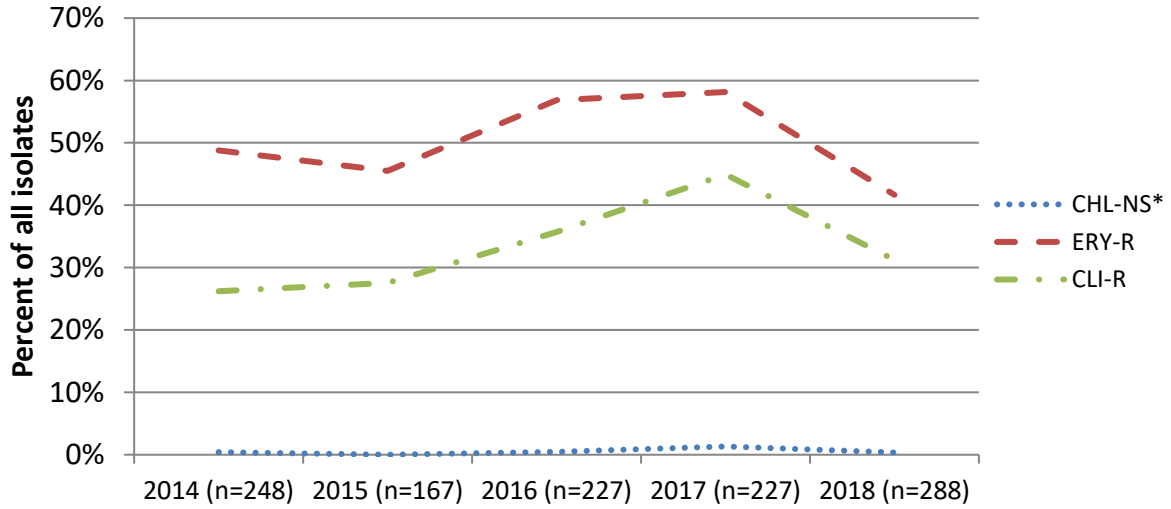
*Percentage of age group isolates (number of isolates). **Other sterile sites include: tissue, deep abscess, amniotic fluid, endometrial fluid and prostate fluid.

Antimicrobial Resistance of Streptococcus agalactiae

Of the 288 invasive *S. agalactiae* isolates tested for antimicrobial resistance by the disc diffusion method in 2018, the proportion of isolates resistant to **erythromycin** decreased from 58.1% (n=132) to 41.7% (n=120) from 2017 to 2018, **clindamycin** resistance also decreased from 44.9% (n=102) in 2017 to 31.3% (n=90) in 2018. Only one isolate was resistant to chloramphenicol during 2018.

Relatively high macrolide (erythromycin) resistance was observed among serotypes IV (71.1%, n=32), II (53.3 %, n=8) and Ib (48.9%, n=22). High resistance to clindamycin was seen in serotype IV (66.7%, n=30) and Ib (44.4%, n=20). High rates of inducible clindamycin resistance were seen in type II (46.7%, n=7).

Figure 44. Antimicrobial resistance of invasive *S. agalactiae*, 2014-2018



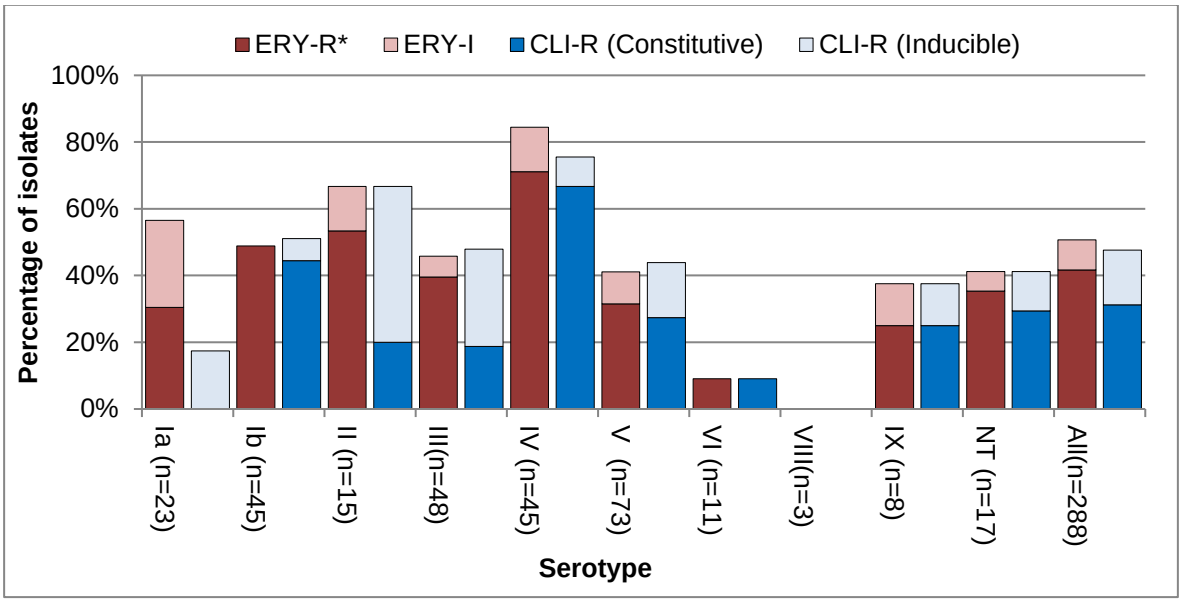
*CHL-NS = Chloramphenicol non susceptible (resistant or intermediate); ERY-R = Erythromycin resistant; CLI-R = constitutively clindamycin resistant

Table 20. Antimicrobial resistance of invasive *S. agalactiae*, 2014-2018

Antimicrobial	Year				
	2014	2015	2016	2017	2018
CHL-NS*	0.4% (1)**	0.0% (0)	0.4% (1)	1.3% (3)	0.3% (1)
ERY-R	48.8% (121)	45.5% (76)	56.8% (129)	58.1% (132)	41.7% (120)
CLI-R	26.2% (65)	27.5% (46)	35.7% (81)	44.9% (102)	31.3% (90)
Total Tested	(248)	(167)	(227)	(227)	(288)

*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 2018



*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 2018

Serotype (Tested)	ERY-R		ERY-I		CLI-R (Constitutive)		CLI-R (Inducible)	
Ia (n=23)	30.4%	(7)	26.1%	(6)	0.0%	(0)	17.4%	(4)
Ib (n=45)	48.9%	(22)	0.0%	(0)	44.4%	(20)	6.7%	(3)
II (n=15)	53.3%	(8)	13.3%	(2)	20.0%	(3)	46.7%	(7)
III(n=48)	39.6%	(19)	6.3%	(3)	18.8%	(9)	29.2%	(14)
IV (n=45)	71.1%	(32)	13.3%	(6)	66.7%	(30)	8.9%	(4)
V (n=73)	31.5%	(23)	9.6%	(7)	27.4%	(20)	16.4%	(12)
VI (n=11)	9.1%	(1)	0.0%	(0)	9.1%	(1)	0.0%	(0)
VIII(n=3)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)
IX (n=8)	25.0%	(2)	12.5%	(1)	25.0%	(2)	12.5%	(1)
NT (n=17)	35.3%	(6)	5.9%	(1)	29.4%	(5)	11.8%	(2)
All(n=288)	41.7%	(120)	9.0%	(26)	31.3%	(90)	16.3%	(47)

*Percentage of isolates (number of isolates).

CONCLUSIONS

Proportions of IPD cases, submitted to NML, caused by PCV7 isolates of *S. pneumoniae* in Canada have declined slightly in 2018 from 2017. Proportions of IPD cases caused by PCV13-only serotypes (1, 5, 7F, 3, 6A and 19A) decreased from 2014 to 2018 overall, however an increase of IPD was observed over the last year from 2017 to 2018. The continued decline in the incidence of IPD 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-PCV13 replacement serotypes such as serotypes 8, 9N, 12F, 15A, 22F, 23A, 23B and 35B. Other serotypes of concern that are increasing in prevalence among <2 year olds include 11A, 15B/C, 22F, 23A and 38. Close monitoring of serotypes 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 about the virulence of this serotype 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.

Overall antimicrobial resistance among isolates of *S. pneumoniae* has remained relatively constant from 2017-2018 and multi drug resistance to three or more classes has decreased. Concern of increases of resistant serotypes 15A and 19A are warranted.

The incidence rate of disease attributed to **invasive *S. pyogenes*** has continued to increase in all age groups from 2013 to 2018, with the exception of the <1 year old age group. Dominant strains in Canada tended to be regionally distributed as follows: *emm74* is prevalent in Western and Central regions of Canada; *emm*6 predominates in Eastern regions and *emm11* in the North. *Emm1* is dominant countrywide. Antimicrobial resistance in Group A *Streptococcus* has decreased in 2018. Although overall resistance is low and Group A Streptococcal disease is readily treated with penicillin, due to the severity of disease, high risk of infection among disadvantaged and marginalized populations, and the heightened public awareness of Group A *Streptococci*, 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 serotype V, followed by III and IV were the predominate strains in Canada during 2018. Macrolide resistance has been relatively high among Group B *Streptococci* but a decrease was observed from 2017 to 2018. 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 *S. pneumoniae* cases serotyped in Canada, 2018

Age group	Total number of isolates serotyped*	Total number of illnesses reported to CNDSS**
<5 years	179	242
5 – 39 years	449	543
40 – 59 years	950	1162
≥60 years	1601	2065
All Ages	**3203***	**4026^**

* All Ages total includes 34 isolates with no patient age. Total does not include isolates from pleural fluid. ** Data from Canadian Notifiable Diseases Surveillance System, PHAC. ^All Ages includes 14 cases with no patient age.

Table B. Proportion of invasive *S. pyogenes* cases typed in Canada, 2018

Age group	Total number of isolates tested*	Total number of illnesses reported to CNDSS**
<5 years	120	130
5 – 39 years	914	843
40 – 59 years	1012	909
≥60 years	1076	1040
All Ages	**3135***	**2922^**

* All Ages total includes 13 isolates with no patient age. Total does not include isolates from pleural fluid. **Canadian Notifiable Diseases Surveillance System, PHAC. ^Difference between NML and CNDSS totals due to variation in provincial laboratories definition of sterile sites.

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