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Arctic health policy: contribution of scientific data

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Abstract

In Western Hemisphere arctic regions, scientific findings in humans, wildlife, and the environment have resulted in major governmental policy formulations. Government policy resulted in establishment of an effective international organization to address scientifically identified problems, including health disparities in arctic indigenous populations. Western scientific data and indigenous knowledge from initial international programs led to international agreements restricting certain persistent organic pollutants. In recent years, scientific data, and indigenous traditional knowledge, have resulted in governmental policy in the United States, Canada, and Nordic countries that includes the full participation of indigenous residents in defining research agendas, interpreting data, communicating information, and local community policy formulation.

Key words: Arctic data – government policy

Background

Current Arctic policy and programs responding to the influence of environmental contaminants and other environmental factors on human health have evolved largely from scientific findings developed over the past twenty years. In addition, the last four decades have produced medical data documenting, in particular, the health problems of Arctic aboriginal residents. Key data, which influenced policy fell into four categories. *1*) Data on health status disparities in aboriginal residents. *2*) Data gathered in the 1980's in Canada which demonstrated highly persistent lipophilic organic compounds of anthropogenic origin in blood specimens from the women in the eastern Canadian Arctic, far from sites of manufacture and use of these chemicals (Kinloch et al., 1992). These results led to acceleration in research in most Arctic countries directed at determining the full nature, scope and impacts of this environmental pollution for human and wildlife populations. *3*) Thinning of the earth's ozone layer, due to widespread manufacture, use and release of anthropogenic compounds such as chloroflurocarbons (CFCs), and the subsequent increased incident ultraviolet radiation in both polar regions, was discovered in the early 1980's. Among a number of effects on humans and wildlife, ultraviolet radiation has been the largest single factor associated with increased skin cancers in human populations. A global agreement (the Montreal Protocol) and legislative restrictions in most countries on the

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manufacture and use of CFCs have been enacted under a phased reduction schedule (Climate Change, 1992). *4*) A global warming trend influenced by atmospheric collection of so-called greenhouse gases such as carbon dioxide, was clearly documented in the mid-80's based on an analysis of decades of data. This warming trend, which was evident in parts of both circumpolar regions, has led to an international effort through the Intergovernmental Panel on Climate Change to identify future trends in global warming and the consequences for human populations and global ecosystems (Climate Change, 2001).

Many other influences beyond strictly environmental factors are impacting the Arctic region. These influences, mostly associated with globalization and rapid change (for example, economic and trade changes, sovereignty and security issues, and instantly accessible entertainment/information media and e-based communication) are also impacting traditional social and cultural approaches. Traditional diet, land use, income expectation, tourism, population movements into and out of the Arctic, and the appearance of new and old diseases are important as well (Bjerregaard et al., 1988). While these forces have a powerful influence on overall physical and psychosocial health, as well as public health policy in Arctic countries, they are not within the scope of this paper.

The content of this paper will focus on the influence that scientific findings in Alaska, Arctic Canada and Greenland related to human and environmental health have had on the development of governmental policy and programs in the Arctic region. Future directions for action in the Arctic as a result of emerging findings will be discussed.

Health status in Arctic regions

Arctic aboriginal populations have experienced improvement in health status with the establishment of a basic public health infrastructure, improvements in medical care, and transportation. As an example of this, the infant mortality for Alaska Natives over a fifty year period is compared to U.S. all races mortality in Figure 1.

In spite of such improvements, significant differences in life expectancy exist in the Arctic. Life

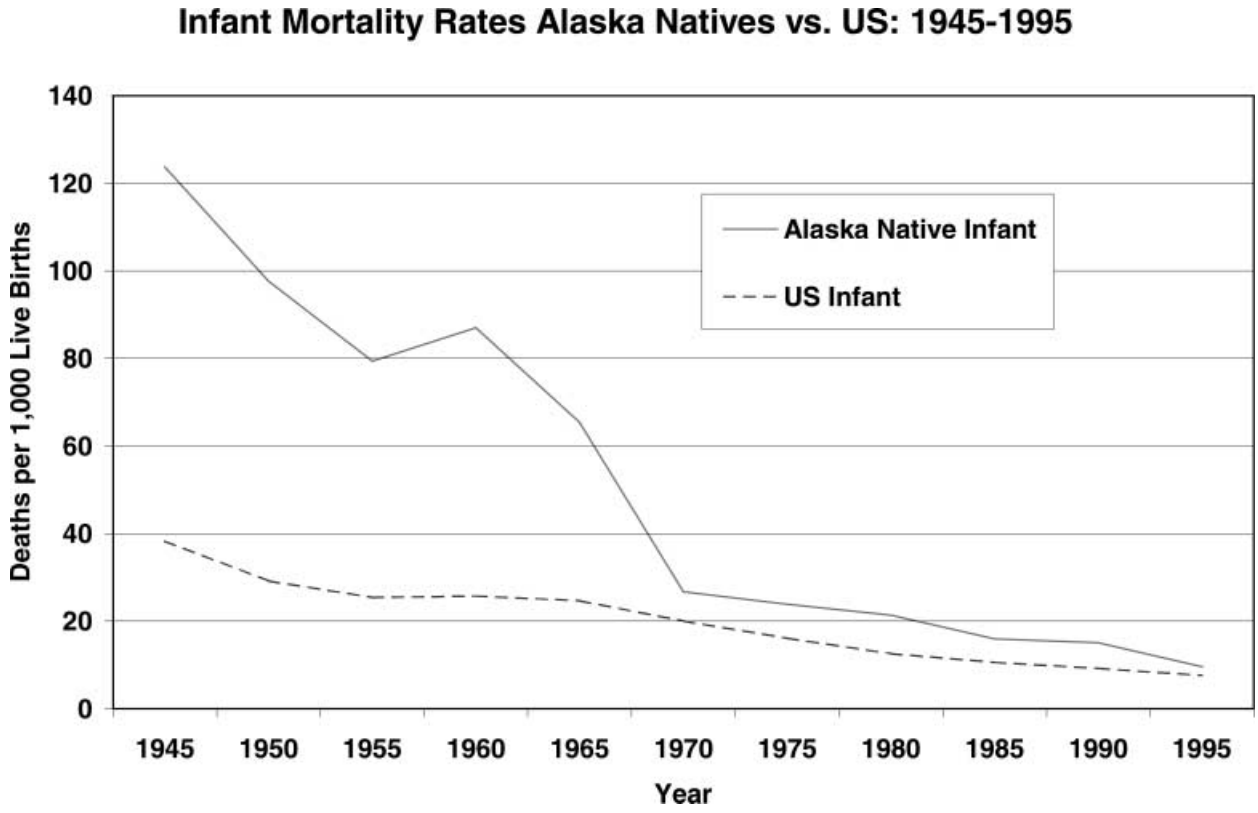

Fig. 1. Infant (under 1 year) mortality rates per 100 000 born, between 1945 and 1995, in US and Alaska Natives. Source: Alaska Area Profile FY2000, Alaska Area Native Health Service.

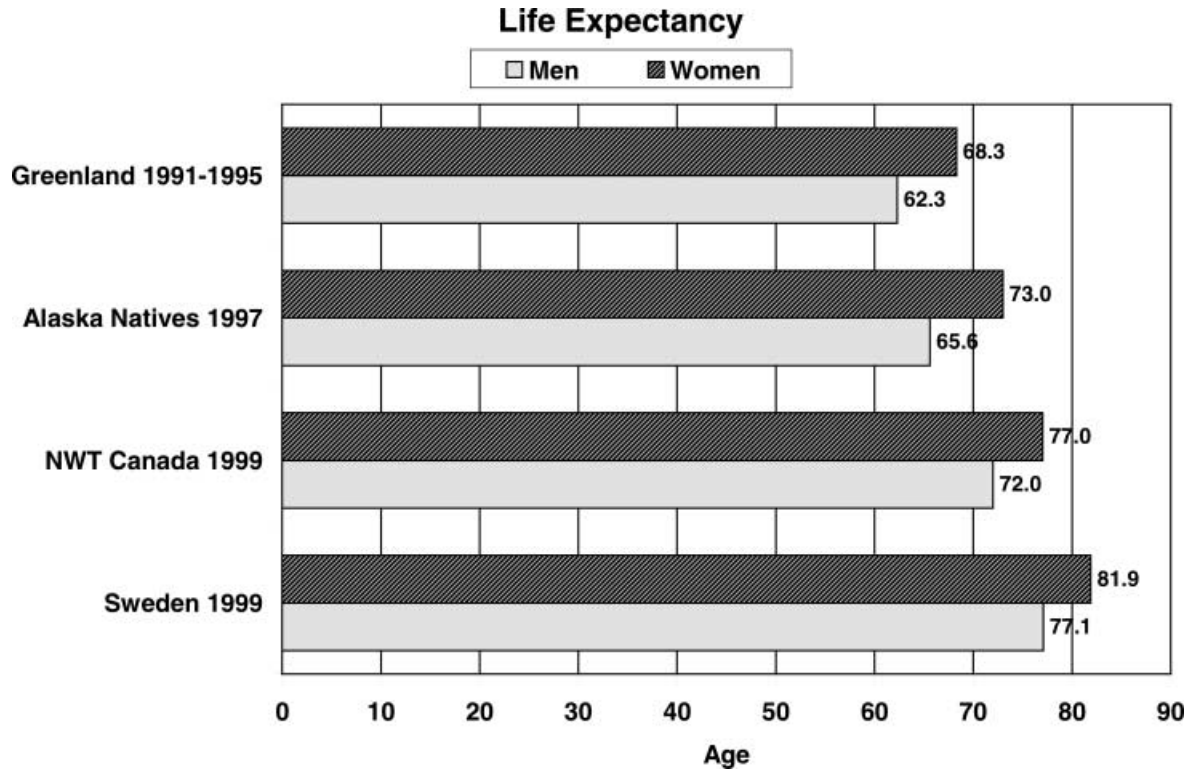

Fig. 2. Life expectancy in the 1990's for the AMAP countries and some indigenous populations. Source: World Health Organization Statistical Database, NOMESCO Health Statistics in the Nordic Countries 1999, The NWT Health Status Report 1999 Canada, Regional Differences in Indian Health 1998–99.

expectancy of aboriginal residents in the western hemisphere, Alaska Natives, Canadian Inuit and Arctic First Nations residents (here represented by Canadian Northwest Territories) and Greenland Inuit, are compared to Sweden, as a representative Nordic population (Figure 2). No data is currently available for comparison from the Russian Federation Arctic residents.

Among aboriginal populations there are certain well-documented differences in causes of morbidity and mortality. Figure 3 shows the population mortality rates for the most common causes of mortality in aboriginal and selected non-aboriginal populations. Mortality for unintentional injury, related to harsh environment, isolation, transportation (access to care) and alcohol use is disproportionately high. Intentional injury mortality (predominantly suicide) related to a variety of factors including the stress on traditional cultures, is even more disproportionate. As seen in Figure 4, in Arctic aboriginal populations this is strikingly an affliction of young people, both men and women, but more so among men.

Cancer has become more common as the Arctic population has grown to include more elders, with tobacco and possibly western diet as contributing factors. However, in Western Hemisphere Inuit, there are distinct differences in cancer experience, as seen in Figure 5. The reason for these differences is not known, but as discussed in the next paragraph, certain unique risk factors have been established with some cancers.

Unusual morbidity due to infectious agents has been well documented among Arctic aboriginal people for many years (Bjerregaard et al., 1988). Initially with tuberculosis and Hepatitis B, modern chemotherapy and vaccines have greatly reduced the morbidity of these as well as other infectious diseases. However, aboriginal infants have a disproportionate burden of severe infectious disease. As an example hospitalization of Alaska Native infants with severe Respiratory Syncytial Virus infections occurs at rates of up to ten times that of other infant populations (Karron et al., 1999). In addition, among Alaska Natives infection with *Helicobacter pylori* takes place at an early age, and rapidly approaches 90% in adults, as seen in Figure 6. This organism is associated with gastrointestinal bleeding, ulcer disease, and certain gastric cancers (Parkinson et al., 2000). In addition, infection with Epstein-Barr Virus is, in Inuit, associated with

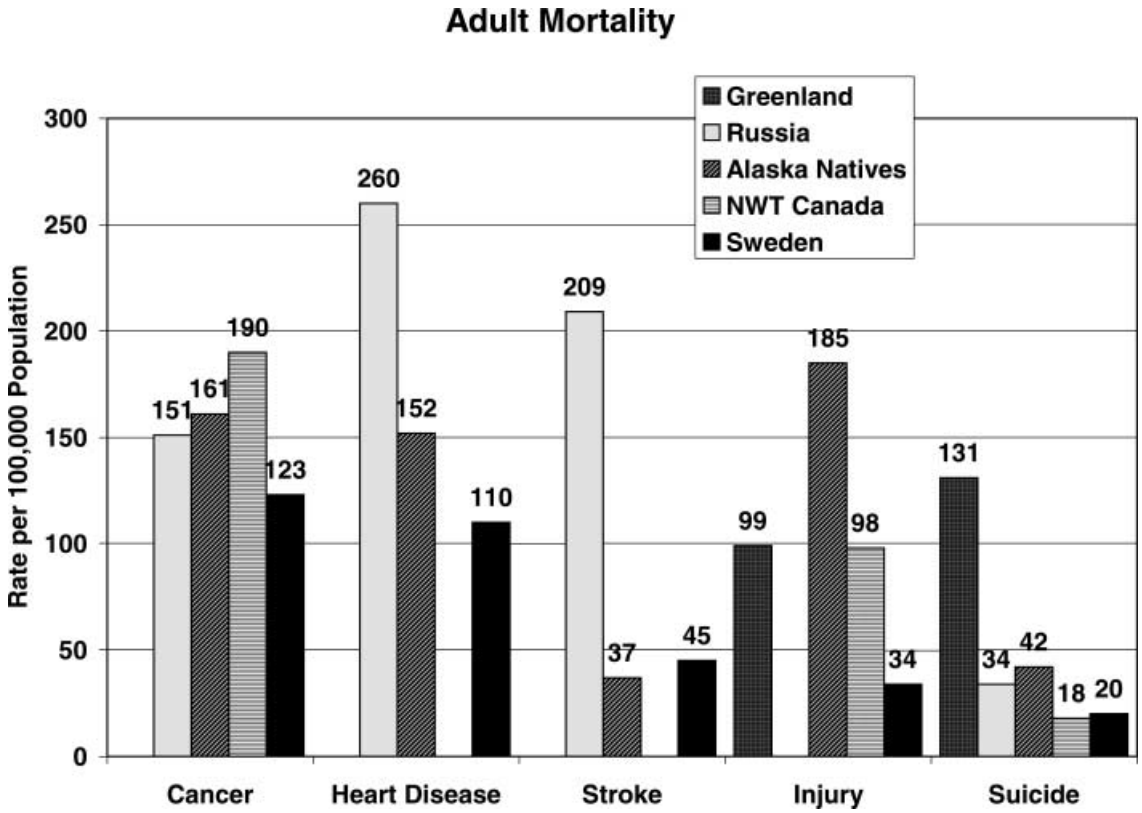

Fig. 3. Adult age-standardized population mortality rates in cancer, heart diseases, stroke, injury and suicide per 100 000 population in the AMAP countries and among some indigenous populations (Russia 1997, Alaska Natives 1994–96, NWT Canada 1991–96, Greenland 1991–95 and Sweden 1996). Source: World Health Organization Statistical Database, NOMESCO Health Statistics in the Nordic countries 1999, The NWT Health Status Report 1999 Canada, Regional Differences in Indian Health 1998–99.

nasopharyngeal cancer. The reasons for these unusual morbidities associated with infection are not known, but may be related to genetic and/or environmental factors.

The documentation of the marked disproportionate burden of infectious morbidity and mortality has resulted in the establishment of the Arctic Investigations Program of the Center for Disease Control and Prevention, in Anchorage, Alaska to study this phenomenon.

The extraordinary mortality rate from unintentional injury includes injury mortality during work (occupational injury mortality) as well as injury during subsistence hunting and fishing. This data has led to the establishment of a permanent field office of the National Institute of Occupational Safety and Health (NIOSH) in Anchorage to address these events, and define targeted prevention programs.

Current Arctic environmental health policy and program initiatives

The Arctic Environmental Protection Strategy and national programs

The Arctic Environmental Protection Strategy (AEPS) was created by agreement in 1991 by the eight Arctic states largely in response to the alarming findings in the eastern Canadian Arctic. Governments were concerned about the health implications of relatively high levels of lipophilic, highly persistent organic compounds of anthropogenic origin, such as polychlorinated biphenyls (PCBs) and a variety of pesticides such as DDT, in the breast milk of Inuit women from northern Quebec and Baffin Island in the Canadian North West Territories (currently Nunavut) (Dewailly et al., 1993). Governments were also concerned about the influence of these same pollutants on top-of-the-food-chain species. These data and the results of analyses of marine mammal tissues in the Canadian Arctic,

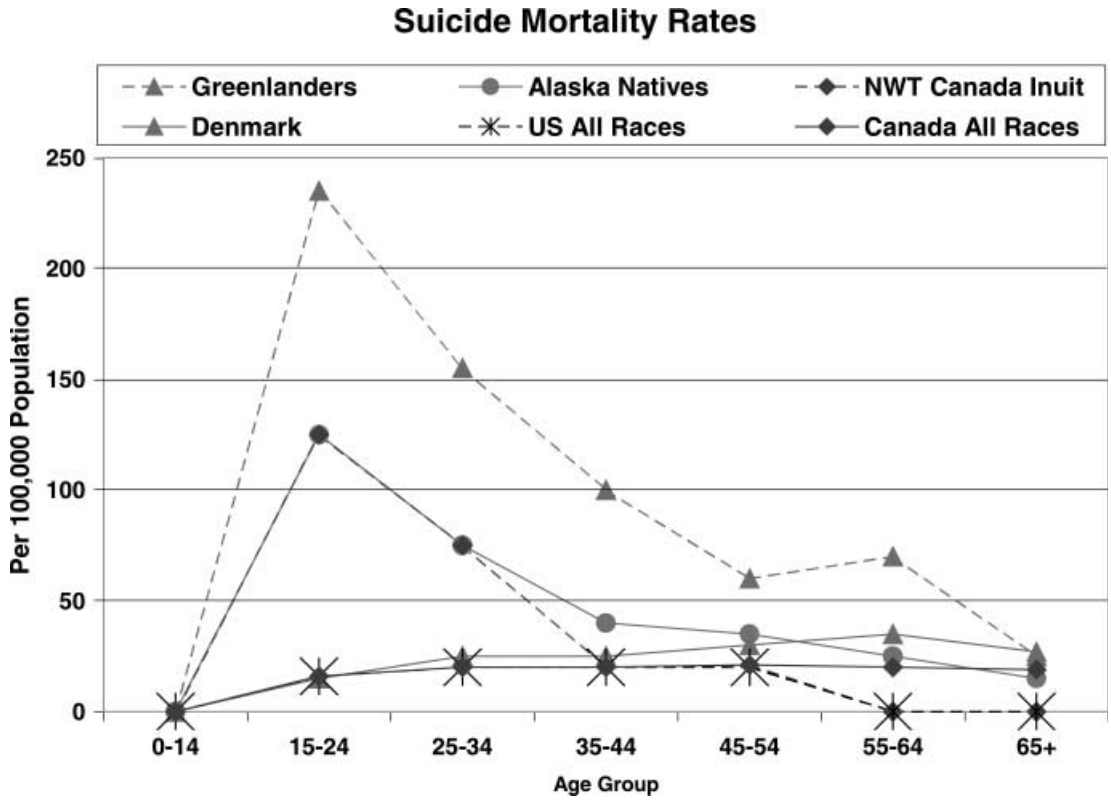

Fig. 4. Suicide mortality rates per 100 000 population among Greenland Inuit, Alaska Natives, NWT Canada Inuit, Canada All Races, US All Races, and in Denmark in (1980–89). Source: The Circumpolar Inuit: Health of a Population in Transition.

Greenland and Scandinavia also raised two other key issues (Muir et al., 1992). A need was recognized to define of the transport mechanisms for these relatively high molecular weight compounds that are only semi-volatile yet they migrate thousands of kilometers from where they were manufactured and used into the Arctic ecosystem. The mechanisms were investigated which allowed levels of these substances to be substantially lower in human populations in the southern areas of these same Arctic countries where the chemicals were created and used.

The result of these investigations was that long range transport of these persistent organic pollutants (POPs), that were thought to remain generally in the local areas where they were applied, used, spilled, or discharged, was likely taking place by air and ocean currents and possibly some river systems. Furthermore, uptake and extensive biomagnification into the food web of the Arctic had occurred and had resulted in exposure of Arctic residents through traditional subsistence food consumption (Muir et al., 1992).

These implications posed significant questions about effects on wildlife and human health, and rapidly led to recognition that an organized multination scientific effort would be needed to gather sufficient data to create informed public policy. Coordinated program effort was needed in three categories. The first category involved assessment of levels of pollutants in air, water, biota, and humans. The second category involved determination of transport mechanisms. The third area of research involved investigation of health effects in plants, wildlife, and humans. The recognition that the investigation of these three research areas would require international collaboration resulted in governmental policy decisions by all eight Arctic States to jointly form a new intergovernmental entity, the AEPS, in 1991(Declaration, 1991).

At the inception of the AEPS, the representatives of the eight nations created four permanent programs: the Arctic Monitoring and Assessment Program (AMAP), the Conservation of Arctic Flora and Fauna Program (CAFF), the Protection of Arctic Marine Environment Program (PAME) and the Emergency Program for Preparedness and Response (EPPR)(Declaration, 1991). The CAFF, PAME and EPPR Programs are not directly concerned with human health and will not be further discussed.

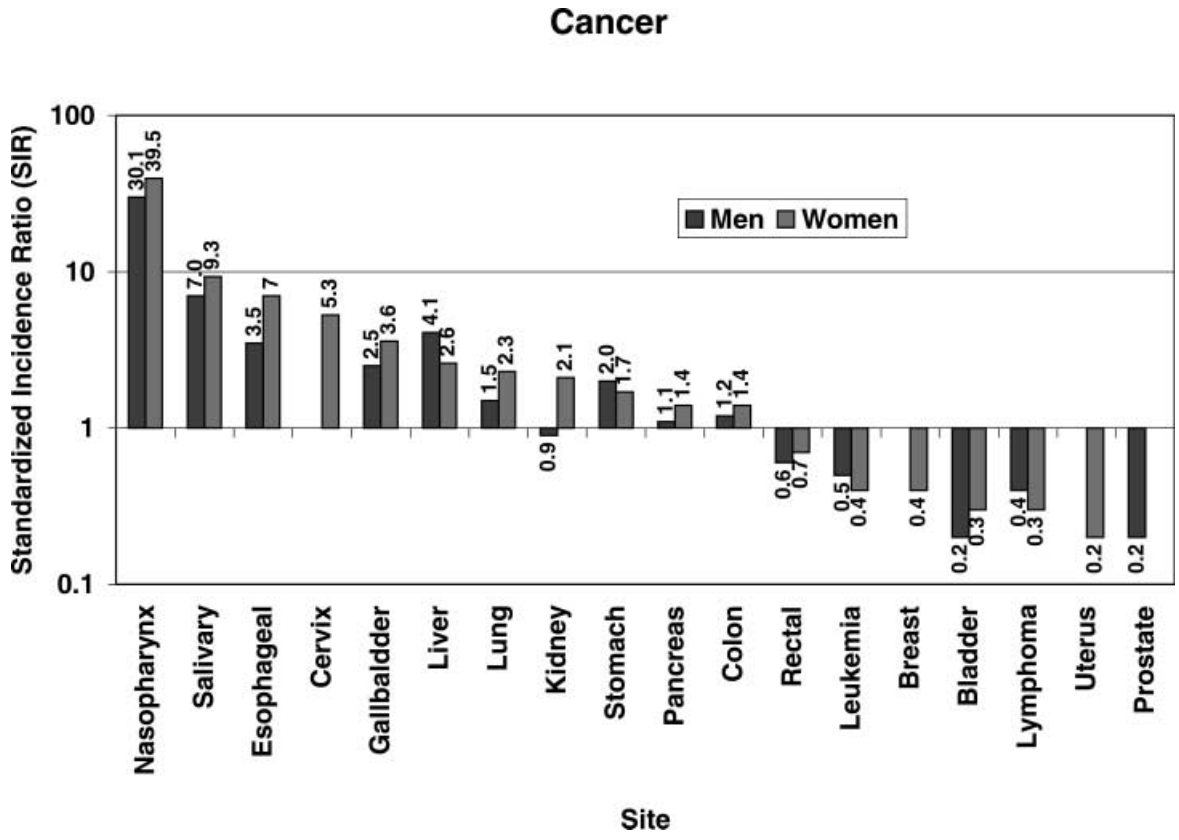

Fig. 5. Standardized incidence ratio for selected cancer sites among men and women circumpolar Inuit in the time period 1969–88. Source: The Circumpolar Inuit: Health of a Population in Transition.

National responses led to the creation of various program entities such as the Northern Contaminants Program in Canada in 1992. This Canadian Federal Government initiative funded physical, chemical, health, social, and policy research in the Canadian Arctic using a public, private, academic and aboriginal partnership process for project development, approval, management and implementation. The United States agencies responded to the concerns of the Alaska Natives with individual agency program initiatives, beginning in the late 1990's. Initially, there was little coordination between agencies.

The Arctic Monitoring and Assessment Program (AMAP) was equipped with separate expert groups to address the scientific questions around key pollution topics including: POPs, heavy metals, transport pathways, radio nuclides, petroleum hydrocarbons, climate change (including ozone depletion and ultraviolet radiation) and human health. Each expert group consisted of identified key national experts, usually national government scientists. Also included were scientists from universities, regional governments, and representatives from permanent participant indigenous organizations.

The initial work of the AMAP Human Health Expert Group (HHEG) under Phase 1 of AMAP (1994 to 1997) consisted of a coordinated multination assessment of levels of a group of persistent lipophilic organic pollutants and heavy metals in the blood of pregnant women and their newborn infants (Summary, 1997). These women were in some countries selected for use of subsistence species in traditional diets, while in other countries, they were selected based only on residence in the far north of their country. The mean levels of the sum of measured PCB congeners from initial country assessments are shown in Table 1, including initial U.S. data not available for the original publication.

The detailed findings of the HHEG were published along with the findings of the other AMAP workgroups in 1998. The key Governmental health recommendations included: 1) "Weighing the well-known benefits of breast milk and traditional food against the suspected but not yet fully understood effects of contaminants, it is recommended that consumption of traditional food continues, with recognition that there is a need for dietary advice to Arctic peoples so they can make informed choices

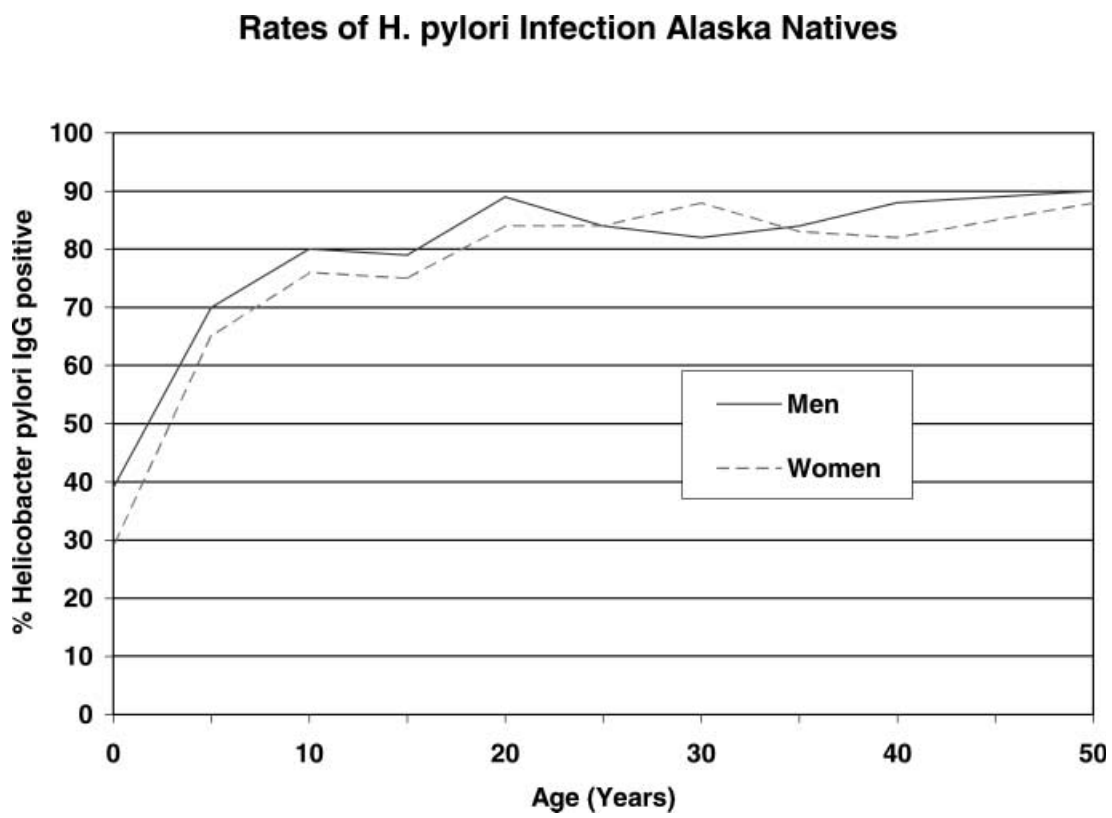

Fig. 6. Rates of *Helicobacter pylori* infection among Alaska Natives by age group and sex 1980–86. Source: Arctic Investigations Program, CDC, Parkinson, A. J., et al., 2000.

Table 1. Comparison of Aleutian and Pribilof Islands (Alaska 1999) with AMAP Maternal Plasma Study.

	n	Sum PCB
Aleutian/Pribilof-WCBA	40	333
Canada	67	167
Greenland	117	571
Sweden	40	222
Norway	60	173
Iceland	40	230
Russia	51	231

AMAP Maternal Plasma Study (geometric means, ppb lipid). Sum of 14 Congeners. Aleutian/Pribilof values are arithmetic means. Source: Arctic Monitoring and Assessment Program 1994–96, State of Alaska Section of Epidemiology 1999

concerning the foods they eat." 2) "Breast feeding should continue to be promoted." 3) "There is a need for improved information on spatial and temporal trends to clarify the adverse effects of POPs, methylmercury, and cadmium on human populations, especially on child development (Summary, 1997)."

The Arctic Council of Ministers and International Governance

The data that became available through the various national programs in the Arctic region and that were analyzed during Phase 1 of the AMAP had a number of profound social and policy outcomes, resulting from the recommendations listed at the end of section 2.1 of the Assessment Report (Summary, 1997).

In 1995, international negotiations began on separate protocols for control of POPs and metals under the United Nations sponsored Convention on the Long-range Transport of Airborne Pollutants. Both protocols were based in the United Nations Economic Commission for Europe (UNECE), one of five world regions recognized by the United Nations Environment Program. Negotiations concluded successfully in 1998. Significantly, all eight Arctic nations signed the protocols and most have now ratified them.

Building on the success of the AEPS and recognizing the need for political leadership in the Arctic region, the same eight countries with territory and

populations north of 60°N latitude created the Arctic Council in 1998. The Arctic Council is the successor of the AEPS. In addition to governmental representatives of these countries, the aboriginal populations of these regions are represented by six aboriginal organizations, which are afforded the non-voting status of "permanent participants", with an Indigenous People's Secretariat established in Copenhagen.

In 1997 the United Nations Environment Program Governing Council adopted a resolution for the development of a legally binding global instrument for 12 POPs. Negotiations began in 1999 and led to signature of the Stockholm Convention on Certain Persistent Organic Pollutants in 2001. All Arctic countries signed the Convention and many have now ratified the convention.

The work of the AMAP and the traditional knowledge of aboriginal groups greatly influenced public understanding and profiled the plight of Arctic people who eat traditional diets. Many indigenous groups have come forward at international negotiating sessions for both the UNECE Protocols and the Stockholm Convention and spoken eloquently of the disruption that concerns about POPs have on traditional culture, on physical and psychosocial health, and on the land they have called home for millennia.

Public Health officials in most Arctic regions have had to face what many call the "Arctic dilemma" (Summary, 1997). This issue relates to the risks, compared to benefits, of consuming traditional diets. Traditional food species have been examined in many Arctic regions. In general, predators at the top of the food web, especially larger and male examples, have the highest levels of POPs (Muir et al., 1992). There is, however, wide variation in the Arctic, and certain regions have consistently high levels, notably eastern Greenland, western Greenland, and eastern Arctic Quebec, while other regions have lower levels, such as western Arctic Canada, and the Arctic Coast of Alaska (Muir et al., 1992). Human tissue levels of aboriginal residents of these regions generally show the same trends, with levels much lower than those of major predator subsistence species, such as seals and beluga whales (Summary, 1997). The "Arctic dilemma" then becomes an issue of regional scientific data, which is critical to policy formation, including federal governmental policy, regional public health policy, and village-level hunting/fishing and dietary policy. Thus, in the Faroe Islands, scientific data documented elevated mercury levels in maternal blood, due to the consumption of pilot whales, and studies of children showed subtle neurophysiological effects when born to highly exposed women (Grandjean and White et al., 1998). Public health authorities issued advisories to reduce this exposure, and follow-up studies have shown reduced exposure (Summary, 2002). In the Seychelle Islands similar mercury exposure from fish had no discernable effect, so no dietary change was felt necessary (Davidson et al., 2001). In the United States, concerns over prenatal mercury exposures at levels an order of magnitude lower than in the Faroe Islands prompted the United States Food and Drug Administration to issue guidance on fish consumption (U.S. FDA, 2001). Exceptions to the guidelines were issued in Alaska, based on regional fish data, and the Public Health value of marine food (Public Health Advisory, 2000). The AMAP Human Health Expert Group stated clearly that while estimated risks to health might be measurable for some highly exposed Arctic people, the known benefits of breast feeding and consuming traditional diets outweigh these risks at this time.

AMAP's Phase 2 Program

At the direction of the Arctic Council, the AMAP created a Phase 2 program (1997 to 2002). Specific attention was to be paid to interactive effects of a variety of pollutants and physical factors such as ultraviolet exposure and climate change. The HHEG developed an 'effects program' in response to the direction of the Arctic Council to investigate the combined effects on health of chemical, metals and physical agents on exposed Arctic residents. The research was designed to provide results that could be used to improve advice to Arctic residents about risk reduction, while maintaining traditional diets which are central to indigenous culture and have proven health benefits (Summary, 1997). The report of the Human Health Expert Group Phase 2 assessment was presented to the Arctic Council Ministerial Meeting in Finland in 2002. Key findings included: *1*) Comparisons of blood contaminant levels confirm that all Arctic residents are exposed to POPs and metals and that relative exposures differ across the Arctic. The highest levels are found in populations consuming marine mammals and primarily in the eastern Canadian Arctic and Greenland. *2*) Research on effects of methyl mercury on neurodevelopmental development of children in the Faeroe Islands has indicated that high levels of prenatal exposure were associated with subtle neurophysiological changes (Grandjean and White, 1998). These children also had prenatal exposure to persistent organic compounds and these compounds or the mixture with mercury, may have been responsible

for a portion of the associated affects (Grandjean and White, 1998). *3*) Research from Arctic Quebec has suggested an association between prenatal exposure to POPs and increased risk for middle ear infection in certain periods in infancy (Dewailly et al., 2000). A larger study with more specific infection, growth, and neurodevelopment endpoints is in progress in Arctic Quebec. *4*) Faroe Islands public health officials have issued advisories limiting pilot whale muscle intake in women during pregnancy. Since this advisory, surveys of maternal blood indicate significant reduction in mercury in the Faeroe Island women (SOAER, 2002). *5*) Traditional diets are very high in quality, providing excellent nutrition and energy requirements and may lead to lower rates of cardiovascular disease and diabetes (SOAER, 2002). *6*) Levels of POPs such as PCB and DDT are only expected to decline marginally over the next 10 years and then significantly by 2030. Levels of mercury are expected to increase slightly in the near term and decline only moderately by 2030 (SOAER, 2002). *7*) Public Health advisories should be local (i.e., specific to the residents in particular areas), developed with public input, and clearly aimed at reducing unnecessary exposure while maximizing beneficial traditional food consumption and breast feeding.

Science and Arctic indigenous residents

The Arctic Council has, from its inception, recognized the unique status of Arctic indigenous peoples. Representatives of these groups participate in all Arctic Council programs and workgroups. Within the member countries, indigenous groups are increasingly consulted, and are more involved in planning and directing research involving their environment, traditional foods and health.

United States, Canadian and Danish (Greenlandic) federal policy has, since the early 1970's, encouraged indigenous groups and local governments to assume management of their own health care programs. Gradually, over the last ten years, U.S. policy has been allowing much greater local control in the creation of local health priorities, and reallocation of heath care dollars to reflect differences in Native American health care requirements. Alaska Natives, Canadian First Nations groups and Greenlandic Inuit have identified safety of traditional food as a critical health and cultural need, using AMAP data to support this message. As a result, in the U.S., Canada and Greenland, policy evolved to meet this need.

United States Native American aboriginal environmental policy and program development

Aboriginal participation and partnerships have been essential elements of successful studies, analysis, communication, and policy development. Policy that recognizes the value of the Native American traditional knowledge, the importance of Native American involvement in establishing a research agenda, and the capability of Native American organizations to plan and carry out research is a profound shift in governmental policy. The Canadian model of the Northern Contaminants Program, as well as the research data and experience of Canadian Arctic communities, investigating their own contaminant issues, materially assisted this policy development.

The United States Environmental Protection Agency Office of International Activities has supported a program of human tissue monitoring in Alaska Native mothers and infants, to provide trend data for levels of POPs and heavy metals, as well as trends in health effects. The Center for Disease Control National Center for Environmental Health is a key collaborator in this program, providing laboratory support, and environmental epidemiological analytic support. A consortium of Alaska Native Tribal health programs, the Alaska Native Tribal Health Consortium (ANTHC), is responsible for the design, implementation, and data dissemination. The State of Alaska, with ANTHC will create any needed health advisories.

The United States Agency for Toxic Substances and Disease Registry (ATSDR) has responded to AMAP data and funded studies requested by Alaska Native communities aimed at better characterizing the Alaska Natives traditional subsistence diet, it's nutrient components, benefits and risks. This is the first such study for any U.S. population. The National Institute for Environmental Health Sciences has responded to the requests of Arctic communities, as well as the steadily increasing amount of human tissue data by establishing programmatic efforts to gather Alaska Native traditional knowledge of environmental issues, and by supporting studies designed to look for health effects of POPs and heavy metals on child health in the Arctic, as well as basic toxicologic research. The Canadian government supports identical scientific efforts, and the combination of U.S. and Canadian indigenous populations will increase the statistical power of similar studies on these sparse populations. The U.S. National Institutes of Health has recently recognized the importance of the role of Native Americans in directing their own health research, and has also

recognized the growing capability of Native American organizations to design, and implement the programmatic portions of their research agenda. In 1999, the NIH offered, for the first time, Native American Research Center for Health (NARCH) grants. The first of these unique center grants were awarded in 2001, including a NARCH grant to the ANTHC.

Canada aboriginal environmental policy and program development

Research and policy development in Canada has been a collaborative effort. Five Federal Departments have worked as partners in the Northern Contaminants program with the three territorial governments and aboriginal groups to manage the research and policy setting. Other research contributions from the Canadian Toxic Substances Research Fund, national granting councils and the Government of Quebec have also supported scientific understanding of contamination in the Arctic.

Canada has led and funded most of the eight nation circumpolar blood monitoring study completed in 1999 and provides the international 'quality assurance/quality control' center for blood analyses for POPs.

The Center for Indigenous Nutrition and Knowledge at McGill University, through core funding from the Government of Canada and through other granting agencies, has created a comprehensive nutritional assessment program for all Canadian Arctic communities. The University of Laval has developed an extensive research and policy development capacity and conducted nutrition, developmental, exposure, morbidity, communication and policy initiatives in the Nunavik region of Arctic Quebec.

Canada has created the Arctic Policy Initiative to define the complex nature of policy development for the Canadian Arctic in a rapidly changing global community. Utilizing Arctic environmental data, and community input, Canada has also developed a Federal Sustainable Development Strategy for the North to ensure that governmental and non-governmental sector activities are integrated and take account of social, cultural, environmental and economic considerations.

Danish federal policy

The Danish government granted home rule sovereignty to Greenland in May 1, 1979. The direction of Greenlandic health care programs as well as research agendas involving human health and wildlife has been established by the Greenland Home Rule Government for several years. The Greenlandic government is a full participant in AMAP and the Arctic Council. In addition, the Greenland Inuit are represented by the Inuit Circumpolar Council, a permanent participant indigenous organization in the Arctic Council. The government of Denmark continues to provide extensive scientific and medical technical support.

Future research directions

The Arctic Council AMAP HHEG has defined a series of goals under the Phase 2 Program with the intention to look for a wide range of human effects in Arctic populations (SOAER, 2002). These effects are well documented in a variety of wildlife and laboratory species, but only a few human arctic populations have shown any effects to date from the levels of exposure seen in the Arctic, and these have been subtle (Grandjean and White, 1998; Bjerregaard et al., 2000). The inherent problems with effects studies in Arctic populations are related to a number of factors. *1*) Small population size, in remote communities, making precise time-dependent observation difficult. *2*) Exposure in many locations is to low levels of pollutants. *3*) The end points in effect studies related to infection, growth, and neurodevelopment have many confounding influences from other sources. *4*) Exposure is never to a single agent, rather it is to a complex mixture of organic compounds and metals. *5*) The presence of potentially mitigating antioxidants and micronutrients in the traditional diet. *6*) Genetically diverse populations. *7*) Social and cultural barriers to population based research in the Arctic. Despite these limitations there are ongoing cohort studies in Arctic Quebec, Greenland and the Faeroe Islands that are likely to provide statistically valid results in the near future.

Classical single agent toxicological investigative techniques in the laboratory will not be sufficient by themselves, to address the issue of a balanced assessment of risk and benefit of traditional diet. While single agent studies are essential, especially in investigation of newly discovered POPs, the problems listed above require additional research approaches.

Mixture toxicology is time-consuming, and technically difficult, but will be important in establishing mechanisms of effect, as well as potentially mitigating effects.

Biomarkers of effect are important epidemiological and public health tools, and will need further support. Each must be linked to a particular physiological event or impact that by itself or in combination can be related to an adverse effect.

Long-term population cohort studies to assess the risk factors and protective factors in Arctic populations need to be started. These populations, with their unique traditional diet, offer unique opportunity to define dietary risk and protective factors in the development of chronic diseases. These cohorts should include infants and young parents, as well as adults. The United States NIH has recently funded the initial phase of a long-term cohort study of Native Americans, to include Alaska Natives, to begin to address these questions.

Improved techniques to integrate the benefits of traditional diet, including cultural benefits, into risk assessments for POPs and heavy metal exposure are also needed. This will require a paradigm shift on the part of governmental agencies and many investigators, where focus is entirely on risk.

A monitoring plan for blood sampling is also needed across the Arctic to determine whether estimates of exposure are valid and trends in levels of old and newly-recognized POPs and metals in human tissues.

Summary

Scientific data from Arctic human health studies has had a profound influence on policy formation at the national governmental levels within the United States. Permanent CDC facilities now conduct research, and create effective prevention strategies, directed at major sources of disease and death among Arctic residents. International examples include formation of the Arctic Council, the AMAP human tissue monitoring and effects studies, the ACIA, the UNECE Protocols on POPs and Metals, the Stockholm Convention on POPs, and CFC phase out legislation.

Over the past 30 years, the Arctic states have come to fully appreciate the traditional knowledge of the environment that is the heritage of Arctic indigenous people. Traditional knowledge is critical in defining and implementing the aboriginal research agenda, as well as informing scientific knowledge, and formulating carefully focused health policy at all levels.

Governmental policy and research funding needs to recognize the importance of the social, cultural and nutritional benefits of traditional diets and should create methods to work with communities to integrate this information into benefit-risk evaluations at the local level. Policy also needs to incorporate both traditional knowledge and western science to focus on protecting the developing fetus and child through supportive health programs and communication strategies for the family and by supporting the documented benefits of breast-feeding.

Future Arctic environmental health research is essential if governments are to create wise and effective public policy. Science moves forward incrementally and data has been, and continues to be, the basis for decision-making. The new research in the Arctic will need to make use of western scientific techniques, both in molecular biology and population epidemiological approaches combined with traditional knowledge of aboriginal residents. Only in this coordinated approach can science eventually understand and eliminate Arctic health disparities.

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