Chapter 10

Risk Reduction Strategies for Arctic Peoples

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Summary

The Arctic region and its peoples are extremely sensitive to global environmental pollution. The levels of persistent organic pollutants (POPs) and metals in Arctic peoples and their traditional food supply vary considerably throughout the circumpolar region and there remains a need for local risk reduction strategies in some regions of the Arctic where current levels of POPs and/or metals are above levels of concern. In general, it has been most effective when local public health authorities, working in concert with the community at risk and experts from a variety of disciplines, develop risk reduction strategies that address the risks and benefits components for a specific concern. However, the global nature of contamination by some POPs and metals and their capacity to travel to the poles from the mid-latitudes also requires international, regional and national risk management approaches to control their manufacture, use, transportation, storage, and disposal. Based on current global trends, and various activities to manage risks, there are likely to be minor decreases in POPs in the tissues of Arctic populations in Greenland, the Faroe Islands, eastern Canada, western Alaska, and eastern and western Russia by 2010, and minor increases in mercury (Hg) levels in Greenland and eastern Canada. There are likely to be major decreases in both POPs and Hg levels in these same populations by 2030. In general, levels of most POPs and metals in populations in western Canada, Iceland, Norway, Sweden, Finland, and central Russia are already reasonably low and are only likely to decline marginally by 2030. These predictions will be heavily influenced by prompt ratification and implementation of the Stockholm Convention on POPs and other multinational environmental agreements.

10.1. Introduction

The global nature of contamination by POPs and some metals, and their capacity to travel from the mid-latitudes to the poles requires risk management approaches that encompass international, regional, and national strategies to control their manufacture, use, transportation, storage, and disposal. Currently there are several international agreements that have been negotiated to address regional pollution (e.g., the Århus Protocols on Persistent Organic Pollutants and Metals under the United Nations Economic Commission for Europe's (UN ECE) Convention on Long-Range Transboundary Air Pollution (LRTAP), and the North American Agreement on Environmental Co-operation (NAAEC), which is the side agreement to the North American Free Trade Agreement), and others to address global pollution issues (e.g., the Stockholm Convention on POPs, the Basel Convention on Wastes, and the Rotterdam Convention on Prior Informed Consent). When ratified and fully implemented, these Conventions, Agreements and Protocols should significantly reduce new circulating sources of some of the most dangerous POPs to which Arctic populations are exposed. Considering the steady movement of these compounds over months and years into the Arctic, and their persistent nature, especially in polar regions, it could take many years for significant reductions to be observed in Arctic media, and especially in the fish and wildlife which serve as the primary food supply for indigenous populations.

The levels of POPs in Arctic peoples vary considerably throughout the circumpolar region (chapter 5). Based on current data on physiological, biochemical and genotoxic effects of POPs (chapter 6) and their impacts on population health (chapter 9) there remains a need for local risk reduction strategies in some regions of the Arctic where current levels of POPs and/or metals are above levels of concern. In general, it has been most effective for local public health authorities working in concert with the community at risk and experts from a variety of bio-medical, biological and physical disciplines to develop risk reduction strategies that address each specific concern. These local strategies are able to take account of the nature of the problem, the at-risk group(s) most in need of protection, the primary exposure route(s), the different levels of education and understanding in the community, and the social and cultural needs of the exposed group(s). Where a risk reduction strategy involves decreasing exposure to contaminants found in food, local advice can be extremely specific, focusing on where and when animals are caught, what normally consumed parts of the animal are best avoided (chapter 7), how food can be prepared to lessen contaminant intake, how much can be safely consumed while still ensuring that nutritional benefits are maintained, and when it is wise to decrease consumption because of age or fertility status. The likelihood that local advice is implemented is enhanced because the governance (e.g., the local legal authority) and support structure (e.g., public health support staff, phone information system, news media, etc.) are almost always in place prior to the issuance of the public health strategy. As environmental, social, cultural, and economic conditions change (due to a variety of interrelated factors such as climate change, the appearance of new contaminants or changing levels of existing contaminants, changes in local, regional and national governance policies, behavioral changes in the population, habits or genetics, etc.) so local risk reduction strategies need to be developed that are more able to adapt promptly and effectively to meet these changing local conditions and needs.

10.2. Risk reduction case studies

This section discusses some recent risk reduction strategies that have been applied in the Arctic countries. The information is based on material submitted by the individual countries and where possible describes the effectiveness of the strategies employed.

10.2.1. Alaska

Following the issuance of national fish advisories by the U.S. Environmental Protection Agency (EPA) and the U.S. Food and Drug Administration (FDA), the latter recognized that Hg levels in Alaskan fish were lower than average levels in other fish consumed in the United States and amended their original advisory; recommending that Alaskan consumers contact their local health and food safety authorities for specific consumption advice. The Alaskan Division of Public Health has determined that Hg levels are very low in most of the frequently consumed fish species and that there are documented health, social, cultural, and economic benefits associated with fish consumption. This Agency through a consensus process involving a variety of scientists, health policy experts and community leaders concluded that 'the known benefits of fish consumption far outweigh the theoretical and controversial potential adverse effects from mercury found in Alaska fish' and that 'substitution of other less healthy, less nutritious food for Alaska fish would result in far greater harm to health'. It is strongly recommended by the Alaskan Division of Public Health (and endorsed by ten partner organizations) that all Alaskans, including pregnant women, women who are breast feeding, women of child-bearing age, and young children continue unrestricted consumption of fish from Alaskan waters (SOA, 2001).

10.2.2. Canada

A number of experiences in Canada have lead to an approach where scientists, health policy makers, and community leaders work together to develop specific advice pertaining to specific findings in a manner that is respectful of cultural and social issues and of maximum benefit to the health of local consumers.

10.2.2.1. High levels of persistent organic pollutants in marine mammals

In 1995, Health Canada and Environment Canada officials presented research results on the levels of organochlorine compounds in Arctic marine mammals to the Northwest Territories (NWT) Technical Committee on Arctic contaminants. This committee comprised northern indigenous representatives, government health and research representatives, as well as representatives from the national Inuit organization, the Inuit Tapiriit Kanatami (ITK) (previously the Inuit Tapirisat of Canada (ITC)). The research indicated the presence of a number of organochlorine compounds, including toxaphene, dieldrin and polychlorinated biphenyls (PCBs), in high concentrations in ringed seal (*Phoca hispida*) fat and beluga whale (*Delphinapterus leucas*) fat and skin. The Committee's discussion of the data with regional representatives, the evaluation processes and decision-making responsibilities lead to consensus building on necessary future action. The regional representatives wanted to ensure that the release of the contaminant information was well coordinated, that the approach of providing 'advice' be used rather than a restrictive advisory or warning, and that the communication of any message must come from regional Inuit leaders in an easily understood local language. The following national press release was issued by the President of the ITK: "So far as we are aware, the risks to public health from continuing to eat beluga and seal blubber are very small and are outweighed by the benefits to you of these foods. However, Inuit must judge for themselves what is an acceptable risk for themselves and their families". Regional leaders presented the information to their communities in a coordinated fashion and through the ITK. They supported the basic message that the benefits of consuming these foods outweighed the risks and that food consumption decisions were ultimately individual decisions.

10.2.2.2. Mercury in Arctic waterfowl

In 2001, Health Canada released a health hazard assessment for Hg and selenium (Se) levels determined by the Canadian Wildlife Service in livers from waterfowl harvested in northern Canada between 1988 and 1994. The evaluation of the data led to a recommendation that "…it would be considered prudent to limit consumption of the livers…" of some waterfowl species. The evaluation information was immediately provided to the Yukon Contaminants Committee, the NWT Contaminants Committee, the Nunavut Contaminants Committee, the Nunavik Nutrition and Health Committee, and the Labrador Inuit Association. The diverse membership of these environmental contaminants committees provided the fora and perspectives necessary for a balanced discussion about the importance of the results for northerners. Dietary survey information on consumption of waterfowl livers was also of value in the discussions because it provided information on frequency and seasonal consumption of duck livers, as well as on economic, spiritual, cultural, and social benefits. Based on the discussions, the groups made the risk management decision not to issue advice to limit consumption of waterfowl livers, but to update current communication materials and to provide a fact sheet discussing the elevated levels of Hg found in some of the bird livers.

10.2.2.3. Lead shot in traditional foods

The results of studies on cord blood lead (Pb) carried out between 1993 and 1995 show that 7.6% of Nunavik newborns (n=238) had blood Pb levels of 100 µg/L and over, compared to 0.2% for babies from the southern part of Quebec (n=955). Subjects with high concentrations were uniformly distributed across the territory. Moreover, 2.1% of the samples from Nunavik showed blood Pb levels of >150 µg/L. These data, together with data collected in Nunavik during the 1992 Santé Québec survey, revealed that 24% of women between 18 and 39 years had blood Pb levels of >100 µg/L. While Pb exposure through contamination from industrial activities, from vehicle emissions, from ingestion of old Pb-based

paint or through drinking water was unlikely in the Inuit communities of Nunavik, the consumption of contaminated game was a plausible source of exposure. Relatively high levels of Pb have been reported in caribou (*Rangifer tarandus*) and many species of waterfowl that are key elements of the traditional Inuit diet. Caribou pick up Pb via the consumption of lichens, which in turn receive lead from the atmosphere. However, Pb levels observed in waterfowl are generally thought to be due to the ingestion by birds of lead shot used by hunters. Isotopic analyses of the Pb in the blood of infants from Nunavik and southern Quebec revealed that the source of Pb found in the infants from the two regions is different. Based on analyses of various brands of lead shot it has become clear that elevated levels of Pb in Nunavik infants come primarily from the direct ingestion of lead shot, lead fragments and lead dust in hunted game and less from airborne sources (as was the case in children from southern Quebec). Furthermore, X-rays of the abdomen of Nunavik Inuit reveal the presence of lead shot in the digestive system, thus supporting the hypothesis that lead shot ingestion is the main source of contamination. This problem was also observed in Cree communities from northern Ontario. These findings in Nunavik support the current bans in place in many countries on the use of lead shot (for the protection of waterfowl). They also suggest that less toxic shot, such as steel shot, be used by hunters wishing to protect themselves and their families from the health impacts of Pb exposure. Currently discussions are underway with hunters associations and the regional Health Board on a complete ban on lead shot and retailers are being asked to purchase only non-lead shot.

10.2.2.4. Mercury exposure in Nunavik women and the Arctic char promotion programme

Studies in Nunavik have indicated elevated levels of Hg in women of reproductive age. Most concentrations reported were in the range of a 'level of concern' and some at or above the 'action level', using Canadian terminology (see chapter 9, Figure 9·1), and may pose a risk to the health of the fetus. However, local public health authorities took into consideration the high level of intake of Se (which may counteract methylmercury-induced toxicity) in the diet of these same women, and consequently did not recommend a reduction in seafood consumption. Recently, a project to reduce risks among pregnant women exposed to food chain contaminants has commenced in Nunavik. This programme promotes the consumption of Arctic char (*Salvelinus alpinus*) among pregnant women living in three selected communities in Nunavik. Arctic char contain very few contaminants and are very nutritious. The evaluation of this project will include how extensively and consistently pregnant women participate in the programme and how efficient the programme is at reducing contaminant intake (especially Hg) while maintaining or improving nutritional status. Results of this project will help regional public health authorities decide whether or not to recommend this moderate change in eating pattern among a broader number of communities in Nunavik.

10.2.2.5. Seabird egg intervention on the lower north shore of the St. Lawrence River

Traditional consumption of seabird eggs in communities along the lower north shore of the St. Lawrence River has led to a pattern of contamination in human tissue that is very similar to that observed in the eggs themselves. Evaluation of the temporal trends of several persistent contaminants in umbilical cord plasma of newborns in these remote Canadian coastal populations, following advice to reduce seabird egg consumption, revealed reductions of between 25% and 69% over a seven-year period. No monthly or seasonal pattern was detected. Using n-3 fatty acid concentrations in umbilical plasma phospholipids as a surrogate for long-term fish consumption, the decrease in tissue concentrations of OCs could not be explained by a reduction in fish consumption. These results suggest that prenatal exposure to POPs has declined in this population. This decline seems to be due to a decrease in the contamination levels in the eggs themselves and a reduction in the consumption of seabird eggs following the public health advice provided to the communities.

10.2.3. Greenland

10.2.3.1. Lead levels

As in other countries, levels of blood Pb have declined as a result of the global reduction in use of leaded gasoline. To further reduce human exposure to Pb, discussions are underway with hunters associations to replace lead shot with less toxic alternatives.

10.2.3.2. Consumption of traditional foods

Greenland health authorities encourage the consumption of traditional foods for nutritional and cultural reasons. Despite documented high intakes of several contaminants through some dietary components, no advice has been given to reduce consumption of any specific traditional food items.

10.2.4. Iceland

Levels of POPs and metals in the Icelandic population are among the lowest in the Arctic. No risk management initiatives related to reduction in exposure to POPs and metals through food exposure are in place or contemplated at this time.

10.2.5. Faroe Islands

10.2.5.1. Consumption of pilot whale meat and blubber

Since 1989, research results from the Faroe Islands have shown that dietary intakes of Hg, the primary source of which is pilot whale (*Globicephala melaena*) meat and organs, is likely to slightly impair neurological development in children. It is also suspected that dietary PCBs, the main source of which is whale blubber, affect the central nervous system and sexual organs of the developing fetus. Based on the demonstrated effects of Hg exposure and on a general assessment of PCBs, the following dietary recommendation, which placed special em-

phasis on protection of women of child-bearing age, was issued in 1998.

Blubber – High PCB levels in blubber lead to a recommendation that adults eat pilot whale blubber only once to twice a month. However, the best way to protect the fetus against the potential harmful effects of PCBs is for girls and women not to eat blubber until they have given birth to their children.

Meat – The mercury content of pilot whale meat is high and is one of the main mercury sources. Therefore it is recommended that adults eat no more than one to two meals [based on pilot whale] a month. Women who plan to become pregnant within three months, pregnant women, and nursing women should abstain from eating pilot whale meat.

Organs - Pilot whale liver and kidneys should not be eaten at all.

These recommendations are still considered by the Faroese Public Health Authority to be the most appropriate advice at the present time. This dietary recommendation may be revised as new information is acquired.

Recent examinations have demonstrated that, on average, the Faroe Islands population has a PCB intake which is five to ten times higher than that of Danes. In addition it has been established that the PCB content of breast milk of Faroe Island women is very high compared to average breast milk PCB concentrations in most other Western European countries. Pilot whale meat and blubber have for many years been considered healthy for human consumption, and in recent years it has been stated again and again that marine fats, as found in whale blubber, can prevent cardiovascular disease. Public heath authorities in the Faroe Islands do not claim that pilot whale meat and blubber are unhealthy, but rather point out that pilot whale meat and blubber contain substances which international authorities consider capable of causing health problems. Remarkably, levels of Hg have declined by approximately 80% in the adult population over the last nine years. Similar declines have not been seen in the PCB levels. The decline in Hg levels appears to be based on reduced consumption of pilot whale products as proposed in the original public health advisories, and the short biological half-life of Hg.

10.2.6. Norway

10.2.6.1. Blood lead reductions

Blood Pb concentrations have declined in the general population in Norway over the last three decades, mainly due to the change from leaded to unleaded gasoline. Concentrations of Pb in blood reported in the first AMAP Assessment Report (AMAP, 1998) are some of the lowest ever reported or determined. In 2001, Norway decided to ban lead shot, based on the recent knowledge of Pb impacts on reproductive health and child development, even at relatively low levels.

10.2.6.2. Organic contaminants in fish

Fish taken from some coastal areas and fjords of southern Norway have been found to contain concentrations of POPs that exceed health guidelines. The same species are often regularly consumed by coastal populations. Women in these areas have been advised to avoid consumption during their child-bearing years and especially during pregnancy and nursing. The same high concentrations have not been documented in coastal areas and fjords north of the Arctic Circle.

10.2.6.3. Flame retardants in bird eggs

In early 2002, Norwegian health authorities announced a severe restriction on the consumption of gull (*Larus* spp.) eggs in northern regions because of findings of high levels of persistent flame retardants in these eggs. Gulls and other fish-eating birds are known to bioconcentrate most POPs, sometimes as much as one million times relative to levels in water. This is the first human consumption advisory based on flame retardants.

10.2.7. Sweden

The Swedish National Food Administration revised its advice on fish consumption in 1995 as a result of contamination levels determined in the Baltic Sea and some inland lakes and recommended as follows.

All consumers – A maximum of one meal per week of pike (*Esox lucius*), Baltic herring (*Clupea* spp.), Baltic salmon (*Salmo salar*), and eel and only occasional meals of cod (*Gadus morhua*) livers.

Girls and women of child-bearing age – No cod livers, a maximum of one meal per week of pike, eel and halibut (*Hippoglossus hippoglossus*), and a maximum of one meal per month of Baltic herring. For salmon the recommendation is a maximum of one meal per month regardless of whether it comes from the Baltic or inland lakes.

Lactating women – No consumption of pike, halibut, eel, or cod livers.

Pregnant women – No consumption of pike, halibut, eel, or cod livers, a maximum of one meal per month of herring from the Baltic and salmon from either the Baltic or inland lakes.

10.2.8. Finland

10.2.8.1. Food and fish advisories

Finland has set national limits for commercial food contamination and applies these to all food sold in the country, including the Arctic regions of Lapland. Levels of contaminants in sport fish are also monitored and there are no restrictions on fish consumption due to contaminants. There are also no restrictions on the consumption of reindeer meat from Finnish herds. Radionuclide contamination from the Chernobyl reactor accident in Russia in 1992 did not lead to contamination of reindeer in Finland.

10.2.9. Russia

10.2.9.1. Blood lead levels

Blood Pb concentrations in populations of the bigger cities of the Kola Peninsula are moderately elevated compared to levels in populations from neighboring areas in Norway. This is probably due to the continuing

use of leaded gasoline. Elevated blood levels (up to concentrations that are of medical concern) have been documented in children living in remote areas of the Kola Peninsula, with a diet based on natural, local products. This has recently been linked to the use of lead shot. The authorities are now working to prepare new guidelines on the use of lead shot.

10.2.9.2. Social and cultural impacts of modernization in the Kola Peninsula

The pollution problems associated with the nickel (Ni) smelters and refineries of the Kola Peninsula present a significant Arctic regional dilemma. Modernization of the Ni producing facilities, which will also help to reduce environmental pollution in the area, is likely to benefit the health of the workers and the general population of the area. However, modernization may also result in up to 50% of the workers losing their jobs. This level of job loss in remote regions is likely to have dramatic social consequences for communities and for the well-being of workers and their families. The political solution to date has been to slow the rate of the needed industrial rehabilitation, to give people the chance to retire, to retrain or to find other types of work. Authorities believe that remediation of the environment is of secondary importance to maintaining social cohesion during rapidly changing economic conditions. Recent new economic development in the area is promising and may enable more rapid environmental rehabilitation. A number of guidance documents for environmental health risk evaluation have been published by Russian public health authorities to promote the safety of populations in these and other parts of Russia.

10.3. Long-term impacts of risk reduction strategies and scenarios for changing global conditions

This section discusses the long-term implications of current and future risk management strategies on the exposure of Arctic populations to pollutants, and the influence of changing global conditions on health in the circumpolar region.

10.3.1. The influence of Arctic food on health risk management decisions

As omnivorous consumers, humans act as predators in the food chain. As a result they become exposed to ever increasing amounts of contaminants the higher up the food chain they feed. It is clear that food is the primary source of exposure to most POPs and a significant source of most metals, especially methylmercury. We are what we eat.

Strong evidence to support this reality occurs in recent findings provided in this report (see chapters 5 and 7).

Example A. In Canada, the Inuit consume fish and marine mammals as part of their traditional diet whereas the Dene/Métis consume fish and terrestrial mammals. Because marine mammals have significantly higher concentrations of POPs and metals than terrestrial mammals, the PCB and Hg levels in Inuit are approximately five times higher than the corresponding levels in Dene/Métis.

Example B. In Greenland, a recent study of contaminant levels among the Inuit living on the east and west coasts, both groups consuming a traditional diet high in marine mammals, indicated that while Hg levels in adults were similar, PCB levels were almost five-fold different between the two groups. Dietary evidence revealed that Greenlanders living on the east coast consumed polar bear (*Ursus maritimus*) fat which has very high PCB levels and moderate Hg concentrations, whereas the Greenlanders on the west coast eat more seals and walrus (*Odobenus rosmarus*) which are moderate in both PCBs and Hg.

Example C. Comparisons of non-indigenous and indigenous groups in Siberian Russia reveal that the non-indigenous group has a three-fold higher concentration of DDT even though it is consuming lesser amounts of traditional food than the indigenous group. These data indicate either contamination of the domestic food supply or a local source as the most significant contributor of DDT to population exposure in the region.

Examples A and B, and to the extent that food contamination is the cause, Example C, illustrate both the primary role of food in determining human body burdens and the importance of understanding local dietary patterns and contaminant levels in the dietary components when evaluating exposures and developing risk reduction strategies.

The health chapter of the first AMAP Assessment Report (AMAP, 1998) introduced the concept of the 'Arctic Dilemma' (i.e., vigorously supporting the consumption of traditional foods with their known nutritional, social, cultural and spiritual benefits while recognizing that these same foods are the primary source of environmental contaminants). Data in the present report strengthen this concept. The weight of evidence for harmful effects of POPs and metals has been augmented through epidemiological investigation (chapter 9) and biomarker studies (chapter 6). Yet knowledge of the nutritional value of traditional foods and the links they have with social, cultural, and spiritual integrity are also enhanced. Overall, the evidence is still compelling that traditional food is more nutritious than market food, reduces risk factors for several disease conditions such as heart disease and diabetes, and can bind communities together in ways that market foods do not. It is also clear that, in some areas of the Arctic, there is a need for some groups such as women who are fertile or pregnant to substitute their intake of the most contaminated food items with less contaminated but similarly nutritious items in order to minimize the risks for their babies. The AMAP Human Health Expert Group affirms that, despite the presence of contaminants in human milk, breast feeding is the best and safest form of infant nutrition, essential for optimal mother–child bonding, and critical for proper development of the infant immune system, and should therefore continue.

10.3.2. Global change and risk management

The development of risk reduction strategies for population groups must take account of changing global conditions and also changes in or surrounding the at-risk populations themselves. These changes may impact social,

cultural, spiritual, physical, or economic underpinnings of life in the circumpolar region. Some examples follow.

The availability, quality and delivery of healthcare can vary by region, size and location of community, and as a consequence of competing governmental and public health fiscal priorities. These factors can affect necessary monitoring of population trends (e.g., diseases, contaminant exposure, food consumption patterns, etc.), medical intervention and the availability of local advice from health professionals. Nevertheless, there are encouraging trends in health statistics that indicate overall population health is improving in many areas.

The emergence of new contaminants in the Arctic food chain (chapter 4), and, e.g., temperature changes that affect the permafrost, wildlife movements, disease vectors, food availability, water quality and other physical factors can significantly affect where communities live or how communities live.

Changes in the diet of indigenous communities toward consumption of less traditional food is, whilst lowering contaminant intakes, also leading to increased intake of carbohydrates, saturated fats and food additives, probably lower levels of intake of essential dietary components, and increased incidence of diabetes and heart disease (chapter 7).

Levels of smoking undoubtedly vary among population groups in the Arctic; however the rate is generally high and increasing in children and adolescents (chapter 8) as has been seen in southern regions of the circumpolar countries. Empowerment of communities to continue to address smoking rates (greater than 35% of pregnant mothers smoke in many areas) and a high intake of alcohol (rates of fetal alcohol syndrome up to five times national averages) will be essential to reduce these significant stressors of individual and community health.

Economic recession, natural resource development, increased immigration and tourism, low self-esteem among individuals and within communities, and the growing need for money to purchase commodities and food associated with a changing way of life can also affect community integrity and responses. These factors and other social pressures are likely to be partially responsible for high suicide rates, increasing substance abuse and the growing sense of poor self-worth associated with a lack of income (previously far less essential for traditional community life).

The Arctic peoples appear to be extremely sensitive to global pressures, supporting the need for ongoing monitoring of social and ecosystem changes and population health and well-being.

10.3.3. Future scenarios in the Arctic

Evaluating the combined effects of global pressures and local and global risk management strategies is speculative and can only be qualitative. There are, however, some significant international initiatives and also some scientific aspects that can be applied to speculation on future outcomes related to POPs, metals, and disease rates.

10.3.3.1. Speculation factors for POPs

1. The UN ECE Protocol on POPs is ratified by 2003 and primary sources of sixteen POPs are severely reduced or eliminated in Europe, Canada and the United States by 2010 and in Russia by 2020.
2. The Stockholm Convention on POPs is ratified by 2004 and primary sources of several POPs are severely reduced or eliminated throughout the Northern Hemisphere by 2020.
3. Secondary sources (environmental sinks) continue to yield POPs that are transported to the Arctic through 2030, however, the extent of the airborne transport from secondary sources declines by 20% by 2030.
4. Biological half-lives for POPs (the time it takes for POP levels to decline to 50% of their starting value) in human tissues are between one and seven years depending on the POP. If there are no additional exposures, and a mean half-life of five years is applied to existing tissue concentrations, then current levels of POPs in the Arctic population will decline by approximately 70% by 2010 and 98% by 2030.
5. Human intake of contaminants declines as the trend toward less consumption of traditional food (especially marine mammals) continues over the next ten years. In addition, human intake of contaminants declines as levels of contaminants in food slowly begin to decline after 2015 as a result of speculation factors 1 to 3.

Conclusions. Overall levels of POPs currently found in the tissues of Arctic residents may decline by 5% to 10% by 2010 and by 30% to 50% by 2030 (Figure 10·1). These changes will be most noticeable for PCBs, toxaphene, hexachlorobenzene, chlordane, DDT and DDE. The Arctic regions that will be most affected by reductions will be western and eastern Greenland and the Faroe Islands, followed by eastern Canada, western Alaska, and western and eastern Russia. Lesser reductions will be observed in western Canada, Iceland, Norway, Swe-

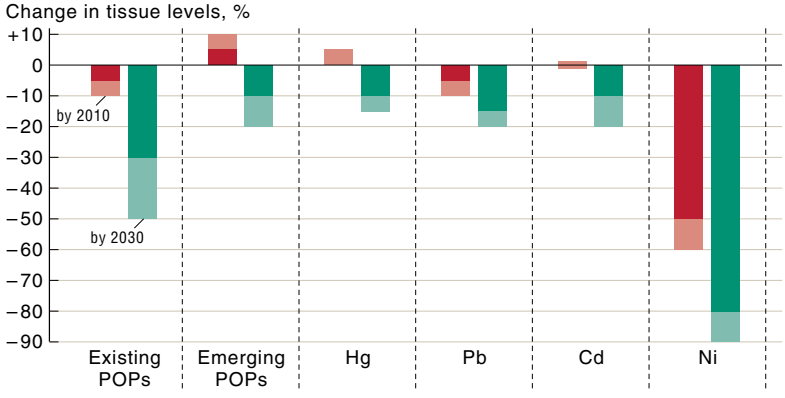

Figure 10·1. Predicted percentage change in levels of POPs and metals in the tissues of Arctic residents by 2010 and 2030 relative to 2000 levels. Speculation factors and assumptions taken into account in the predicted changes in tissue levels are described in sections 10.3.3.1, 10.3.3.2, and 10.3.3.3.

Aggregated estimates for all existing POPs in tissues are based on most affected Arctic areas (eastern/western Greenland, Faroe Islands, eastern Canada, western Alaska, eastern/western Russia). Hg: Greenland and eastern Canada only. Pb: All areas. Cd: Combined reductions (smokers and non-smokers). Ni: Russian nickle refinery areas only. Darker and lighter portions of columns show minimum and maximun predictions, respectively.

den, Finland, and central Russia (except for β-HCH) where the levels are already low and there is almost no reliance on marine mammals as a regular food source.

10.3.3.2. Speculation factors for metals

1. The UN ECE Protocol on Metals, which covers Hg, Pb and cadmium (Cd), is ratified by 2005. A global agreement is reached on metals emissions by 2010.
2. Total emissions and long-range transport of Hg continue and even increase from North America and southeast Asia through 2010 with continued reliance on fossil fuels (especially oil and coal) for energy. Traditional food consumption continues to decline over the next ten years. Unlike POPs, it is established that the half-life for mercury in human tissues is relatively short.
3. Global use of leaded fuels continues to decline and is absent in the Northern Hemisphere by 2015. Lead shot is replaced by less toxic alternatives in the circumpolar region by 2010, reducing Pb levels in the environment and Pb fragments in food portions collected through hunting. Traditional food consumption continues to decline over the next ten years. Unlike POPs, it is established that the half-life for lead in human tissues is relatively short.
4. Smoking, which is the single largest contributor to Cd levels in human tissues, decreases only marginally in Arctic populations by 2010 and significantly by 2030.
5. Industrial emissions of Ni and other metals from large smelting operations in the Arctic decrease significantly in western Russia by 2010.

Conclusions. Mercury levels in populations living in the eastern Canadian Arctic and Greenland will remain at current levels or increase by 5% through 2010 and will decline by 10 to 15% by 2030 (Figure 10·1). Lead levels measured in blood will continue to be low and will decline by 5% to 10% by 2010 and 15% to 20% by 2030. The currently small proportion of individuals exposed to lead shot fragments will reduce almost to zero by 2010, eliminating blood Pb levels above 50 µg/L across the Arctic by 2030. The percentage of the population with high levels of Cd will decline by 30% by 2030 as the proportion of smokers declines. Cd levels in individuals who continue to smoke will only decline marginally by 2030 as the number of cigarettes smoked per day per smoker gradually declines. The reduction in Cd levels in the general population (smokers and non-smokers) will be minimal by 2010 and between 10% and 20% by 2030. Ni levels in individuals living near Russian smelters will decline by 50% to 60% by 2010 and 80% to 90% by 2030.

10.3.3.3. Speculation factors for emerging POPs

1. National and international attention focuses on emerging POPs, such as polybrominated diphenylethers (PBDEs) and perfluorooctane sulfonate (PFOS) (see chapter 4), and on the current use pesticides such as lindane, and others, leading to severe restrictions or elimination of these chemicals under the UN ECE Protocol on POPs or the Stockholm Convention on POPs by 2010.

Conclusions: Levels of PBDEs, PFOS and β-HCH (resulting from use of lindane) will continue to increase by 5% to 10% through 2010 and will decline marginally by 10% to 20% by 2030 (Figure 10·1). Fewer POPs will be detected in the Arctic after 2010, and those found will be at lower levels, as most European and North American counties have been screening chemicals prior to their entry into commerce and those ratifying the Stockholm Convention on POPs will be developing screening systems.

10.3.3.4. Speculation factors for population morbidity and mortality

1. Globalization through to 2010 leads to more immigration, tourism, resource development, and pressure for income to afford commodities advertised globally and increasingly in the Arctic. The number and range of products consumed in the Arctic increases steadily as does the potential for introduction of infectious diseases.
2. Less traditional food and more commercial food are consumed by Arctic populations through 2010 followed by stabilization in the balance of traditional and commercial food consumption by 2030.
3. Increased awareness of globalization and contaminant issues and higher levels of attained education among Arctic populations through to 2030, leading to greater awareness of risks and benefits of lifestyle and diet choices.
4. Better healthcare and availability of services region-wide by 2010 and greater emphasis on and acceptance of disease prevention and management and health promotion by 2030.
5. Lower levels of exposure and body burdens of POPs and metals by 2030, as described in sections 10.3.3.1 to 10.3.3.3.
6. New and/or changing disease vectors associated with climate change.

Conclusions. Throughout the Arctic, disease rates for circulatory disorders, diabetes and some cancers will increase through 2010 as a result of globalization pressures, poorer dietary components including changes away from traditional foods, smoking and alcohol consumption, less exercise and, for cancers, current levels of POPs (Figure 10·2). These rates will begin to stabilize by 2030 as a result of lower levels of contaminants, greater public awareness and acceptance of healthy lifestyle at-

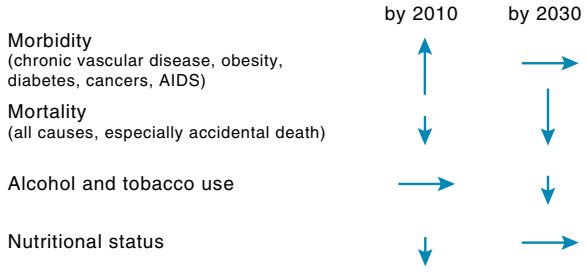

Figure 10·2. Qualitative future changes in morbidity, mortality, alcohol and tobacco use, and nutritional status among Arctic residents. Speculation factors and assumptions taken into account in the predicted changes are described in section 10.3.3.4. Orientation of the arrows and length of the shaft indicate direction of change and relative magnitude of change, respectively.

tributes and better healthcare and disease management approaches. Mortality rates will decline marginally by 2010 and significantly by 2030 as deaths due to accidents are reduced and prevention and management of diseases improves. Alcohol and tobacco use will continue unchanged through 2010 and decline by 2030 as awareness and understanding of the driving forces behind these lifestyle choices and greater community empowerment increase. Nutritional status will decline through 2010 and stabilize by 2030 as Arctic populations return to consumption of nutritious traditional foods that have lower levels of contaminants.

10.4. Conclusions and recommendations

The most effective and rapid risk management strategies are those developed locally with the community that they are designed to assist. Once evaluated for their effectiveness, they can be used as case studies to assist the development of risk reduction strategies in other parts of the Arctic. The key success factors for these strategies will be based on how and when the people most affected are engaged in the decision-making process. Any strategies based on traditional food substitution should ensure that the value of the dietary components is sustained.

It is essential that countries ratify and implement multinational environmental agreements, especially the Protocols on POPs and metals to the LRTAP Convention, and the Stockholm Convention on POPs as these are the only effective long-term solutions for reducing human exposure to POPs and metals.

The complexity of changing conditions and the need for inclusion of multiple determinants of health in decision-making makes forecasting future population trends very difficult. Based on current global trends, and various activities to manage risks, there are likely to be minor decreases in POPs in the tissues of Arctic populations in Greenland, the Faroe Islands, eastern Canada, western Alaska, and eastern and western Russia by 2010 and minor increases in Hg levels in Greenland and eastern Canada. There are likely to be major decreases in both POPs and Hg levels in these same populations by 2030. In general, levels of most POPs and metals in populations in western Canada, Iceland, Norway, Sweden, Finland and central Russia are already reasonably low and are only likely to decline marginally by 2030. These predictions are heavily dependent on prompt ratification and implementation of the Stockholm Convention on POPs and other multinational environmental agreements.

There remains a key need to fill in data gaps in order to validate and update exposure and disease estimates for various regions of the Arctic. Special emphasis should be placed on children and youth, for whom data are difficult to gather and who are most vulnerable to a range of change agents, e.g., POPs, metals, early childhood nutrition, education, availability of health care, tobacco and alcohol use, etc.

Serious consideration by all Arctic countries should be given to eliminating the use of lead shot as one relatively simple means of reducing the small number of excursions in blood Pb among consumers (especially children) of hunted game.