



At the nomad camp

POLFO / EUGENE FISCHER

Human Health

In some Arctic populations, contaminant levels are high enough that they can affect children's mental development. Contaminants may also be affecting children's resistance to infections. In addition, there are concerns about effects on hormones that are important for growth and sexual development. The major source of these contaminants is from eating marine mammals. These are the same foods that provide important nutrients, energy in a harsh climate, and also a sense of identity in a time of rapid cultural change.

This situation challenges the international community to prevent further input of persistent contaminants into the global environ-

ment. Of highest priority is the need to lower emissions of mercury and POPs. The situation also poses a challenge at the local level. How should public health officials and community leaders advise people about their eating habits? How should the cultural and health benefits of traditional foods be weighed against the health risks of the contaminants they contain?

This chapter examines human health and contaminants in the Arctic in the context of changing cultures, lifestyle, and food habits. The focus is on persistent organic pollutants and heavy metals. The effects of radioactivity on human health are discussed in the chapter *Radioactivity*.



At the youth club

PER FOLKVER / BAN



ARCTIC INSTITUTE / STEENSBY

Inuit boy, Greenland,
1909.

Health and culture

AMAP has a mandate to evaluate the combined effects of pollutants in the Arctic. But human health is much broader than just pollutants. From a public health perspective, the human environment is the sum of physical, chemical, biological, social, and cultural factors that affect people's well-being. Aside from data on levels and effects of pollutants, any

Inuit boy, Greenland,
1994.



evaluation of combined effects thus has to include information about nutritional status and socio-economic context, among other things.

This knowledge is also directly relevant for understanding the effects of contaminants on human health. For example, lifestyle factors such as smoking and health indicators such as obesity may influence contaminant levels and

effects. Moreover, changes in smoking, drinking, and dietary habits can make it difficult to single out contaminants as the cause of an observed change in health.

Finally, knowledge about the broader health perspective is important when the results of contaminants studies are used, for example by public health officials communicating with, or giving advice to, local communities.

A starting point in creating a context for contaminants and human health is to learn about Arctic cultures and how cultures and the lives of people are changing. The previous AMAP assessment gave a detailed presentation of different population groups in the Arctic. Among great diversity of culture, there are some common themes. For example, most indigenous communities still live close to their environment and use local resources for food.

Over the past 50 years, the population in most regions of the Arctic has increased dramatically. The main reasons are decreases in infant mortality and fewer people dying of infectious diseases. Safer water supplies, better sewage disposal, the development of rural hospitals, and community-based health care have helped prevent and improve the treatment of injuries and illness.

Better transportation infrastructure has also brought major changes. Imported foods are now readily available and accepted. Tobacco and alcohol reach the Arctic on a scale not previously possible. Modern communications have made western culture visible even in the most remote settlements, spurring further cultural change.

In most regions, government policies and modern lifestyles encourage indigenous peoples to reside in fixed locations instead of moving with the seasons. Survival often depends on a complex web of government-funded economic support combined with employment in various community service jobs. Cash incomes have become increasingly important, as the lifestyle has become more similar to western society.

Traditional activities such as hunting and gathering still play an important social role, tying people in a community together at a time when both culture and social networks are stressed by the influences of western culture. In some areas,

and for some groups of people, traditional activities also play a role in the local economy.

A common theme across the Arctic is the extremely rapid pace of change. This has had a major impact on people's health, both positive and negative. A case history of life among Inuit in North America and Greenland gives a glimpse of the social and cultural changes among one group of Arctic people.

A case history of changes in Inuit culture and health

The Inuit of Alaska, Canada, and Greenland are descended from people who migrated from northeastern Asia across the Bering land bridge between 4500 and 20 000 years ago. The first contact between Inuit and Europeans was at the end of the 10th century. By the late 15th century, European whalers had started hunting in the Baffin Bay area and, a century later, several European countries started to explore and colonize parts of the Arctic. The central Canadian Arctic and Northern Greenland, however, remained isolated until the early 20th century. Contact and colonization was accompanied by cultural change. Christianity replaced traditional beliefs, and the Inuit adopted some of the tools brought by the Europeans, even if traditional hunting methods were used until the early part of the 20th century in most regions.

The colonizers also brought new infectious diseases to the Arctic, with devastating consequences. Only a few years after colonization, there was an epidemic of smallpox in Greenland. In 1800, another epidemic wiped out whole districts. During the following centuries, respiratory infections, influenza, smallpox, and typhoid fever killed a substantial part of Greenland's population.

The new diseases hit Alaska particularly hard. Russian and European explorers introduced syphilis, which became epidemic in the Aleutians and southeastern Alaska during the 18th and 19th centuries. In 1900, an influenza epidemic, 'The Great Sickness', killed thousands of people and destroyed entire villages. By the late 18th century, tuberculosis was well established. It remained common for 150 years, with very high death rates.

These and other infectious diseases remained a serious threat to people's health until the 1950s,



even if the first extremely disruptive years after colonization were followed by periods of relative tranquility. Aside from a number of disease epidemics, starvation and chronic malnutrition were common.

The changes brought by the colonizers had a large impact on population numbers. In the 16th-18th centuries, the population of North American and Greenland Inuit was probably around 75 000. By 1900, it had declined to 35 000. During the 20th century, the population slowly recovered as mortality decreased and fertility increased. By 1970, the Inuit population had reached its pre-contact level again.

Naval visit by HMS *Bulldog* and USS *Nautilus* at Nuuk, Greenland, 1860. Painted by Aron from Kangeq. Reproduced by permission from Her Majesty the Queen's Reference Library, Amalienborg, Copenhagen.

From isolated self reliance to integration

The colonization of the Arctic had a profound impact on the way of life in Inuit communities. Before contact, they were relatively isolated, self-reliant societies based on fishing and hunting. In the past 50 years, many Inuit communities have become partially integrated into the economy of their respective national states, and the world. Village economies have become based more and more on wage earning, even if

Saami life, 1930 and 1997.



ANNIE GIÆVER



STAFFAN WIDSTRAND



ARCTIC INSTITUTE / JETTE BANG

Carving up a seal, 1939 and 1994.



PER FOLKVER

unemployment is still common. Infrastructure and housing have changed, often with local people merely watching as outside workers do the construction. Travel, radio, television, and, lately, the internet have increased contact with the rest of the world. The population has grown and many people have moved to larger communities. In the process of modernization, non-Inuit people have moved into the communities, where they often hold well-paid jobs and influential positions.

Modernization has also affected aspects of people's lifestyles that are closely connected to health. On the positive side, fewer people are killed in accidents. Traditional Inuit life was extremely perilous. Many hunters died young, leaving their wives and children behind in poor social conditions. Another positive development is that most people now have better access to health care. Housing conditions, sanitation, and food security have also improved, which has led to decreased transmission of infectious diseases. Seasonal starvation has disappeared, improving overall resistance to infections.

On the downside, the transition to more store-bought food has brought changes in eating habits, which in combination with a more sedentary lifestyle have increased the risk of obesity. This in turn has led to an increased risk of diabetes. Together with smoking habits, obesity is also connected to cardiovascular diseases. There is some evidence that Inuit have a genetic predisposition – an inherited sensitivity – to arteriosclerosis (clogged blood vessels), but that their traditional diet of marine mammals and fish offers protection against this and related heart diseases.

Travel and migration have brought new infectious diseases, including HIV. Tuberculosis is again on the rise after having been a seldom-seen disease.

Increased access to alcohol and tobacco is closely connected to ill health. Smoking is a

risk factor for many cancers and also for cardiovascular diseases and chronic lung disease, which are important health problems among modern Inuit. Many communities have prohibited alcohol, but in others alcohol is responsible for the majority of health problems. It is a factor in many accidents with all-terrain vehicles and snowmobiles. It is also the largest contributor to a high prevalence of violence and suicide among Inuit. Since the 1970s, suicide has become a major cause of death, especially among young men in Greenland.

The influx of non-Inuit, rapid growth in population, and the increasing concentration of people in larger settlements have profoundly altered the social structure of Inuit communities. Together with other socio-cultural changes, stress and psychological problems have become more common.

In summary, social changes have increased physical survival in all age groups among the Inuit. However, this increase has probably come at the expense of mental and social health. The disease pattern in the future will depend on whether current lifestyle trends can be turned in a more healthy direction.

Statistics reflect health status

Many of the themes in Inuit history appear throughout the Arctic, but there are also differences. Some of these similarities and differences are reflected in population and health statistics. The statistics also gives a basis for comparing the health status of groups of people and for monitoring changes over time.

The recent regrowth of the population in parts of the Arctic is reflected in a high proportion of young people compared with the average European population. This is particularly true for Alaska, Canada, Greenland, and the Saami regions.

In most parts of the Arctic, life expectancy has improved. However, in many areas it is

still low compared with respective national rates. For example, in Russia, life expectancy among indigenous peoples is 10-20 years lower than the Russian average.

In most countries, the largest single contributor to an improvement in life expectancy is that fewer children die soon after birth. Other factors include an overall improvement in health status as a result of safer drinking water, control of infectious disease, and access to health care. Infant mortality has decreased in recent decades, but in Greenland, Canada, and Alaska, it is still more common than the respective national rates. Infant mortality is also very high among Russian indigenous groups.

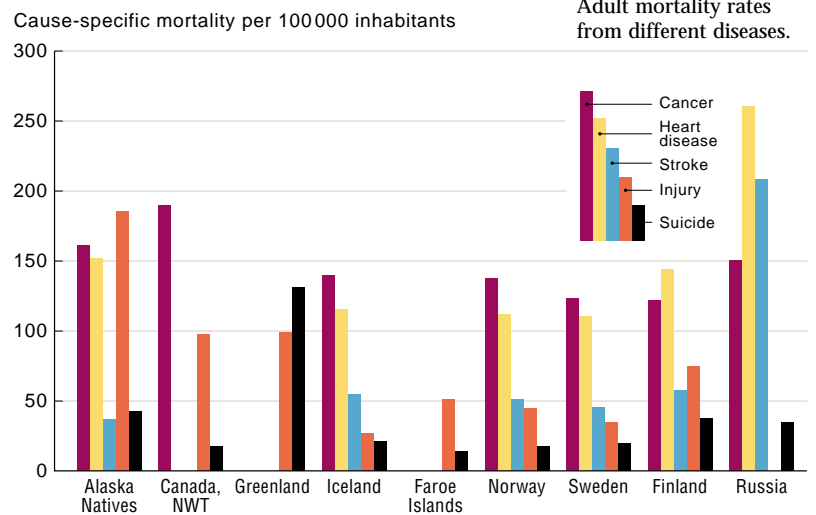
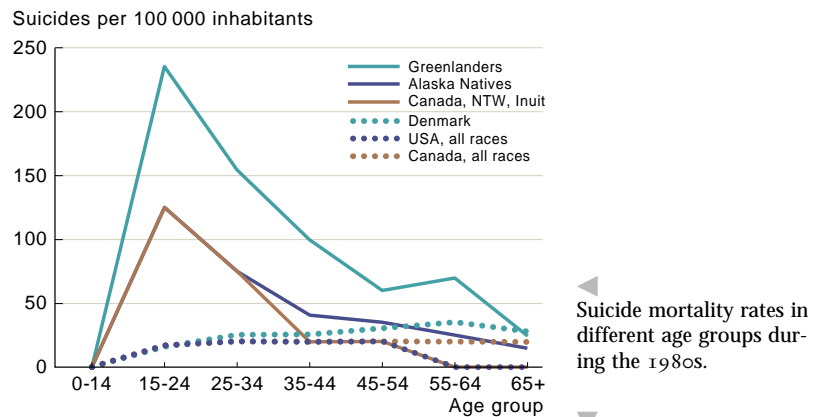
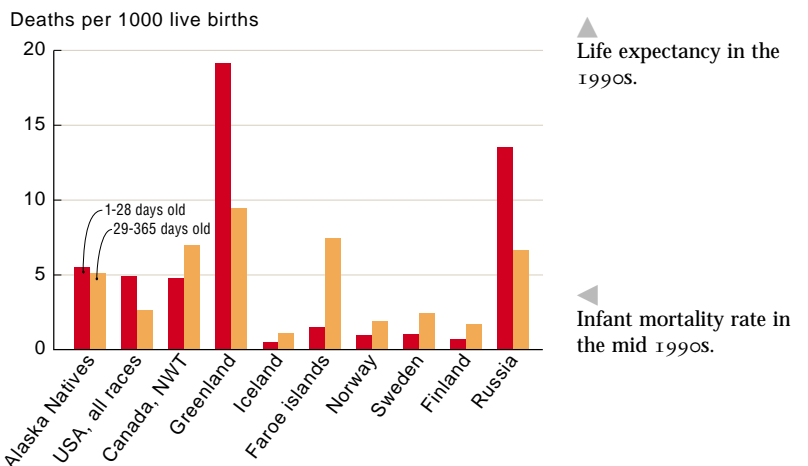
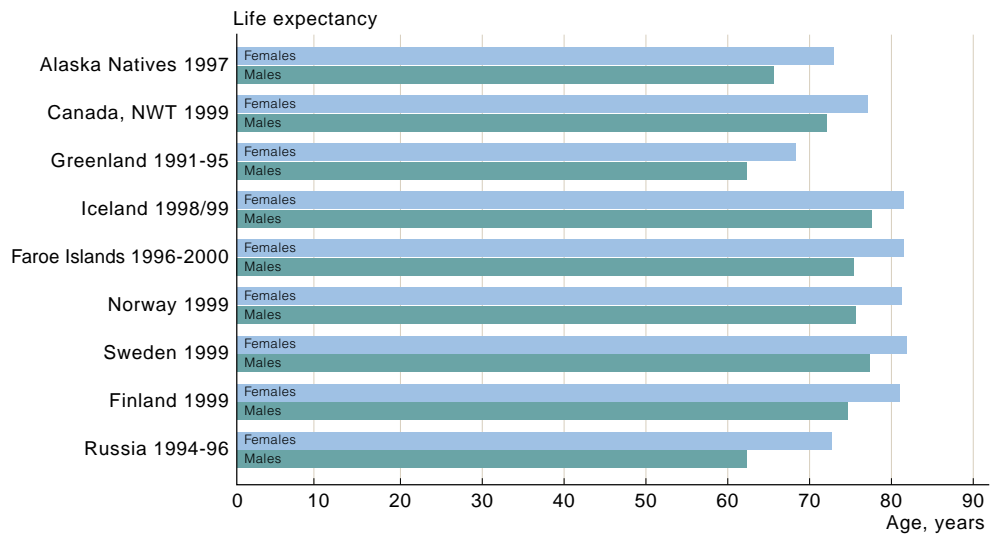
Throughout the Arctic, injuries, for example in accidents, and suicide are the most common causes of death in adults under 45. Suicide is a major problem, especially among men. Wide variations exist and may reflect differences in cultural stress, economy, or rates of depressive illness. Injuries and infections are the most common causes of ill health.

For people over 45, heart disease, strokes, and cancer are the most common causes of both disease and death, with some regional variation. These lifestyle-related diseases reflect a new trend with connections to a more sedentary lifestyle and to smoking. Obesity and diabetes have increased from very low levels and are now as common in the Arctic as they are in most developed western countries. In Russia, injuries, infectious disease, especially tuberculosis, cardiovascular disease, parasites and respiratory disease are common. Many health problems are related to alcoholism.

Infections kill far fewer people than in earlier times. However, respiratory infections in infants are still much more common than among other population groups. For adults, some sexually transmitted diseases are more common. Among Canadian and Greenland Inuit, the rates of gonorrhea and chlamydia are 10 to 100 times higher than in southern Canada and Denmark.

Food and other lifestyle factors

The way we live – our lifestyle – can have a great impact on health. It includes the everyday activities of work and leisure, our relationships to the people around us, and our food habits. The different components of a life style are often difficult to separate from one another. For example, eating together and sharing food provide not only nutrients and



energy, but also play a role in affirming social and cultural ties. Our everyday activities of work and leisure influence whether we eat country foods, such as game and wild plants, or groceries bought with money earned in employment.

Among Arctic indigenous people, country foods still play an important role in nutrition and well-being. For many people, these traditional foods are also a source of community spirit, pride, and self-respect, and are a way to educate children about a culture. In Greenland the word used for traditional Inuit food – *Kalaalimernit* – literally means little pieces of Greenlanders, as opposed to the word for imported food – *Qallunaamernit* – which means little pieces of Danes. The traditional Inuit foods are thus considered the necessary building blocks of Inuit. They can provide health, bodily warmth to withstand the cold climate, strength, and well-being in a way that imported foods simply cannot.

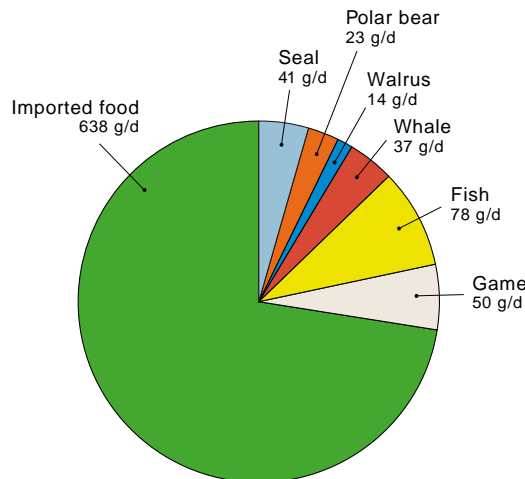
The role of traditional foods has also received increasing attention because food is the major source of contaminants for people in the Arctic. Knowing dietary habits is therefore important in estimating exposure.

The use of tobacco, alcohol, and drugs are other major aspects of lifestyle that have direct implications for health. Smoking is also a source of contaminants.

Food habits are changing in Greenland and Canada

In spite of the many benefits of traditional foods, eating habits have changed over the past 50 years. This is illustrated by the fact that people get a larger share of their energy requirements from store-bought food than in the past. In North America and Greenland, indigenous peoples get between 60 and 90% of their food from the store.

The changing times can also be illustrated by differences between young and old people. Interviews with three generations of adult women in Nulax, British Columbia (outside the Arctic), showed that there had been a steady decline in the use of traditional foods



▶ Coagulated blood is a traditional Chukchi food.

Estimated daily intake of traditional and imported foods in East Greenland in 2001.

because of restrictions associated with fish and game laws, better availability of market food, and increasing employment that left less time for traditional harvesting. In Baker Lake, Northwest Territories, where caribou is a key component of the traditional diet, consumption decreased from over 250 grams per day in the late 1960s to less than 70 grams by 1989.

Among Baffin Inuit, teenagers eat less than half the traditional foods that middle-age people consume. Among Greenland Inuit, people older than 60 ate more than 40 meals a month of seal, whale, wild fowl, or local fish, whereas 18-24 year-olds had half as many traditional meals. In general, men eat traditional food more often than women.

Country foods are still important in Russia

In Russia, the trend toward more market food is not as clear. More market foods are transported to rural settlements, but high prices in combination with low incomes and strong traditions still make people rely heavily on country foods. For example, the indigenous people of the Taymir Peninsula still eat 400 grams of reindeer meat per day. A recent dietary survey of pregnant women from northern Siberia showed that indigenous mothers ate 320 grams of reindeer per day, which is ten times higher than non-indigenous mothers in nearby towns. The indigenous women also ate twice as much fish and three to five times as much game.



PAVEL ABRUYUTIN

Scandinavia, Iceland, and the Faroe Islands have western diets with local influences

In Scandinavia, Iceland, and the Faroe Islands, the diet is typically western, but with an emphasis on local resources. For example, fish is often on the dinner table in Iceland and in the coastal areas of northern Norway. In the Faroe Islands, meat and blubber from pilot whales are still important foods and many people eat them several times a month. For women of childbearing age, there have been food advisories based on the heavy load of contaminants in the whales, and recent research following pregnant women indicates that they have drastically decreased their consumption. In northern Scandinavia, local products such as reindeer meat, lamb in some areas, fish, berries, and mushrooms are more common foods than in the rest of Scandinavia. A recent dietary survey of Norwegian Saami showed that their diet was changing toward a more typical Norwegian diet.

Changes affect health

The gathering and hunting as well as the preparation of traditional foods are activities that require a lot of energy, particularly as they often involve hard physical exercise in low temperatures. An early dietary survey, from 1926, showed that a traditional Inuit hunter in East Greenland could have an energy intake one and a half times that which is normal today. The energy came almost exclusively from meat and fat from marine mammals. As wage earning and the market economy have gradually replaced the local economy, these physical activities have been replaced by the much less energy-demanding tasks of picking up and preparing food from the supermarket. If energy



intakes are not reduced accordingly, people are likely to get fat and increase the risk for diseases that are associated with being overweight. In some cultures, such as the Dene/Métis in Canada, the problem is compounded by store-bought food having higher energy content than traditional food. The traditional foods are often high in protein and fats and low in carbohydrates, whereas the imported foods often have high fat and sugar content but may have low nutritional value.

Market foods lack important nutrients

Dietary changes can also lead to specific nutritional deficiencies. For example, local fish products are usually not replaced by the equivalent products from the store but by cheaper alternatives that do not provide the same amounts of calcium, vitamin D, and iodine. In Nuuk, the capital of Greenland, the average iodine intake is only half of the recommended value. In Greenland villages, where people eat more country foods, iodine intake is sufficient. Another example is that fish skin and bones

are important sources of calcium for many Inuit. Fish fillets from the store lack this needed nutrient. Calcium is especially important in the context of contamination, since deficiencies may increase the body's uptake of heavy metals. Traditional Inuit foods, especially muktuk (whale skin and blubber), meat, and liver from whales, seals, and seabirds, are also rich in selenium. This trace nutrient is thought to play a role in protecting against some of the damage from mercury.

Marine fatty acids protect against heart disease

One of the most important benefits of a marine diet is the high content of certain fatty acids that can protect against reduced flow of blood to the heart muscle and related heart diseases. These are the n-3-fatty acids, which are produced by plankton in the sea and passed along to fish and marine mammals in the marine food web. They are also present in high proportions in the fat of game animals such as hare, deer, caribou, and muskox that graze on plants in the wild. The fat from farm animals derives from feed that contains fatty acids that are less healthy.

Lower intake of the healthy fatty acids and a higher proportion of other fats may also play a role in increasing the risk for diabetes. This disease has been relatively rare among Inuit, but has become more common in the past 30 years.

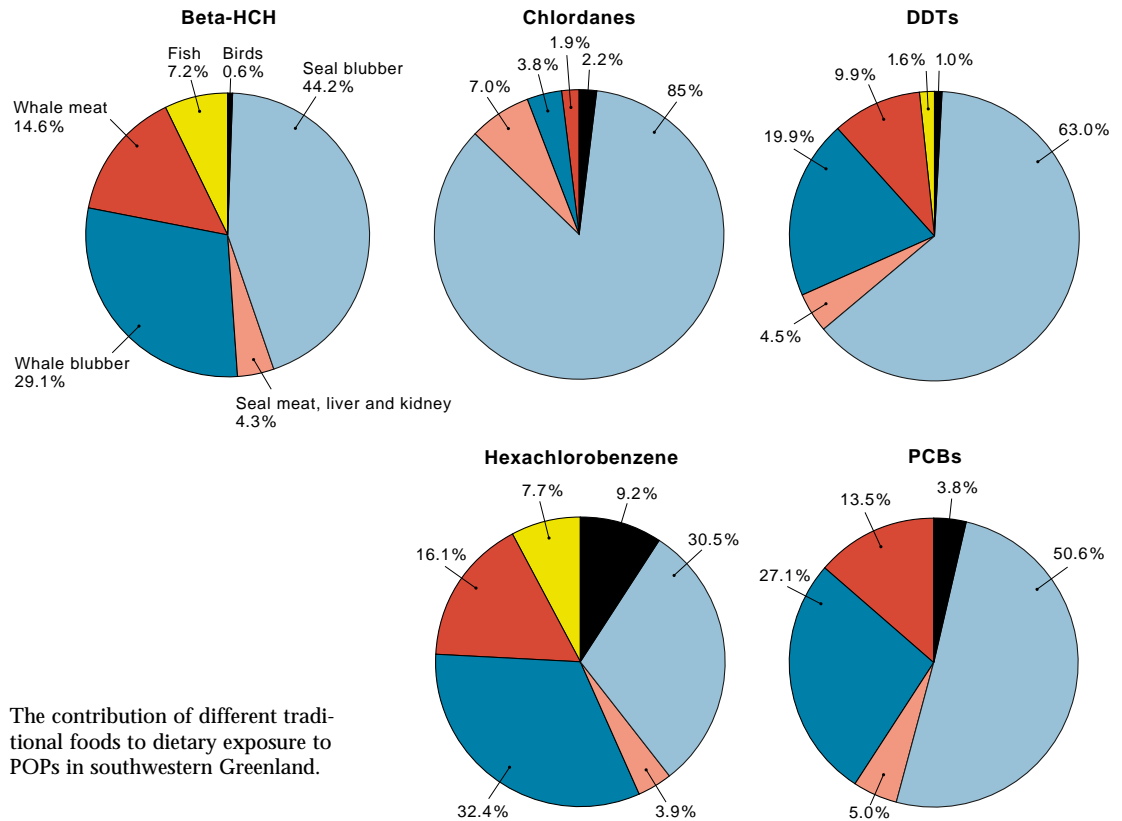
The high intake of marine fatty acids may contribute to strokes caused by bleeding in the brain, a cause of death that is relatively common among some Inuit groups. However, the benefits from protection against heart disease probably outweigh this increased risk.

The composition of lipids in the blood depends not only on what a person eats, but also on inherited abilities to convert lipids from one form to another. There are differences among population groups in this inherited ability. Inuit as a group seem to be less able to create some very important fatty acids from other fatty acids in the diet. This makes it extra important to get these nutrients via animal foods, emphasizing the health value of the traditional diet.

The n-3 fatty acids are also important in brain development in the growing fetus and for the proper development of vision.

Food is a source of contaminants

It is well known that many contaminants accumulate in the animals that Arctic people eat. Persistent organic pollutants accumulate especially in fatty tissues, such as the blubber of marine mammals. Birds can also have high levels, especially in the liver. Heavy metals, such as cadmium and mercury, accumulate in muscle, kidney, and liver of both marine and terrestrial animals.



The contribution of different traditional foods to dietary exposure to POPs in southwestern Greenland.

Knowing dietary habits and the contaminant levels in various foods, it is possible to estimate exposure. The picture will differ both among individuals and among population groups depending on what people eat.

Most Canadian Dene/Métis fall well below the Canadian guidelines for exposure to persistent organic pollutants. However, for toxaphene and chlordanes, average intakes are much closer to guideline values, which some individuals exceed.

The picture for Inuit of Baffin Island and Greenland raises more concern. For Baffin

Inuit, mean intake of chlordanes and toxaphene in the late 1980s exceeded Canadian dietary guidelines. Recent studies, from 1998-99, show that Baffin Inuit mean intakes continue to exceed the dietary guidelines for chlordanes and toxaphene, to say nothing of the most highly exposed individuals. Preliminary results from dietary studies in West Greenland show that the traditional diet leads to an intake of chlordanes and PCBs that exceeds the tolerable daily intake. It is thus clear that a substantial number of Inuit have higher exposures than are considered acceptable.

Estimated weekly intakes of lead, cadmium, and mercury as they relate to WHO public health guidelines for provisional tolerable weekly intake. Selenium may protect against mercury toxicity.



Similar calculations have been made for heavy metals (see diagram at bottom of this spread). Some populations with a high intake of meat from marine mammals exceed dietary guidelines for mercury and cadmium. The levels of metals vary tremendously between animals and among the various organs in an animal. Moreover, some forms of the metals are more easily taken up than others. In general, the liver and kidney of large marine and terrestrial animals and the liver of fish have the highest metals concentrations. Caribou and moose liver can contain high concentrations of lead, cadmium, and mercury. Because the mercury in these organs is not readily taken up by the body, however, the most important sources of mercury are meat from seals and toothed whales. For some population groups, freshwater fish, especially predatory species such as northern pike, can be an important dietary source of mercury.

Seabirds and bird liver are important sources of lead. The use of lead shot in hunting adds to the lead burden in human food. One boiled murre served as soup can yield as much as 50 micrograms of lead, which is about a quarter of the provisional daily intake proposed by WHO. A Russian study of metal levels showed that children in some remote areas of the Kola Peninsula had high enough lead levels to cause concern for their health. The lead most probably comes from lead shot.

Smoking is extremely common

Tobacco smoke contains a number of substances that are well known to affect people's health. They include more than 50 cancer-causing substances. Smoking is also known to cause lower birth weight. Tobacco smoke is a major source of cadmium, a contaminant that has been linked to kidney dysfunction, brittle bones, and reduced fertility.

The nicotine in cigarette smoke is broken down by the same enzymes in the body that take care of organochlorine contaminants. There are studies showing that the levels of these contaminants are higher in the blood of smokers than in blood of non-smokers among Arctic population groups.

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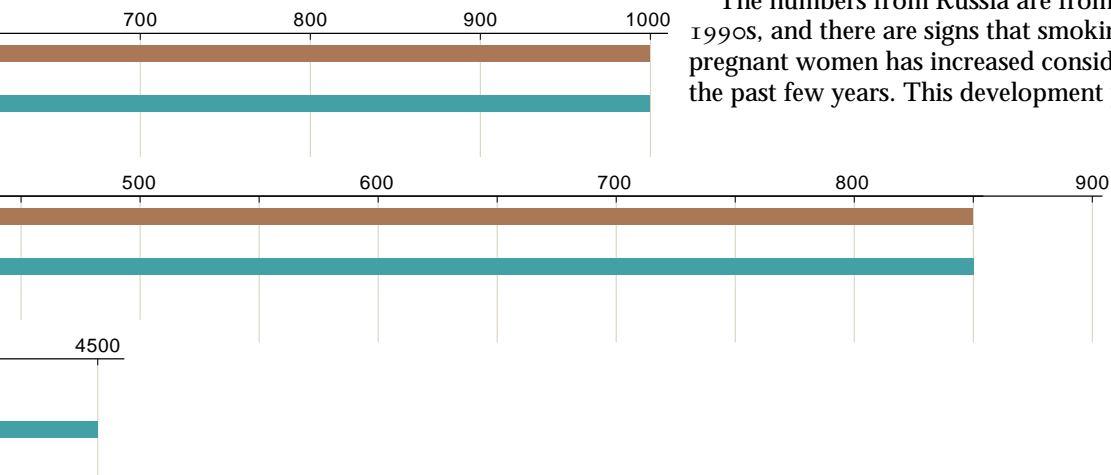
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Advice against smoking, Greenland.

In many Arctic populations, smoking is very common and is one factor behind the increasing prevalence of heart diseases, chronic lung disease, and many cancers. Lung cancer, which is closely related to smoking, is at least as common among indigenous people in the Arctic as among other groups of people.

High levels of smoking among pregnant women are a particular concern as smoking is a well-known risk factor for the health of the child. In a survey in Greenland, about 60% of the pregnant women answered that they smoked daily. The numbers are somewhat lower in Russia, Norway, and Finland but still high. In northern Russia and Norway, approximately one in five pregnant mothers smoked daily. In Finland, 12% of the women giving birth said they smoked daily.

The numbers from Russia are from the mid-1990s, and there are signs that smoking among pregnant women has increased considerably in the past few years. This development parallels





Smokers 1922-2002.

the increase in western contacts and western-style advertising. Women with university-level education and high socio-economic status smoked the most, indicating that smoking has become associated with high status. This is in contrast with the situation in Western Europe, where women who smoke often have only lower education.

Alcohol causes problems in many communities

Trying to estimate alcohol and drug consumption or illegal drug use is notoriously difficult. However, there is no doubt that alcohol and drugs have caused health and social problems in many Arctic communities. Surveys of Greenland residents have shown that 39% of the

men and 12% of the women meet the criteria for binge drinking or high alcohol consumption. Among Inuit in Arctic Canada, between 13 and 29% have problems with alcohol. In a survey among Alaska Natives, 29% of the men and 21% of the women report binge drinking. This can be compared with a national US rate of 14%. In the Russian Arctic, alcohol use has increased since Perestroika. It is especially a problem among men.

One study has looked at the effects of alcohol in terms of deaths from disease and accidents. The picture varied considerably among regions. The risk of vehicle accidents was much higher in Canada than in the Nordic countries and higher still in Alaska and Russia. Alaska, Russia, and Finland had the highest mortality from homicide. Most problems were more serious in northern areas than farther south. Greenland, the Faroe Islands, and Iceland were not part of the study.

Alcohol abuse poses a special problem in connection with pregnancy as alcohol can affect the growing fetus. The result can be lower birth weight and brain dysfunction. In severe cases, growth is impaired and the child develops characteristic facial features. These severe effects are called fetal alcohol syndrome. From 1988 to 1994, the Alaska Native health care system

documented fetal alcohol syndrome at a rate of 4.2 per thousand live births, a much higher rate than in the US population (0.3-1 per 1000). It is quite possible that fetal alcohol syndrome is common in other Arctic populations, but there is no documentation. In Scandinavia and Russia, alcohol abuse during pregnancy is fortunately scarce in most indigenous cultures. An ongoing project by AMAP's Human Health group will add new knowledge on this issue.

Cocaine and marijuana represent large problems in many Alaskan and Canadian Arctic communities. Their use has a seasonal variation and there may be links to seasonal depression, which is common in countries with very short winter days. Injection drugs seem to be as common in northern areas as they are farther south.

Environmental contaminants and their effects

A large number of environmental contaminants can potentially affect people in the Arctic. Most of them can be included in the broad categories of persistent organic pollutants, heavy metals, and radionuclides. Descriptions about the sources, pathways, and general biological effects of these substances are given in the previous chapters. This chapter focuses on how persistent organic pollutants and heavy metals may influence the health of people living in the Arctic. The emphasis is on sensitive targets, such as the brain, hormones important for sexual development, and the body's defense against infections. The effects are likely to be subtle and it is difficult to establish a cause-effect relationship with contaminants. Nevertheless, new results since the previous AMAP assessment show that the mercury levels present in some Arctic populations can cause subtle effects on fetal brain development. The growing brain of a fetus is also sensitive to PCBs. PCBs are also implicated in effects on young children's defense against infections.

The growing brain is very vulnerable to mercury

Many toxic chemicals can affect the nervous system. Especially sensitive is the growing brain of a fetus. Mercury is one of the pollutants that raises concern. The risks are con-

Young Inuit girls in a Tuborg beer marketing campaign at Qaqortoq, Greenland, 1906.



Inuit girl collecting empty beer bottles for recycling, 1996.

nected with a chemical form of mercury called methylmercury, which accumulates in marine and aquatic food webs.

The effects of methylmercury first became apparent in children whose mothers had eaten foods that were contaminated with very high levels of methylmercury. Recently it has become clear that much lower exposure to methylmercury may also have effects, though they are much more subtle. The new knowledge comes from three epidemiological studies, one in the Faroe Islands, one in the Seychelles, and one in New Zealand. In none of the studies did the children have any apparent signs of mercury poisoning. The average hair mercury concentrations in these studies varied between 4.3 and 8.8 micrograms per gram, with a significant number of infants having levels above 10 micrograms per gram.

In the Faroe Islands study, the children's performance in neurobehavioral tests showed that mercury levels had an effect on fine motor function, attention, language, visual-spatial abilities, and verbal memory. The New Zealand study also found some adverse effects from mercury exposure, whereas no correlation between mercury exposure and neurobehavioral effects was found in the Seychelles study. Interpreting these somewhat conflicting results has been a major challenge, but it appears that mercury levels that are currently

considered 'safe' can affect the brain development of a child in its mother's womb. The individual may never be aware of any effects as there are no apparent symptoms, but even small changes in brain development can have implications for daily life. In the Faroe Island study, it was calculated that a doubling in prenatal exposure to mercury corresponded to a delay in child development of 1-2 months during the first seven years of life. It is not known how significant such a delay will be when the child grows up.

Several Arctic populations exceed mercury guidelines

AMAP's circumpolar survey of contaminants in maternal blood shows that the mercury levels in the Faroe Islands are not unique in the Arctic, and that some other groups are exposed to similarly high or higher levels.

There is no international agreement on a new 'safe' level, or reference dose for mercury, below which there are no known effects and which can thus be used to justify public health actions. One point of departure has been 12 micrograms per gram in the mother's hair, which is in the same range as WHO's recommendation of 10-20 micrograms per gram. The US Environmental Protection Agency applies a safety factor of ten, which results in a reference

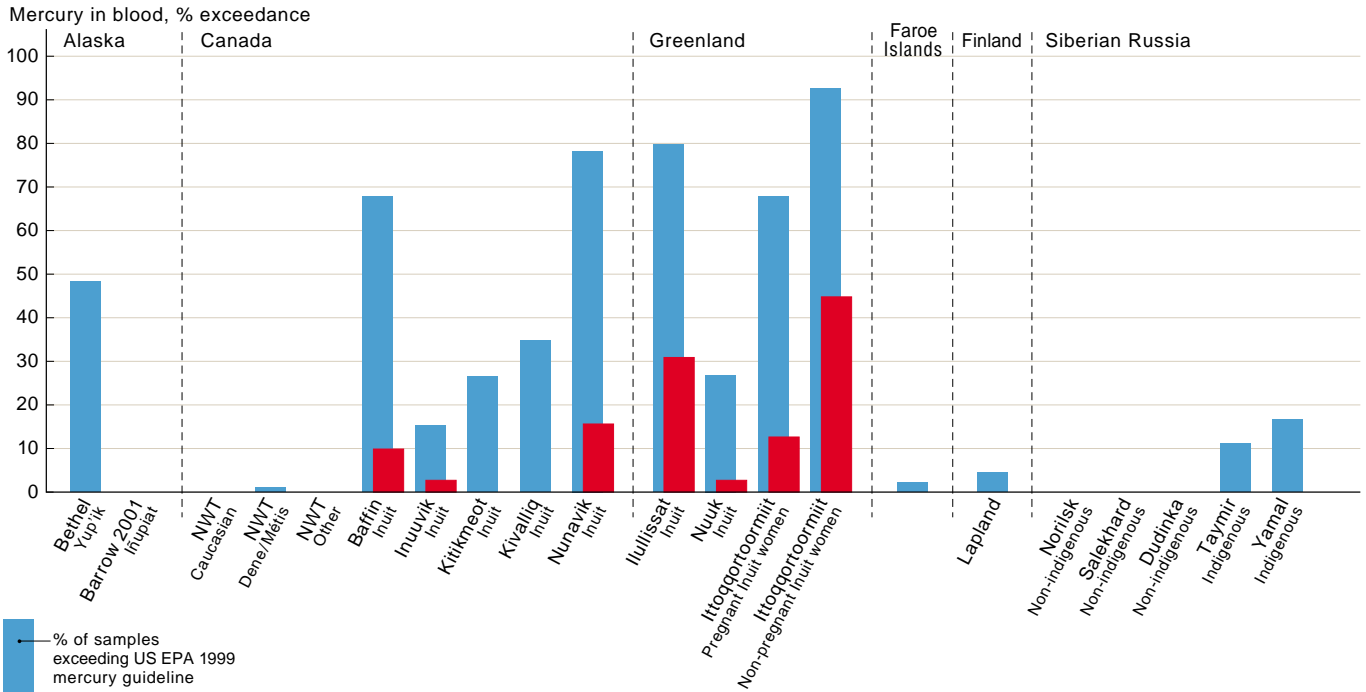
Measuring neurobehavioral effects



Measuring subtle changes in neurobehavioral development is a challenge. There is a battery of different tests looking at coordination, reaction time, and memory. The pictures show two of the tests that were used to study Faroese children in an epidemiological study looking for effects of mercury. Test scores were compared with the mercury exposure the children had while they were still in their mother's womb.

In the upper picture, the doctor examines the fine motor skills and coordination abilities of a Faroese boy by asking him to move his arm forward so that his fingertips will touch hers. He will next have to do the same task with closed eyes, to see how well he remembers the movement he did before.

The lower picture shows what is called the evoked potentials examination. The girl is watching a screen with a changing chessboard pattern. This will create well-defined nerve impulses to the visual cortex in the brain. The electrodes on her head measure how fast these impulses travel, and an amplified signal shows up on the measuring device. Mercury is known to have an effect on this signal.





 % of samples exceeding US EPA 1999 mercury guideline
 % of samples exceeding Health Canada mercury guideline

Mercury levels in blood of women of reproductive age as they relate to US EPA and Canadian guidelines for increasing risk range.

▶▶ Selenium/mercury ratio in hair of humans and animals from Greenland.

▶ Mercury concentrations in hair of humans and animals from Greenland.

▼ Mummies from 15th and 16th century graves in Greenland have provided hair which can be analyzed for mercury to show historical levels of this metal in people and their diet.

dose of 1.2 micrograms per gram in maternal hair. This is equivalent to a cord blood concentration of 5.8 micrograms per liter. Health Canada has guidelines that a maternal blood level between 20 and 100 micrograms of mercury per liter indicates increasing health risks, and that levels above 100 micrograms per liter constitute a health risk.

A large proportion of Greenlandic women exceed the stricter US EPA guideline, and many women also exceed the Canadian guideline of 20 micrograms per liter. Among Canadian Inuit, a few women exceed the Canadian guideline whereas about a third exceeded the stricter US EPA levels. Among the Yup'ik in western Alaska, almost half of the mothers exceeded the stricter US EPA levels.

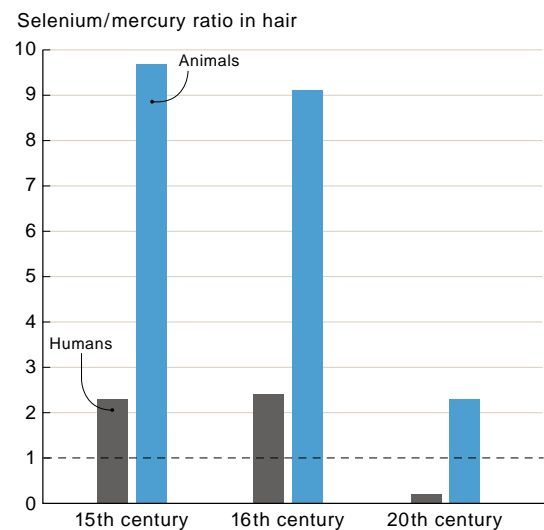
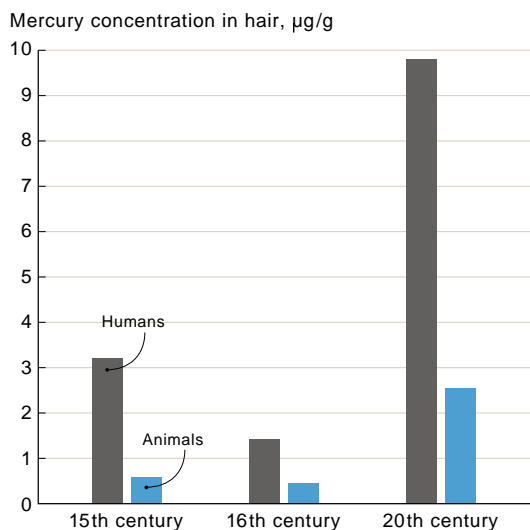
In Siberia, none of the mercury levels exceeded the 20 microgram per liter guidelines, but in two regions (Taymir and Yamal) some women exceeded the stricter limit.

In summary, high mercury levels appear to pose a threat to children's development in some Arctic populations.

Mercury mechanism stresses protective role of marine foods

The mechanisms behind the effects of methylmercury on the central nervous system are not well understood. One possible explanation could be that mercury increases the production of reactive oxygen in the body. This oxygen has a chemical form that is different from the oxygen in air. It is produced in several natural processes in the body. While there are natural defenses against this aggressive form of oxygen, mercury might diminish some of these defense mechanisms. Other factors might enhance the defenses. They include beneficial nutrients such as selenium, which together with marine fatty acids is known to decrease oxidative stress. Traditional marine diets are thus both the source of harmful methylmercury and of beneficial nutrients.

Mercury can be measured in hair from people or animals, and preserved hair samples have been used to determine a time trend for this contaminant. The human hair samples show



HN LEE / GREENLAND NATIONAL MUSEUM

that mercury levels in Inuit are three-fold higher in the 20th century compared with the 15th and 16th centuries. In animal hair from seal and reindeer, similar increases are seen. At the same time, selenium levels in human hair have decreased because of changing eating habits. In animal hair, there is no similar decrease in selenium. Selenium may counteract the toxic effects of mercury. However, the lower levels of selenium may not be adequate to prevent the effects of the higher levels of mercury. Thus, there may now be an impact on human health that was not as likely in the past.

Some POPs can also affect brain development

Some organic pollutants can also affect the development of children's brains. Most knowledge about low exposure through the food web comes from studies outside the Arctic. The focus has been on PCBs. The effects that have been linked to PCB exposure in the womb include lower birth weight, slower growth, poorer visual recognition memory, deficiencies in psychomotor development, and poorer intellectual functioning. Some of these effects appear to be irreversible. Although much larger quantities of PCBs are transferred to nursing infants by breast feeding than across the placenta in the womb, virtually all the neurobehavioral effects have been linked specifically to exposure before birth. This indicates that the embryo and fetus are particularly vulnerable to these substances.

PCBs were measured in the same Faroese study that looked at the effects of mercury. In this case, however, it has been difficult to specifically pinpoint PCBs as the cause of the effects on behavior. There were some indications that both contaminants had the same effect on the nervous system, potentially making the effect worse when both mercury and PCBs are present.

The levels of exposure in the epidemiological studies looking specifically at PCBs are lower than for the most highly exposed Arctic popu-

lations. Comparing the results from the circumpolar study of contaminant levels in maternal blood with public health guidelines again provides a disturbing picture, especially for Inuit who rely heavily on marine mammals in their diet as well as for some non-indigenous groups.

Health Canada's maternal blood guideline for PCBs sets the level of concern at 5 micrograms per liter and the action level at concentrations above 100 micrograms per liter.

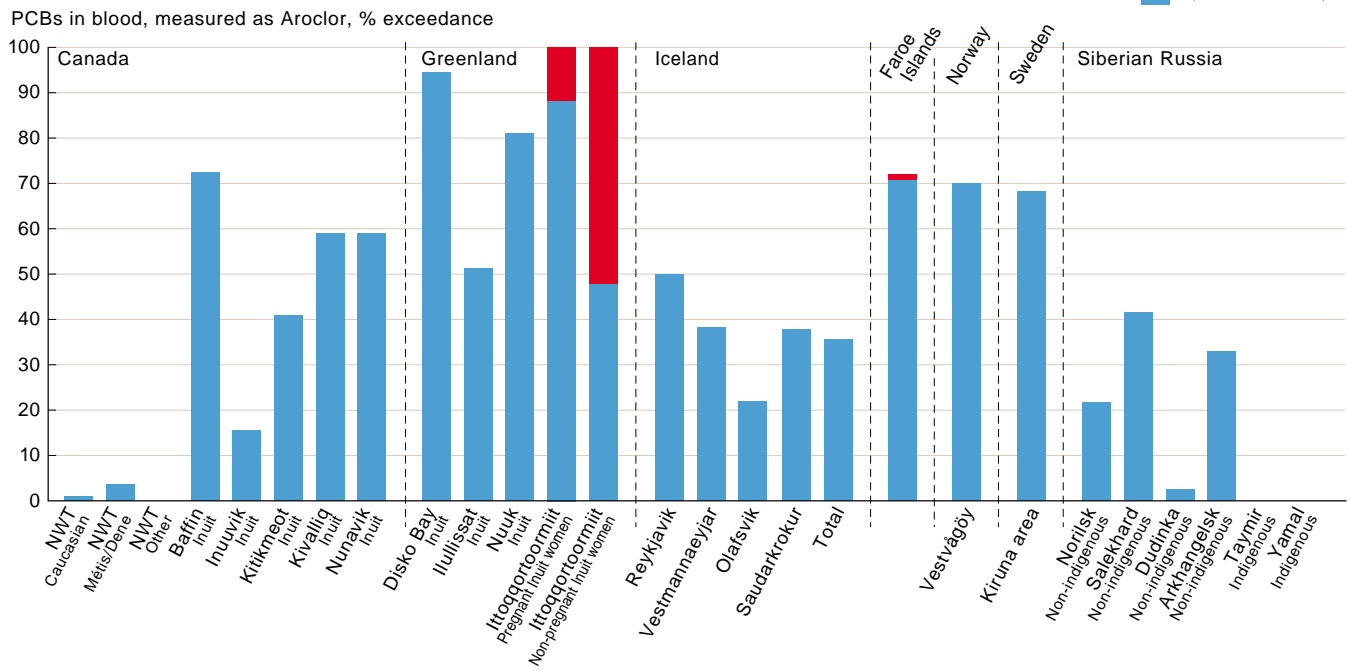
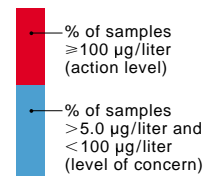
In the Canadian Arctic, the proportion of the samples from Inuit women from Northwest Territories and Nunavut that exceeded the level of concern ranges from 16 to 73%, although none exceeded the action level. In Greenland, a high proportion (50-95%) of women of child-bearing age exceeded the level of concern. In one area, Ittoqqortoormiit, 12% of the pregnant women also exceeded the Canadian action limit. More than half of the non-pregnant women exceeded this limit. There is no apparent explanation for the differences among different groups of women.

Although the situation is worst in Greenland and among Canadian Inuit, a number of women in other population groups also exceed the level of concern. They include non-indigenous women in Russia, Iceland, Norway, and Sweden.

Hormone mimics may disturb reproduction

It is well known that high levels of organic pollutants can lead to reproduction problems in wildlife. The causes range from the animals having gross changes in the reproductive tract to changes in mating behavior. During the 1990s, it has become clear that there is a common link between many of the reproductive problems. Many organic pollutants can disrupt the endocrine system, the hormones in the body. Some of the endocrine disruptors mimic the female sex hormone estrogen, whereas others block its action. Other compounds interfere with the male sex hormone testosterone, and some chemicals interfere with both systems.

PCB levels in blood of women of reproductive age; percentage of samples exceeding public health guidelines for levels of concern and action.



Experiences from a synthetic estrogen that was used to treat threatening miscarriage in pregnant women (diethylstilbestrol, DES) show that the effects of endocrine disruptors do not always appear in the adults who have been exposed, but may only be seen in the next generation. Often, a fetus in the womb is much more sensitive. In the growing body, the chemicals disturb the fine-tuned interaction of hormones steering the development of the reproductive system, causing irreversible damage.

The picture of endocrine disruption as a toxic mechanism has focused attention on diseases that might be connected with such mechanisms. For men in the western world they include increases in the incidence of testicular cancer, prostate cancer, and possibly also the number of newborn boys with undescended testes or malformed penises. For women, a rise in breast cancer has been discussed in this context, but the connection to contaminants is not very clear.

There are, as yet, no completed studies from the Arctic reporting contaminant effects on reproductive health, but such studies may be appropriate considering the high levels of some contaminants that are known to cause reproductive problems in animals. Recent results from biomarker studies also emphasize the need for further studies. Using cell cultures, it has been possible to look at the hormone-disrupting effect of the actual mixture of contaminants that is present in human blood in the Arctic. Results from East Greenland show that the blood sample, after being stripped of all natural hormones, is able to affect normal hormone processes in cultured human cells. It is too early to say anything about the significance of these findings for health of the Greenlanders in the study areas.

Weakened defenses against disease

The immune system has been increasingly recognized as a sensitive target for environmental contaminants. The cells of the immune system help identify and destroy foreign material such

Mechanism behind PCB effects raises concern about other contaminants

One mechanism behind the effects of PCBs on the developing nervous system could be that some of these compounds interfere with thyroid hormones in the body. Thyroid hormones regulate the growth of nerve cells and the way that nerve cells develop different specific functions. In the fetus, the thyroid is essential for growth and for the brain and central nervous system to develop normally. The PCBs as manufactured may not cause detrimental effects themselves. In the body, they are changed into new forms, for example hydroxylated metabolites, or OH-PCBs. The OH-PCBs bind strongly to the special protein that normally transports thyroid hormones from the blood to the brain.

Several compounds that are chemically related to PCBs can also affect the thyroid system. They include dioxins, brominated flame retardants, phthalates, and some pesticides. Phenolic compounds, such as pentachlorophenols, are known to bind strongly to the blood-brain transport protein.

as bacteria and viruses that enters the body. The immune system also plays a role in recognizing cancer cells. An overactive immune system is involved in allergic reactions.

There are a number of contaminants that affect the immune system. In almost all animal species that have been tested, PCBs, dioxins, and furans suppress various components of it. The effects may be more severe in unborn or very young children, when the immune system is still maturing, than later in life. Other contaminants suspected to have such effects are dioxin-like compounds, chlordanes, hexachlorobenzene, PAHs, and possibly also other endocrine disruptors such as DDTs.

Another way the immune system may be disturbed is via vitamin A deficiency. The immune system needs a certain level of vitamin A to function properly. But vitamin A metabolism can be altered by contaminants, specifically by PCBs and dioxins.

In addition to the animal studies, evidence for effects on the immune system comes from studies showing an increased rate of infection among people who have been exposed to organic pollutants. From the Arctic, there is a study from Nunavik that shows a connection between high levels of organochlorine contaminants and increased incidence of ear infections early in life. A recent study of children in Northern Quebec has looked at immune effects of PCBs and DDTs. The preliminary results support the hypothesis that the high incidence of respiratory infections observed in Inuit children is due in part to high prenatal exposure to persistent organic pollutants.

Metals can also be toxic to the immune system. Both mercury and lead have been shown to affect various immune cells. Inorganic mercury can also induce allergies and hypersensitivity. Lead seems to promote hypersensitivity, rashes, and autoimmune response.

Mercury may increase the risk for cardiovascular diseases

There are some indications that mercury can increase the risk for cardiovascular diseases. A Finnish report has noted a correlation in fish-eating Finnish men between high levels of mercury and the risk of coronary heart diseases. The mechanism could be that the mercury promotes the breakdown, or oxidation, of lipids, creating forms that are known to initiate clogged arteries. N-3 fatty acids in combination with selenium and other antioxidants may counteract this effect of mercury. Among Inuit who get large amounts of these nutrients in their traditional diet, death from heart disease is much less common than among other people.

In the Faroe Island study, low-level prenatal mercury exposures have been associated with higher blood pressure in 7-year-old children. This can also be important because high blood

pressure is a risk factor for heart disease later in life. Although insufficient for risk assessment purposes, this evidence suggests that the cardiovascular system is a potential target for mercury and even a slight negative impact could have a major effect on public health.

Cadmium can damage the kidneys

Cadmium accumulates in the kidneys and liver. Even at modest exposure, the kidney can be irreversibly damaged. This leads to the body losing proteins and essential minerals. Recent research has also linked cadmium to the development of osteoporosis (brittle skeleton). Women deficient in iron are especially at risk. The new data from outside the Arctic on cadmium toxicity have led to the conclusion that the guideline for maximum recommended intake is too high to protect against harmful effects.

Cadmium accumulates in the fluid around the egg and can reduce fertility. It has also been related to early menopause, the age when a woman can no longer get pregnant. The growing fetus is partially protected against cadmium. The metal accumulates in the placenta. However, at high enough levels, some of the cadmium passes through this barrier.

For people, the major source of cadmium is tobacco smoke. Significant dietary sources are the kidney and liver from caribou/reindeer and whale. In some areas of the Arctic, such as Greenland, cadmium intake via the diet is higher than dietary guidelines, in addition to exposure from heavy smoking. Dietary intake of iron is also high, which might protect against cadmium from food being absorbed in the body. Nevertheless, there is a need to look more closely at the connection between cadmium intake and the occurrence of effects on the kidneys and skeleton.

Focus on the Kola Peninsula

On the Kola Peninsula of Russia, there has been a fear that pollution from the mining and smelting industry has an adverse effect on health of newborns, especially those born to women working in these industries. To investigate the risks, a study looked closely at the concentrations of nickel and various nutrients in the women of Archangelsk, Nikel, and Monchegorsk in Russia, and Kirkenes, Hammerfest, and Bergen in Norway. Although nickel concentrations were higher among the Russian women, there was no connection to birth weight. However, birth weights overall were lower for the Russian women, and there were signs that insufficient nutrition may play a role.

Another finding was that high levels of lead could cause low birth weight. Lead is also known to be neurotoxic and can affect children's mental development.

Combined effects are difficult to evaluate

Arctic populations are exposed to a mixture of contaminants. Some of them may affect the same sensitive systems in the body, through similar or different mechanisms. A key concern, therefore, is the possibility of interactive effects. If these occur, health risks may be underestimated if the contaminants are looked at one at a time.

There are laboratory studies showing that mixtures of contaminants can cause combined effects. These effects can be additive, where each contaminant adds its effects to the others, or antagonistic, where contaminants actually counteract each other's effects. In a few cases, laboratory studies have shown synergistic effects between contaminants, where the different substances enhance each other's effects. As a further complication, some contaminants may have one effect at low concentrations and completely different effects at higher concentrations.

The effects of contaminants are also influenced by the person's general health. Inherited characteristics, nutritional status, and lifestyle factors such as smoking can thus play a major role in sensitivity to contaminants. Age also plays a role, and young children are often more sensitive than adults.

Epidemiological studies can provide information about combined effects that include both contaminants and other factors. This can be the case even when the intention is to study a single contaminant. The overall situation usually varies from one group of people to another, and contradictory findings can sometimes be explained by looking at the situation as a whole.

It may also be too simplistic to look at only one effect of a specific contaminant. The same substance or one of its breakdown products may act on other, even more sensitive systems in the body. Any risk assessment thus has to take into account which system in the body would be most sensitive, along with an evaluation of which individuals in a group would be most sensitive.

At this point, it is impossible to evaluate the combined effects of all contaminants and other factors that influence human health in the Arctic. AMAP's Human Health Program is designed to gather information from a number of different areas to make better assessments of combined effects in the future.

A female worker at the October Mine at Norilsk.

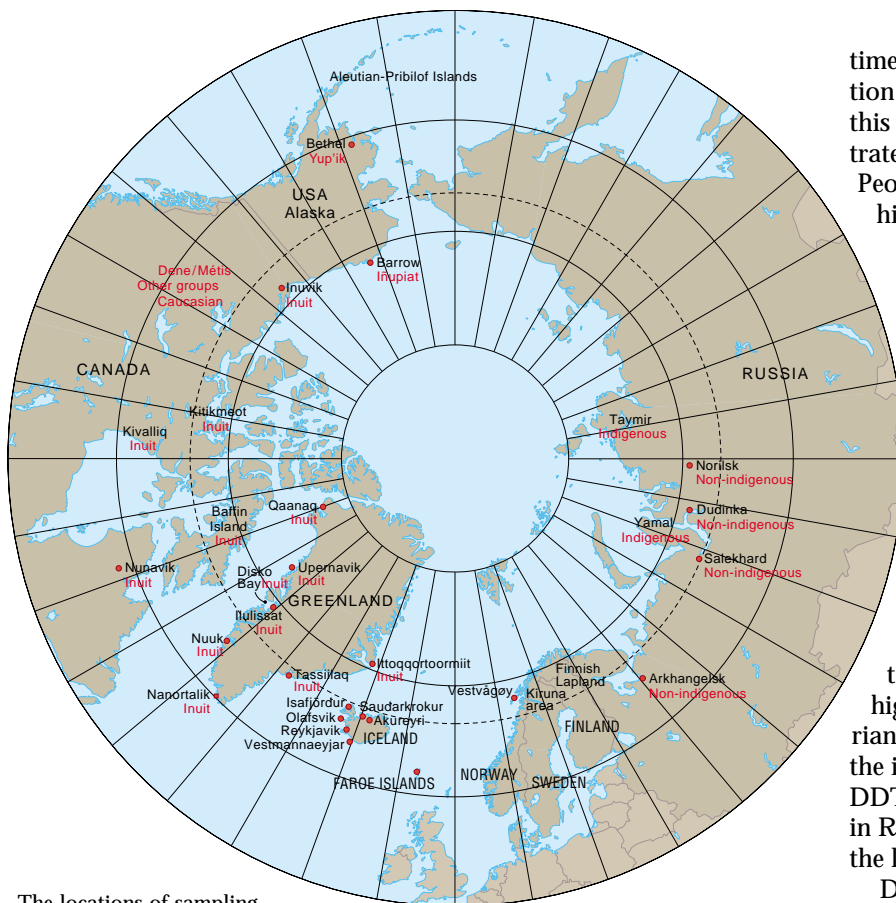


BRYAN & CHERRY ALEXANDER



BRYAN & CHERRY ALEXANDER

Health check at the Norilsk hospital.



The locations of sampling in AMAP's phase II circumpolar blood monitoring study.

Spatial trends in maternal blood

In 1994, AMAP initiated a circumpolar study of contaminant levels in maternal blood. A few early results were presented in the previous AMAP assessment. In this report these results are combined with new, much more complete data. As they relate to public health guidelines, the data are discussed in the previous section *Contaminants and Human Health*. This section presents geographical trends and their possible explanations.

A general picture that emerges is that levels of persistent organic pollutants and mercury are higher in people who rely heavily on food from marine mammals, such as the Inuit of Greenland and Arctic Canada. In Russia, levels of DDTs and HCHs (hexachlorocyclohexanes) are higher in non-indigenous people, which could indicate that these pesticides are still being used in Russia.

Some pesticide levels reflect current use

Several organochlorine pesticides or their breakdown products are included in the circumpolar survey.

Oxychlordanes are a component and breakdown product of technical chlordane. Its levels are higher among Inuit in Canada and Greenland and Aleuts in Alaska compared with the Nordic countries, and highest on the east coast of Greenland. In Canada, levels are 4 to 15

times higher among Inuit than in other population groups. The most likely explanation for this pattern is that oxychlordanes are concentrated in traditional marine mammal foods. People who rely heavily on these foods have higher levels.

Using other studies, it is possible to include Russia in the comparison. The results show that levels in the non-indigenous population of the Archangelsk region of Russia are higher than among non-indigenous people of Norway, Iceland, Finland, and Canada. This indicates that chlordanes are used either in the Archangelsk region or in Russian agriculture.

Similar patterns can be seen for DDE, which is a breakdown product of DDT, and for beta-HCH. Beta-HCH is a component of technical HCH. It is very persistent. Levels of DDE and beta-HCH are higher among non-indigenous people in Siberian Russia and in Archangelsk compared with the indigenous groups. It is thus likely that DDT and HCH-based pesticides are still used in Russian agriculture or to control insects in the local environment.

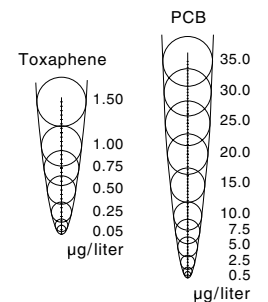
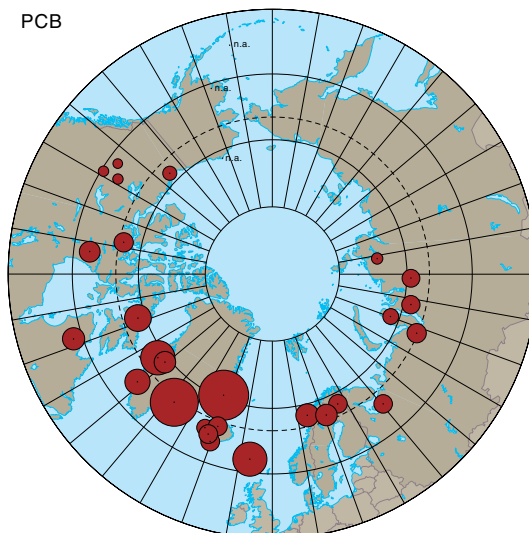
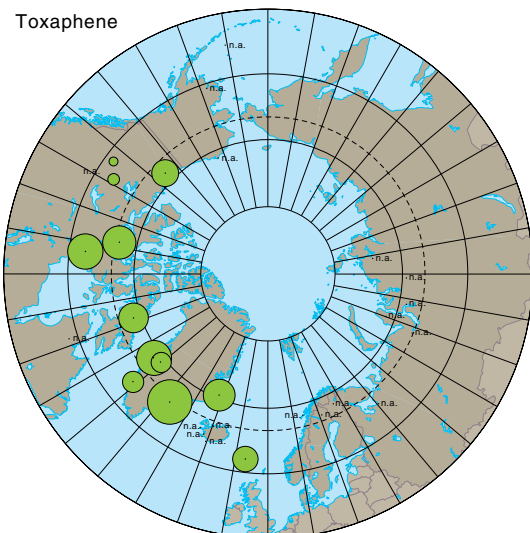
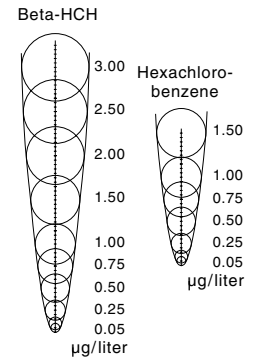
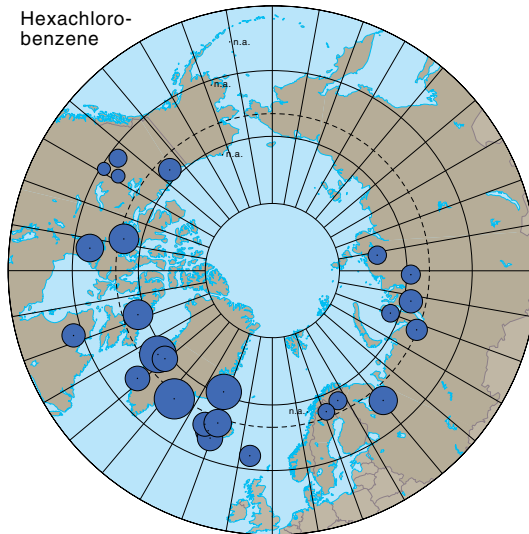
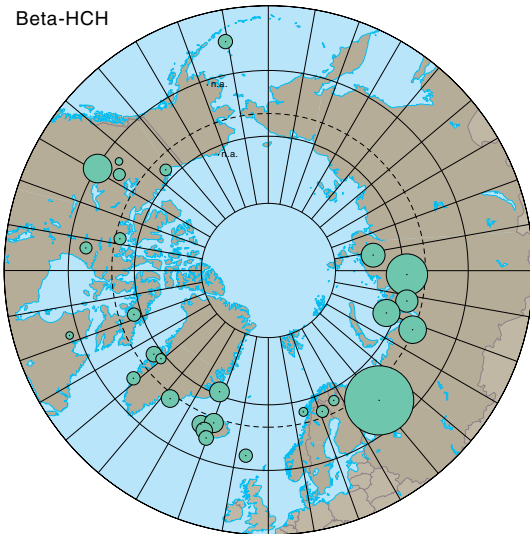
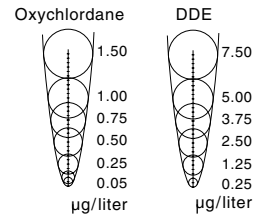
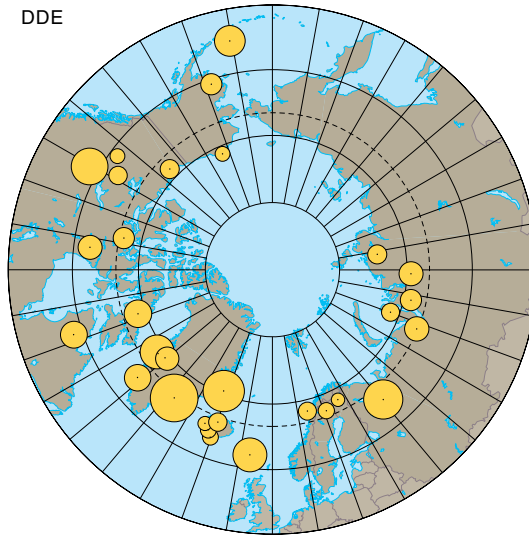
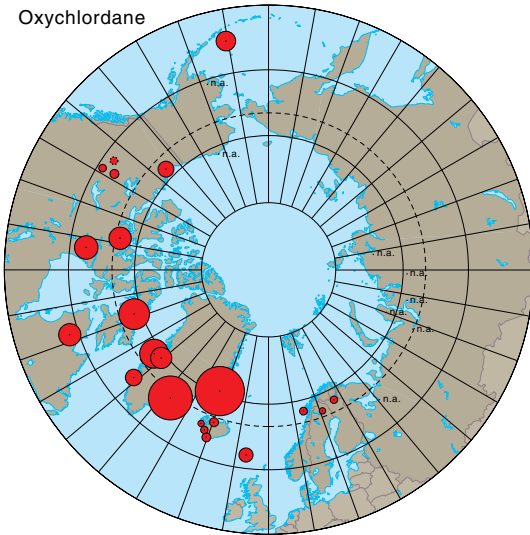
DDT and beta-HCH levels are also 5-12 times higher among people in the category 'other groups' in Canada than in specified groups. The 'other groups' category includes people from Africa and East Asia, regions where these pesticides are still in use. They may have been exposed while living in those areas, or perhaps via food imported directly from their home countries.

Among indigenous peoples, DDT and beta-HCH levels are higher among most Inuit groups in Canada and Greenland than among the Dene/Métis of Canada, who rely more on fish and terrestrial animals, or indigenous peoples of Russia, who rely heavily on reindeer.

A number of other pesticides are included in the AMAP Human Health program, such as toxaphene, mirex, and hexachlorobenzene. The general pattern is that levels are higher among people who rely heavily on marine mammals in their traditional diet.

PCB and mercury levels are connected to marine diet

PCB levels in human blood are best explained by people's food habits. Indigenous people who rely heavily on marine mammals have the highest levels. PCB levels are highest in Greenland, especially in communities on the east coast. Seal consumption is common throughout Greenland but in the northern and eastern regions of Greenland, polar bear is also part of the traditional diet, and the contaminant levels are higher in polar bear than in seals. In southern Greenland and in the bigger towns, people eat



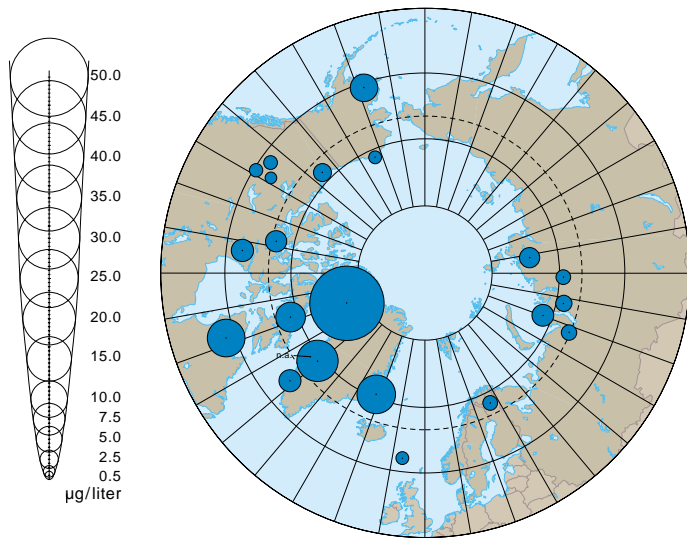
relatively more fish and imported foods. In Canada, levels are higher among Inuit living on Baffin Island than among other Inuit groups.

In the Faroe Islands, blubber from pilot whale is the main source of PCBs. Pilot whale consumption has decreased due to public health advice. So far there is very little change in PCB blood levels, however, and the levels

are still two to three times higher than in other Nordic countries.

Among non-indigenous populations, the highest levels are in mothers from Norway, Sweden, and Russia. The levels are in the same range as for Inuit from western and northern Canada. The most likely sources are a high intake of PCB-contaminated marine fish and the common commercial food supply.

POP concentrations in human blood. n.a. indicates not available.



Mercury concentrations in human blood.

The highest levels of mercury are found in Inuit of Canada and Greenland plus the Yup'ik in western Alaska. For Inuit, the mercury comes mainly from the muscle of marine mammals. In western Alaska, the levels can probably be explained by high intake of northern pike. In the Faroe Islands the major source of mercury is pilot whale.

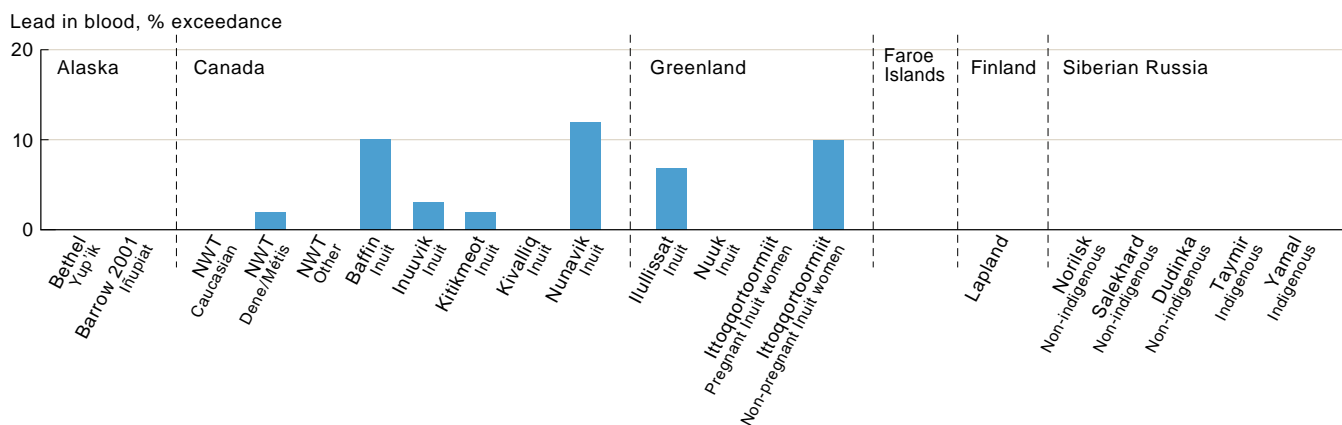
Other metals

Cadmium levels are higher among Inuit in Canada and Greenland than in other population groups in the Arctic. The most important source of cadmium for people is cigarette smoke, and the high levels can be explained by the high smoking rates along with high cadmium content in Canadian tobacco.

For lead, levels are moderately elevated among some of the Inuit groups and for Dene/Métis compared with other groups in Canada. The most likely source of the lead is lead shot used for hunting. Some Inuit and Dene/Métis in Canada, along with some women in Greenland, exceed the public health action guideline for lead.

In Russia and northern Finland, there has been concern that pollution from the metal smelters could lead to elevated metal levels in people working at these smelters or in their near vicinity. The data in the AMAP survey do not indicate that women living close to the smelters have higher metal levels.

Lead levels in women of reproductive age: percentage of samples exceeding blood guideline action level (100 µg/liter).



Do contaminants pose a risk to human health?

The previous AMAP assessment raised concern that contaminant levels in some groups of Arctic people were high enough to affect their health. Since then, more data has been gathered and epidemiological studies have provided more knowledge about the potential effects of low-level chronic exposure, as discussed in the previous sections. To summarize the data presented earlier in the chapter, these studies show subtle neurotoxic effects of methylmercury in some regions of the Arctic where meat from marine mammals is an important part of the diet. The severity of the effects is related to the dose the child receives in the womb, before it is born. Exposures to mercury in the Arctic vary widely. In communities where exposures are high enough to cause health concerns, AMAP considers the evidence strong enough to warrant public health strategies to reduce the mercury exposure of women of child-bearing age, especially pregnant women.

For persistent organic pollutants, emerging epidemiological evidence suggests a negative influence on human health in both Arctic and non-Arctic regions. Again, the main risk is for the child being exposed in its mother's womb.

So far, the major concerns have been for effects on the growing brain. However, it appears that the developing immune system is also sensitive to contaminants. Moreover, there are health effects that have not yet been well investigated but that will be important to look at in the future. They include the role of contaminants in fertility problems, cardiovascular diseases, and osteoporosis.

For contaminants, mercury and PCBs have been in focus. Based on high intake, AMAP concludes that there is also a need to look closely at potential effects of toxaphene, chlordanes, and all substances with dioxin-like effects.

Most health problems are caused by a combination of factors. Compared with the role of lifestyle and inheritance, contaminants alone may play a modest role but are likely to be important in combination with other factors. The only way to reduce exposure to environmental contaminants in the long-term is through national and international controls on emissions and use.

Dietary advice may be necessary

Several international conventions and protocols address emissions of POPs and heavy metals. When ratified and implemented, they should reduce new releases of some of the most dangerous POPs to which Arctic populations are exposed. However, these substances are persistent in the environment and it will take in the order of 20 years before there are significant reductions in levels in the fish and wildlife that Arctic people eat. In the meantime, there is a need to consider local risk reduction strategies in the regions of the Arctic where contaminant levels are high enough to cause health concern.

This is not an easy task. The main source of the contaminants is traditional foods, such as marine mammals. These foods provide beneficial nutrients as well as cultural and spiritual identity, and are known to promote health. A switch away from these foods can thus have negative effects on health. On the other hand, the evidence of subtle effects of contaminants in traditional foods is emerging. This underlines the necessity of dietary recommendations that carefully weigh risks against benefits.

In the previous assessment, AMAP concluded that it may be prudent to consider some dietary advice. In communities where exposures are high enough to cause health concerns, the updated scientific assessment confirms the need for balanced dietary advice for young women and pregnant women to help them reduce exposure levels prior to pregnancy. Dietary advice may also be needed for children to limit accumulation of POPs from an early age and for men of reproductive age because of possible effects on male fertility.

A need for local involvement

The specifics of weighing risks and benefits of traditional foods vary between different groups of people. Any dietary advice therefore has to take the local situation into account. In general, risk-benefit discussions have been most fruitful when local public health authorities have worked in concert with the community at risk and also with experts from a variety of disciplines. These local strategies are able to take account of the nature of the problem, the exposure route, the level of education and understanding, and the social and cultural needs of the community.

There are some examples of successful programs to reduce exposure to contaminants. In the Faroe Islands, new knowledge about the effects of mercury and possibly of PCBs on children's development led to new, stricter dietary recommendations in 1998. Previous diet advice, from 1977 and 1989, had some restrictions. Now, adults are recommended not to eat meat or blubber from pilot whales more than once or twice a month. Girls and women are recommended not to eat pilot whale blubber at

all until they have given birth to their children, to limit exposure to PCBs, which remain in the body for a long time. Biologically available mercury leaves the blood within a couple of months, and women who plan to become pregnant within three months as well as pregnant and nursing women are recommended to abstain from eating pilot whale meat. People seem to follow the recommendations and levels of mercury in Faroese women have declined approximately 80% in the past nine years. Similar declines have not been seen for PCBs.

Another example of dietary recommendations leading to reduced contaminant levels is from the lower north shore of the St. Lawrence River in Canada, where people traditionally consume seabird eggs. Advice about reducing consumption of seabirds eggs, along with declining contaminant levels in the eggs, have reduced the level of persistent organic pollutants in newborns between 25 and 69% over a seven-year period.

Other communities have chosen not to issue any dietary recommendations. In Canada, high POP levels in marine mammals raised concern and a committee comprised of representatives of northern indigenous groups, government health and research agencies, and national Inuit organizations met to evaluate the options and consider how to best communicate the issues. The result was that the Inuit Tapirisat of Canada coordinated the message to regional leaders with a basic statement that '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 acceptable risk for themselves and their families'.

Also in Canada, high mercury levels in waterfowl livers and an initial recommendation by Health Canada to limit consumption of liver of some waterfowl species started a discussion that involved a wide range of organizations. The discussions took into account not only contaminant levels but also information about how often people ate duck livers and the economic, spiritual, cultural, and social benefits of this food. The group made a risk management decision not to issue advice to limit consumption of waterfowl livers, but to update current communication materials and to provide fact sheets discussing the elevated levels of mercury.

Promoting healthy foods is an alternative to restrictive dietary recommendations. In Nunavik, Canada, this approach is currently being evaluated in three communities. The program promotes Arctic char as a fish of choice for pregnant women. Arctic char contains relatively few contaminants and is nutritious. The aim is to reduce intake of mercury.

The health consequences of using lead shot in hunting are an issue in many parts of the Arctic. Current actions to limit exposure range from banning lead shot to discussions with

hunter associations as a preparation for future bans. In some places, retailers are asked to provide only steel shot.

Breast feeding should continue

Breast milk can contain almost all of the persistent organic pollutants and there has been concern how this affects children who breast feed. However, breast feeding also has many benefits. They include enhanced bonding between mother and child, providing the baby with nutrients, and boosting the child's immune system. The previous AMAP assessment therefore concluded that breast feeding should continue since the benefits outweighed the currently known risks.

This recommendation to continue breast feeding is re-emphasized in the updated scientific assessment. The health benefits are substantial. Moreover, dietary advice may help women of child-bearing age bring down contaminant levels in the milk. In addition, the epidemiological studies of effects of contaminants suggest that the health risks for the child are mostly associated with exposure in the womb, rather than through breast milk. This exposure can only be prevented by bringing down the contaminant levels in the environment and by dietary advice to girls and women. Even if restrictions in breast feeding are not currently recommended, this may need to be reevaluated if contaminant levels increase or if other information indicates increased risk.

Summary

From a public health perspective, the environment is the sum of physical, chemical, biological, social and cultural factors that affect people's well being. In the Arctic, the rapid pace of cultural change is having a large impact on human health. On the positive side, infectious diseases and accidents have become less common. But there are less positive aspects, too. As lifestyles become more western, the rates of obesity, cardiovascular diseases, and diabetes have increased. Many people smoke, and high consumption of alcohol is common in many Arctic communities. Suicide is an important cause of death among young men.

Food habits in the Arctic are changing and store-bought food is becoming more important. However, local resources still play an important role, both in supporting cultural and social ties and in providing important nutrients, some of which protect against diseases.

Some traditional foods have high levels of contaminants. The fat of marine mammals and birds contains many persistent organic pollutants, while their meat and that of some predatory freshwater fish can contain high levels of mercury. The kidney and liver of caribou/reindeer and whale can have high levels of cadmium, although cigarette smoke is a more im-

portant source of cadmium exposure. Smoking also seems to be connected to levels of POPs in people. Lead is present in birds that are hunted in areas where lead shot has been used in the past or is still being used.

Since the previous AMAP assessment, knowledge about the effects of contaminants on human health has increased in terms of both individual and population-level effects. Moreover, the human health monitoring program has provided information about the levels of contaminants in people, in particular in women giving birth. The main conclusion of this report is that we are even more certain than before that the current exposure of some Arctic populations to the existing mixture of contaminants is inducing some subtle adverse effects.

One of the main concerns is the damage contaminants can do to the developing brain, while a child is still in the womb. Epidemiological studies show that mercury levels in parts of the Arctic are high enough to cause subtle neurobehavioral effects. The people at increased risk live in areas with high intake of marine mammals, such as Inuit in Greenland and Canada, or people with high intake of some fish species, such as Yup'ik in western Alaska. Moreover, PCB levels in blood exceed public health guidelines, indicating a risk for similar neurobehavioral effects in some groups of people in Greenland and Canada. Emerging evidence from Arctic epidemiological studies suggests that PCBs may also decrease resistance to infections in the first year of life.

In addition to the main focus on neurobehavioral and immune effects, contaminants are known to affect hormone systems in the body that are important for sexual development and the ability to have children. A new concern is on the role of mercury in cardiovascular diseases.

For other contaminants, there is a need to look more closely at the potential effects of toxaphene, chlordanes, and all dioxin-like substances, where intake via traditional food is high and in some cases exceeds public health guidelines.

In the long run, international conventions or protocols are the only ways to reduce the contaminant load in Arctic traditional foods and thus in people. However, it will take many years before levels decrease, and in the short-term dietary advice may also be prudent. Such advice has to recognize the importance of traditional foods for people's health and well-being, and to weigh risks against benefit. The advice has to be developed locally and must take into account the needs of the communities involved.

At the international level, the highest priority has to be ratifying and implementing the Stockholm Convention on Persistent Organic Pollutants and the protocols on POPs and heavy metals in the UN ECE Convention on Long-range Transboundary Air Pollution (LRTAP). In addition, the public health threat supports continued work toward a global agreement on mercury.

