National Laboratory Surveillance of *Streptococcus pneumoniae* and *Streptococcus pyogenes* In Canada Annual Summary 2010

Streptococcus and STI Unit
Bacteriology and Enteric Diseases Program
National Microbiology Laboratory
Public Health Agency of Canada
Winnipeg, Manitoba

Public Health Agency of Canada
Agence de la santé publique du Canada
Canada

This report was prepared by:

Walter Demczuk

Averil Griffith

Ravinder Singh

Irene Martin, Unit Head

Matthew Gilmour, Acting Director

Streptococcus and STI Unit
Bacteriology and Enteric Diseases Program
National Microbiology Laboratory
Public Health Agency of Canada
1015 Arlington Street, Room H2600
Winnipeg, Manitoba R3E 3R2
Tel: (204) 789-6063 Fax: (204) 789-5012
NML.StrepSTI@phac-aspc.gc.ca

Table of Contents

Acknowledgements 4

Executive Summary 6

Introduction 7

Methods 8

Results and Discussion 11
- *Streptococcus pneumoniae* 11
- *Streptococcus pyogenes* (Group A *Streptococcus*) 16

Conclusion 19

Appendices (Raw Data Tables) 20

References 29

Figures and Tables

Table 1. Number of invasive *Streptococcus pneumoniae* isolates tested at NML from April 1 to December 31, 2010 9

Figure 1. Clinical isolation sites of *Streptococcus pneumoniae* 9

Table 2. Number of Invasive *Streptococcus pyogenes* isolates tested at NML from April 1 to December 31, 2010 10

Figure 2. Clinical isolation sites of *Streptococcus pyogenes* 10

Figure 3. Age distribution of *Streptococcus pneumoniae* serotypes in Canada 11

Figure 4. Age distribution of *Streptococcus pneumoniae* serotypes in Western Canada 12

Figure 5. Age distribution of *Streptococcus pneumoniae* serotypes in Central Canada 13

Figure 6. Age distribution of *Streptococcus pneumoniae* serotypes in Eastern Canada 13

Figure 7. Regional distribution of cumulative vaccine coverage of *Streptococcus pneumoniae* serotypes in 2010 from children aged 0 to 14 years 14

Figure 8. Regional distribution of cumulative vaccine coverage of *Streptococcus pneumoniae* isolates serotypes in 2010 from adults aged 15 to 64 years 15

Figure 9. Regional distribution of cumulative vaccine coverage of *Streptococcus pneumoniae* serotypes in 2010 from seniors aged 65 years and older 15

Figure 10. Regional distribution of *Streptococcus pyogenes emm* Types 16

Figure 11. Prevalent *Streptococcus pyogenes emm* Types isolated from children 0 to 14 years of age 17

Figure 12. Prevalent *Streptococcus pyogenes emm* Types isolated from adults 15 to 64 years of age 17

Figure 13. Prevalent *Streptococcus pyogenes emm* Types isolated from seniors 65 years of age and over 18

Figure 14. Source distribution of prevalent *Streptococcus pyogenes emm* Types 18

Appendix A. Serotypes of *Streptococcus pneumoniae* reported by NML, April 1 – December 31, 2010 20

Appendix B. *Emm* and T-Types of *Streptococcus pyogenes* (Group A *Streptococcus*) reported by NML, April 1 to December 31, 2010 25

Acknowledgements

The results presented in this report represent *Streptococcus* isolates kindly submitted to the National Microbiology Laboratory, Winnipeg (NML) from the following hospitals or provincial public health laboratories:

British Columbia Centre for Disease Control, Vancouver, British Columbia: Dr. Linda Hoang, Ingrid Pocock, Ana Paccagnella, Loretta Janz, Sultana Mithan, Tazim Rahim

Saskatchewan Disease Control Laboratory, Regina, Saskatchewan: Dr. Greg Horsman, Evelyn Nagle, Rosanne Kitzul

Cadham Provincial Laboratory, Winnipeg, Manitoba: Dr. Jared Bullard, Dr. Paul Van Caeseele, Denise Sitter

Public Health Laboratories, Ontario Agency for Health Protection and Promotion, Etobicoke, Ontario: Dr. Dylan Pillai, Dr. Jonathan Gubbay, Prasad Rawte

Toronto Invasive Bacterial Disease Network, Mt. Sinai Hospital, Toronto, Ontario: Dr. Alison McGeer, Dr. Agron Plevneshi, Sylvia Pong-Porter, Wallis Rudnick

Laboratoire de santé publique du Québec, Ste-Anne-de-Bellevue, Québec: Dr. Robert Laurence, Dr. Brigitte Lefebvre, Marc-Christian Domingo, Francois Robillard

Queen Elizabeth II Health Science Centre, Halifax, Nova Scotia: Dr. David Haldane

New Brunswick Regional Hospitals: Dr. Alexander Doroshenko, Maryse Thibeault. Eric Brisson, Francine Plourde, Dr. L. Thibault, Dr. Lewis Abbott, Melanie Stace, Peter Delaney, Linda Turgeon, Tammy Mahaney

Queen Elizabeth Hospital, Charlottetown, Prince Edward Island: Dr. Lei Ang

Newfoundland Public Health Laboratory, St. John's, Newfoundland: Dr. L. Robberts, Sandra March

Stanton Territorial Hospital Laboratory, Yellowknife, Northwest Territories: Cheryl Case

Whitehorse General Hospital, Whitehorse, Yukon: Rosalyn Robertson, Becky Nash, Chris Cash

We would also like to thank:

Amanda Shane (Surveillance and Outbreak Response Division) and Julie A. Laroche (Immunization Division), Centre for Immunization and Respiratory Infectious Diseases, PUBLIC HEALTH AGENCY OF CANADA

Dr. George Zhanel at the Department of Medical Microbiology and Infectious Diseases, University of Manitoba for his expert guidance and contributions to this report.

Streptococcus pneumoniae is responsible for a range of infections including **invasive pneumococcal disease (IPD)** [meningitis, septicaemia, bacterial pneumonia] to upper respiratory infections, otitis media and sinusitis. From 2002 to 2006, **pneumococcal immunization programs** using a 7-valent pneumococcal conjugate vaccine (PCV7) were established in all provinces and territories and led to dramatic decreases in invasive disease caused by constituent PCV7 serotypes: 4, 6B, 9V, 14, 18C, 19F and 23F. Serotype replacement with non-PCV7 vaccine serotypes (NVT) has since been observed among pneumococcal infections in Canada.

In response to a shift in prevalence of serotypes away from those contained in the PCV7 vaccine, a 10-valent Pneumococcal, *Haemophilus influenzae*, Diphtheria vaccine (PHiD10) was developed which in terms of *S. pneumoniae* was composed of the PCV7 serotypes plus serotypes 1, 5 and 7F.

Furthermore, with the introduction the 13-valent PCV13 (includes the PHiD10 serotypes as well as serotypes 3, 6A and 19A) in many provinces this year, monitoring of *S. pneumoniae* serotypes is important as it directly informs and predicts the effectiveness and composition of vaccine formulations.

A 23 valent polysaccharide pneumococcal vaccine (PPV23) is primarily recommended for adults aged 65 years or older and includes all PCV13 serotypes except 6A, plus serotypes 2, 8, 9N, 10A, 11A, 12F, 15B, 17F, 20, 22F and 33F.

Within the text of this document, the associated vaccine is indicated in superscript beside the pneumococcal serotype; for example serotype $23F^{PCV7}$, $7F^{PHiD10}$, $19A^{PCV13}$, or $33F^{PPV23}$, $6C^{NVT}$.

Group A *Streptococcus* infections range in severity from mild pharyngitis to severe invasive disease of soft tissues potentially resulting in toxic shock syndrome and necrotizing fasciitis. Increased mortality and morbidity rates have recently classified Group A *Streptococcus* infections as a re-emerging disease.

Data presented in this summary is intended to provide a national and regional baseline providing local jurisdictions the opportunity to put the distribution of jurisdictional information into context. This report can also be used in conjunction with future reports to establish trends to estimate the effectiveness of newly introduced vaccine formulations over time.

Executive Summary

- This report summarizes the characterization of 1124 invasive *Streptococcus pneumoniae* (IPD) and 660 invasive *Streptococcus pyogenes* (Group A Streptococcus; iGAS) isolates collected in Canada between April 1 to December 31, 2010 and submitted by provincial and territorial public health laboratories and hospitals to the NML for surveillance purposes (Tables 1, 2; page 10).
- Nationally, the proportion of isolates of *S. pneumoniae* serotypes associated with the PCV7 vaccine is relatively low, representing 6% of the child isolates and reflecting the efficacy of this vaccine in reducing the number of IPD cases due to these serotypes among children (Figure 7; page 14).
- Serotypes $7F^{PHiD10}$ and $19A^{PCV13}$ are most prevalent in all age groups representing 18% and 21% of child isolates, 23% and 10% of adult isolates, and 11% and 13% of senior isolates, respectively (Figure 3; page 11).
- The recently introduced PCV13 vaccine covers 56% of the child strains (figure 7, page 14) and 46% of the isolates from adults and seniors (Figures 8, 9; page15).
- The PPV23 vaccine targeted to adults covers 78% of the isolates reported in adults and 70% in seniors (Figures 8, 9; page 15).
- Elevated levels of non-vaccine serotypes (NVT) among child isolates include serotype $6C^{NVT}$, $15A^{NVT}$ and $23B^{NVT}$ (Figure 3; page 11).
- Prominent serotypes among adult strains include $12F^{PPV23}$, $22F^{PPV23}$ and $6C^{NVT}$ (Figure 3; page 11).
- In the senior age group levels of serotype $22F^{PPV23}$, $6C^{NVT}$ and $15A^{NVT}$ are elevated (Figure3; page 11).
- In children *Streptococcus pyogenes* (Group A *Streptococcus*) *emm*1, *emm*12 and *emm*4 are the most prevalent types together representing half of all the strains tested (Figure 11; page 17).
- In adults and seniors *emm*1, emm89 and *emm*28 types are prevalent accounting for 38% of the isolates (Figures 12, 13: pages 17, 18).

Introduction

As of April 1, 2010, the National Microbiology Laboratory (NML), Winnipeg began offering *Streptococcus* reference services. The unit undertakes surveillance, reference diagnostics, research activities and outbreak support on *Streptococcus pneumoniae* and *S. pyogenes* (Group A *Streptococcus*) causing invasive disease.

This report is intended to relay the current distribution of serotypes of invasive *S. pneumoniae* and *emm* types of *S. pyogenes* isolated from sterile sites that are forwarded from Canadian provincial public health laboratories, regional health units and reference centres to the NML. Data presented in this report presents aggregated counts of isolates received from all sources and reported by NML.

Invasive pneumococcal disease (IPD) is an acute and serious illness caused by *Streptococcus pneumoniae.* Invasive disease may lead to several serious syndromes including bacteremia, meningitis and/or bacteraemia [1,2], with children being at greatest risk for infection [3,4]. Of the 92 distinct pneumococcal serotypes currently recognized, the majority of disease worldwide is caused by only a few serotypes.

Vaccines that target the common serotypes have been very effective in reducing the burden of disease in developed nations, however the **replacement of vaccine serotypes with non-vaccine types has become a serious concern** [5, 6, 7, 8].

The PCV7 vaccine was licensed in Canada in June 2001 [9, 22] and by 2006 immunization programs were established in all provinces and territories [10] which have led to dramatic decreases in invasive disease caused by PCV7 serotypes. Since the introduction of vaccination programs, serotype replacement has been observed among pneumococcal infections in Canada with an increase in non-PCV7 serotype infections [5, 8]. With the introduction of the PCV13 vaccine in many provinces this year, surveillance of *S. pneumoniae* serotypes is important as it allows for the monitoring of serotype replacement, which directly informs vaccine development. The PPV23 vaccine is available for adults; however it is not effective in children due to a poor T-cell-independent antibody response in immature immune systems [11].

Invasive *Streptococcus pyogenes* (Group A *Streptococcus,* iGAS) is responsible for a wide range of diseases including bacteraemia, streptococcal toxic shock syndrome and skin and soft tissue infections of which necrotizing fasciitis is most notorious [12]. Surveillance of strains is important to monitor **increasing virulence patterns associated with this re-emergent organism** [13, 14]. The M protein, encoded by the *emm* gene, is an important virulence factor and an epidemiological marker used to characterize *S. pyogenes* isolates.

Methods

S. pneumoniae and S. pyogenes strains were submitted to the NML from provincial and territorial public health laboratories for surveillance purposes.

Caution should be exercised when interpreting 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 or territory may be submitted for testing and therefore this report does not reflect true incidence of disease in Canada. Submission of isolates to the NML is voluntary and not standardized across the country. Accordingly, the data presented in this summary report is intended to provide submitting jurisdictions an **aggregated national and regional context** in which to view their local situation.

All peumococcal isolates were screened by bile solubility and optochin (Oxoid) analyses and iGAS were confirmed using PYR (pyrrolidonyl naphthylamide) reaction (BBL DrySlide PYR kit) and susceptibility to bacitracin (Oxoid) and trimethoprim/sulfamethoxazole susceptibility discs (BBL; 1.25/23.75 µg/ml) [15]. Sterile clinical isolation sites include blood, cerebrospinal fluid or other nervous tissue (CSF), pleural fluid, peritoneal fluid, pericardial fluid, joint fluid, internal body sites and muscle including surgical or biopsy samples and aspirates and any site in a case of toxic shock syndrome or necrotizing fasciitis [16, 17].

Serotyping of IPD at NML is performed by observing the Quellung reaction using pool, group, type and factor commercial antisera from SSI Diagnostica; Statens Serum Institute, Copenhagen, Denmark [18, 19]. Isolates for which a Quellung reaction is not observed are confirmed by *rpoB* gene sequencing [20, 21] as well as PCR multiplex serotyping as outlined at: http://www.cdc.gov/ncidod/biotech/strep/pcr.htm.

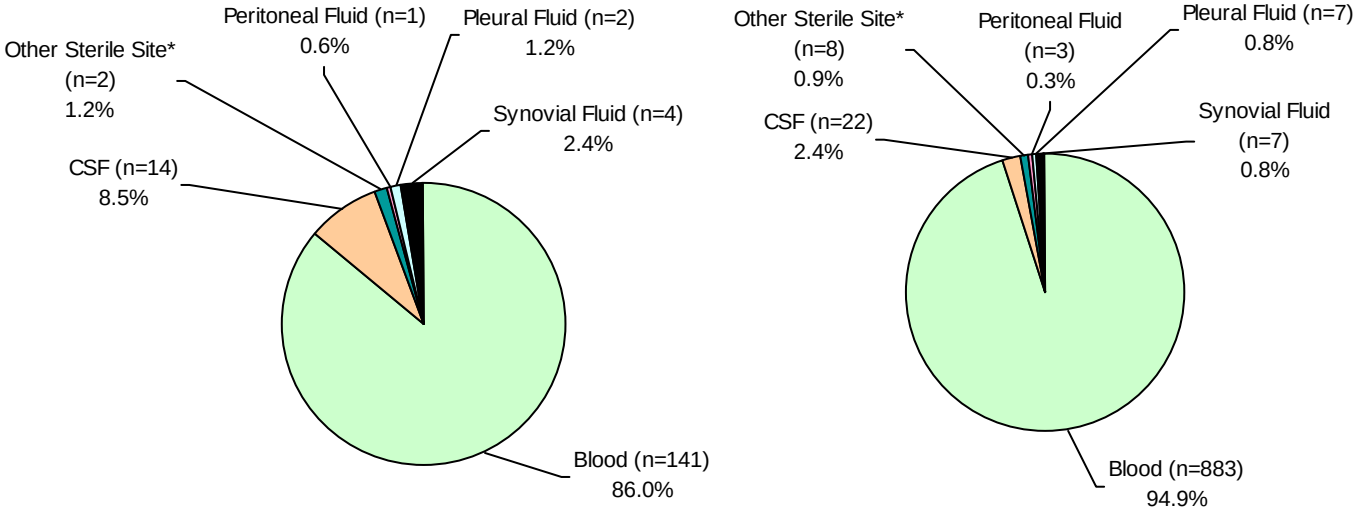
The *emm* and T types are determined for all iGAS isolates submitted to the NML. Isolates are characterized using the *emm* sequencing CDC protocol available at: http://www.cdc.gov/ncidod/biotech/strep/M-ProteinGene_typing.htm. The *emm* sequences obtained are compared with the CDC (Atlanta) data bank (www.cdc.gov/ncidod/biotech/strep/strepblast.htm) and results are reported to the type level, not the subtype level (*emm*4.4 is reported as *emm*4). T-typing is performed using commercial *Streptococcus* agglutination Anti-T Typing Sera purchased from TransEurope Chemicals, Czech Republic.

Table 1. Number of invasive *Streptococcus pneumoniae* isolates in each age group tested at NML from April 1 to December 31, 2010

Region*	<2 yrs	2 - 4 yrs	5-14 yrs	15-64 yrs	>65 yrs	Not Given	Total
Western and Northern	41	13	15	196	148	10	**423**
Central	31	18	15	254	249	18	**585**
Eastern	13	5	13	38	45	2	**116**
Canada	**85**	**36**	**43**	**488**	**442**	**30**	**1124**

*Western and Northern regions include: British Columbia to Manitoba and Northern Territories; Central regions: Ontario and Quebec; and Eastern regions: all maritime provinces including Newfoundland and Labrador.

Figure 1. Clinical isolation sites of *Streptococcus pneumoniae*



Children (≤ 14 years, n=164)

* 2 eye isolates

Adults/Seniors (≥15years, n=930)

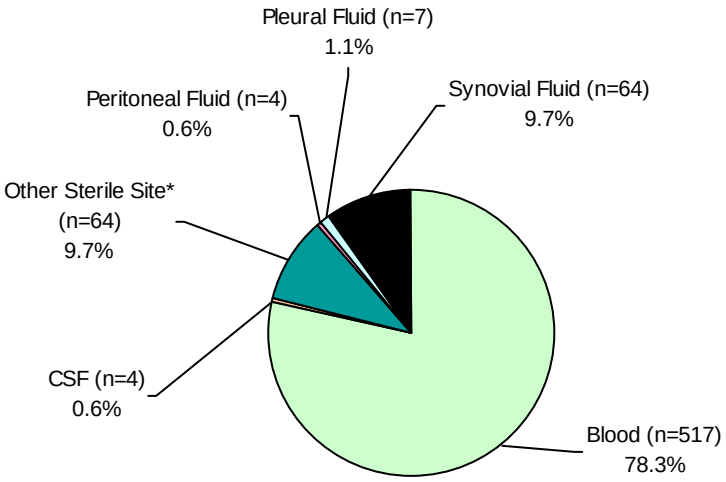
** 1 aortic value, 5 eye, 1 leg deep tissue and 1 chest cavity

Table 2. Number of invasive *Streptococcus pyogenes* isolates in each age group tested at NML from April 1 to December 31, 2010

Region*	<2 yrs	2 - 4 yrs	5 - 14 yrs	15 - 64 yrs	>65 yrs	Not Given	Total
Western and Northern	14	5	9	133	33	6	**200**
Central	10	20	39	232	125	7	**433**
Eastern		1	4	17	4	1	**27**
Canada	**24**	**26**	**52**	**382**	**162**	**14**	**660**

*Western and Northern regions include: British Columbia to Manitoba and Northern Territories; Central regions: Ontario and Quebec; and Eastern regions: all maritime provinces including Newfoundland and Labrador.

Figure 2. Clinical isolation sites of *Streptococcus pyogenes*



*Other sterile sites include biopsy tissue, necrotizing fasciitis or toxic shock syndrome tissue, internal/deep tissue body or surgical sites.

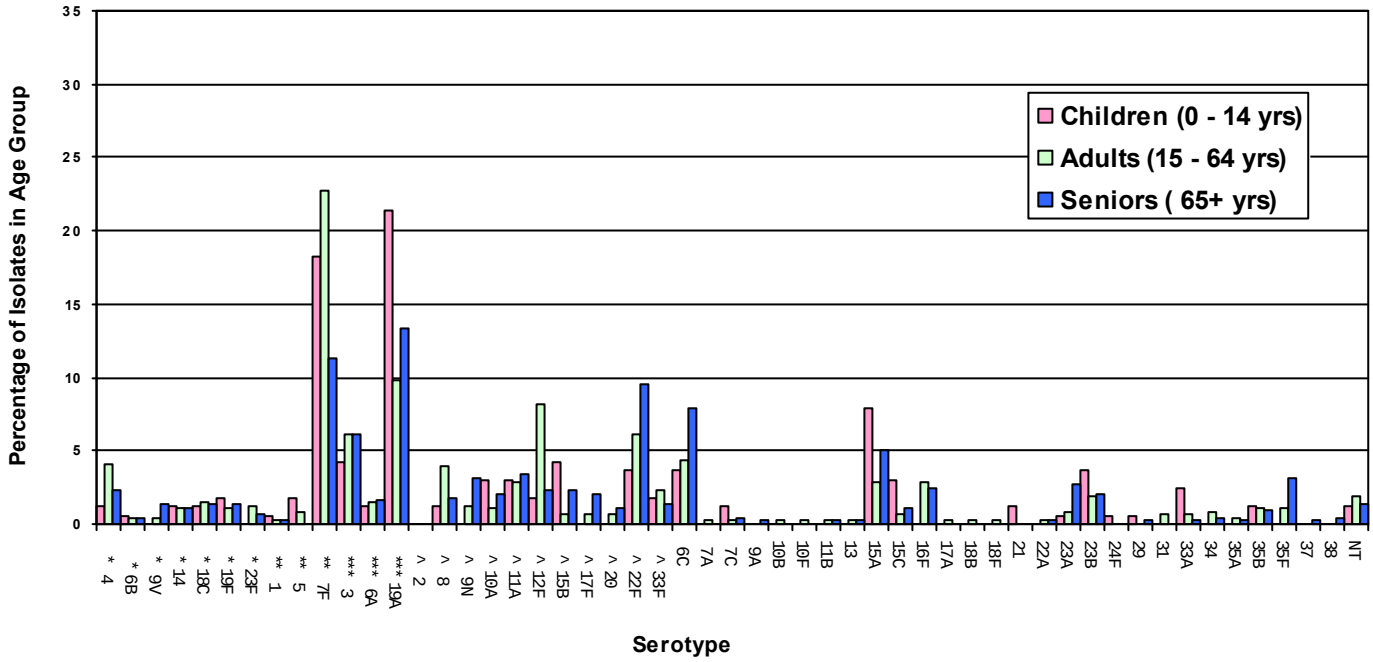
Results and Discussion

Streptococcus pneumoniae

Of the 1124 isolates tested at NML, **patient age** information was provided for 1094 isolates of which 15% (n=164) where isolated from children 0 to 14 years of age, 45% (n=488) from adults aged 15 to 64 years and 40% (n=442) were from seniors 65 years of age or older (Table 1). Blood was the most frequent **clinical isolation site** accounting for 91% of all isolates submitted for testing. CSF isolates represented a significantly higher proportion of the child isolates than adult and senior isolates ($p<0.001$). Of the 1065 isolates with **gender** information specified, 52% were from male patients.

Nationally, the proportion of **PCV7 serotypes** (4, 6B, 7V 14, 18C 19F and 23F) were relatively low representing only 9% of all isolates collected between April and December 2010. Serotypes **7F**^{PHiD10} and **19A**^{PCV13} were most prevalent in all age groups, together accounting for 43% of child isolates, 33% of adult isolates, and 24% of senior isolates. Other serotypes also prevalent among **all age groups** were serotype 22F^{PPV23} and the non vaccine type (NVT) 6C. Among isolates from **children**, serotypes 15A^{NVT} and 23B^{NVT} were also slightly elevated; 12F^{PPV23}, 3^{PCV13}, and 4^{PCV7} among **adult** isolates; and in **seniors** 15A^{NVT} and 3^{PCV13} (Figure 3).

Figure 3. Age distribution of *Streptococcus pneumoniae* serotypes in Canada



*Component of PCV7 vaccine, ** additional component of the PHiD10 vaccine, *** additional component of the PCV13 vaccine, ^ additional component of the PPV23 vaccine except 6A.

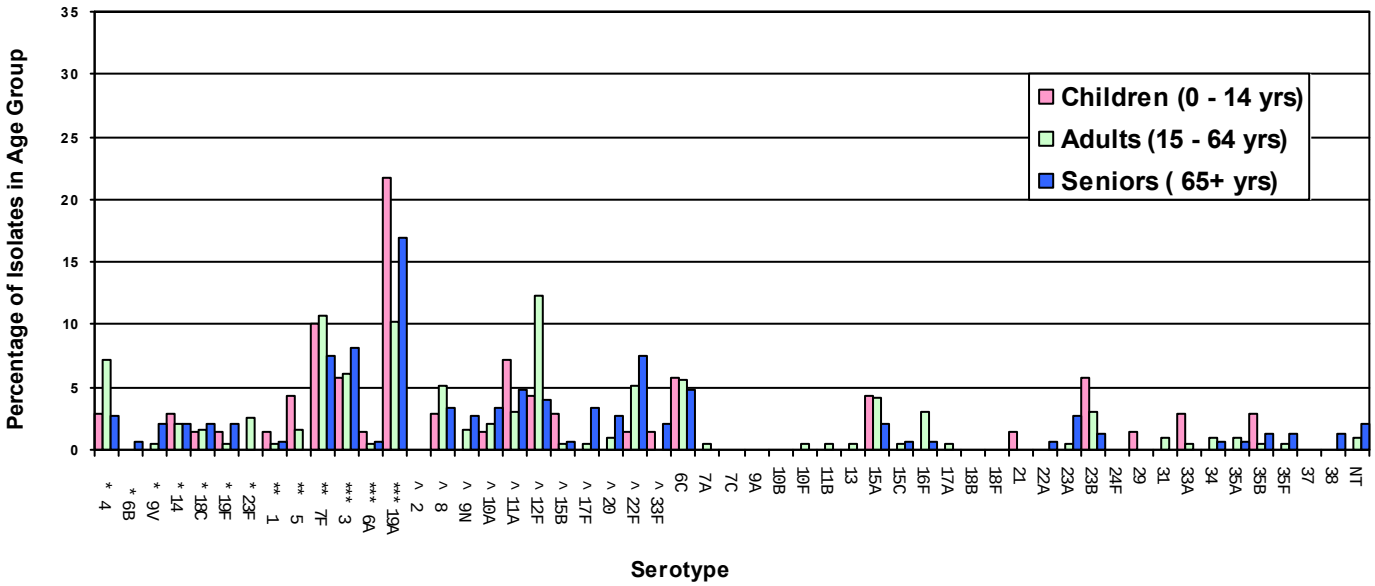
Regional Distribution of *Streptococcus pneumoniae* Serotypes

Serotype **19A**[PCV13] was the most prevalent serotype in **children and seniors** in **Western** regions of Canada accounting for 22% and 17% of the isolates, respectively, whereas among **adults 12F**[PPV23] was most prevalent representing 12% of the isolates tested in that age group.

Serotype **7F**[PHiD10] was most prevalent in all age groups in **Central** Canada with 22%, 33% and 13% as well as in **Eastern** regions with 29%, 18% and 15% of child, adult and senior isolates, respectively. In Western Canada this serotype represents a relatively smaller proportion of the isolates with only 10%, 11% and 8% of child, adult and senior strains. In Central and Eastern Canada 19A[PCV13] was the second most prevalent serotype among child and adult isolates.

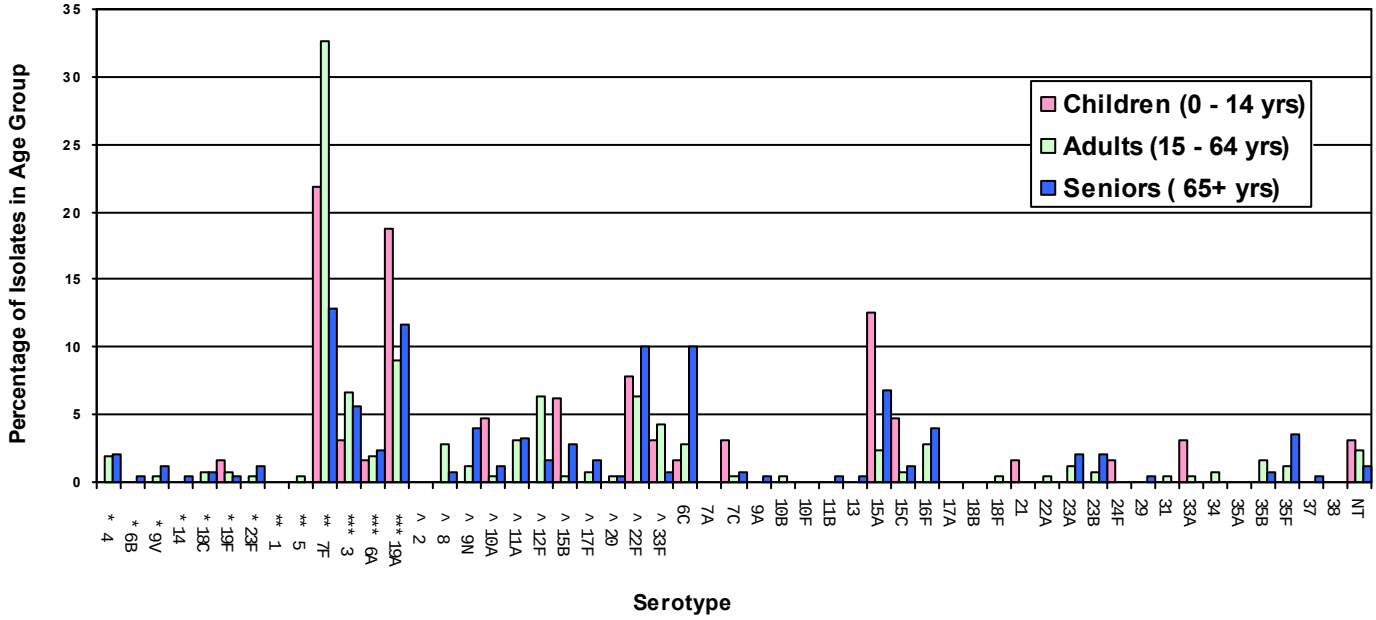
The proportion of serotype **15A**[NVT] among **child isolates** was higher in **Central** Canada (13%) relative to Western (4%) and Eastern (6%) regions as well as **22F**[PPV23] which was also elevated in **Central** Canada with 7% of the strains compared to 2% in the West and 0% in the Eastern provinces. Serotype **23B**[NVT] was elevated the **Western and Eastern** regions accounting for 6% of the child isolates, but only about 1% of child isolates form the Central region. Serotype **35B**[NVT] was greater in **Western** regions with 3% of child isolates compared to none in Central or Eastern Canada.

Figure 4. Age distribution of *Streptococcus pneumoniae* serotypes in Western Canada



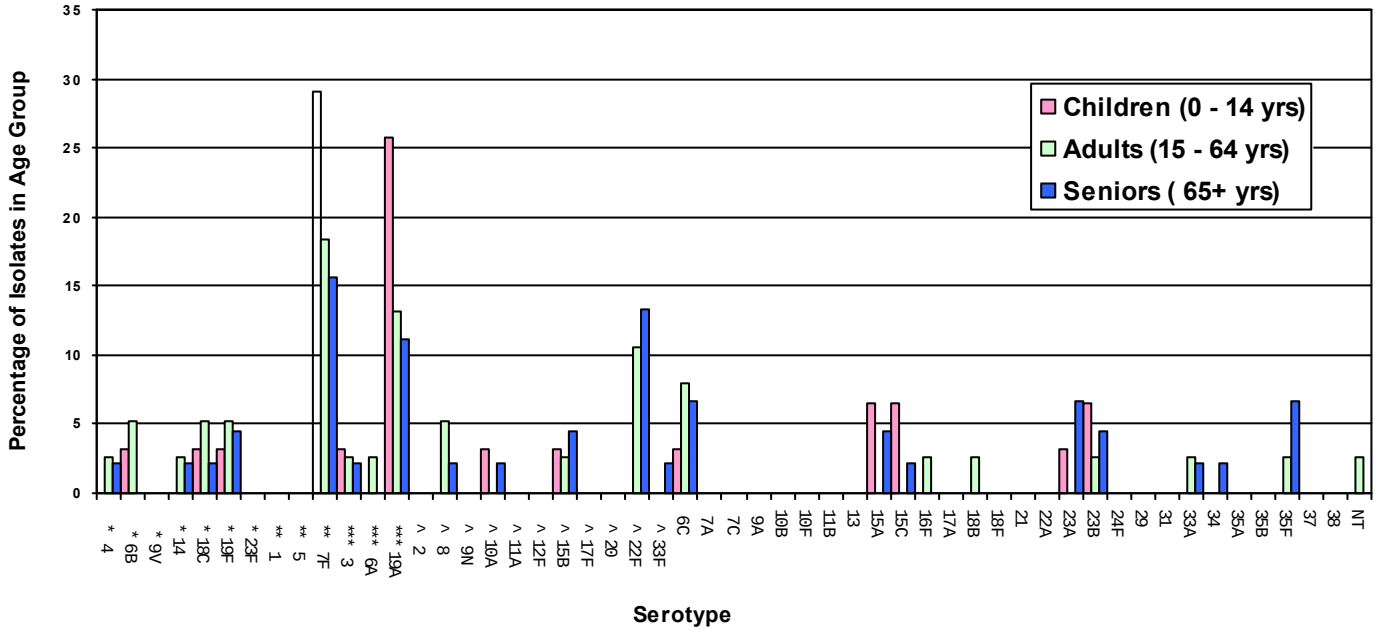
* Component of PCV7 vaccine, ** additional component of the PHiD10 vaccine, *** additional component of the PCV13 vaccine, ^ additional component of the PPV23 vaccine except 6A.

Figure 5. Age distribution of *Streptococcus pneumoniae* serotypes in Central Canada



*Component of PCV7 vaccine, ** additional component of the PHiD10 vaccine, *** additional component of the PCV13 vaccine, ^ additional component of the PPV23 vaccine except 6A.

Figure 6. Age distribution of *Streptococcus pneumoniae* serotypes in Eastern Canada



*Component of PCV7 vaccine, ** additional component of the PHiD10 vaccine, *** additional component of the PCV13 vaccine, ^ additional component of the PPV23 vaccine except 6A.

Coverage of Serotypes by Vaccines

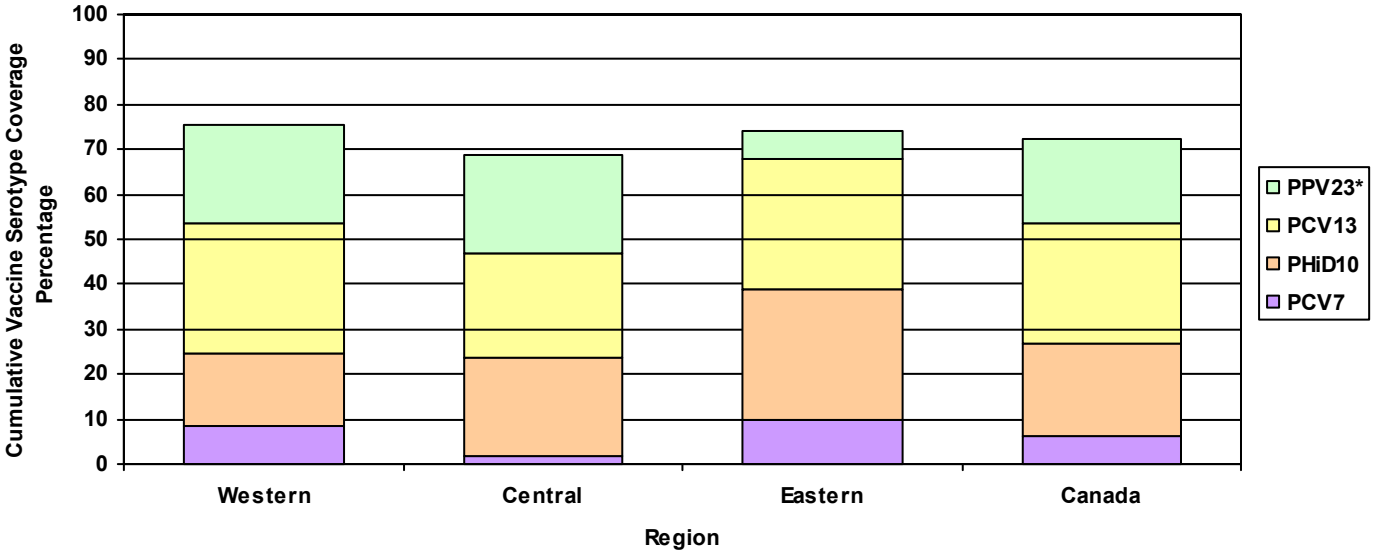
Children:
After the introduction of the PCV7 vaccine (composed of serotypes 4, 6B, 9V 14, 18C 19F and 23F) in all provinces and territories by 2006, the proportion of this group of serotypes decreased dramatically [5, 6, 8, 10]. In 2010, those serotypes covered by the **PCV7** vaccine represented a small proportion (6%) of all *S. pneumoniae* serotypes in children.

Greater serotype coverage is available with the 10-valent **PHiD10** vaccine (includes all the PCV7 serotypes and the additional serotypes 1, 5 and 7F) wherein **21%** of the isolates from children are covered. Broader coverage is provided by the 13-valent vaccine **PCV13** (PHiD10 serotypes as well as serotypes 3, 6A and 19A) for a coverage of **54%**.

A higher proportion of isolates in **Eastern (68%)** and **Western (52%)** Canada were covered by the PCV13 vaccine due to high levels of $7F^{PHiD10}$ and $19A^{PCV13}$ in those regions. A relatively smaller proportion of **Central** isolates **(47%)** were covered by this vaccine, partly due to higher numbers of $22F^{23}$ and $15A^{NVT}$ serotypes which are not a component of this vaccine formulation.

Adult immunization with **PPV23** vaccine (includes all PCV13 serotypes except 6A, plus serotypes 2, 8, 9N, 10A, 11A, 12F, 15B, 17F, 20, 22F and 33F) may indirectly convey protection to children by lowering levels of the constituent serotypes in adults, thereby lowering transmission rates of these serotypes from adult/senior to child populations. Nationally, **73%** of the isolates tested from children are covered by the PPV23 vaccine.

Figure 7. Regional distribution of cumulative vaccine coverage of *Streptococcus pneumoniae* serotypes in 2010 from children aged 0 to 14 years



* Although the PPV23 vaccine is not used in children, this data is presented to provide information concerning potential serotype coverage of adult vaccine types due to possible transmitted infections between adult/senior and child populations.

Adults and Seniors

The PPV23 vaccine serotypes in Canada account for 78% of the pneumococcal infections in adults and 70% of those in seniors. In Western Canada, the PPV vaccine offers slightly broader coverage of serotypes among seniors than in adults. In Central and Eastern regions however greater coverage of serotypes is evident in adults due to the relatively higher rates of $6C^{NVT}$, $15A^{NVT}$, $23A^{NVT}$ and $35F^{NVT}$ observed among the senior isolates.

Figure 8. Regional distribution of cumulative vaccine coverage of *Streptococcus pneumoniae* serotypes in 2010 from adults aged 15 to 64 years

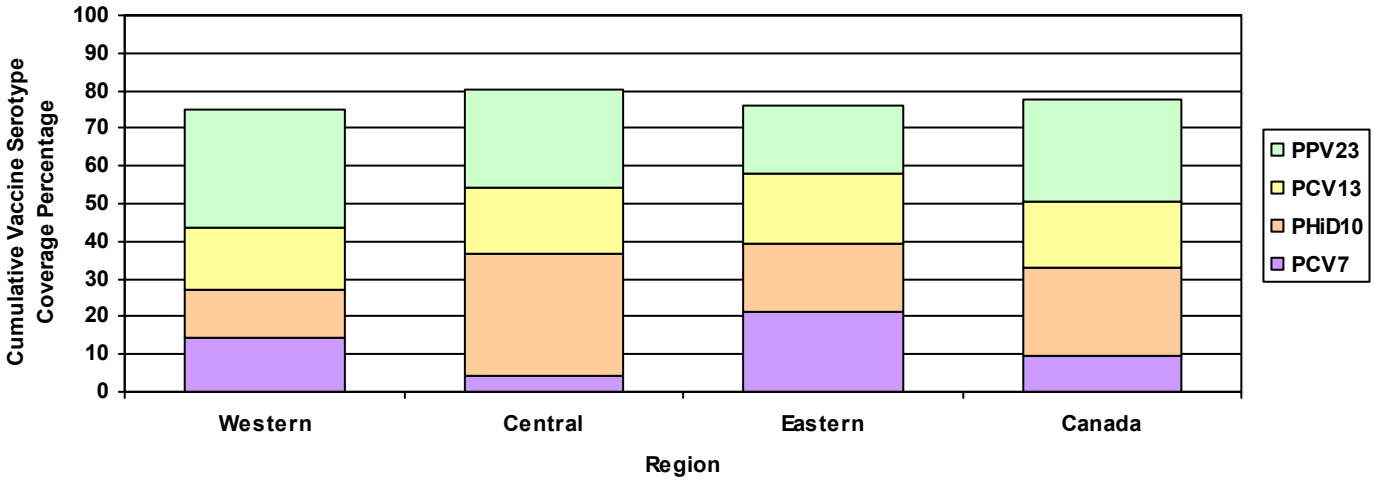
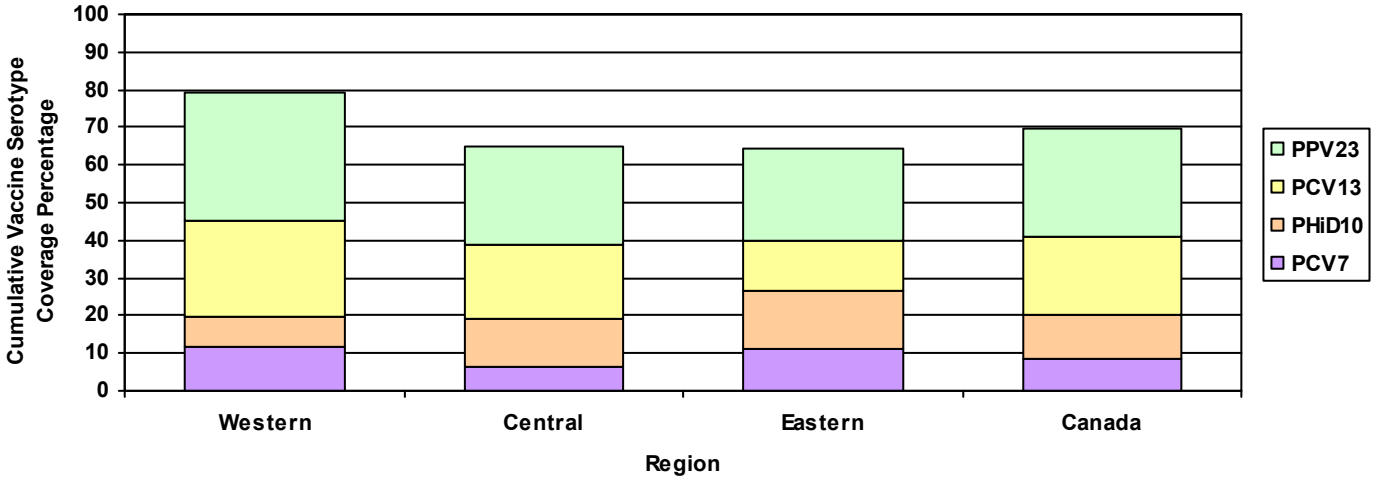


Figure 9. Regional distribution of cumulative vaccine coverage of *Streptococcus pneumoniae* serotypes in 2010 from seniors aged 65 years and older



Streptococcus pyogenes (Group A *Streptococcus*)

Of the 660 *Streptococcus pyogenes* isolates tested at the NML by *emm* typing and T serotyping there was **no significant difference** observed in the relative proportions of **clinical isolation sites** between adults and children. Fifty-two percent of the isolates were collected from **male** patients.

The **most prevalent** *emm* type in Canada is ***emm*1** accounting for 25% of child, 17% of adult and 19% of senior strains. Among **child** infections, ***emm*12** is next most prevalent (16%) whereas this type ranks 6th (5%) and 4th (11%) of adult and senior strains, respectively. Among the **adult and senior** isolations, ***emm*89** is prevalent with 12% and 18% representation, whereas in children *emm*89 accounts for only 6% of the isolates. *Emm* types were relatively evenly distributed through the regions with the exception of ***emm*83 and *emm*77** which is more prevalent the **West**.

Among **blood** isolates ***emm*1** accounted for 21% of the isolations, followed by *emm*89 with 14%. The predominant types isolated from **synovial fluid** and joints was ***emm*4** (16%), *emm*1 (13%), *emm*28 (13%) and *emm*83 (11%). Isolates from **other clinical sites** (mainly deep tissue and necrotizing fasciitis specimens) were largely represented by *emm*1 (12%), *emm*89 (11%) and ***emm*83** (13%).

Figure 10. Regional Distribution of *Streptococcus pyogenes* *emm* Types

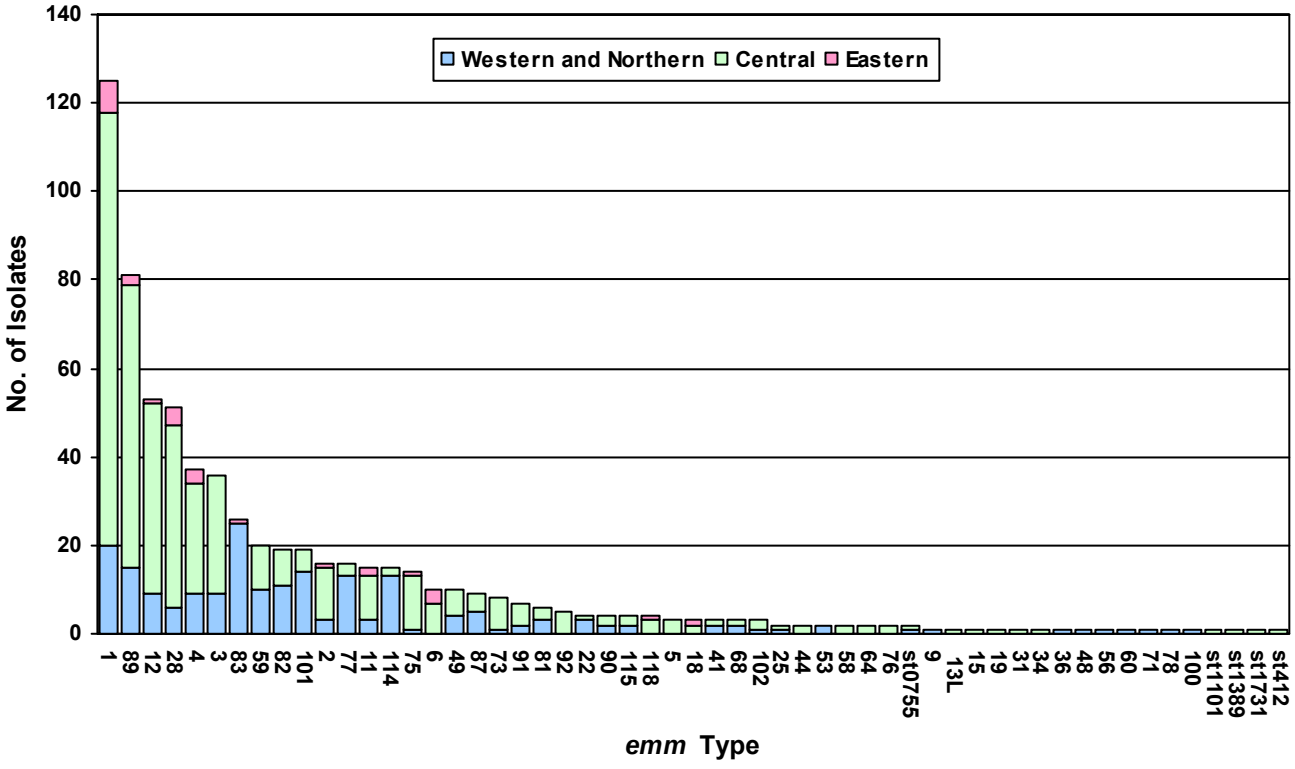


Figure 11. Prevalent *Streptococcus pyogenes* *emm* Types isolated from children 0 to 14 years of age

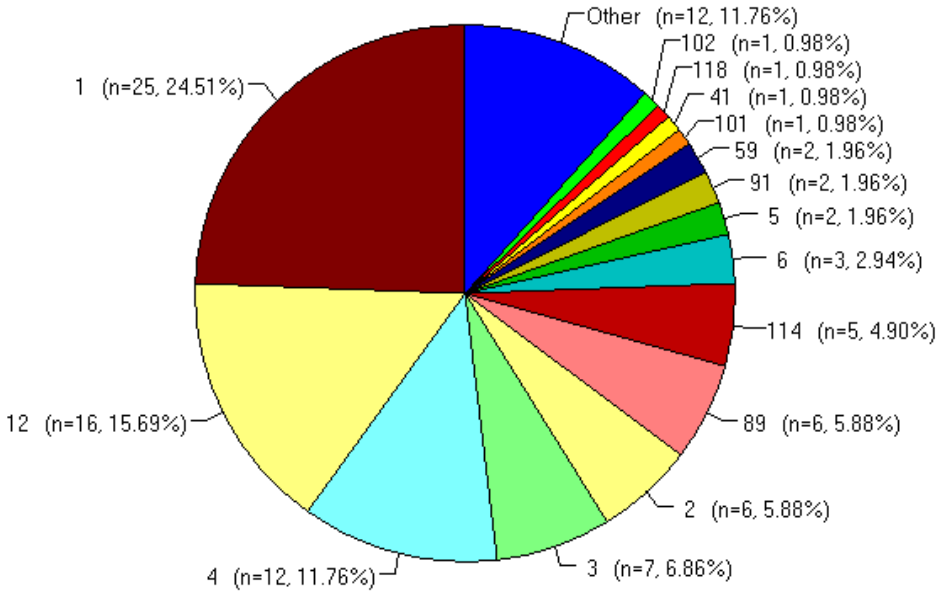


Figure 12. Prevalent *Streptococcus pyogenes* *emm* Types isolated from adults 15 to 64 years of age

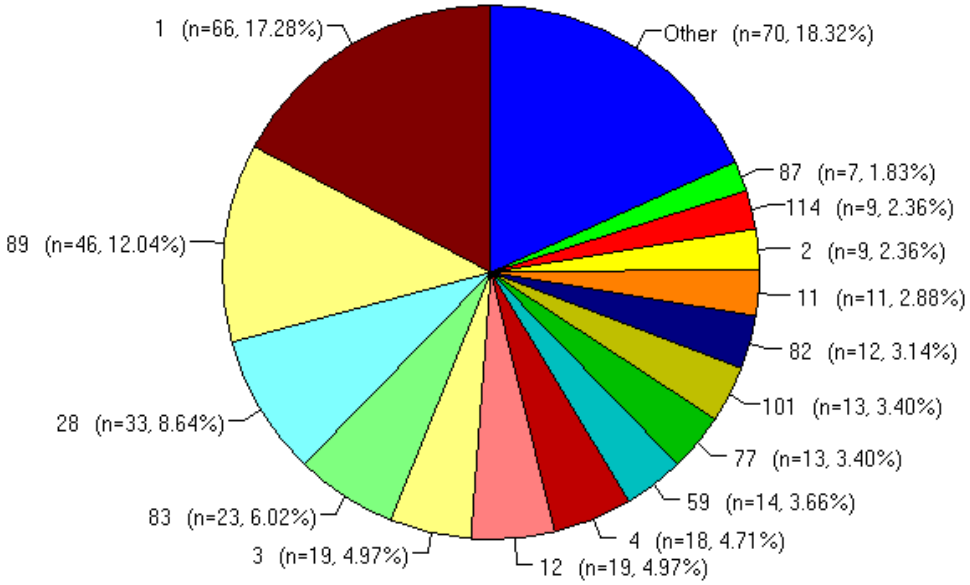


Figure 13. Prevalent *Streptococcus pyogenes emm* Types isolated from seniors 65 years of age and over

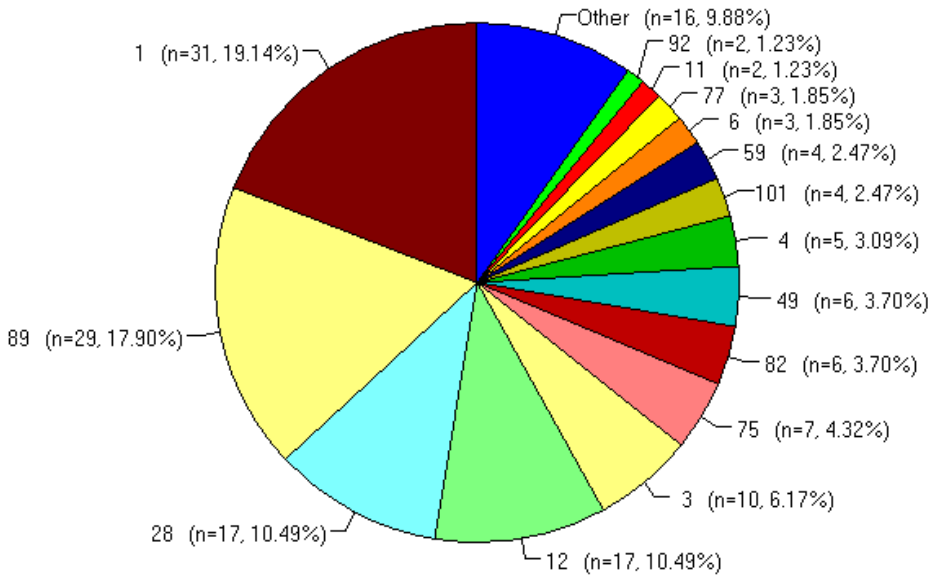
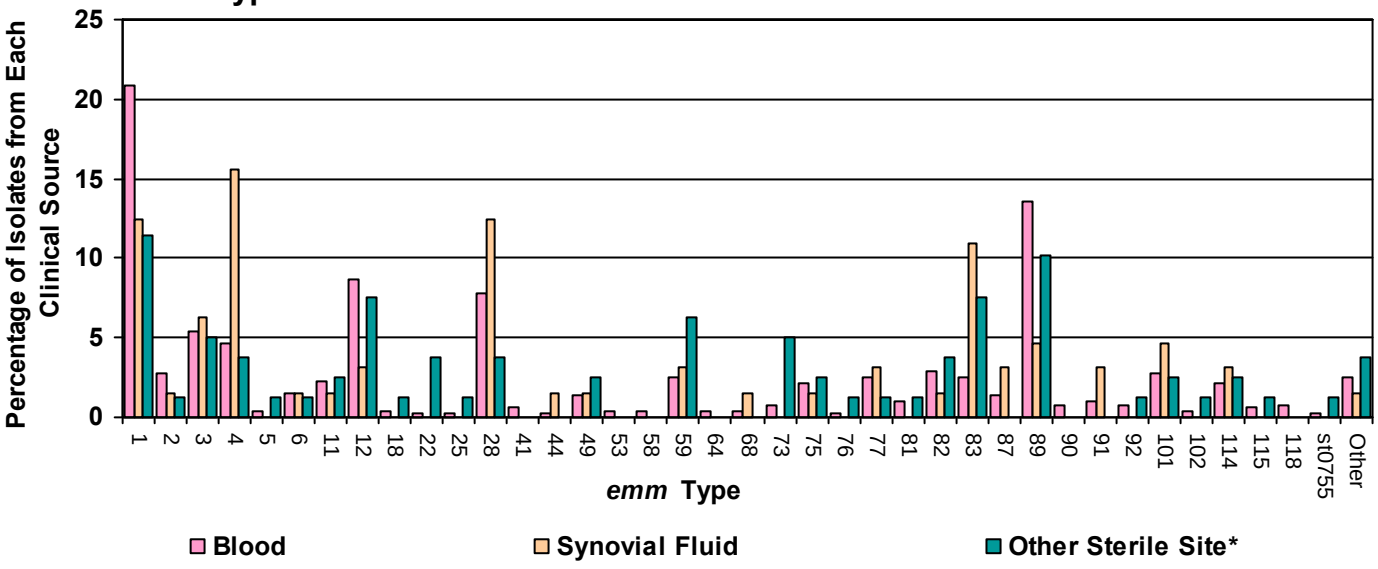


Figure 14. Source distribution of prevalent *Streptococcus pyogenes emm* Types



*Other sterile sites include CSF, biopsy tissue, necrotizing fasciitis tissue, internal/deep tissue body or surgical sites.

Conclusion

The effectiveness of the 7-valent pneumococcal vaccine (PCV7) in lowering rates of disease attributed to the constituent serotypes may be tempered by increases in disease resulting from other non-vaccine serotypes. With the recent introduction of the 13-valent (PCV13) vaccine, a similar decrease in two prevalent serotypes 7F and 19A in children may be observed in the future. However, due to limitation in the number of serotypes that can be included in an effective multi-valent vaccine, a concurrent rise in non-vaccine serotypes may occur. Although eradication of disease caused by *S. pneumoniae* may not be a realistic goal, the continued monitoring of the relative prevalence of serotypes circulating in the Canadian population will help inform and guide the development and composition of new vaccines which will lower the total burden of disease.

Due to the severity, high risk of infection and heightened public awareness of *S. pyogenes*, the continued monitoring and surveillance of circulating types is important to help identify outbreaks of disease and to inform and guide public health interventions associated with this re-emergent organism.

Appendices

Appendix A: Serotypes of *Streptococcus pneumoniae* reported by NML April 1 – December 31, 2010

Serotype	Age Group	Western	Central	Eastern	Canada
1	2 - 4 yrs	1	-	-	**1**
	15 - 64 yrs	1	-	-	**1**
	>65 yrs	1	-	-	**1**
	Subtotal	3	-	-	**3**
3	<2 yrs	3	1	-	**4**
	5 - 14 yrs	1	1	1	**3**
	15 - 64 yrs	12	17	1	**30**
	>65 yrs	12	14	1	**27**
	Not Given	-	1	-	**1**
	Subtotal	28	34	3	**65**
4	5 - 14 yrs	2	-	-	**2**
	15 - 64 yrs	14	5	1	**20**
	>65 yrs	4	5	1	**10**
	Subtotal	20	10	2	**32**
5	<2 yrs	1	-	-	**1**
	2 - 4 yrs	1	-	-	**1**
	5 - 14 yrs	1	-	-	**1**
	15 - 64 yrs	3	1	-	**4**
	Subtotal	6	1	-	**7**
6A	<2 yrs	1	-	-	**1**
	2 - 4 yrs	-	1	-	**1**
	15 - 64 yrs	1	5	1	**7**
	>65 yrs	1	6	-	**7**
	Not Given	-	1	-	**1**
	Subtotal	3	13	1	**17**
6B	5 - 14 yrs	-	-	1	**1**
	15 - 64 yrs	-	-	2	**2**
	>65 yrs	1	1	-	**2**
	Not Given	-	1	-	**1**
	Subtotal	1	2	3	**6**
6C	<2 yrs	4	1	1	**6**
	15 - 64 yrs	11	7	3	**21**
	>65 yrs	7	25	3	**35**
	Subtotal	22	33	7	**62**
7A	15 - 64 yrs	1	-	-	**1**
	Subtotal	1	-	-	**1**
7C	2 - 4 yrs	-	1	-	**1**
	5 - 14 yrs	-	1	-	**1**
	15 - 64 yrs	-	1	-	**1**
	>65 yrs	-	2	-	**2**

Serotype	Age Group	Western	Central	Eastern	Canada
	Subtotal	-	5	-	**5**
7F	<2 yrs	3	4	5	**12**
	2 - 4 yrs	1	4	1	**6**
	5 - 14 yrs	3	6	3	**12**
	15 - 64 yrs	21	83	7	**111**
	>65 yrs	11	32	7	**50**
	Not Given	1	1	-	**2**
	Subtotal	40	130	23	**193**
8	<2 yrs	2	-	-	**2**
	15 - 64 yrs	10	7	2	**19**
	>65 yrs	5	2	1	**8**
	Not Given	1	-	-	**1**
	Subtotal	18	9	3	**30**
9A	>65 yrs	-	1	-	**1**
	Subtotal	-	1	-	**1**
9N	15 - 64 yrs	3	3	-	**6**
	>65 yrs	4	10	-	**14**
	Subtotal	7	13	-	**20**
9V	15 - 64 yrs	1	1	-	**2**
	>65 yrs	3	3	-	**6**
	Subtotal	4	4	-	**8**
10A	<2 yrs	-	2	-	**2**
	2 - 4 yrs	1	-	-	**1**
	5 - 14 yrs	-	1	1	**2**
	15 - 64 yrs	4	1	-	**5**
	>65 yrs	5	3	1	**9**
	Subtotal	10	7	2	**19**
10B	15 - 64 yrs	-	1	-	**1**
	Subtotal	-	1	-	**1**
10F	15 - 64 yrs	1	-	-	**1**
	Subtotal	1	-	-	**1**
11A	<2 yrs	2	-	-	**2**
	2 - 4 yrs	2	-	-	**2**
	5 - 14 yrs	1	-	-	**1**
	15 - 64 yrs	6	8	-	**14**
	>65 yrs	7	8	-	**15**
	Subtotal	18	16	-	**34**
11B	15 - 64 yrs	1	-	-	**1**
	>65 yrs	-	1	-	**1**
	Subtotal	1	1	-	**2**
12F	<2 yrs	3	-	-	**3**
	15 - 64 yrs	24	16	-	**40**
	>65 yrs	6	4	-	**10**
	Not Given	2	1	-	**3**
	Subtotal	35	21	-	**56**
13	15 - 64 yrs	1	-	-	**1**
	>65 yrs	-	1	-	**1**
	Subtotal	1	1	-	**2**
14	<2 yrs	2	-	-	**2**
	15 - 64 yrs	4	-	1	**5**

Serotype	Age Group	Western	Central	Eastern	Canada
	>65 yrs	3	1	1	**5**
	Subtotal	9	1	2	**12**
15A	<2 yrs	2	4	-	**6**
	2 - 4 yrs	1	4	2	**7**
	15 - 64 yrs	8	6	-	**14**
	>65 yrs	3	17	2	**22**
	Not Given	1	1	-	**2**
	Subtotal	15	32	4	**51**
15B	<2 yrs	2	1	1	**4**
	2 - 4 yrs	-	3	-	**3**
	15 - 64 yrs	1	1	1	**3**
	>65 yrs	1	7	2	**10**
	Subtotal	4	12	4	**20**
15C	<2 yrs	-	2	-	**2**
	5 - 14 yrs	-	1	2	**3**
	15 - 64 yrs	1	2	-	**3**
	>65 yrs	1	3	1	**5**
	Not Given	-	1	-	**1**
	Subtotal	2	9	3	**14**
16F	15 - 64 yrs	6	7	1	**14**
	>65 yrs	1	10	-	**11**
	Subtotal	7	17	1	**25**
17A	15 - 64 yrs	1	-	-	**1**
	Subtotal	1	-	-	**1**
17F	15 - 64 yrs	1	2	-	**3**
	>65 yrs	5	4	-	**9**
	Not Given	-	1	-	**1**
	Subtotal	6	7	-	**13**
18B	15 - 64 yrs	-	-	1	**1**
	Subtotal	-	-	1	**1**
18C	5 - 14 yrs	1	-	1	**2**
	15 - 64 yrs	3	2	2	**7**
	>65 yrs	3	2	1	**6**
	Subtotal	7	4	4	**15**
18F	15 - 64 yrs	-	1	-	**1**
	Subtotal	-	1	-	**1**
19A	<2 yrs	9	7	5	**21**
	2 - 4 yrs	4	3	2	**9**
	5 - 14 yrs	2	2	1	**5**
	15 - 64 yrs	20	23	5	**48**
	>65 yrs	25	29	5	**59**
	Not Given	-	5	1	**6**
	Subtotal	60	69	19	**148**
19F	<2 yrs	1	1	1	**3**
	15 - 64 yrs	1	2	2	**5**
	>65 yrs	3	1	2	**6**
	Not Given	-	-	1	**1**
	Subtotal	5	4	6	**15**
20	15 - 64 yrs	2	1	-	**3**
	>65 yrs	4	1	-	**5**

Serotype	Age Group	Western	Central	Eastern	Canada
	Not Given	-	1	-	**1**
	Subtotal	6	3	-	**9**
21	<2 yrs	1	-	-	**1**
	2 - 4 yrs	-	1	-	**1**
	Subtotal	1	1	-	**2**
22A	15 - 64 yrs	-	1	-	**1**
	>65 yrs	1	-	-	**1**
	Subtotal	1	1	-	**2**
22F	<2 yrs	1	3	-	**4**
	2 - 4 yrs	-	1	-	**1**
	5 - 14 yrs	-	1	-	**1**
	15 - 64 yrs	10	16	4	**30**
	>65 yrs	11	25	6	**42**
	Not Given	2	3	-	**5**
	Subtotal	24	49	10	**83**
23A	5 - 14 yrs	-	-	1	**1**
	15 - 64 yrs	1	3	-	**4**
	>65 yrs	4	5	3	**12**
	Subtotal	5	8	4	**17**
23B	5 - 14 yrs	4	-	2	**6**
	15 - 64 yrs	6	2	1	**9**
	>65 yrs	2	5	2	**9**
	Not Given	1	-	-	**1**
	Subtotal	13	7	5	**25**
23F	15 - 64 yrs	5	1	-	**6**
	>65 yrs	-	3	-	**3**
	Not Given	-	1	-	**1**
	Subtotal	5	5	-	**10**
24F	<2 yrs	-	1	-	**1**
	Subtotal	-	1	-	**1**
29	2 - 4 yrs	1	-	-	**1**
	>65 yrs	-	1	-	**1**
	Subtotal	1	1	-	**2**
31	15 - 64 yrs	2	1	-	**3**
	Subtotal	2	1	-	**3**
33A	<2 yrs	1	2	-	**3**
	2 - 4 yrs	1	-	-	**1**
	15 - 64 yrs	1	1	1	**3**
	>65 yrs	-	-	1	**1**
	Subtotal	3	3	2	**8**
33F	<2 yrs	1	1	-	**2**
	5 - 14 yrs	-	1	-	**1**
	15 - 64 yrs	-	11	-	**11**
	>65 yrs	3	2	1	**6**
	Subtotal	4	15	1	**20**
34	15 - 64 yrs	2	2	-	**4**
	>65 yrs	1	-	1	**2**
	Subtotal	3	2	1	**6**
35A	15 - 64 yrs	2	-	-	**2**
	>65 yrs	1	-	-	**1**

Serotype	Age Group	Western	Central	Eastern	Canada
	Subtotal	3	-	-	**3**
35B	<2 yrs	2	-	-	**2**
	15 - 64 yrs	1	4	-	**5**
	>65 yrs	2	2	-	**4**
	Subtotal	5	6	-	**11**
35F	15 - 64 yrs	1	3	1	**5**
	>65 yrs	2	9	3	**14**
	Not Given	1	-	-	**1**
	Subtotal	4	12	4	**20**
37	>65 yrs	-	1	-	**1**
	Subtotal	-	1	-	**1**
38	>65 yrs	2	-	-	**2**
	Subtotal	2	-	-	**2**
NT	<2 yrs	-	1	-	**1**
	5 - 14 yrs	-	1	-	**1**
	15 - 64 yrs	2	6	1	**9**
	>65 yrs	3	3	-	**6**
	Not Given	1	-	-	**1**
	Subtotal	6	11	1	**18**
Total		**423**	**585**	**116**	**1124**

Appendix B: *Emm* and T-Types of *Streptococcus pyogenes* (Group A *Streptococcus*) reported by NML April 1 to December 31, 2010

emm Type	T-Type	Western	Central	Eastern	Canada
1	NT	-	3	-	**3**
	T1	20	95	7	**122**
	Subtotal	20	98	7	**125**
2	T2	3	7	1	**11**
	T2/28	-	4	-	**4**
	T28	-	1	-	**1**
	Subtotal	3	12	1	**16**
3	NT	1	3	-	**4**
	T3	-	1	-	**1**
	T3/13/B3264	8	23	-	**31**
	Subtotal	9	27	-	**36**
4	NT	1	3	-	**4**
	T4	8	22	3	**33**
	Subtotal	9	25	3	**37**
5	NT	-	1	-	**1**
	T5/27/44	-	2	-	**2**
	Subtotal	-	3	-	**3**
6	NT	-	1	-	**1**
	T6	-	6	3	**9**
	Subtotal	-	7	3	**10**
9	T9	1	-	-	**1**
	Subtotal	1	-	-	**1**
11	NT	-	4	-	**4**
	T11	3	5	2	**10**
	T8/25/Imp.19	-	1	-	**1**
	Subtotal	3	10	2	**15**
12	NT	1	3	-	**4**
	T12	8	40	1	**49**
	Subtotal	9	43	1	**53**
13L	T3/13/B3264	-	1	-	**1**
	Subtotal	-	1	-	**1**
15	T14	-	1	-	**1**
	Subtotal	-	1	-	**1**
18	NT	-	2	1	**3**
	Subtotal	-	2	1	**3**
19	NT	-	1	-	**1**
	Subtotal	-	1	-	**1**
22	NT	3	-	-	**3**
	T12	-	1	-	**1**
	Subtotal	3	1	-	**4**
25	NT	-	1	-	**1**
	T1	1	-	-	**1**
	Subtotal	1	1	-	**2**
28	NT	-	6	-	**6**
	T28	4	32	3	**39**

emm Type	T-Type	Western	Central	Eastern	Canada
	T28/8	1	3	1	**5**
	T3/13/B3264	1	-	-	**1**
	Subtotal	6	41	4	**51**
31	T8/25/Imp.19	-	1	-	**1**
	Subtotal	-	1	-	**1**
34	NT	-	1	-	**1**
	Subtotal	-	1	-	**1**
36	NT	1	-	-	**1**
	Subtotal	1	-	-	**1**
41	NT	1	-	-	**1**
	T3/13/B3264	1	1	-	**2**
	Subtotal	2	1	-	**3**
44	NT	-	1	-	**1**
	T5/27/44	-	1	-	**1**
	Subtotal	-	2	-	**2**
48	T4/28	1	-	-	**1**
	Subtotal	1	-	-	**1**
49	NT	2	2	-	**4**
	T14	2	4	-	**6**
	Subtotal	4	6	-	**10**
53	NT	1	-	-	**1**
	T3/13/B3264	1	-	-	**1**
	Subtotal	2	-	-	**2**
56	NT	1	-	-	**1**
	Subtotal	1	-	-	**1**
58	T2	-	2	-	**2**
	Subtotal	-	2	-	**2**
59	NT	2	2	-	**4**
	T11	8	7	-	**15**
	T8/25/Imp.19	-	1	-	**1**
	Subtotal	10	10	-	**20**
60	T4	1	-	-	**1**
	Subtotal	1	-	-	**1**
64	T8/14	-	2	-	**2**
	Subtotal	-	2	-	**2**
68	NT	-	1	-	**1**
	T12	2	-	-	**2**
	Subtotal	2	1	-	**3**
71	NT	1	-	-	**1**
	Subtotal	1	-	-	**1**
73	T3/13/B3264	1	7	-	**8**
	Subtotal	1	7	-	**8**
75	T25	1	12	1	**14**
	Subtotal	1	12	1	**14**
76	T12	-	2	-	**2**
	Subtotal	-	2	-	**2**
77	NT	3	1	-	**4**
	T13/28/9	-	2	-	**2**
	T2/8/25/Imp.19	7	-	-	**7**
	T8/25/Imp.19	3	-	-	**3**

emm Type	T-Type	Western	Central	Eastern	Canada
	Subtotal	13	3	-	**16**
78	NT	1	-	-	**1**
	Subtotal	1	-	-	**1**
81	NT	-	1	-	**1**
	T3/13/B3264	2	2	-	**4**
	T8/25/Imp.19	1	-	-	**1**
	Subtotal	3	3	-	**6**
82	NT	2	1	-	**3**
	T5/27/44	9	7	-	**16**
	Subtotal	11	8	-	**19**
83	NT	1	-	1	**2**
	T3/13/B3264	19	-	-	**19**
	T8/25/Imp.19	5	-	-	**5**
	Subtotal	25	-	1	**26**
87	NT	-	1	-	**1**
	T28	5	3	-	**8**
	Subtotal	5	4	-	**9**
89	NT	1	7	-	**8**
	T11	-	4	-	**4**
	T3/13/B3264	14	53	2	**69**
	Subtotal	15	64	2	**81**
90	T3/13/B3264	2	2	-	**4**
	Subtotal	2	2	-	**4**
91	NT	1	1	-	**2**
	T28	1	1	-	**2**
	T28/8	-	1	-	**1**
	T8/25/Imp.19	-	2	-	**2**
	Subtotal	2	5	-	**7**
92	TImp.19	-	5	-	**5**
	Subtotal	-	5	-	**5**
100	NT	1	-	-	**1**
	Subtotal	1	-	-	**1**
101	NT	5	2	-	**7**
	T3/13/B3264	6	3	-	**9**
	T8/25/Imp.19	3	-	-	**3**
	Subtotal	14	5	-	**19**
102	NT	1	-	-	**1**
	T3/13/B3264	-	2	-	**2**
	Subtotal	1	2	-	**3**
114	NT	9	-	-	**9**
	T3/13/B3264	4	2	-	**6**
	Subtotal	13	2	-	**15**
115	T8/25/Imp.19	2	2	-	**4**
	Subtotal	2	2	-	**4**
118	NT	-	-	1	**1**
	T3/13/B3264	-	3	-	**3**
	Subtotal	-	3	1	**4**
st0755	T3/13/B3264	1	1	-	**2**
	Subtotal	1	1	-	**2**
st11014	T2/8/25/Imp.19	-	1	-	**1**

emm Type	T-Type	Western	Central	Eastern	Canada
	Subtotal	-	1	-	**1**
st1389	T3/B3264/9	-	1	-	**1**
	Subtotal	-	1	-	**1**
st1731	T4	-	1	-	**1**
	Subtotal	-	1	-	**1**
st412	T1	-	1	-	**1**
	Subtotal	-	1	-	**1**
Total		**200**	**433**	**27**	**660**

References

[1] Schuchat A, Robinson K, Wenger JD, Harrison LH, Farley M, Reingold AL, *et al*. Bacterial meningitis in the United States in 1995. Active Surveillance Team. 1997. N Engl J Med;337(October (14)):970–6.

[2] Marchessault V, editor. Canadian immunization guide. 6th ed. Ottawa: Canadian Medical Association; 2002.

[3] Robinson KA, Baughman W, Rothrock G, Barrett NL, Pass M, Lexau C, *et al*. Epidemiology of invasive *Streptococcus pneumoniae* infections in the United States, 1995–1998: opportunities for prevention in the conjugate vaccine era. JAMA. 2001(April). 285(13):1729–35.

[4] Scott JA, Hall AJ, Dagan R, Dixon JM, Eykyn SJ, Fenoll A, et al. Serogroup-specific epidemiology of *Streptococcus pneumoniae*: associations with age, sex, and geography in 7,000 episodes of invasive disease. 1996 (June). Clin Infect Dis. 22(6):973–81.

[5] Kellner JD, Vanderkooi OG, MacDonald J, Church DL, Tyrrell GJ, Scheifele DW. Changing epidemiology of invasive pneumococcal disease in Canada, 1998-2007: update from the Calgary-area Streptococcus pneumoniae research (CASPER) study. 2009 (July). Clin Infect Dis. 49(2):205-12.

[6] Weinberger DM, Malley R, Lipsitch M. Serotype replacement in disease after pneumococcal vaccination. 2011 (April). The Lancet, Available online ISSN 0140-6736, DOI: 10.1016/S0140-6736(10)62225-8. (http://www.sciencedirect.com/science/article/B6T1B-52M217X-4/2/f3141605bd8e55b78bbc1df8f2dd8677)

[7] McIntosh ED, Reinert RR. Global prevailing and emerging pediatric pneumococcal serotypes. 2011 (Jan). Expert Rev Vaccines. 10(1):109-29.

[8] Tyrrell GJ, Lovgren M, Chui N *et al*. Serotypes and antimicrobial susceptibilities of invasive Streptococcus pneumoniae pre- and post-seven valent pneumococcal conjugate vaccine introduction in Alberta, Canada 2000-2006. 2009. Vaccine; 27: 3553-3560.

[9] An Advisory Committee Statement (ACS), National Advisory Committee on Immunization (NACI). Statement on recommended use of pneumococcal conjugate vaccine. 2002 (January). Can Commun Dis Rep;28(Pt 2):1–32.

[10] Bettinger JA, Scheifelea DW, Kellner JD, et. al. The effect of routine vaccination on invasive pneumococcal infections in Canadian children, Immunization Monitoring Program, Active 2000–2007. 2010. Vaccine; 28: 2130–2136.

[11] Merck & Co., Inc., Whitehouse Station, NJ 08889, USA. Pneumovax ® 23 (Pneumococcal vaccine polyvalent). Available: http://www.merck.com/product/usa/pi_circulars/p/pneumovax_23/pneumovax_pi.pdf

[12] Cunningham MW. Pathogenesis of Group A Streptococcal Infections. 2000 (July) Clin. Micro. Rev.; 470-511.

[13] Siljander T, Lyytikäinen O, Vähäkuopus S, *et al.* Epidemiology, outcome and emm types of invasive group A streptococcal infections in Finland. 2010. Eur J Clin Microbiol Infect Dis; 29: 1229-1235.

[14] Schwartz B, Facklam RR, Breiman RF. Changing epidemiology of group A streptococcal infection in the USA. 1990. Lancet 336:1167-1171.

[15] Spellerberg, B and Brandt, C.*Streptococcus* In: Murray PR, Baron EL, Jorgensen JH, Landry ML, Pfaller MA. editors. *Manual of clinical microbiology*. 9th ed. Washington: American Society for Microbiology; 2007. p. 412-429.

[16] Case Definitions for Communicable Diseases under National Surveillance - 2009**.** 2009**.** Can Commun Dis Rep;35s2. Available: http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/09vol35/35s2/Pneumoco-eng.php

[17] Minnesota Deptarment of Health, Infectious Disease Epidemiology, Prevention and Control Division. Available: http://www.helath.state.nm.us/divs/idepc/dtopics/invbacterial/sterile.html.

[18] Austrian R. The Quellung reaction, a neglected microbiological technique. 1976. Mt. Sinai J. Med. 43:699–709.

[19] Lovgren M, Spika JS, Talbot JA. Invasive *Streptococcus pneumoniae* infections: serotype distribution and antimicrobial resistance in Canada, 1992–1995.1998 (February). CMAJ;158(3):327–31.

[20] Drancourt M, Roux V, Fournier P E, Raoult D. *rpoB* Gene Sequence-Based Identification of Aerobic Gram-Positive Cocci of the Genera *Streptococcus*, *Enterococcus*, *Gemella*, *Abiotrophia* and *Granulicatella*. 2004 (February). J. Clin. Micro. 42(2): 497-504.

[21] Clinical Laboratory Standards Institute. Interpretative Criteria for Identification of Bacteria and Fungi by DNA Target Sequencing, Approved Guideline. 2008. MM18-A; 28(12): 21-24.

[22] National Advisory Committee on Immunization (NACI). Update on Pediatric Invasive Pneumococcal Disease and Recommended Use of Conjugate Pneumococcal Vaccines. CCDR 2010 – Vol. 36, Advisory Committee Statement (ACS-3). April 2010. Available: http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/10vol36/acs-3/index-eng.php.