Arctic Council Ministerial Report
April 2009

International Circumpolar Surveillance: Prevention and Control of Infectious Diseases: 1999-2008

Summary

Human health is a critical component of any sustainable development program. Sustainable economic development is frequently accompanied by changes in a number of factors, which impact human health and promote the emergence of infectious disease problems. With increased air travel and international trade Arctic communities are no longer isolated from infectious disease threats. Circumpolar surveillance of infectious diseases may serve as an early warning system of emerging threats and provide increased capacity to monitor the effectiveness of public health control measures.

The purpose of this Sustainable Development Working Group project is to establish an integrated International Circumpolar Surveillance (ICS) system for infectious diseases by creating a network of hospital and public health laboratories throughout the Arctic. The network would allow collection and sharing of uniform laboratory and epidemiologic data between Arctic countries that will describe the prevalence of infectious diseases of concern to Arctic residents and assist in the formulation of prevention and control strategies.

The ICS network was established in 1999, first linking clinical and public health laboratories in the U.S. Arctic (Alaska), and northern Canada for the surveillance of invasive diseases caused by *Streptococcus pneumoniae*. Greenland, joined the pneumococcal surveillance network in 2000, followed by Iceland, Norway and Finland in 2001, and the northern Swedish country of Norbotten in 2003. In 2000, expanded surveillance of other invasive bacterial diseases caused by *Haemophilus influenzae, Neisseria meningitidis*, and groups A and B streptococcus was implemented in the U.S. Arctic and northern Canada; Greenland began expanded reporting in 2001 and N. Sweden in 2003. Surveillance of invasive disease caused by these bacteria was chosen because rates of these diseases are elevated in indigenous peoples of the north, strains of these bacteria may acquire antibiotic resistance, these bacteria are routine cultured in the clinical laboratory, and diseases caused by clinically important serotypes of *Streptococcus pneumoniae*, *Haemophilus influenzae* and *Neisseria meningitidis* are vaccine preventable.

Rates of invasive pneumococcal disease for the period 1999-2006 were higher in Alaska Native and northern Canadian Aboriginal populations than in non-Native and non-Aboriginal populations. The highest rates occur in Native and Aboriginal children under the age of two years. Analysis of pneumococcal serotypes causing disease in Arctic North American populations indicates that between 86-93% of invasive pneumococcal disease could potentially be prevented. In the U.S. Arctic (Alaska), statewide use of the infant 7-valent conjugate vaccine began in 2001. Immunization programs using both the 23-valent adult vaccine and the 7-valent conjugate vaccine were begun in two northern Canadian regions in 2002 and have since been

initiated in all northern Canadian regions. Continued surveillance of invasive pneumococcal disease in these regions will monitor the impact and effectiveness of these vaccine programs.

Surveillance of invasive diseases caused by *Haemophilus influenzae*, *Neisseria meningitidis*, and groups A and B *Streptococcus* were undertaken in the U.S. Arctic, northern Canada, Greenland and N. Sweden in 2000-2006. Norway provided *Neisseria meningitidis* data beginning in 2005 and *Haemophilus influenzae* data beginning in 2006.

Prior to 1991, rates of invasive *Haemophilus influenzae* type b disease in the U.S. Arctic were among the highest in the world, however since the introduction of conjugate vaccine programs in 1991, the rates of invasive *Haemophilus influenzae* type b disease have declined by 92%. Universal vaccine programs for invasive *Haemophilus influenzae* type b disease began in Canada in 1992 and there have been similar reductions in rates of invasive disease caused by *Haemophilus influenzae* type b. Surveillance in 2000-2006 show that overall rates of *Haemophilus influenzae* type b remain elevated in the U.S. Arctic when compared to the general U.S. population. The most common serotype in northern Canada was serotype a. Non-typeable *Haemophilus influenzae* comprised the largest proportion of cases in Norway and the U.S. Arctic.

Continued surveillance for invasive diseases caused by all serotypes of *Haemophilus influenzae* in Arctic countries is important to be able to monitor the impact of conjugate vaccine programs and to monitor the potential emergence of other serotypes that may replace *Haemophilus influenzae* type b as a major cause of severe diseases in Arctic populations.

Similarly, surveillance of diseases caused by *Neisseria meningitidis* showed that in the U.S. Arctic, the highest rates of disease occurred in Alaska Native children less than two years old (14/100,000). The majority of *Neisseria meningitidis* isolates serogrouped in all countries were serogroup B followed by Y (Norway and the U.S. Arctic) or C (Greenland and N. Canada). As in the case of *Streptococcus pneumoniae* and *Haemophilus influenzae*, continued surveillance of invasive diseases caused by *Neisseria meningitidis* allows for the monitoring of disease trends in populations, the detection of clusters of disease, and provides serogroup information critical for vaccine recommendations.

ICS continued surveillance of invasive bacterial diseases and related quality control programs in the US Arctic, northern Canada, Greenland, Iceland, Norway, Finland and northern Sweden during 2007-2008. A number of new ICS activities were undertaken during the Norwegian Chairmanship as part of the International Polar Year's Arctic Human Health Initiative. These included:

Reports of ICS activities (1999-2005 data) were published in the January 2008 issue of *Emerging Infectious Diseases* (www.cdc.gov/eid/content/14/1/contents_v14n1.htm). ICS papers include:

- The International Polar Year, 2007-2008., An opportunity to focus on Infectious Diseases in Arctic regions. Parkinson, AJ. Emerg. Infect Dis J. 2008. 14 (1) 1-3.

- International Circumpolar Surveillance, an Arctic network for surveillance of infectious diseases. Parkinson, AJ., Bruce MG, Zulz T . Emerg. Infect Dis J. 2008. 14 (1) 18-24.

- International Circumpolar Surveillance for invasive pneumococcal disease, 1999-2005. Bruce, MG., Deeks, SL., Zulz, T., Druden, D., Navarro C., Lovegren, M., Jette, L., Kristinsson, K, Sigmundsdottir, G., Jensen, KB., Lovoll, O., Nuorti JP., Herva E., Nystedt, A., Sjostedt, A., Koch., Hennessey TW., Parkinson, AJ. Emerg. Infect Dis J. 2008. 14 (1) 25-33.

- Epidemiology of Haemophilus influenzae serotype a, North American Arctic, 2000-2005. Bruce, MG., Deeks, SL., Zulz, T., Navarro, C., Palacious, C., Case, C., Hemsley C., Hennessy, T., Corriveau, A., Larke, B., Sobel, I., Lovegren M., DeByle C., Tsang R., Parkinson AJ. Emerg. Infect Dis J. 2008. 14 (1) 48-55

- Invasive Bacterial Diseases in Northern Canada. Naushaba Degani, Christine Navarro, Shelley L. Deeks, Marguerite Lovgren, and the Canadian International Circumpolar Surveillance Working Group. Emerg. Infect Dis J. 2008. 14 (1) 34-40

An ICS Tuberculosis Working Group was established with participation from the US, Canada, Greenland/Denmark and the Russian Federation (lead country Canada).

The ICS Viral Hepatitis Research Working Group established in Novosibirsk, Russian Federation, June 16, 2006, conducted meetings in Copenhagen, Denmark, October 16-17, 2007, and September 16-17, 2008. The purpose of this working group is to coordinate collaborative viral hepatitis research activities in circumpolar countries.

An ICS *Helicobacter pylori* Working Group was established and conducted a meetings in Copenhagen, Denmark, October 18, 2007, and September 18, 2008. The purpose of this working group is to coordinate collaborative research activities on *Helicobacter pylori* infections and diseases in circumpolar countries.

An ICS Sexually Transmitted Infections Working Group will be established following a working group meeting on Alaska Native Inuit, First Nations and Metis that was held in Anchorage, Alaska, US, April 16-17, 2008. A follow-up meeting is expected to occur at the 14th International Congress on Circumpolar Health, July 12-16, 2009, Yellowknife, NWT Canada.

Together with the Northern Forum, ICS conducted a workshop on Infectious Diseases and Surveillance Methods, in Moscow April 24-26, 2008. This workshop was attended by infectious disease experts from Moscow and 12 northern regions of the Russian Federation. The purpose of this workshop was to explore potential linkages, and sharing of surveillance information between public health authorities in northern regions of the Russian Federation and ICS participating countries.

A major objective of the IPY is the establishment of well-coordinated and Sustained Arctic Observing Networks (SAON) (www.arcticobserving.org). ICS represents an international circumpolar collaborative information system for infectious diseases and potentially could be considered a model SAON for human health. This concept was presented at the Sustainable Arctic Observing Networks II meeting in Edmonton, Alberta, Canada. April 9-11, 2008.

Plans for 2009-2010 include

- Continue surveillance of invasive bacterial diseases and related quality control programs in the US Arctic, northern Canada, Greenland, Iceland, Norway, Finland and northern Sweden during 2009-2010.

- Initiate standardized collection of tuberculosis data in the US Arctic, northern Canada and Greenland.

- Explore potential mechanisms for sharing of infectious disease surveillance information between public health authorities in northern regions of the Russian Federation and ICS participating countries.

- Coordination of Hepatitis and *Helicobacter pylori* research activities will continue.

- Formation of a circumpolar Sexually Transmitted Infections working group to explore collaborative research and intervention activities in circumpolar countries.

- Expansion of ICS to include non-infectious disease problems important in Arctic communities. It is anticipated that an ICS surveillance system for Birth Defects will be established in 2009 (lead country Canada).

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Introduction

Arctic populations have long endured the debilitating effects of endemic and epidemic infectious diseases, the effects of which have impacted social and economic development in circumpolar regions of the globe (Parkinson, Bruce et al. 2008). Because infectious diseases are a global threat, their prevention and control is aided by international collaboration; global surveillance is a critical component of this effort.

The International Circumpolar Surveillance project was established in 1998 and aims to create an infectious disease surveillance network of hospital and public health laboratories and authorities throughout Arctic regions: the U.S. Arctic (Alaska), northern Canada, Greenland, Iceland, Norway, Finland, Sweden and the northern regions and Oblasts of the Russian Federation. ICS allows for the collection, comparison and sharing of uniform laboratory and epidemiologic data on infectious diseases of concern, and assists in the formulation of prevention and control strategies.

Early goals for ICS were to identify collaborators with expertise in infectious disease prevention and control and public health in Arctic regions and to develop political support for the establishment of an international network. These goals were achieved through the engagement of the International Union for Circumpolar Health and the Arctic Council.

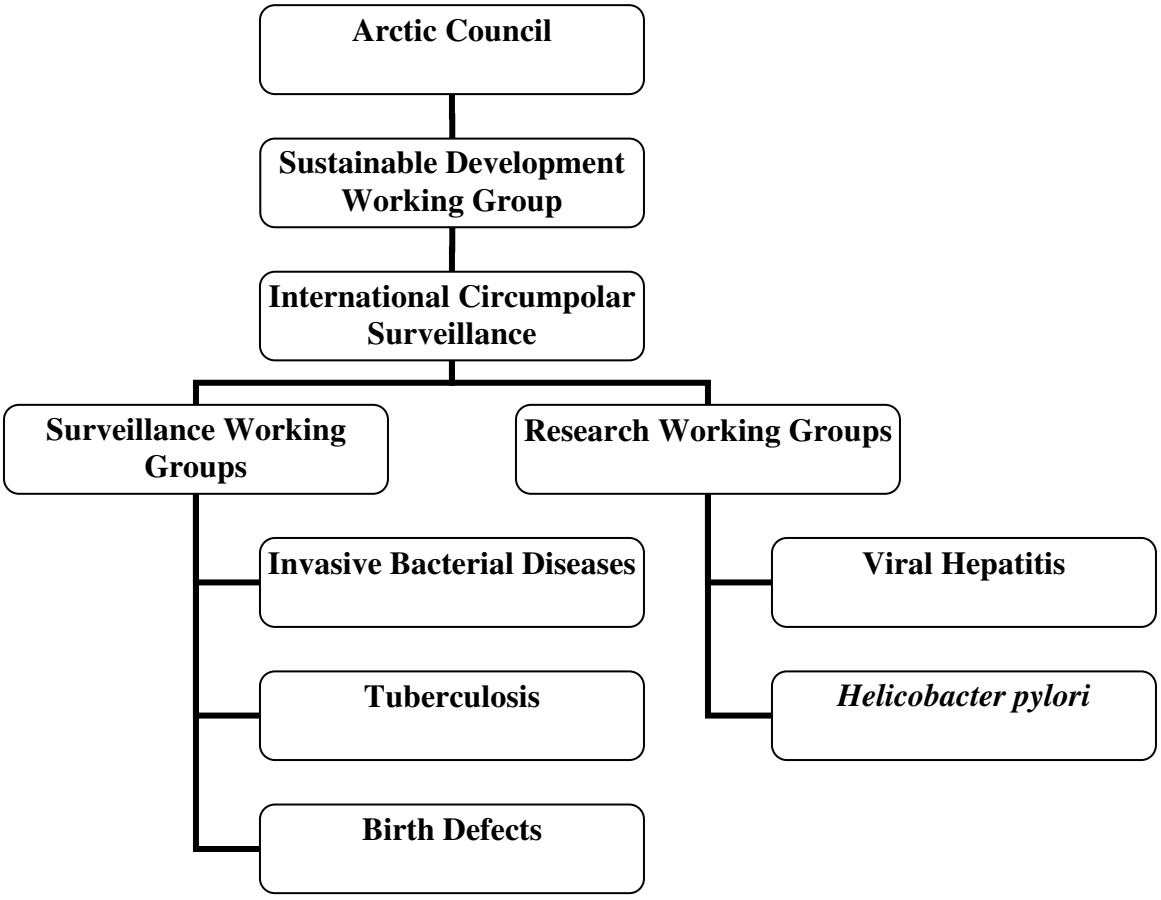
The International Union for Circumpolar Health (IUCH) is a union of five circumpolar health organizations. These include the American Society for Circumpolar Health, the Canadian Society for Circumpolar Health, the Nordic Council for Arctic Medical Research, the Siberian Branch of the Russian Academy of Sciences, Medical Section, and the Danish Greenlandic Society of Circumpolar Health. The objective of the IUCH is to promote international cooperation in circumpolar health. The IUCH sponsors the International Congress on Circumpolar Health, a meeting held every three years. The last meeting was held in Novosibirsk, Russian Federation, June 12-16, 2006. There are currently eight active working groups affiliated with the IUCH. These are: Birth defects, Cancer, Health Surveys, Indigenous Peoples, Injury Prevention, Occupational Safety & Health and Infectious Diseases. ICS is an activity of the IUCH Infectious Disease Working group.

The Arctic Council was established in 1996 as a ministerial level forum to provide a means of promoting cooperation and coordination among the Arctic Nations (United States, Canada, Greenland, Iceland, Norway, Sweden, Finland, and Russia) on common Arctic concerns, in particular those of sustainable development and environmental protection. Consultation and participation with indigenous peoples in the Arctic Council is achieved through representation from the Inuit Circumpolar Conference, the Saami Council, the Russian Association of Indigenous Peoples of the North, Aleut International Associations, and the Indigenous Peoples Secretariat as permanent participants of the Arctic Council. The Arctic Council provides access to governmental, non-governmental and indigenous peoples organizations important for improving human health in Arctic regions, as well as to other multi-national economic cooperatives with interests in multinational infectious disease prevention and control (e.g.., International Union for Circumpolar Health, Council of Nordic Ministers, European Union's Northern Dimension, Council of Baltic State Ministers). The increasing role of the Arctic Council in addressing public health issues provides a unique opportunity to partner with Arctic nation ministries of health, non-governmental organizations and indigenous peoples

organizations to address health concerns of circumpolar communities. The Arctic Council oversees and coordinates programs formally established in 1989 under the Arctic Environmental Strategy which include: Arctic Monitoring and Assessment Program (AMAP), Protection of Arctic Marine Environment, Conservation of Arctic Flora and Fauna, Emergency Prevention, and Preparedness and Response, and Sustainable Development and Utilization (SDU).

Human health activities currently reside in the AMAP and the SDU working groups. The "International Circumpolar Surveillance: Prevention and Control of Emerging Infectious Diseases" program was endorsed as a project within the Sustainable Development and Utilization working group in 2000. An ICS steering committee was formed in 1999 consisting of public health experts with interests in health problems in Arctic populations. Members are drawn from each participating country and from interested permanent participant indigenous people's organizations. The purpose of the steering committee is to guide and review ICS activities, approve reports and publications, and recommend new surveillance activities. Individual projects are managed by working groups that focus on diseases or condition(s) under surveillance (Figure 1).

Figure 1: ICS Organizational Chart



The ICS Invasive Bacterial Disease Working Group, currently chaired by the U.S. (managed by the Centers for Disease Control, Arctic Investigations Program), coordinates the surveillance of invasive bacterial diseases caused *by Streptococcus pneumoniae, Haemophilus influenzae, Neisseria meningitidis*, and groups A and B *Streptococcus*. These pathogens were selected for

ICS for the following reasons: 1) rates of these diseases are elevated in indigenous peoples of the north, 2) strains of these pathogens are rapidly acquiring resistance to commonly used antibiotics, 3) these pathogens are routinely cultured in the clinical laboratory, and 4) invasive disease caused by *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Neisseria meningitidis* is vaccine preventable in infants or adults. While no vaccines are currently available for diseases caused by groups A and B *Streptococcus*, detection is important for possible outbreaks and to assess the effectiveness of control measures.

An ICS Tuberculosis Working Group, chaired by Canada (managed by the Public Health Agency of Canada) has been established to improve detection of tuberculosis, assess tuberculosis incidence and trends, and promote collaboration on tuberculosis research. In addition, two ICS research groups have been formed to coordinate collaborative research on viral hepatitis and diseases caused by *Helicobacter pylori*.

Surveillance - Invasive Bacterial Diseases

Beginning in 1999, collaborative surveillance of invasive disease caused by *Streptococcus pneumoniae* was initiated in Alaska and northern Canada. Isolates of *Streptococcus pneumoniae* recovered from patients with invasive disease are collected from 23 clinical laboratories in Alaska and 14 clinical laboratories in northern Canada. The isolates are forwarded to regional reference laboratories in Alaska and Alberta or Quebec. The reference laboratories perform confirmation, serotyping and antimicrobial susceptibility and report identified cases to local public health personnel who review medical charts and provided clinical, demographic, and immunization history data on standardized case report forms. Case and culture information is forwarded to the ICS coordinator at the Arctic Investigations Program for analysis, report generation and dissemination. In 2000, Greenland joined the ICS network. Pneumococcal isolates from patients with invasive disease are forwarded from 15 district hospitals to reference laboratories in Nuuk, Greenland, and Copenhagen, Denmark, for confirmation, serotyping and susceptibility testing. Iceland, Norway and Finland joined ICS in 2001. In Iceland, 10 district hospitals participate and forward isolates to a reference laboratory in Reykjavik. Pneumococcal isolates from 33 district hospitals in Norway are sent to reference laboratories in Oslo or Tromso for confirmation, serotyping and susceptibility testing, and, in Finland, pneumococcal isolates from patients with invasive disease are forwarded to reference laboratories in Oulu. In Norbotten, Sweden, data is collected at the Department of Microbacteriology, Sunderby Hospital, Lulea; serotyping is performed at the Swedish Institute for Infectious Disease Control in Stockholm.

(Figure 2)

Surveillance of other invasive bacterial diseases (*Haemophilus influenzae*, *Neisseria meningitidis*, groups A & B *Streptococcus*) in the U.S. Arctic, northern Canada and Greenland was added to ICS in 2000; Sweden has also provided data on these organisms since 2003. The total number of cases of disease caused by each organism in ICS participating regions is shown in Table 1.

Interlaboratory quality control programs were established for *Streptococcus pneumoniae* in 1999 and for *Haemophilus influenzae* and *Neisseria meningitidis* in 2005. Reference laboratories in Alaska, Denmark, Iceland and northern Canada participate in the programs.

Figure 2: Participating Countries, ICS 1999-2006

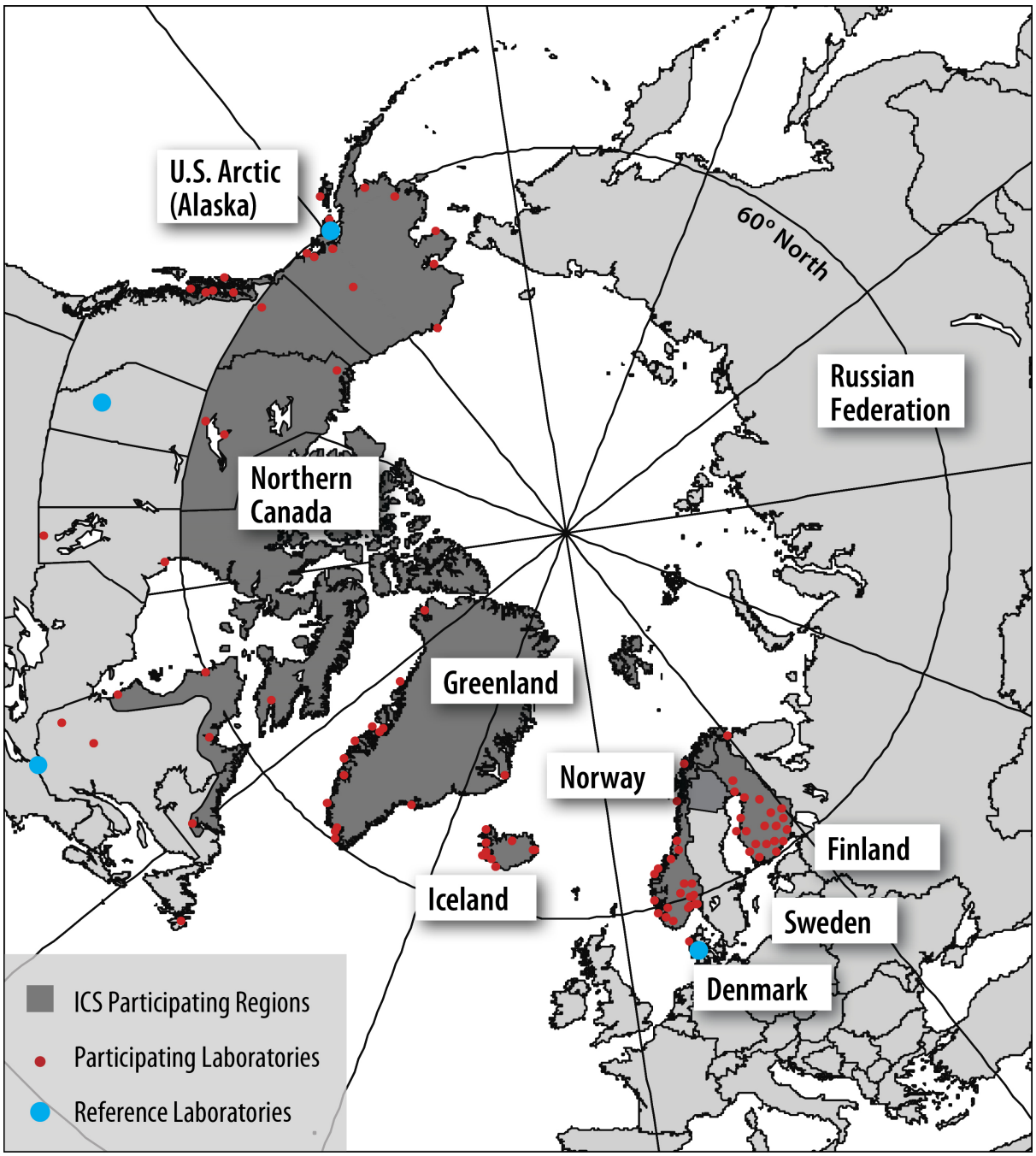


Table 1: Surveillance Organisms Reported by Country, ICS 1999-2006 Data

Country	*S. pneumoniae* n (rate*)	*H. influenzae* n (rate*)	*N. meningitidis* n (rate*)	GAS n (rate*)	GBS n (rate*)
Finland	4,794 (13)	N/A	N/A	N/A	N/A
Greenland	77 (19)	0 (0)	9 (2)	2 (<1)	4 (1)
Iceland	326 (16)	N/A	N/A	N/A	N/A
N. Canada	278 (27)	77 (8)	10 (1)	63 (7)	19 (2)
N. Sweden	124 (12)	7 (<1)	1 (<1)	13 (1)	44 (4)
Norway	6,708 (21)	72 (<1)	71 (<1)	N/A	N/A
U.S. Arctic	906 (18)	95 (2)	37 (<1)	215 (5)	164 (4)
Total	13,213 (15)	251 (<1)	128 (<1)	293 (4)	231 (3)

*Cases per 100,000

Data Management and Analysis

In the U.S. Arctic and northern Canada, laboratory, demographic and clinical data are collected prospectively, while in Greenland, Iceland, Norway, Finland, and northern Sweden summary data are reported in aggregate at the end of the year. All data are entered into a database maintained at Arctic Investigations Program where the data are analyzed and a yearly summary report is produced.

Population estimates used in calculating disease rates were obtained from websites in each country: Finland, http://www.stat.fi, Greenland, http://www.statgreen.gl, Iceland, http://www.hagstofa.is, Northern Canada, http://www.statcan.ca, Northern Sweden, http://www.scb.se/default____2154.asp, Norway, http://www.ssb.no, U.S. Arctic, http://www.labor.state.ak.us. Demographic information for each participating region or country is shown in Table 2.

Table 2: ICS Participating Country Demographics

Country	Mean Population	% Indigenous	Region Size, km^2
Finland	5,224,833	<1	339,290
Greenland	56,616	Unknown	2,131,863
Iceland	290,369	Unknown	102,968
N. Canada	132,956	59	4,506,600
N. Sweden	252,271	<5	160,580
Norway	4,558,603	<1	323,760
U.S. Arctic	648,902	19	1,518,807

Statistical analyses were performed using EpiInfo 3.5 (Centers for Disease Control & Prevention, Atlanta, GA) and SAS 9.2 (SAS Institute, Cary, NC).

Results - *Streptococcus pneumoniae*

Streptococcus pneumoniae (pneumococcus) is a leading cause of disease and death worldwide. In the U.S., it is the most common cause of meningitis, community acquired pneumonia, acute otitis media and sinusitis (2000). The emergence and spread of drug-resistant strains of pneumococcus have complicated treatment of these common infections (Whitney, Farley et al. 2000). Among the indigenous peoples of the U.S. Arctic, the rate of invasive pneumococcal disease is one of the highest in the world and is four times that for non-indigenous people (Bruce, Deeks et al. 2008). While there are more than 90 different serotypes of *Streptococcus pneumoniae*, a substantial proportion of pneumococcal disease is potentially preventable through the use of the 23-valent pneumococcal polysaccharide vaccine in adults and the 7-valent conjugate vaccine in children less than five years of age.

Isolates of invasive *Streptococcus pneumoniae* were sent to reference laboratories for confirmation, serotyping and antimicrobial susceptibility testing. Clinical and demographic data were collected on a standard form. In the U.S. Arctic and northern Canada, susceptibility testing was conducted by micro broth dilution method according to CLSI recommendations. In Finland and Greenland, testing was conducted by agar dilution and, in Iceland, Norway, and N. Sweden, disc diffusion methods were used. In the U.S. Arctic, northern Canada, Greenland, Norway, and N. Sweden, serotyping was performed by the Quellung method using antisera from Statens Serum Institute in Cophenhagen, Denmark. Laboratories in Iceland performed serotyping using co-agglutination with Statens Serum Institute antisera. In Finland, serotyping was performed using counterimmunoelectrophoreisis.

A total of 13,213 invasive *Streptococcus pneumoniae* (invasive pneumococcal disease) cases were reported to ICS during the period 1999-2006. Cases were reported beginning in 1999 in the U.S. Arctic and northern Canada; Finland, Greenland, Iceland, and Norway began reporting in 2000; N. Sweden began reporting in 2003. A summary of the case demographics are presented in Table 3.

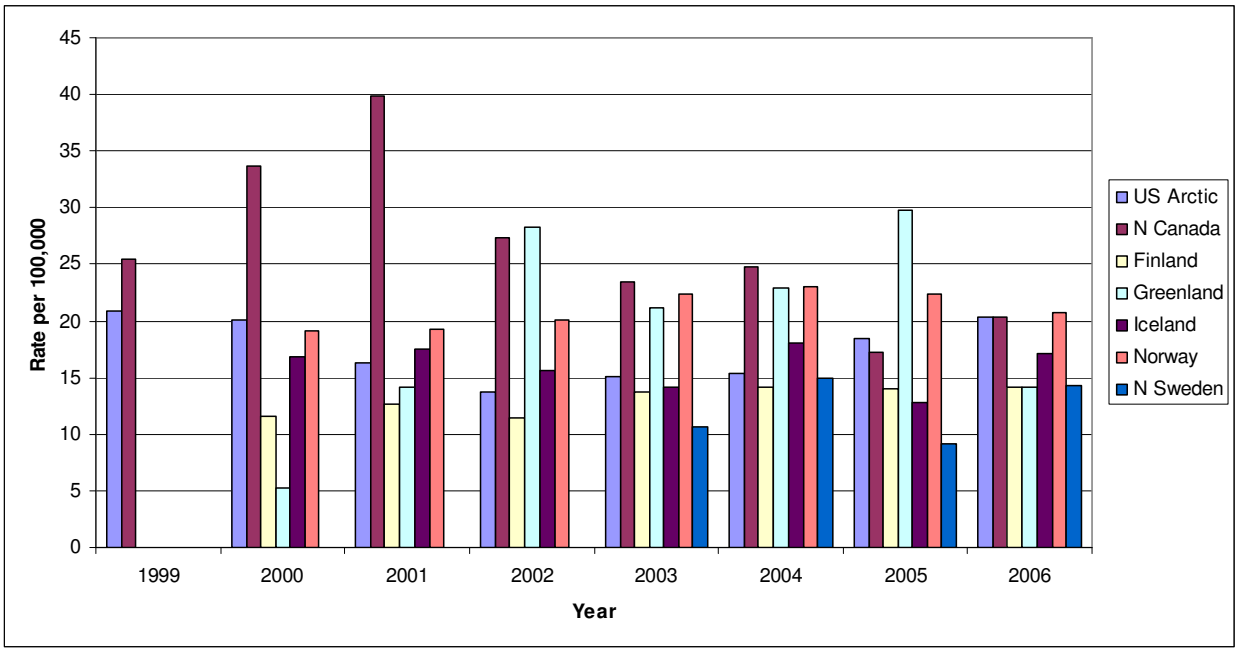
Table 3: Invasive Pneumococcal Disease Case Demographics, ICS 1999-2006* Data

Country	# Cases (rate†)	Sex M (%)	Age Min-Max (Median)	< 2 yrs n (rate†)	2-64 yrs n (rate†)	65+ yrs n (rate†)	# Deaths (CFR‡)
Finland	4,794 (13)	2,698 (56)	0-101 (55)	449 (55)	2,795 (9)	1,550 (27)	[a]
Greenland	77 (19)	41 (53)	0-91 (46)	9 (72)	64 (18)	4 (19)	15 (21)
Iceland	326 (16)	175 (54)	0-99 (55)	51 (86)	149 (9)	126 (53)	36 (12)
N. Canada	278 (27)	161 (58)	0-89 (37)	59 (149)	190 (20)	29 (68)	12 (5)
N. Sweden	124 (12)	53 (43)	1-99 (66)	4 (21)	58 (7)	62 (32)	[a]
Norway	6,708 (21)	3,346 (50)	0-99 (64)	421 (50)	3,089 (12)	3,198 (67)	472 (7)
US Arctic	906 (18)	500 (55)	0-102 (42)	180 (110)	563 (12)	163 (51)	107 (12)

*N. Canada and U.S. Arctic began data collection in 1999, the remaining countries in 2000 (except Sweden which began in 2003)
†Cases per 100,000 population per year
‡Case fatality ratio
[a]Finland and N. Sweden did not report outcome data

Annual rates of invasive pneumococcal disease in each country varied over time (Figure 3).

Figure 3: Invasive Pneumococcal Disease Rates, ICS 1999-2006



Two countries, northern Canada and the U.S. Arctic, reported the race or ethnicity of persons with pneumococcal infection. Rates for the period 1999-2006 were higher in Alaska (44/100,000) and northern Canadian (35/100,000) indigenous populations than in non-indigenous populations (11/100,000) and (10/100,000) respectively. Alaska and northern Canadian indigenous populations had consistently higher rates of disease in all age categories than non-indigenous populations. The highest rates occurred in Alaska and northern Canadian indigenous children under the age of two years, 244/100,000 and 167/100,000 respectively, compared with non-indigenous rates of 40/100,000 ($p < 0.001$) and 76/100,000 ($p = 0.05$), respectively.

The most common clinical presentations associated with invasive *Streptococcus pneumoniae* cases were pneumonia with bacteremia, bacteremia and meningitis. Clinical diagnoses other than bacteremia and meningitis are not reported in the Finland and N. Sweden data. All reported clinical presentations for each country are shown in Table 4.

The most prevalent pneumococcal serotypes reported by ICS countries during the period 1999-2006 were 1 (Greenland, N. Canada), 4 (Norway), 7 (Iceland), 14 (Finland, Norway), and 19A (U.S. Arctic). Serotypes were not reported by N. Sweden. All serotypes reported by each country are shown in Table 5.

Table 4: Clinical Presentation of Invasive Pneumococcal Disease Cases, ICS 1999-2006 Data

	Finland n (%)	Greenland n (%)	Iceland n (%)	N Canada n (%)	N Sweden n (%)	Norway n (%)	US Arctic n (%)
Pneumonia*	0 (0)	36 (47)	3 (<1)	184 (66)	0 (0)	3,087 (46)	558 (62)
Bacteremia	4,586 (96)	17 (22)	298 (91)	57 (21)	114 (92)	2,628 (39)	197 (22)
Meningitis	208 (4)	17 (22)	18 (6)	17 (6)	10 (8)	526 (8)	65 (7)
Empyema	0 (0)	1 (1)	0 (0)	8 (3)	0 (0)	0 (0)	45 (5)
Septic arthritis	0 (0)	1 (1)	6 (2)	3 (1)	0 (0)	27 (<1)	9 (<1)
Peritonitis	0 (0)	0 (0)	0 (0)	5 (2)	0 (0)	0 (0)	9 (<1)
Cellulitis	0 (0)	0 (0)	0 (0)	1 (<1)	0 (0)	0 (0)	8 (<1)
Pericarditis	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	3 (<1)
Endocarditis	0 (0)	3 (4)	0 (0)	0 (0)	0 (0)	0 (0)	2 (<1)
Epiglottitis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4 (<1)	2 (<1)
Osteomyelitis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (<1)
Appendicitis	0 (0)	0 (0)	0 (0)	1 (<1)	0 (0)	0 (0)	0 (0)
Amnionitis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (<1)	0 (0)
Other	0 (0)	1 (1)	0 (0)	2 (<1)	0 (0)	404 (6)	6 (<1)
Total Cases	4,794	77	326	278	124	6,700	906

*with bacteremia

Pneumococcal susceptibility to penicillin was reported from the U.S. Arctic and northern Canada for 1999-2006, from Greenland, Iceland and Finland for 2001-2006, and from N. Sweden for 2003-2006. The U.S. Arctic reported that 5% of pneumococcal isolates were fully resistant to penicillin, compared with 3% from northern Canada and 1% from Finland; < 1% of isolates from Greenland, Iceland, and N. Sweden were fully resistant to penicillin.

For countries reporting serotype data, 86-93% of pneumococcal cases in persons ≥ 2 years of age were potentially preventable with use of the 23-valent polysaccharide vaccine (Table 6). Use of the 7-valent conjugate vaccine would have potentially prevented 40-84% of pneumococcal cases in children < 2 years of age during the period 1999-2006. Analysis of pneumococcal serotypes causing disease in North American arctic populations indicates that greater than 40% of invasive pneumococcal disease in children less than 2 years old could potentially be prevented. In Alaska, statewide use of the infant 7-valent conjugate vaccine began in 2001. Immunization programs using the 7-valent conjugate vaccine were initiated in all northern Canadian regions by 2006. Prior to the initiation of 7-valent conjugate vaccine programs in the U.S. Arctic and northern Canada, the proportion of preventable pneumococcal disease in children less than 2 years old in each region was 84% and 78%, respectively. Continued surveillance of invasive pneumococcal disease in these regions will monitor the impact and effectiveness of these vaccine programs for both preventing invasive pneumococcal disease and reducing the proportion of isolates from patients that are resistant to antibiotics.

Table 5: Invasive *Streptococcus pneumoniae* Serotypes by Country, ICS 1999-2006 Data

Serotype	Finland n (%)	Greenland n (%)	Iceland n (%)	N. Canada n (%)	Norway n (%)	U.S. Arctic n (%)
1	52 (1)	13 (20)	12 (4)	73 (27)	16 (6)	17 (2)
2	2 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
3	341 (7)	4 (6)	21 (7)	8 (3)	8 (3)	48 (6)
4	561 (12)	9 (14)	23 (7)	16 (6)	53 (18)	60 (7)
5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (<1)
6	0 (0)	0 (0)	0 (0)	0 (0)	25 (9)	0 (0)
6A	151 (3)	3 (5)	9 (3)	8 (3)	0 (0)	25 (3)
6B	330 (7)	3 (5)	20 (6)	16 (6)	0 (0)	27 (3)
7	1 (<1)	0 (0)	41 (13)	0 (0)	21 (7)	0 (0)
7C	2 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	5 (<1)
7F	318 ((7)	3 (5)	18 (6)	4 (2)	0 (0)	74 (9)
8	78 (2)	2 (3)	2 (<1)	25 (9)	4 (1)	49 (6)
9	0 (0)	0 (0)	18 (6)	0 (0)	32 (11)	0 (0)
9A	2 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9N	155 (3)	0 (0)	0 (0)	0 (0)	0 (0)	20 (2)
9V	342 (7)	1 (2)	14 (4)	11 (4)	0 (0)	29 (4)
10	39 (<1)	0 (0)	0 (0)	0 (0)	2 (<1)	0 (0)
10A	5 (<1)	0 (0)	0 (0)	8 (3)	0 (0)	16 (2)
11	0 (0)	0 (0)	4 (1)	0 (0)	2 (<1)	0 (0)
11A	68 (1)	0 (0)	0 (0)	0 (0)	0 (0)	16 (2)
11B	1 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	1 (<1)	0 (0)	4 (1)	0 (0)	1 (<1)	0 (0)
12F	129 (3)	9 (14)	0 (0)	8 (3)	0 (0)	52 (6)
13	6 (<1)	0 (0)	0 (0)	1 (<1)	0 (0)	2 (<1)
14	633 (13)	3 (5)	37 (12)	20 (8)	53 (18)	67 (8)
15	0 (0)	0 (0)	3 (<1)	0 (0)	2 (<1)	0 (0)
15A	12 (<1)	0 (0)	0 (0)	1 (<1)	0 (0)	10 (1)
15B	29 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	10 (1)
15C	29 (<1)	1 (2)	0 (0)	2 (<1)	0 (0)	8 (1)
16	22 (<1)	0 (0)	1 (<1)	1 (<1)	3 (1)	0 (0)
16F	2 (<1)	1 (2)	0 (0)	7 (3)	0 (0)	17 (2)
17	14 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17F	3 (<1)	1 (2)	0 (0)	1 (<1)	0 (0)	10 (1)
18	1 (<1)	0 (0)	7 (2)	0 (0)	5 (2)	0 (0)
18B	6 (<1)	0 (0)	1 (<1)	0 (0)	0 (0)	0 (0)
18C	201 (4)	2 (3)	3 (<1)	12 (5)	0 (0)	16 (2)
18F	1 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	1 (<1)
19	0 (0)	0 (0)	0 (0)	0 (0)	17 (6)	0 (0)
19A	206 (4)	2 (3)	3 (<1)	7 (3)	0 (0)	78 (10)
19B	1 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19C	0 (0)	0 (0)	1 (<1)	0 (0)	0 (0)	0 (0)
19F	212 (5)	0 (0)	5 (2)	4 (2)	0 (0)	22 (3)

Serotype	Finland n (%)	Greenland n (%)	Iceland n (%)	N. Canada n (%)	Norway n (%)	U.S. Arctic n (%)
20	24 (<1)	0 (0)	1 (<1)	3 (1)	0 (0)	12 (1)
21	0 (0)	0 (0)	0 (0)	1 (<1)	0 (0)	0 (0)
22	0 (0)	0 (0)	10 (3)	1 (<1)	12 (4)	0 (0)
22A	29 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	5 (<1)
22F	145 (3)	7 (11)	0 (0)	7 (3)	0 (0)	33 (4)
23	0 (0)	0 (0)	22 (7)	0 (0)	22 (8)	0 (0)
23A	27 (<1)	0 (0)	3 (<1)	0 (0)	0 (0)	7 (<1)
23B	2 (<1)	0 (0)	0 (0)	1 (<1)	0 (0)	4 (<1)
23F	353 (8)	0 (0)	17 (5)	13 (5)	0 (0)	17 (2)
24	1 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
25	1 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
28	3 (<1)	0 (0)	0 (0)	0 (0)	1 (<1)	0 (0)
29	4 (<1)	0 (0)	0 (0)	0 (0)	1 (<1)	0 (0)
31	10 (<1)	0 (0)	0 (0)	0 (0)	1 (<1)	3 (<1)
33	40 (<1)	0 (0)	2 (<1)	0 (0)	8 (3)	0 (0)
33A	0 (0)	0 (0)	0 (0)	1 (<1)	0 (0)	0 (0)
33F	3 (<1)	1 (2)	0 (0)	1 (<1)	0 (0)	16 (2)
34	10 (<1)	0 (0)	0 (0)	1 (<1)	0 (0)	6 (<1)
35	2 (<1)	0 (0)	0 (0)	0 (0)	2 (<1)	0 (0)
35A	1 (<1)	0 (0)	0 (0)	1 (<1)	0 (0)	0 (0)
35B	29 (<1)	0 (0)	0 (0)	3 (1)	0 (0)	5 (<1)
35F	42 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	5 (<1)
37	1 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	2 (<1)
38	12 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	9 (1)
39	3 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
41	1 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
42	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (<1)
46	1 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 6: Proportion of Vaccine Preventable Cases from Invasive Pneumococcal Disease, ICS 1999-2006 Data

	Finland n/Denom* (%)	Greenland n/Denom* (%)	Iceland n/Denom* (%)	N. Canada n/Denom* (%)	U.S. Arctic n/Denom* (%)
Cases ≥ 2 years old with serotype in the 23-valent pneumococcal polysaccharide vaccine	3,272/3,698 (88)	54/58 (93)	144/166 (87)	194/213 (91)	550/643 (86)
Cases < 2 years old with serotype in the 7-valent pneumococcal conjugate vaccine	206/295 (70)	3/7 (43)	29/33 (88)	31/53 (58)	68/168 (40)

*Number of isolates serotyped by country by age group

Results - *Haemophilus influenzae*

Haemophilus influenzae causes a wide variety of diseases ranging from upper respiratory tract illness such as conjunctivitis, otitis media, and sinusitis, to lower respiratory tract diseases (epiglotittis, pneumonia and empyema), to invasive disease outside the respiratory tract (meningitis, septic arthritis). There are six different serotypes (a-f) of *Haemophilus influenzae*. Type b (Hib) was the most common cause of childhood meningitis in the United States prior to the introduction of childhood conjugate vaccines in 1991. The incidence of invasive *Haemophilus influenzae* type b disease has declined by over 90% in countries where the vaccine is widely used (Bruce, Deeks et al. 2008).

Isolates of invasive *Haemophilus influenzae* were sent to reference laboratories for confirmation and serotyping. In the U.S. Arctic, northern Canada, and Greenland, serotyping was performed by the latex agglutination method using commercial antisera. N. Sweden did not provide serotype data.

A total of 251 invasive *Haemophilus influenzae* cases were reported to ICS during the years 2000-2006. Data for cases of invasive *Haemophilus influenzae* (all serotypes) were collected in Norway (beginning 2006), N. Sweden (since 2003), Greenland (since 2001), northern Canada and the U.S. Arctic (both since 2000). Greenland did not report any occurrences of invasive *Haemophilus influenzae* disease during this period. Demographics of the cases reported by N. Canada, N. Sweden, Norway, and the U.S. Arctic are presented in Table 7.

Table 7: Invasive *Haemophilus influenzae* Case Demographics, ICS 2000-2006 Data

Country	# Cases (rate*)	Sex M (%)	Age Min-Max (Median)	< 2 yrs n (rate*)	2-64 yrs n (rate*)	65+ yrs n (rate*)	# Deaths (CFR†)
N. Canada	77 (8)	44 (57)	0-94 (1)	50 (145)	19 (2)	8 (21)	3 (5)
N. Sweden	7 (<1)	4 (57)	14-87 (60)	0 (0)	4 (<1)	3 (2)	‡
Norway	72 (<1)	33 (46)	0-95 (72)	2 (<1)	41 (<1)	29 (<1)	5 (7)
U.S. Arctic	95 (2)	52 (55)	0-91 (39)	29 (20)	43 (1)	23 (8)	15 (16)

*Cases per 100,000 population per year
†Case fatality ratio
‡Outcomes not reported by N. Sweden

The highest rates of invasive *Haemophilus influenzae* disease were found in N. Canada during this time period. Annual rates of invasive disease caused by *Haemophilus influenzae* in each country are shown in Figure 4.

Alaska and northern Canadian indigenous children less than two years old had the highest rates of disease; 57 cases per 100,000 and 171 cases per 100,000 respectively. The most common clinical presentations were pneumonia with bacteremia in the U.S. Arctic (46%) and Norway (46%) and meningitis in northern Canada (26%). All of the N. Sweden cases were reported as presenting with bacteremia only. All reported clinical presentations for each country are shown in Table 8.

The most common serotype in northern Canada was serotype a, which comprised 50% of isolates serotyped. In the U.S. Arctic, serotype b was the most common serotype and accounted for 24% of serotyped isolates. Serotype f occurred most often in Norway (25%), however, the largest proportion of cases were non-typeable (71%). The U.S. Arctic also had a large proportion of non-typeable cases (37%). The proportion of each serotype reported by country is shown in Figure 5.

Figure 4: Invasive *Haemophilus influenzae* Disease Rates, ICS 2000-2006

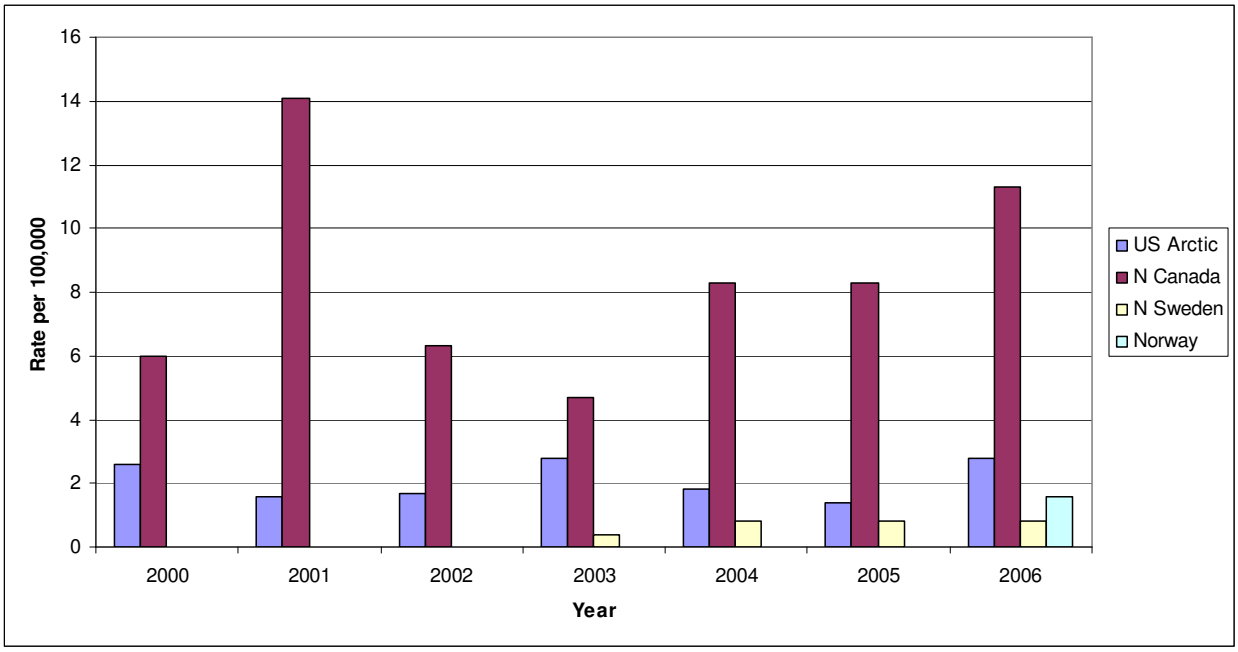
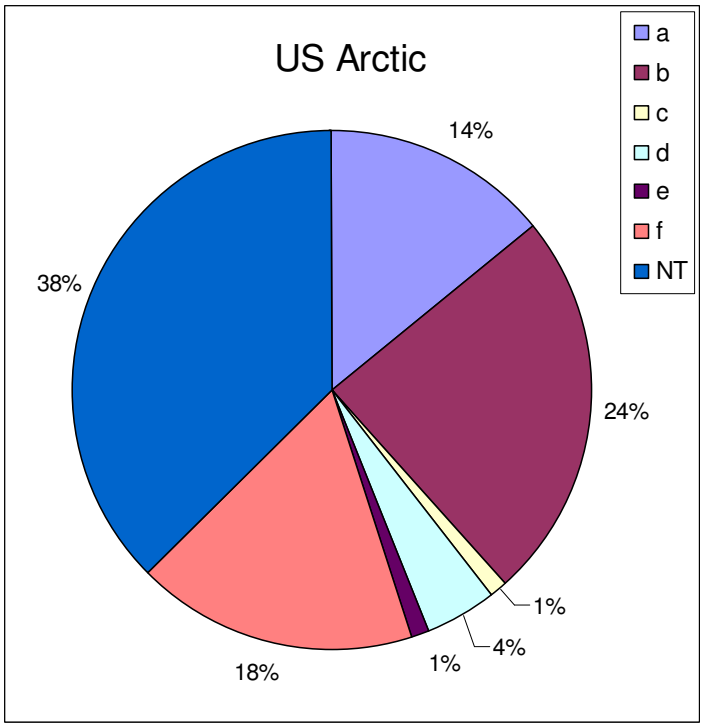


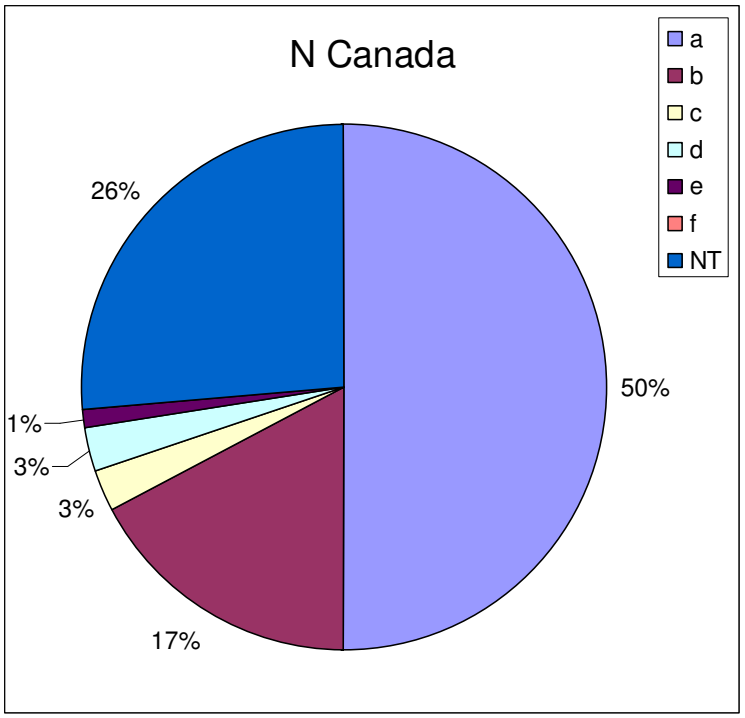
Table 8: Clinical Presentation of Invasive *Haemophilus influenzae* Cases, ICS 2000-2006 Data

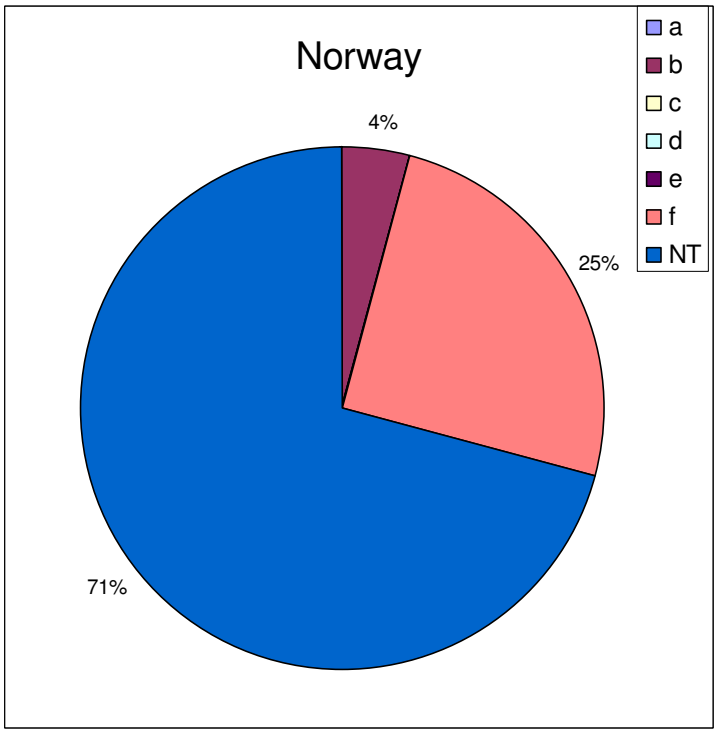
	N. Canada n (%)	N. Sweden n (%)	Norway n (%)	U.S. Arctic n (%)
Pneumonia*	19 (25)	0 (0)	33 (46)	46 (48)
Bacteremia	26 (34)	7 (100)	27 (38)	23 (24)
Meningitis	20 (26)	0 (0)	4 (6)	16 (17)
Empyema	2 (3)	0 (0)	0 (0)	3 (3)
Septic arthritis	5 (6)	0 (0)	1 (1)	3 (3)
Cellulitis	2 (3)	0 (0)	0 (0)	0 (0)
Peritonitis	0 (0)	0 (0)	0 (0)	2 (2)
Osteomyelitis	1 (1)	0 (0)	0 (0)	0 (0)
Pericarditis	1 (1)	0 (0)	0 (0)	1 (1)
Other	1 (1)	0 (0)	7 (10)	0 (0)
Total	77	7	72	94

*with bacteremia

Figure 5: Proportion of *Haemophilus influenzae* Serotypes by Country, 2000-2006







Prior to 1991, rates of invasive *Haemophilus influenzae* type b disease in the U.S. Arctic were among the highest in the world, however, since the introduction of conjugate vaccine programs in 1991, the rates of invasive *Haemophilus influenzae* type b disease have declined by 92%. Universal vaccine programs for invasive *Haemophilus influenzae* type b disease began in Canada in 1992 and they have experienced a similar decline in rates of invasive disease caused by *Haemophilus influenzae* type b. During the seven year surveillance period, we identified a high proportion of non-b serotypes in N. Canada and the U.S. Arctic with particularly high rates of disease caused by serotype a. Among indigenous children less than two years of age, serotype a rates were 107/100,000 and 22/100,000 in N. Canada and the U.S. Arctic, respectively.

Continued surveillance for invasive diseases caused by all serotypes of *Haemophilus influenzae* in Arctic countries is important to be able to monitor the impact of conjugate vaccine programs and to monitor the potential emergence of other serotypes that may replace *Haemophilus influenzae* type b as a cause of severe diseases in these populations.

Results - *Neisseria meningitidis*

Neisseria meningitidis is a leading cause of bacterial meningitis in many parts of the world. Incidence tends to increase in winter and spring; epidemics occur irregularly. Meningococcal disease is primarily a disease of young children, but outbreaks can occur in older ages such as new military recruits and college students. There are 13 serogroups, however, groups B and C are responsible for most cases of invasive disease in the U.S. Group A is common in Africa where it causes large epidemics in sub-Saharan regions, Nepal, and India, whereas group B is common in South America. Group C has been responsible for community outbreaks in both the U.S. and Canada (Rosenstein, Perkins et al. 2001). Vaccines containing Groups A, C, Y and W-135 meningococcal polysaccharides are available and new Group B conjugate vaccines are in development.

Isolates of invasive *Neisseria meningitidis* were sent to reference laboratories for confirmation and serogrouping. Clinical and demographic data were collected on a standard form. Serogroup testing of *Neisseria meningitidis* isolates from Alaska was performed at the Canadian National Centre for Meningococcal Disease in the CNS Infections Laboratory in Winnipeg during the years 2000-2004. Beginning in 2005, Alaska isolates were serogrouped at AIP.

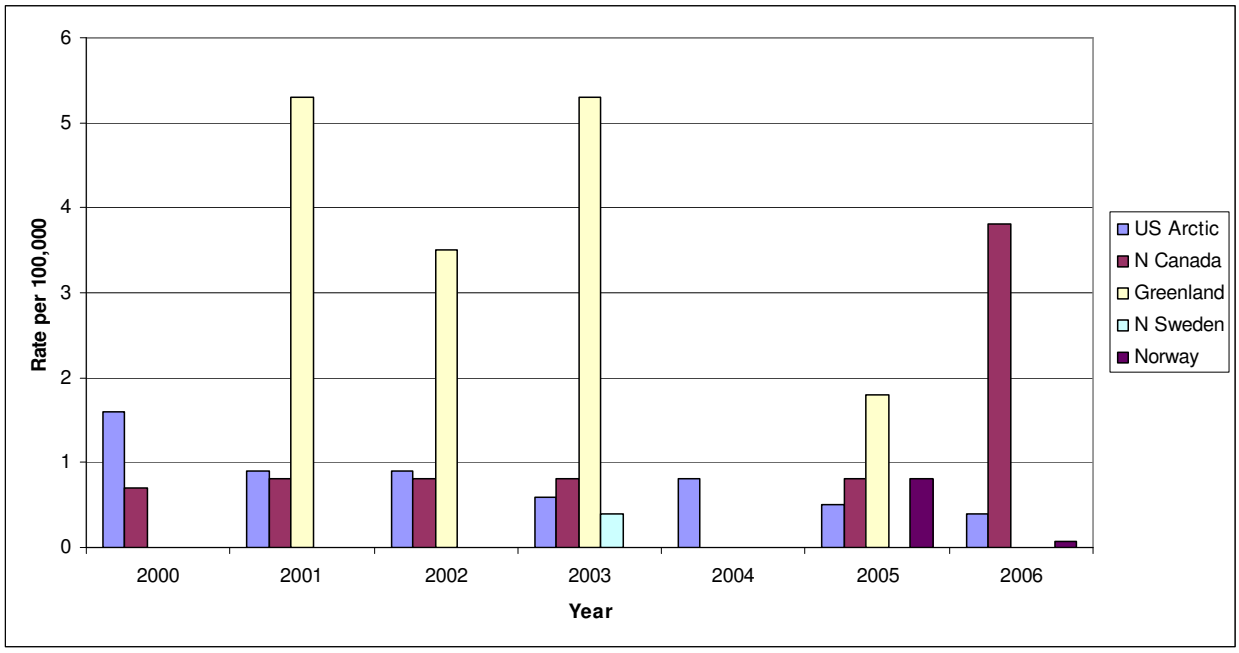
A total of 128 invasive *Neisseria meningitidis* cases were reported to ICS from the U.S. Arctic (since 2000), N. Canada (since 2000), N. Sweden (since 2003), Norway (beginning 2001) and Greenland (since 2001). Case demographics are presented in Table 9. Annual rates of invasive disease caused by *Neisseria meningitidis* in each country are shown in Figure 6.

Table 9: Invasive *Neisseria meningitidis* Case Demographics, ICS 2000-2006 Data

Country	# Cases (rate*)	Sex M (%)	Age Min-Max (Median)	< 2 yrs n (rate*)	2-64 yrs n (rate*)	65+ yrs n (rate*)	# Deaths (CFR†)
Greenland	9 (2)	6 (67)	1-41 (9)	3 (24)	5 (1)	1 (5)	0 (0)
N. Canada	10 (1)	3 (30)	0-52 (1)	7 (20)	3 (<1)	0 (0)	2 (20)
N. Sweden	1 (<1)	1 (100)	1 case <1	1 (5)	0 (0)	0 (0)	‡
Norway	71 (<1)	33 (46)	0-98 (21)	6 (<1)	50 (<1)	15 (<1)	12 (17)
U.S. Arctic	37 (<1)	21 (57)	0-90 (13)	6 (4)	30 (<1)	1 (<1)	6 (17)

*Cases per 100,000 population per year
†Case fatality ratio
‡Outcomes not reported by N. Sweden

Figure 6: Invasive *Neisseria meningitidis* Disease Rates, ICS 2000-2006



In N. Canada, the rate of disease was higher in non-indigenous children (25/100,000) than indigenous children (20/100,000). In the U.S. Arctic, the highest rates of disease occurred in indigenous children less than two years old (14/100,000) compared with 0/100,000 among non-indigenous children.

The majority of *Neisseria meningitidis* isolates serogrouped in all countries were serogroup B followed by Y (Norway and the U.S. Arctic) or C (Greenland and N. Canada). The proportion of each serogroup reported by country is shown in Figure 7.

The most common clinical presentation of *Neisseria meningitidis* in all countries was meningitis, reported for the single case in N. Sweden, 89% of cases in Greenland, 70% of cases in N. Canada and 56% of cases in Norway and the U.S. Arctic (Table 10).

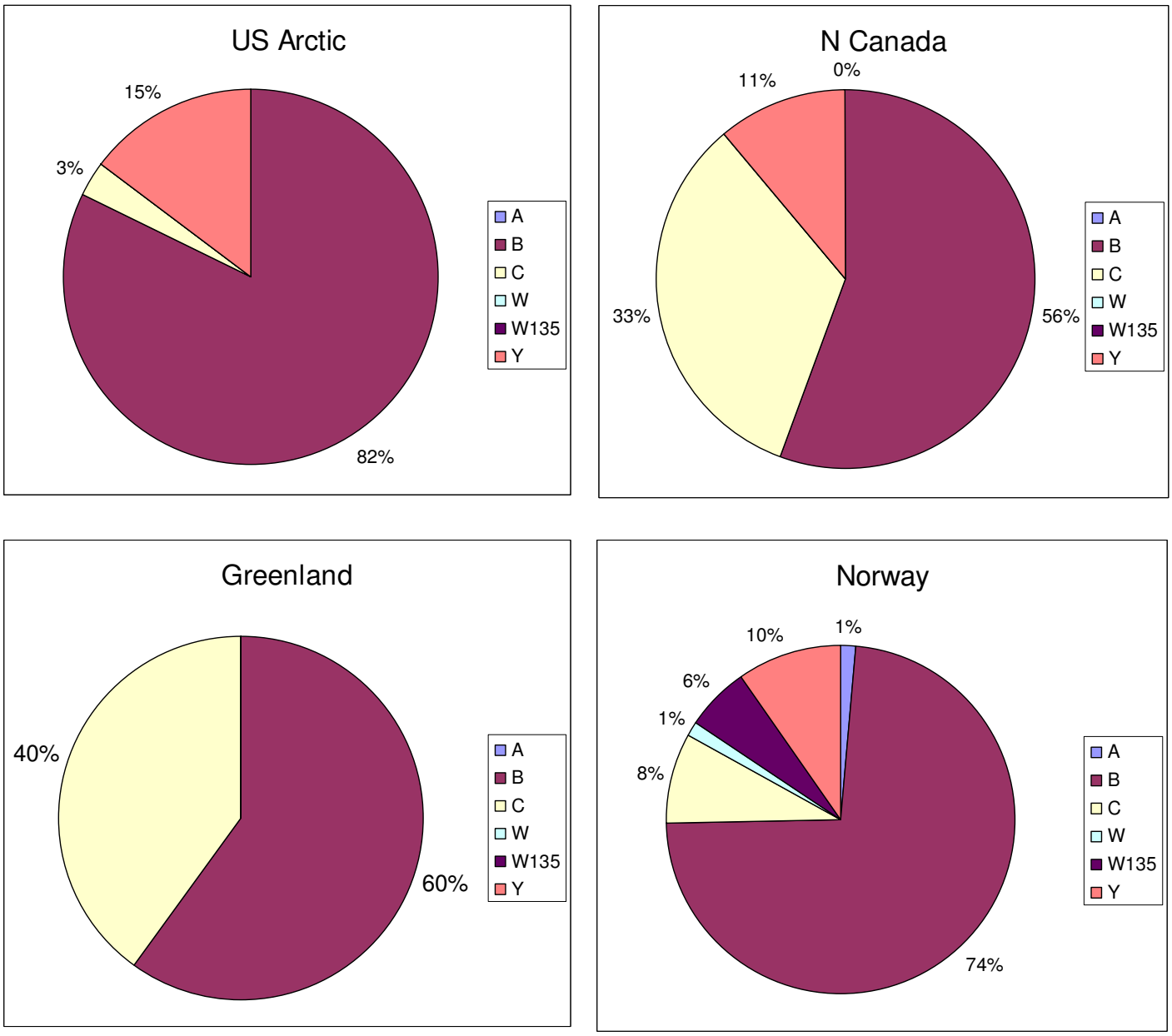
Surveillance of invasive diseases caused by *Neisseria meningitidis* not only allows for the detection of clusters of disease but also provides serogroup information critical for vaccine recommendations.

Table 10: Clinical Presentation of Invasive *Neisseria meningitidis* Cases, ICS 2000-2006 Data

	Greenland n (%)	N. Canada n (%)	N. Sweden n (%)	Norway n (%)	U.S. Arctic n (%)
Pneumonia*	0 (0)	1 (10)	0 (0)	5 (8)	1 (3)
Bacteremia	1 (11)	1 (10)	0 (0)	20 (34)	14 (38)
Meningitis	8 (89)	7 (70)	1 (100)	33 (56)	21 (56)
Septic arthritis	0 (0)	1 (10)	0 (0)	1 (2)	1 (3)
Total	9	10	1	59	37

*with bacteremia

Figure 7: Proportion of Invasive *Neisseria meningitidis* Serogroups by Country, 2000-2006



Results - Group A *Streptococcus*

Group A *Streptococcus* (GAS) causes non-invasive disease such as pharyngitis, rheumatic fever and soft tissue infections. However, it also can be the source of serious invasive disease including bacteremia, pneumonia, necrotizing fasciitis and streptococcal toxic shock syndrome. Group A streptococcal infections cause significant morbidity and mortality worldwide with an estimated 500,000 deaths annually; in the U.S., 9,000-11,000 cases occur each year with 1,100-1,800 deaths (O'Loughlin, Roberson et al. 2007; Thigpen, Richards et al. 2007). A proposed 26-valent vaccine based on group A *Streptococcus emm* types may be used in children less than 5 years old and adults greater than 65, the age groups most affected by disease caused by GAS (O'Loughlin, Roberson et al. 2007).

A total of 293 invasive group A *Streptococcus* cases were reported to ICS during the period 2000-2006. Data for cases of invasive group A *Streptococcus* were collected in N. Sweden (since 2003), Greenland (since 2001), northern Canada and the U.S. Arctic (both since 2000). Isolates of invasive group A *Streptococcus* were sent to reference laboratories for confirmation. Clinical and demographic data were collected on a standard form. Case demographics are presented in Table 11. Annual rates of invasive disease caused by group A *Streptococcus* in each country are shown in Figure 8. Rates in N. Canada show an increasing trend over time.

Figure 8: Invasive Group A *Streptococcus* Disease Rates, ICS 2000-2006

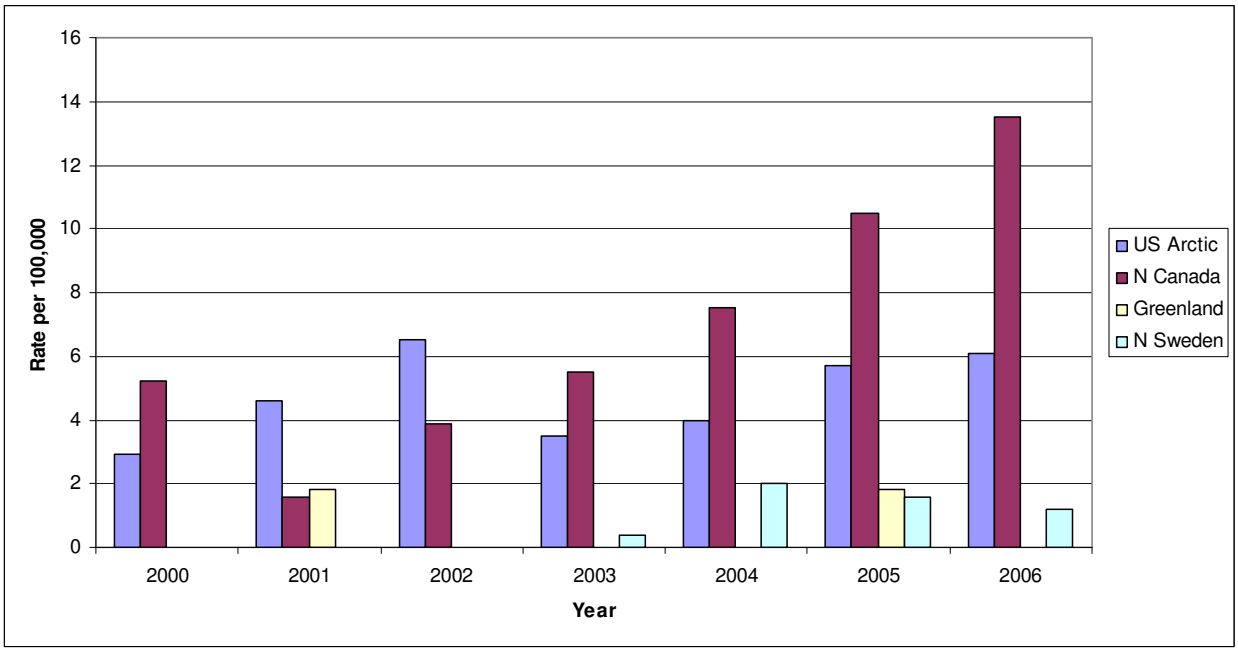


Table 11: Invasive Group A *Streptococcus* Case Demographics, ICS 2000-2006 Data

Country	# Cases (rate*)	Sex M (%)	Age Min-Max (Median)	< 2 yrs n (rate*)	2-64 yrs n (rate*)	65+ yrs n (rate*)	# Deaths (CFR†)
Greenland	2 (<1)	1 (50)	53-64 (59)	0 (0)	2 (<1)	0 (0)	1 (50)
N. Canada	63 (7)	40 (63)	0-89 (37)	15 (43)	35 (4)	13 (35)	9 (15)
N. Sweden	13 (1)	7 (54)	33-91 (67)	0 (0)	4 (<1)	9 (5)	‡
U.S. Arctic	215 (5)	111 (52)	0-93 (43)	18 (13)	161 (4)	36 (13)	20 (9)

*Cases per 100,000 population per year
†Case fatality ratio
‡Outcomes not reported by N. Sweden

Eighty-six percent of all reported group A *Streptococcus* cases in northern Canada occurred in indigenous people; the highest rates of disease were in children less than two years old (60/100,000). In the U.S. Arctic, the highest rates of disease also occurred in indigenous children less than two years old (33/100,000).

The most common group A S*treptococcus* clinical presentation in northern Canada and the U.S. Arctic was cellulitis with bacteremia, occurring in 29% and 33% of cases respectively. In N. Sweden, the most common clinical presentation was bacteremia (92% of cases). One case in Greenland presented with meningitis, the second with pericarditis. All reported clinical presentations for each country are shown in Table 12.

N. Canada and the U.S. Arctic provided *emm* typing data for group A *Streptococcus* isolates. The most common *emm* types in N. Canada were 1 (12%), 3 (12%), 5 (10%), and 59 (10%); in the U.S. Arctic the most common types were 3 (11%), 41 (9%), and 12 (8%). The proportions of all *emm* types reported by country are shown in Table 13.

Continued surveillance of invasive GAS disease is important to improve understanding of GAS epidemiology, for identification control of outbreaks of GAS disease, and to monitor changes in *emm* types for assessing the potential application of future vaccines in these populations.

Table 12: Clinical Presentation of Invasive Group A *Streptococcus* Cases, ICS 2000-2006 Data

	Greenland n (%)	N. Canada n (%)	N. Sweden n (%)	U.S. Arctic n (%)
Bacteremia	0 (0)	14 (22)	12 (92)	53 (25)
Pneumonia*	0 (0)	10 (16)	0 (0)	29 (13)
Meningitis	1 (50)	0 (0)	0 (0)	2 (1)
Empyema	0 (0)	2 (3)	0 (0)	11 (5)
Cellulitis*	0 (0)	18 (29)	0 (0)	70 (33)
Necrotizing fasciitis	0 (0)	5 (8)	0 (0)	6 (3)
Septic arthritis	0 (0)	6 (10)	1 (8)	18 (8)
Osteomylitis	0 (0)	1 (2)	0 (0)	3 (1)
Pericarditis	1 (50)	0 (0)	0 (0)	0 (0)

Endocarditis	0 (0)	0 (0)	0 (0)	3 (1)
Endometritis	0 (0)	0 (0)	0 (0)	2 (1)
Peritonitis	0 (0)	0 (0)	0 (0)	4 (2)
Bursitis	0 (0)	2 (3)	0 (0)	2 (1)
Epiglottitis	0 (0)	0 (0)	0 (0)	1 (<1)
Amnionitis	0 (0)	1 (2)	0 (0)	1 (<1)
Septic abortion	0 (0)	0 (0)	0 (0)	1 (<1)
Other	0 (0)	3 (5)	0 (0)	9 (4)
Total	2	62	13	215

*with bacteremia

Table 13: Proportion of Invasive GAS *emm* Types by Country, ICS 2000-2006 Data

***emm* Type**	**N. Canada n (%)**	**U.S. Arctic n (%)**
1	6 (12)	12 (7)
2	0 (0)	4 (2)
3	6 (12)	17 (11)
4	1 (2)	2 (1)
5	5 (10)	9 (6)
6	0 (0)	4 (2)
11	0 (0)	2 (1)
12	2 (4)	13 (8)
22	3 (6)	3 (2)
28	2 (4)	9 (6)
33	0 (0)	1 (<1)
41	3 (6)	15 (9)
44	0 (0)	2 (1)
49	1 (2)	4 (2)
58	0 (0)	2 (1)
59	5 (10)	0 (0)
73	1 (2)	8 (5)
75	1 (2)	1 (<1)
76	0 (0)	8 (5)
77	1 (2)	0 (0)
83	0 (0)	5 (3)
87	1 (2)	12 (7)
89	0 (0)	5 (3)
91	2 (4)	0 (0)
92	2 (4)	11 (7)
94	0 (0)	1 (<1)
102	0 (0)	1 (<1)
103	0 (0)	1 (<1)
114	1 (2)	8 (5)
123	0 (0)	1 (<1)
Other	5 (10)	0 (0)
Total	50	161

Results - Group B *Streptococcus*

Group B *Streptococcus* (*Streptococcus agalactiae*) causes sepsis, pneumonia and meningitis. In adult women, group B *Streptococcus* causes pregnancy-related infections such as sepsis, amnionitis, urinary tract infections and stillbirth. This pathogen emerged in the 1970s as the most common cause of sepsis in newborns. Prevention includes the U.S. recommendation to screen all pregnant women at 35-37 weeks gestation for carriage of group B *Streptococcus* and treatment using antibiotics. Early onset disease (invasive disease that occurs with the first six days of life) has declined by 70% in the U.S. since the early 1990's when screening programs were first introduced (Phares, Lynfield et al. 2008).

Data for cases of invasive group B *Streptococcus* were collected in N. Sweden (since 2003), Greenland (since 2001), N. Canada and the U.S. Arctic (both since 2000). Isolates of invasive group B *Streptococcus* were sent to reference laboratories for confirmation. Clinical and demographic data were collected on a standard form. A total of 231 invasive group B *Streptococcus* cases were reported to ICS during the period 2000-2006. Case demographics are presented in Table 14.

Table 14: Invasive Group B *Streptococcus* Case Demographics, ICS 2000-2006 Data

Country	# Cases (rate*)	Sex M (%)	Age Min-Max (Median)	< 2 yrs n (rate*)	2-64 yrs n (rate*)	65+ yrs n (rate*)	# Deaths (CFR†)
Greenland	4 (1)	2 (50)	61-84 (66)	0 (0)	2 (<1)	2 (10)	2 (50)
N. Canada	19 (2)	6 (32)	0-67 (32)	5 (14)	13 (2)	1 (3)	1 (6)
N. Sweden	44 (4)	23 (52)	0-91 (69)	10 (52)	7 (<1)	27 (14)	‡
U.S. Arctic	164 (4)	90 (55)	0-90 (49)	46 (32)	79 (2)	39 (14)	18 (11)

*Cases per 100,000 population per year
†Case fatality ratio
‡Outcomes not reported by N. Sweden

The highest rates of invasive group B streptococcal disease occurred in children less than two years old in northern Sweden (52/100,000) and indigenous children less than two years old in the U.S. Arctic (31/100,000). Annual rates of invasive disease caused by group B *Streptococcus* in each country are shown in Figure 9.

The most commonly reported clinical presentations for group B streptococcal cases was bacteremia in 47% of cases in northern Canada, 50% of cases in Greenland, 43% of cases in the U.S. Arctic and 98% of cases in N. Sweden. All reported clinical presentations for each country are shown in Table 15.

Continued surveillance is important to be able to monitor disease rates and impact of intervention programs as well as potential adverse consequences (such as the emergence of antibiotic resistance) of using antibiotics as a prevention strategy (Castrodale, Gessner et al. 2007).

Figure 9: Invasive Group B *Streptococcus* Disease Rates, ICS 2000-2006

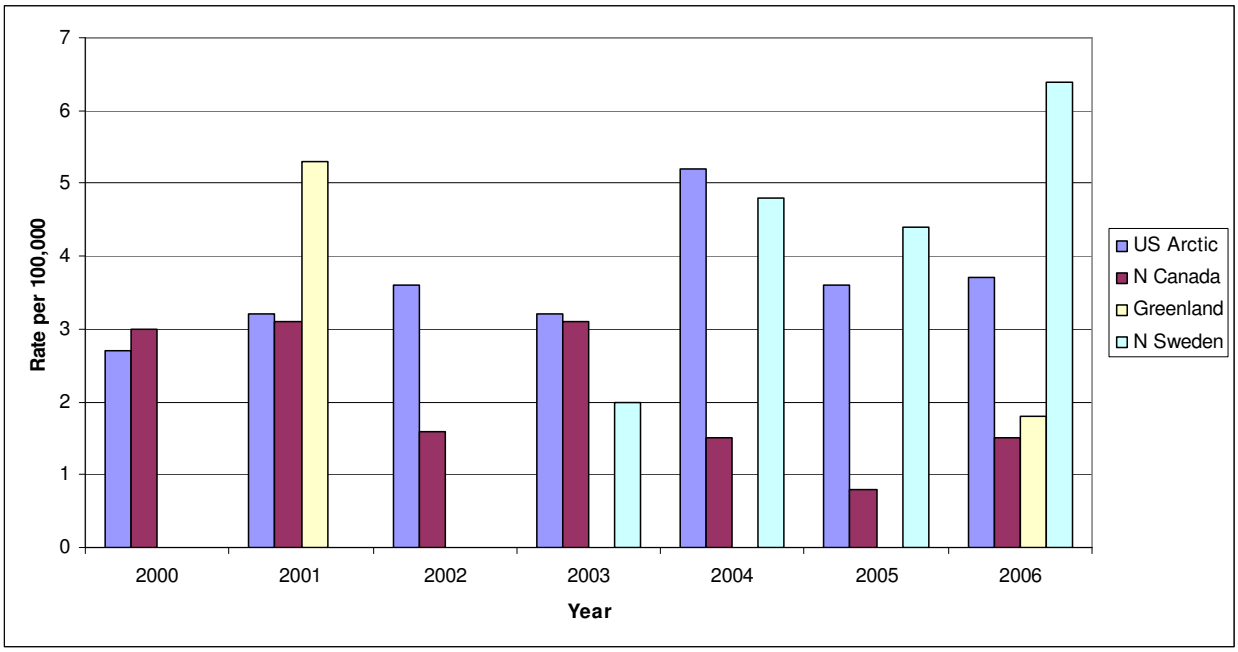


Table 15: Clinical Presentation of Invasive group B *Streptococcus* Cases, ICS 2000-2006 Data

	Greenland n (%)	N. Canada n (%)	N. Sweden n (%)	U.S. Arctic n (%)
Bacteremia	2 (50)	9 (47)	42 (98)	71 (43)
Pneumonia*	1 (25)	0 (0)	0 (0)	19 (12)
Meningitis	1 (25)	3 (16)	1 (3)	14 (9)
Cellulitis*	0 (0)	1 (5)	0 (0)	29 (18)
Septic arthritis	0 (0)	4 (21)	0 (0)	8 (5)
Endocarditis	0 (0)	1 (5)	0 (0)	6 (4)
Peritonitis	0 (0)	0 (0)	0 (0)	6 (4)
Osteomyelitis	0 (0)	0 (0)	0 (0)	5 (3)
Amnionitis	0 (0)	0 (0)	0 (0)	2 (1)
Endometritis	0 (0)	0 (0)	0 (0)	1 (<1)
Other	0 (0)	1 (5)	0 (0)	3 (2)
Total	4	19	43	164

*with bacteremia

Surveillance - Tuberculosis

In spite of advances in drug therapies and programs designed to combat tuberculosis (TB), the disease remains a significant cause of morbidity and mortality world wide. Globally indigenous populations are at increased risk for acquiring tuberculosis, because of issues related to poverty, such as poor housing, lack of access to medical care and drugs, cultural barriers, language difficulties and geographic remoteness. In the Arctic, the incidence of TB has declined dramatically since the 1950's. However, disparities in the rates of tuberculosis remain between indigenous and non-indigenous populations of Canada, United States and Greenland. While high rates of tuberculosis are reported in northern regions of the Russian Federation, the rates in the indigenous populations of these regions are not identified. Micro- epidemics continue to occur in small villages and settlements across the US Arctic (Alaska), northern Canada, and Greenland. In addition, outbreaks among the homeless, largely indigenous populations in larger urban centers are continuing to challenge public health officials in these regions. A particular challenge is the identification of latently infected persons, who are offered treatment to prevent the development of clinical disease.

Because of the concerns regarding the resurgence of TB in the Arctic, an ICS Tuberculosis Working Group was established in 2006 and is currently chaired by the Public Health Agency of Canada's Tuberculosis Prevention and Control. Members include public health officials from the US, Canada, Greenland, Denmark, Sweden and the Russian Federation.

Working group goals include: (1) improve detection of TB, (2) assess TB disease trends, (3) assess the incidence of TB, (4) increase awareness of TB, and (5) collaborate on TB research. The group developed draft Terms of Reference, core data elements, case definition and a data sharing agreement. A work group meeting is planned for July, 2009, in conjunction with the International Congress on Circumpolar Health. Continued collaboration will provide shared data that may identify common issues and assist in developing strategies for TB detection and control in the circumpolar region.

Research – Viral Hepatitis

High rates of hepatitis A, B have been found in Alaska, Canada, Greenland and Russia, especially in indigenous populations. In addition, high rates of hepatitis C are seen in Alaska Native Peoples, Canadian indigenous populations and Russians, especially those living in the Arctic regions. Also, co-infection of hepatitis B and D are found in parts of Greenland and Russia. These viral infections have had an adverse effect on the peoples of the Arctic. Although liver disease is the 12th leading cause of death in Americans, it is the 6th leading causing of death in American Indians and Alaska Natives. Similarly in Canada, deaths from liver disease are also the fifth leading cause of deaths in the 45-65 year age group. Chronic viral hepatitis due to hepatitis B and C are believed to be major contributors to liver disease in these populations. Greenland has one of the highest rates of HBV infection in the world and HBV and HCV are felt to be a major health problem in Russia, especially in remote populations.

At the ICCH in Novosibirsk in 2006, a Viral Hepatitis Workshop was held and from that meeting, a group of interested researchers and public health workers and administrators formed the Viral Hepatitis Arctic Research Group which has been included as a part of the Infectious Disease Working Group of the International Union for Circumpolar Health. The group has met twice more in Copenhagen in October of 2007 and September of 2008. Collaborative studies have been formed among researchers in the Arctic.

Project Progress 2007-2008:

1. Determine the prevalence of active hepatitis B infection in Greenland: The prevalence of HBsAg, the marker for chronic hepatitis B, varies from 8% to 12% in Greenland. To determine what proportion of persons have active liver disease from hepatitis B defined as an ALT level above 40 U/L and an HBV DNA level > 2,000 IU/ml 200 persons who were HBsAg-positive were tested and approximately 15% were found to have met the definition of active liver disease and another 5% had elevated HBV DNA levels but normal ALT levels demonstrating that transmission was ongoing in Greenland and asymptomatic liver disease due to HBV was present.
2. Determine the HBV genotypes present in the Arctic. HBV genotype testing was performed in laboratories in Alaska, Canada, Russia and Denmark. Five HBV genotypes: A2, B6, C, D and F1 were found in Alaska Natives. In Canada, genotypes A, D and B6 were found. In Greenland, genotypes A, B6 and D were found and in Russia, genotypes A, D and C were found.
3. Characterization of a hepatitis Delta (HDV) outbreak in Greenland in persons, predominantly children with chronic HBV infection. An outbreak of severe acute hepatitis was discovered to be due to HDV superimposed on HBV resulting in severe not fatal hepatitis in several children. Epidemiologic investigations by the Statens Serum Institute and laboratory investigations in Denmark and in Alaska were conducted. A paper for publication is being prepared. This investigation led to the introduction of hepatitis B vaccine into the community to try to stop the epidemic.
4. Comparison of the sequences between the same HBV genotypes found in Arctic Countries.
    a. HBV genotype B6. A new subgenotype has been found in Alaska, Canada and Greenland that appears to be less virulent than other HBV genotypes and is related to genotype B1 found in Japan but many centuries distant. These findings were published in the Journal of Infectious Diseases 2007;196:1487-92.

b. Comparison of HBV genotype D between Russia, Canada, Alaska and Greenland. A study to compare sequences and disease associations between those infected with HBV genotype D in Alaska, Greenland, Canada and Russia will be performed in laboratories in each of these countries and sequences will be sent to a collaborating laboratory in Nagoya Japan which has software to do sophisticated comparison of HBV sequences. Project has started in 2008 and will be completed in 2009.
c. Planning for projects to compare sequences of HBV genotypes C and A found in different Arctic Countries. Plans were drawn up to compare the sequences of HBV genotypes D found in Alaska, Canada, Greenland and Russia; Genotypes A found in Alaska, Greenland and Canada and finally genotype C found in Alaska and Russia in 2009-2010.

5. Advocacy for the introduction of routine newborn and childhood immunization with hepatitis B vaccine in Greenland. Greenland is the only country endemic for hepatitis B infection where routine vaccination is not done. Routine vaccination is done in Alaska, Canada and Russia. The group passed a resolution to urge the Danish and Greenland governments to implement routine vaccination. In addition, members of the working group from Denmark and Alaska attending a meeting in Copenhagen also pushed for routine immunization to be started.
6. Studies on Hepatitis C virus (HCV) in the Arctic. A separate subgroup for hepatitis C was organized at the meeting in 2007. The first task is to examine strain differences between HCV in Russia, Alaska and Canada (very low rates of HCV are found in Greenland).

Research will continue in 2009

1. Continue to determine the prevalence of active hepatitis B infection in Greenland but screening more HBsAg-positive persons for ALT and HBV DNA and determine candidates for antiviral therapy
2. Publish descriptive study of hepatitis Delta/HBV outbreak in Greenland
3. Finish study on comparison of HBV genotype D in the Arctic and draft a manuscript
4. Conduct study on comparison of HBV genotypes A and C in the Arctic.
5. Continue to actively advocate for introduction of hepatitis B vaccine in Greenland until this is done.
6. Expand study of hepatitis B in Arctic.
7. Meet for the fourth time at the ICCH conference in July 2009 in Yellowknife.

Research-*Helicobacter pylori*

Helicobacter pylori (H. pylori) is one of the most common infections in humans affecting 30-40% of persons living in the developed world, and 80-90% of persons living in the developing world. *H. pylori* is a major cause of duodenal and gastric ulcers, and infected persons are at increased risk for mucosa-associated lymphoid tissue (MALT) lymphoma, and gastric adenocarcinoma. In addition, infection is also associated with chronic active gastritis. Humans appear to be the major reservoir for *H. pylori*. Acquisition occurs by ingestion of the organism; however, transmission is poorly understood with fecal-oral or oral-oral (saliva, vomitus) being the most likely modes of transmission. Compared with other groups in the U.S., Canada, and Denmark, Indigenous people in Alaska, Northern Canada and Greenland have a higher prevalence of infection with *H. pylori* varying from 47-95%.

In October, 2007 the 1st meeting of the Circumpolar *H. pylori* Research group was held in Copenhagen, Denmark bringing together public health specialists and *H. pylori* researchers from 9 different countries. The Circumpolar *H. pylori* Research Group is part of the Infectious Disease Working Group of the International Union for Circumpolar Health. The 2nd meeting was held in Copenhagen in September 2008. Collaborative studies have been formed and future studies are under consideration.

Project Progress 2007-2009:

1. **Overview of the epidemiology of *H. pylori* among the Arctic countries:** Research group members from different Arctic countries presented data on *H. pylori* prevalence among their populations. It was determined by the group that *H. pylori* infection is highly prevalent in Alaska, Northern Canada, and Greenland with particularly high prevalence among Indigenous populations residing in these countries/Territories. Why rates of infection with *H. pylori* are elevated among Indigenous Arctic populations are not well understood. A review of the literature and an update with results of the most current studies was proposed at the 2007 meeting. In March 2008, a Canadian member of the Circumpolar *H. pylori* Research Group published the following: Goodman et al. *Helicobacter pylori* infection in Canadian and related Arctic and Aboriginal Populations, Can J Gastroenterol Vol 22, No 3, March 2008. In addition, Dr. Michael Bruce, Chairman of the Circumpolar *H. pylori* Research Group gave an invited oral presentation titled "*H. pylori* Infection in the Circumpolar World" at The XXIst International Workshop on *Helicobacter* and related bacteria in Riga, Latvia in September 2008.
2. **Characterizing prevalence and antimicrobial resistance of *H. pylori* among Indigenous and non-Indigenous Arctic communities:**
   Serosurveys conducted in Alaska, Northern Canada and Greenland have demonstrated high *H. pylori* prevalence; however, further studies characterizing antimicrobial resistance and treatment outcome within Indigenous and non-Indigenous communities are needed. Canadian workgroup members have recently begun a study in Canada's Northwest Territories (NWT) to determine prevalence of infection (endoscopy) among all residents of an isolated remote community, to review antimicrobial susceptibility of the organisms and to treat all *H. pylori*-positive persons and determine efficacy of treatment. In Alaska, studies characterizing prevalence of infection, antimicrobial susceptibility, and reinfection have been performed; however, a comprehensive study of 3 populations in different regions of Alaska was recently

completed and this data is currently being analyzed for publication and presentation at the 2009 Circumpolar *H. pylori* Research Group meeting which will take place in Yellowknife, NWT, Canada in July, 2009.

3. **Gastric Cancer and Peptic Ulcer Disease (PUD):**
   Data on diseases associated with *H. pylori* infection among Arctic populations were presented by research group members from each country. It was determined by the research group that rates of gastric cancer are 2-4 fold higher among Indigenous populations in Alaska, Northern Canada, and Greenland when compared with non-indigenous populations residing in the rest of the US, lower Canada, and Denmark. In addition, rates of PUD are elevated in Alaska and Northern Canada when compared with the population at lower latitudes within those countries, and the gastric ulcer to duodenal ulcer ratio is unusually high, up to 5:1 in Alaska and Northern Canada. Discussions are currently under way between research group members from Alaska, Canada, and Greenland to develop an international prospective multicenter case-control study to: 1) look at the relationship between infection with *H. pylori* and its association with gastric cancer, 2) determine risk factors for infection, 3) characterize pathogenic factors (ex. cagA, vacA etc.) within the bacteria that may make some bacteria more likely to cause cancer than others, and 4) characterize host factors (ex. cytokine polymorphisms) that may contribute to host response to infection with the *H. pylori* bacteria. If key risk factors could be identified, then lives could potentially be saved through early screening programs. Research group members in Alaska have recently begun a retrospective case-control study of *H. pylori* and gastric cancer among Indigenous Alaskans using stored sera from the Alaska Area Specimen Bank. This study may help to answer some of the above questions and lay the groundwork for a more comprehensive, future study among Arctic populations.

The International Polar Year

The International Polar Year presented a unique opportunity to advance the circumpolar human health research agenda of the Arctic Council. The Arctic Human Health Initiative (AHHI) was submitted to the IPY International Program Office as an Arctic Council, US led, SDWG IPY coordinating project, which aimed to serve as a focal point for human health research, education, outreach, and communication activities during IPY (2007-2009). The overall goal of the AHHI is to: "*Increase awareness and visibility of human health concerns of Arctic peoples, foster human health research, and promote health strategies that will improve health and well being of all Arctic residents*". Proposed areas of research highlighted by AHHI, included the expansion of research networks that will enhance surveillance and monitoring of health issues of concern to Arctic peoples and increase coordination and collaboration of health research. An ICS proposal was submitted as part of the AHHI. Proposed ICS IPY 2007-2009 activities included: 1) Expansion of ICS to include the northern and far eastern regions of the Russian Federation. 2) The convening of infectious disease working group meetings with infectious disease specialists from northern regions and far eastern of the Russian Federation, to assess the infectious disease problems, surveillance methods, interventions and the training needs of infectious disease specialists in these regions. 3) The development of collaborative arrangements for infectious disease information exchange and inclusion of northern and far eastern regions of the Russian Federation in ICS system 4) Initiate an ICS International Fellowship program(2007-2008) 5) Expansion of ICS to monitor tuberculosis in circumpolar countries. 6) Expansion of ICS to include non infectious diseases, such as injuries, chronic diseases, and birth defects 7) Initiation of research projects to evaluate the long-term sequellae of chronic hepatitis b infections indigenous populations of the Arctic, the investigation of the natural history of *Helicobacter pylori* in Arctic communities, the investigation of the emergence and potential control of invasive bacterial diseases caused by non vaccine serotypes of *Haemophilus influenzae* and 8) Initiation of a community based monitoring system for the detection of zoonotic diseases in subsistence animal species. Information about the ICS proposal and other infectious disease IPY activities can be found at the AHHI website www.arctichealth.org.

Accomplishments of ICS during the IPY has included:
The publication in January 2008 of a special IPY issue of the Emerging Infectious Diseases Journal (www.cdc.gov/ncidod/eid). This edition featured a description of the ICS system, and several reports from the ICS network. Papers also focused on new and reemerging infectious diseases in Arctic regions.

The establishment of the ICS tuberculosis working group. Participating countries include, the US (Alaska), Canada, Greenland/Denmark. A working group meeting is planned in conjunction with the 14th International Congress on Circumpolar Health, to be held in Yellowknife NWT, Canada July 12-16, 2009

The formation of a viral Hepatitis research working group has been formed to examine long term sequellae of chronic hepatitis b and c infections indigenous populations of the Arctic. A working group meeting is planned in conjunction with the 14th International Congress on Circumpolar Health, to be held in Yellowknife NWT, Canada July 12-16, 2009

The formation of a *Helicobacter pylori* research working group that will examine the natural history of *Helicobacter pylori* in Arctic communities, and the potential link between

Helicobacter pylori and gastric cancer in Arctic populations. A working group meeting is planned in conjunction with the 14th International Congress on Circumpolar Health, to be held in Yellowknife NWT, Canada July 12-16, 2009

ICS together with the Northern Forum (www.northernforum.org) sponsored an IPY International Conference on Infectious Diseases in Moscow, April 24-26, 2008. The Conference was attended by infectious disease epidemiologists from northern regions of the Russian Federation. The purpose of this conference was to discuss the possibility of establishing an Infectious Disease Surveillance Network in northern regions of the Russian Federation that would contribute to the ICS network. A follow-up meeting is planned in 2009 to discuss the possibility of forming a tuberculosis working group within northern regions of the Russian Federation that would contribute data to the ICS tuberculosis working group.

A major IPY initiative is the formation of Sustainable Arctic Observing Networks (SAON) for the purposes of long-term monitoring change in the Arctic (www.arcticobserving.org). The ICS is a sustainable observing network for infectious diseases and could be used as a model for establishing observing networks for other human health issues and concerns. This concept was presented at a workshop was held at the Second SAON meeting in Edmonton Alberta Canada April 24-26, 2008.

Future Plans: 2009-2010

Future activities for ICS include:

- Continue surveillance of invasive bacterial diseases and related quality control programs in the US Arctic, northern Canada, Greenland, Iceland, Norway, Finland and northern Sweden during 2009-2010.

- Initiate standardized collection of tuberculosis data in the US Arctic, northern Canada and Greenland.

- Explore potential mechanisms for sharing of infectious disease surveillance information between public health authorities in northern regions of the Russian Federation and ICS participating countries.

- Coordination of Hepatitis and *Helicobacter pylori* research activities will continue.

- Formation of a circumpolar Sexually Transmitted Infections working group to explore collaborative research and intervention activities in circumpolar countries.

- Expansion of ICS to include non-infectious disease problems important in Arctic communities. It is anticipated that an ICS surveillance system for Birth Defects will be established in 2009 (lead country Canada).

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