HUMAN HEALTH IN THE ARCTIC 2021

SUMMARY FOR POLICY-MAKERS

ARCTIC MONITORING AND ASSESSMENT PROGRAMME

ARCTIC COUNCIL

AMAP

KEY FINDINGS

1

Traditional/country and local foods remain central to Arctic peoples' culture and nutrient intake, yet also continue to be the main source of their exposure to contaminants.

- Most local wild foods found in the Arctic are known to be highly nutritious and low in contaminants, but by consuming some types of these foods—particularly certain parts of certain species of marine mammals—Arctic peoples are also exposed to a variety of persistent organic pollutants (POPs) and harmful metals.

2

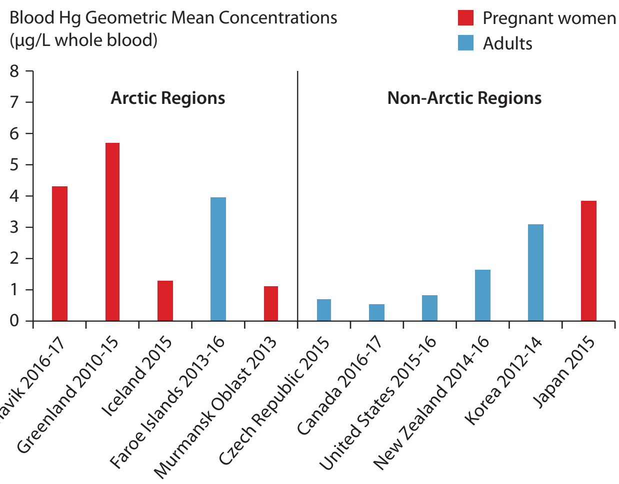
The diets of Arctic peoples are changing, with positive and negative consequences.

- Many Arctic populations have been transitioning toward more Westernized diets. Benefits include reductions in levels of contaminants in the blood of pregnant women; negative impacts include increasing obesity, metabolic disorders, and dental problems related to consuming high-sugar and processed foods. The transition has also resulted in lower intakes of nutrients, especially vitamin D and iodine, in many populations.
- Food security—a measure of physical, social, and economic access to safe, nutritious, and culturally appropriate food—is a concern in some Arctic populations.

3

Levels of many contaminants measured in Arctic populations are declining, but levels of POPs remain higher in some Arctic populations compared with people in regions outside of the Arctic. Methylmercury and per- and polyfluoroalkyl substances (PFASs) also remain a cause for concern.

- Despite being regulated widely across the globe, levels of POPs are still high in some Arctic populations—such as those in Greenland, the Faroe Islands, and Nunavik—compared with those in many other regions outside of the Arctic. For example, PCB-153 levels in Arctic populations are on the high end of the range reported worldwide.
- In a comparative study of mercury levels in pregnant women across seven Arctic countries, the highest mean levels were observed in Greenland and Nunavik. A global assessment reported higher levels of mercury in adults and children in Nunavik, Greenland, and the Faroe Islands compared with those in non-Arctic countries.



Mercury levels in pregnant women and adult men and women, Arctic vs. non-Arctic regions.

- PFASs have been detected in populations in most of the Arctic, with levels and proportions of the different PFASs varying by region. Increasing levels have been observed for some long-chain PFASs, such as PFNA and PFDA, in Greenland, Sweden, and Nunavik.

OBSERVED | PROJECTED | NEW FINDING | UPDATED FINDING | KNOWLEDGE GAP | REINFORCING MESSAGE

4

Contaminants in the Arctic are associated with negative impacts on health.

- Dietary exposure to some POPs, PFASs, and metals such as mercury can have negative impacts on the brain and immune system, increase the risk of childhood obesity, increase the risk of type 2 diabetes later in life, and negatively affect fetal growth and development.
- Foods with high levels of mercury can diminish the cardiovascular benefits of omega-3 fatty acids. Mercury toxicity also has been associated with adverse neurological outcomes, which may be underestimated in studies that fail to account for the beneficial effects of omega-3 fatty acids.
- Genetic makeup, lifestyle, nutrition status, and contaminants interact to influence the risk of adverse effects such as cancer, reproductive effects, impacts on fetal and child growth, metabolic disease, and nervous system disorders. Exposure to contaminants, including some POPs, PFASs, and phthalates, plays a role in the increased incidence of cancer in Arctic regions.

5

To better assess and compare contaminant-related health risks to Arctic populations, harmonized methods and new models for risk assessment need to be developed and used consistently across jurisdictions.

- Different jurisdictions set different guidance values for POPs and metals designed to protect health. These guidance values differ based on factors such as estimated dietary intakes, approaches to uncertainty, the population to be protected, the purpose of the guidance, and the mandate of the organization issuing the guidance.
- Over the past two decades, the number of individual exposures exceeding guidance values for mercury and lead has decreased. Exceedances are still observed in Greenland and Nunavik, particularly during summer and autumn when country foods with higher levels of mercury are in season.
- Risk assessment for Arctic populations is a complex process; there is a need to develop new risk assessment methods and models as well as for greater harmonization of study protocols for estimating the links between exposure and health effects. A number of circumpolar Arctic assessments clearly demonstrate the difficulty of combining results from multiple studies when different protocols have been used.

6

Risk communication can help to reduce health impacts among Arctic populations but reducing contaminants at their source is necessary in the long term.

- Risk communication on contaminants in Arctic countries has focused mainly on avoiding mercury exposure, due to the risks to fetal development and the health of young children, although guidance has also been provided on POPs and other contaminants.
- Effective risk communication requires trusted relationships, targeted and regular communication, and personalized and timely messaging. Sensationalized or alarmist messages can undermine risk communication objectives and can lead to long-lasting confusion and concern about the safety of consuming traditional/country and local foods, thereby reinforcing the transition toward store-bought Western foods.
- It is important to provide balanced information and clear messages that promote the many benefits of consuming traditional/country and local foods while also offering realistic options and strategies for avoiding foods high in contaminants. For example, mercury and POPs are found in high levels in some marine mammals and certain large predatory fish, but exposure can be minimized by eating traditional/country and local foods that are lower on the food chain.

OVERVIEW

Ocean currents, rivers, and the atmosphere carry industrial and agricultural pollutants from lower latitudes to the Arctic, where they accumulate in plants and animals. Through a process known as biomagnification, these contaminants become progressively more concentrated as they move up through food webs, reaching their highest levels in marine mammals and predatory fish that are important components of traditional/country and local diets in much of the Arctic. Many of these chemicals are associated with adverse health impacts on people. The effects of these contaminants may interact with each other and may be further modified by the presence or absence of key nutrients. Exposures, diets, lifestyles, and other circumstances vary widely across the Arctic, leading to differences in risks and health impacts from region to region.

Contaminants of concern in the Arctic fall into three main groups:

- **Persistent organic pollutants** (POPs): Chemicals that are listed under the Stockholm Convention based on evidence of their environmental persistence, bioaccumulation, long-range transport, and toxicity. Their presence in the Arctic mainly stems from long-range transport. Examples include pesticides (e.g., DDT) and industrial chemicals such as flame retardants (e.g., PBDEs) or surface protectants (PFOS, PFOA).
- **Metals:** Examples include lead, mercury, and cadmium.
- **Chemicals of emerging Arctic concern:** A large group of chemicals that are not currently (as of 2020) listed under the Stockholm Convention but have been recognized as a potential concern based on their documented occurrence in Arctic ecosystems. Most are current-use chemicals that are largely unregulated, and some are alternatives for banned chemicals. Some are found in consumer products and their presence in the Arctic is likely to originate from both long-range transport and local sources within the Arctic. Examples include PFASs not already listed under the Stockholm Convention, current-use pesticides (CUPs), and organophosphate esters (OPEs).

This Summary for Policy-makers provides an overview of the key findings of ***AMAP Assessment 2021: Human Health in the Arctic,*** the fifth health assessment published by AMAP since 1998. The full report summarizes the current state of the knowledge on the issue of contaminants and human health in the Arctic using science-based data from regions across the circumpolar Arctic and including some Indigenous perspectives. The report includes updates on information gaps identified in past reports, provides the most comprehensive picture to date of PFAS in the Arctic (both in terms of levels of PFAS in Arctic populations and the health impacts of exposure to PFAS), and for the first time provides a detailed discussion of dietary transitions in the Arctic and their implications for health. In addition, this report examines different approaches to estimating health risks associated with exposure to contaminants and presents new information on the effectiveness of risk communication.Information contained in this report is fully referenced and based first and foremost on peer-reviewed and published results. Furthermore, this AMAP assessment itself was subject to a rigorous peer-review process. Findings of health outcomes associated with exposure to contaminants do not necessarily indicate that contaminants are the sole causes of those outcomes.

WHY THIS IS IMPORTANT

This AMAP assessment's findings provide policy-relevant information on trends in contaminant exposure among Arctic populations, health outcomes related to exposure to contaminants, impacts of dietary transitions, risk assessment and communication, and research priorities. This information is important for informing and validating past and future actions under the Stockholm Convention on Persistent Organic Pollutants, the Minamata Convention on Mercury, and other regulatory efforts. It is also important for informing public health practitioners and will be of relevance and interest to all Arctic peoples.

COVID-19 AND ARCTIC INDIGENOUS COMMUNITIES

The COVID-19 pandemic emerged while this AMAP Human Health assessment was being prepared. The pandemic has highlighted many similarities among Arctic Indigenous regions and communities, including rapid responses by Indigenous institutions that demonstrated the importance of Indigenous Knowledge and self-determination. At the same time, the pandemic represented an additional health stressor on top of those already faced by these communities, and revealed regional inequities in health care, infrastructure, and other services.

Recovering from the pandemic and preparing for others in the future provides governments an opportunity to work with Indigenous Peoples to remedy the profound infrastructure deficits that contribute to vulnerability and underscore the health challenges experienced throughout the Arctic.

ROUTES OF EXPOSURE

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The food that people eat is often the main route of their exposure to contaminants. This is of particular relevance to Arctic peoples whose diets are rich in traditional/country and local foods. The blubber of marine mammals, particularly toothed whales that are higher on the food chain, often has elevated levels of POPs. The meat and organs of some marine mammals—as well as those of predatory fish—often contain high levels of mercury and PFASs. Based on data from Russia, wild plants, seafood, and seaweed can contain high concentrations of heavy metals such as arsenic, cadmium, and aluminum. For people in the Arctic, all of these sources represent significant pathways for exposure to contaminants. This creates a dilemma, because traditional/country and local foods are central to wellbeing and local culture, and are an important source of nutrients for many Arctic populations.

Exposure also occurs through other routes. For example, pregnant and nursing mothers may pass contaminants to their children via the placenta and/or breast milk (although this risk must be placed into perspective considering the many important benefits of breastfeeding). Some contaminants, such as PFASs, are also found in consumer products. The main source of human exposure to lead in some regions of the Arctic is believed to be from the use of lead shot for ammunition.

Still, for Arctic peoples, diet is an important source of exposure to contaminants. Traditional/country and local diets vary across the eight Arctic nations. Marine mammals are an important part of the diet of Inuit populations in Canada, Alaska, and the far east of Russia. They have also been traditionally important in Greenland, although there has been a recent shift toward more intake of terrestrial animals. Terrestrial mammals are a staple food for Indigenous Peoples in Finland, Sweden, Norway, parts of Canada, and western central Arctic Russia. Fish consumption is especially high in Iceland, but is also high among both Indigenous and non-Indigenous populations in other Arctic countries.

THE IMPACT OF CHANGING DIETS ON IODINE AND VITAMIN D IN ARCTIC PEOPLES

Fish and dairy have been major sources of iodine in Arctic diets, especially in Nordic countries. Iodized salt is not widely available in Iceland or Norway, and iodine intake—particularly among young women—has declined in both countries due to dietary shifts away from fish and dairy. A study in Norway found associations between low iodine intake in pregnant women and poorer performance of their children at school, language delays, impacts on behavior skills, and increased attention-deficit symptom scores.

Studies in Alaska have documented significant declines in vitamin D levels among women, infants, and children since the 1960s, in parallel with decreasing fish consumption. Among other concerns such as bone deformities and dental diseases, vitamin D deficiency has been proposed as a possible risk factor for developing autism spectrum disorder.

Finland succeeded in reversing declines in vitamin D consumption through a food fortification program and the issuance of new dietary supplement guidelines, doubling the intake of vitamin D between 2007 and 2017.

A lack of sun in the Arctic, especially in wintertime, has been linked to vitamin D deficiency. Recent evidence indicates that environmental toxins may further trigger vitamin D deficiency.

THE DIETS OF ARCTIC PEOPLES ARE CHANGING

Harvesting and consuming traditional/country and local foods contributes fundamentally to spiritual, cultural, physical, and mental health and wellbeing for northern Indigenous populations, as it fosters a connection to the land and promotes the cultural benefits of sharing the harvest.

> "Our traditional foods are much more than calories or nutrients; they are a lifeline throughout our culture and reflect the health of an entire ecosystem."
>
> *Inuit Circumpolar Council - Alaska (2015). Alaskan Inuit Food Security Conceptual Framework: How to Assess the Arctic from an Inuit Perspective.*

However, Arctic populations have been moving toward store-bought Western foods in recent decades due to greater accessibility (e.g., through development of transportation infrastructure) and to concerns about health impacts from contaminants in traditional/country and local foods, among other reasons.

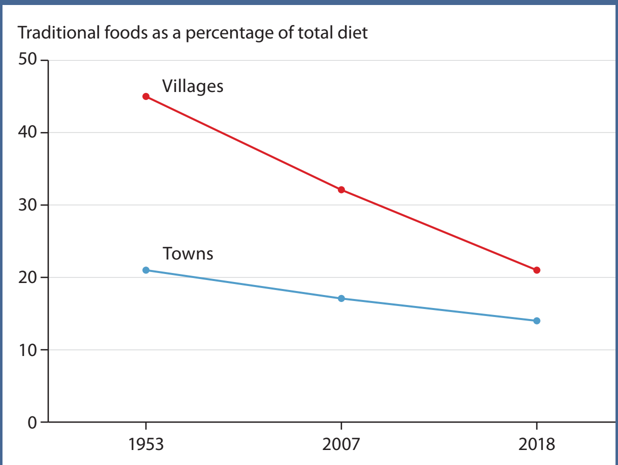

Figure 1. Consumption of traditional foods in Greenland towns and villages, 1953–2018.

Whether a dietary transition is negative or positive for health depends on the specific Westernized foods that are adopted, the specific elements of the traditional diet, and the extent to which the traditional diet is maintained. Communication about dietary risks and benefits is essential.

The details and pace of these transitions vary across and even within Arctic countries, but in general the shifts have been greatest in urban areas and towns, with traditional/country and local foods remaining a larger part of the diet in villages and remote communities (see Figure 1).

The health impacts of dietary transitions in the Arctic are mixed. The benefits of reduced consumption of traditional/country and local foods include significant reductions of contaminants measured in the blood of pregnant women and increases in the consumption of vegetables and fruit in some cases. At the same time, studies have noted troubling trends such as increases in obesity, diabetes, and other metabolic diseases related at least in part to higher consumption of processed foods; declines in dental health related to higher consumption of sugary drinks; and reductions in omega-3 fatty acids, vitamin D, and iodine intake related to reduced consumption of fish and other traditional foods. The greater reliance on store-bought foods has also raised concerns about food insecurity.

FOOD INSECURITY IS A CONCERN IN SOME AREAS

Food insecurity occurs when people lack physical and/or economic access to enough food to meet their dietary needs and satisfy their food preferences. A study of households in Nunavut (Canada) found that those reporting food insecurity increased between 2010 and 2014, rising from a third to nearly half of all households. Store-bought food can be expensive, and does not contribute to community goals of self-sufficiency, sustainable livelihoods, or food sovereignty. In Russia, families are frequently unable to afford store-bought food for periods of time. Climate change also contributes to food insecurity in some regions as increasingly unreliable sea ice conditions make it more difficult to hunt for traditional/country and local foods. National, regional, and local initiatives are under way in some Arctic countries to improve food security and food sovereignty (described in case studies in the full ***AMAP Assessment 2021: Human Health in the Arctic***), including some innovative approaches that could serve as models for other jurisdictions to follow. In Canada, for example, a training facility for processing country foods has been established in the Inuvialuit Settlement Region (northern Northwest Territories), along with a 10-day course in processing techniques that gives community members knowledge and skills to create nutritious and affordable products with extended storage lives that can be eaten year-round.

LEVELS OF CONTAMINANTS IN ARCTIC RESIDENTS

Levels of many POPs measured in the blood of Arctic residents have declined since the 1990s (see Figure 2), although the changes vary by region. However, levels of POPs remain several times higher in some areas of the Arctic compared with non-Arctic nations or non-Arctic regions of Arctic countries. The highest concentrations of most POPs in Arctic residents have been measured in Greenland and the Faroe Islands, Nunavik (northern Quebec, Canada), and the coastal Chukotka district (northeastern Russia).

Despite being regulated widely across the globe, levels of POPs are still elevated in some Arctic populations—such as those in Greenland, the Faroe Islands, and Nunavik—compared with many other regions outside of the Arctic.

Blood mercury levels measured in pregnant women in the Arctic have also declined steeply since the 1990s, but levels in Nunavik and Greenland remain 4 to 5 times higher than those in other Arctic regions. Blood lead levels have also generally declined, although levels appear to be highest in some regions of the Canadian Arctic and Russian Arctic. In specific cases, exposure to metals can be higher near point sources of pollution; for example, residents living near mines and other point sources in the Pechenga district of Murmansk Oblast in Russia have elevated levels of manganese, cobalt, nickel, copper, zinc, arsenic, and lead.

Available measurements of PBDEs show generally low levels across much of the Arctic, with concentrations of many PBDE congeners falling below the limit of detection in several regions; the only exception to this is Alaska.

Todd Mintz/Alamy Stock Photo

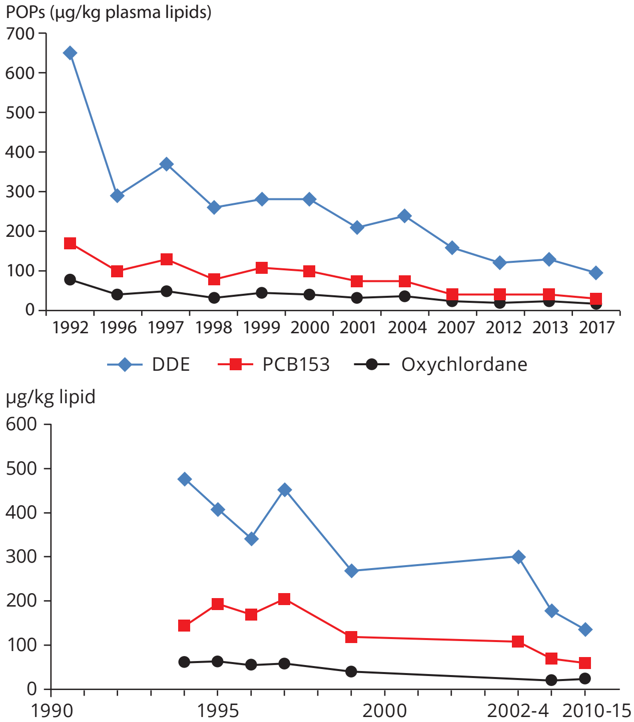

Figure 2. Geometric mean concentrations of POPs in Inuit pregnant women from Nunavik, Canada (above) and Disko Bay, Greenland (below).

Data on PFASs, such as perfluorooctane sulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), and perfluorodecanoic acid (PFDA) show mixed trends: levels of the two regulated POPS, PFOS and PFOA, are declining in regions where data are available, but the long-chain PFASs (PFNA, PFDA, and PFUnDA) appear to have increased in Greenland, Nunavik, and Sweden (see Figure 3). Available data indicate that the highest levels of PFNA are in Nunavik and Greenland. Moreover, despite its decline in most of the Arctic, PFOS remains the most predominant PFAS measured in populations (see Figure 4). Traditional/country and local foods (especially marine mammals) are known to be key sources of exposure to POPs and heavy metals; however, more information is needed on multiple sources of exposure (including consumer products) for PBDEs and PFASs.

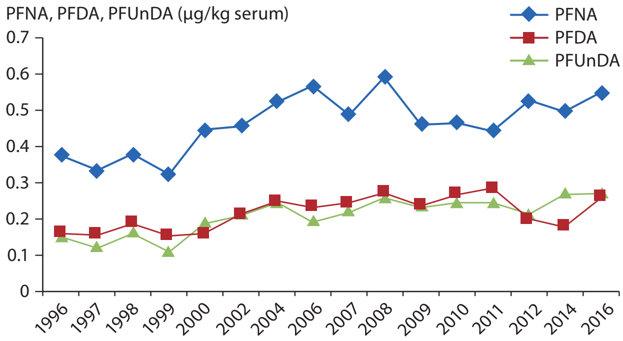

Figure 3. Geometric mean concentrations of PFASs in Swedish first-time mothers from Uppsala; samples collected three weeks after delivery.

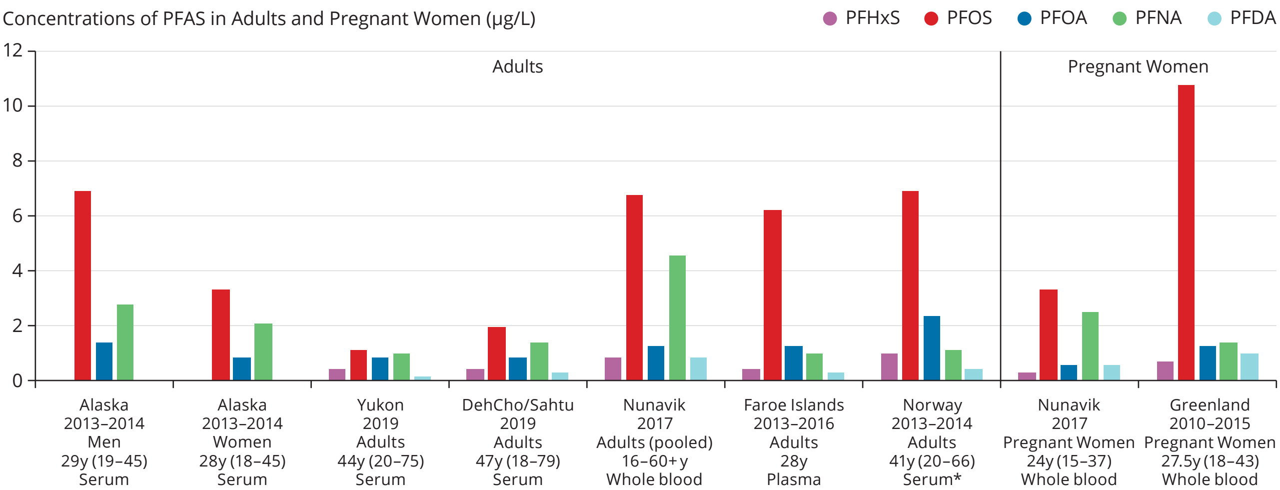

Figure 4. Blood concentrations of PFASs across Arctic countries. Data presented as geometric and arithmetic means in adults and pregnant women. Data presented as arithmetic means are flagged with an asterisk (*).

HUMAN HEALTH IMPACTS FROM CONTAMINANTS

Contaminants found in the Arctic, such as mercury, lead, PCBs, and PFASs, have known or suspected adverse health impacts on humans—especially on developing fetuses and children. Lifestyle, diet and nutrition, and genetics can influence the risk of these impacts.

NEUROBEHAVIORAL EFFECTS

Elevated exposure to mercury during pregnancy has been associated with several neurological outcomes later in childhood, including decreased motor function, attention span, verbal abilities, and memory; lower IQ; and increased risk of attention problems and attention-deficit hyperactivity disorder (ADHD). Follow-up studies suggest that these effects may be permanent. There is inconclusive evidence that exposure to methylmercury after birth may also be associated with adverse neurological outcomes.

The neurobehavioral effects of mercury toxicity may be underestimated in studies that fail to account for the beneficial effects of omega-3 fatty acids.

Exposure to POPs in the Arctic may affect behavior and neurodevelopment, but the evidence is not as strong. Contaminants, along with the dietary transition under way in much of the Arctic, can also contribute to deficiencies in vitamin D and iodine, which have been associated with neurobehavioral disorders.

IMMUNOLOGICAL EFFECTS

Exposure to POPs appears to be linked to negative impacts on the immune system, including increased risk of asthma, allergies, and chronic illnesses related to inflammation such as inflammatory bowel disease. Exposure to some of these chemicals is also associated with reduced white cell counts in the blood of children, while exposure to PFASs can reduce the effectiveness of tetanus and diphtheria vaccines, indicating a general weakening of the immune system.

Vaccinating children against measles, mumps, and rubella seems to reduce the risk of asthma and allergies from exposure to contaminants.

REPRODUCTIVE EFFECTS

Studies in the Arctic suggest that contaminants have negative impacts on reproductive health, including infertility or reduced fertility in both sexes. Exposure to POPs and metals before and during pregnancy can affect fetal development and growth (e.g., PFOA, see Figure 5), posing health risks to children over the course of their lives. Exposure to POPs and mercury can also increase the ratio of male to female live births. Smoking during pregnancy is still relatively high in the Arctic and can affect fetal growth and increase exposure of the fetus to metals such as cadmium. In addition, exposure to POPs via breastfeeding may affect neonatal growth.

CARDIOVASCULAR EFFECTS

Exposure to mercury appears to be related to cardiovascular diseases, including high blood pressure and a greater risk of heart attacks. Fish are a major source of exposure to mercury, but they are also a source of beneficial omega-3 fatty acids that promote cardiovascular health. Promoting higher consumption of fish species with high levels

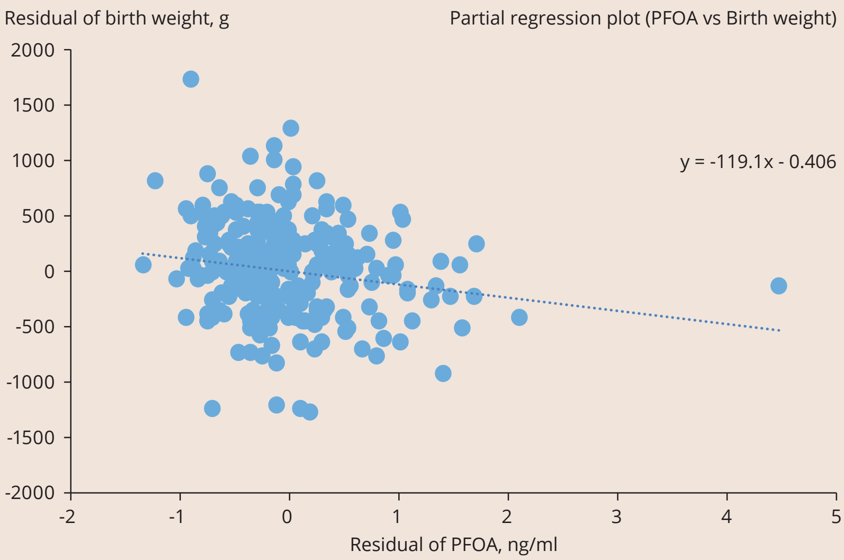

Figure 5. Mothers' exposure to PFOA during pregnancy (in nanograms per milliliter) and birth weight (in grams) in Greenland from 2010–2015. The 0 coordinate represents the adjusted mean residual (the distance between the observed value and the predicted regression line) for birth weight (y axis) and PFOA (x axis).

One day old baby in Puvirnituq hospital, Hudson Bay, Northern Quebec, Canada

One day old baby's footprints are taken by a trainee midwife in Puvirnituq hospital, Hudson Bay, Northern Quebec, Canada

of omega-3 fatty acids but low levels of mercury may help prevent cardiovascular diseases in Arctic populations.

ENDOCRINE EFFECTS

Several types of POPs, including PCBs, organochlorine pesticides, and PFASs, are potential endocrine disruptors; exposure to these chemicals can lead to adverse developmental, reproductive, neurological, cardiovascular, and immune effects in humans. Studies have shown that POPs, PFASs and PBDEs can affect thyroid hormone concentrations in Arctic populations, as can iodine deficiency. Some studies suggest a relationship between exposure to POPs and obesity, and prenatal exposure to POPs may play a role in metabolic diseases such as type 2 diabetes by affecting insulin levels. The risk of developing diabetes also appears to be increased by exposure to zinc as well as harmful metals such as mercury and cadmium, and decreased by consumption of omega-3 fatty acids.

A significant increase in Western lifestyle-related cancers, such as breast cancer, is being observed. POPs and heavy metals are potential carcinogens and can play a role in the increased incidence of cancer in the Arctic.

CARCINOGENIC EFFECTS

Cancer among certain Indigenous Peoples in the Arctic is an increasing public health concern. Studies show that exposure to POPs, heavy metals, PFASs, and phthalates increases the risk of breast and other cancers in the Arctic. The interaction between POPs such as dioxins and Hepatitis B virus may play a role in the high incidence of liver cancer in Arctic populations.

FACTORS THAT MODIFY HEALTH RISKS

Genetic variations can influence health risks caused by exposure to contaminants, as well as health risks related to the dietary and lifestyle transitions under way in the Arctic. Some individuals may face greater risks from chemical exposures than others due to their genetic makeup (and in some cases their sex), including risks of cancer, Parkinson's disease, metabolic disorders, reduced fertility, and other illnesses and disorders.

Some studies suggest that Indigenous populations in the Arctic have evolved over time for genetic adaption to cold climates and traditional/country and local diets, and their resulting genetic makeup may increase their susceptibility to diabetes and cancers later in life.

In addition to genetics, infections as well as lifestyle and dietary factors such as smoking habits and nutrition can affect health risks. Furthermore, the mixtures of chemicals to which people are exposed can affect health risks.

HEALTH RISK ASSESSMENT

People are exposed to mixtures of contaminants whose effects on the body may interact with each other. Other factors—such as nutrition, lifestyle, underlying health conditions, and genetics—also influence the effects of contaminants on health. These realities make it challenging to assess the health risks of exposure to contaminants, especially in the Arctic where consumption patterns may be very different from those in other parts of the world. Arctic cohort studies can play an important role in documenting relationships between exposures and health outcomes in these populations.

National and international authorities have established maximum allowable limits for some heavy metals and POPs in food items; Russia is the only country to have set limits for contaminants in marine mammal tissues. Values for maximum allowable limits and related guidance levels range widely across jurisdictions in the Arctic due to differences in the dates of assessment, estimated exposures, analytical measurements, sampling and other methods, and approaches to uncertainty. They also vary in their fundamental nature: some jurisdictions establish maximum levels of contaminants in food items, others set recommended maximum dietary intakes, and others set reference levels in blood.

Hunter from the Yupik village of New Chaplino, cutting a section of whale blubber and muktuk (skin) into manageable size pieces, while butchering a grey whale that will provide food for the whole community. Checheykiyum Strait. Beringia National Park, Providensky Region, Chukotka, Russian Far East

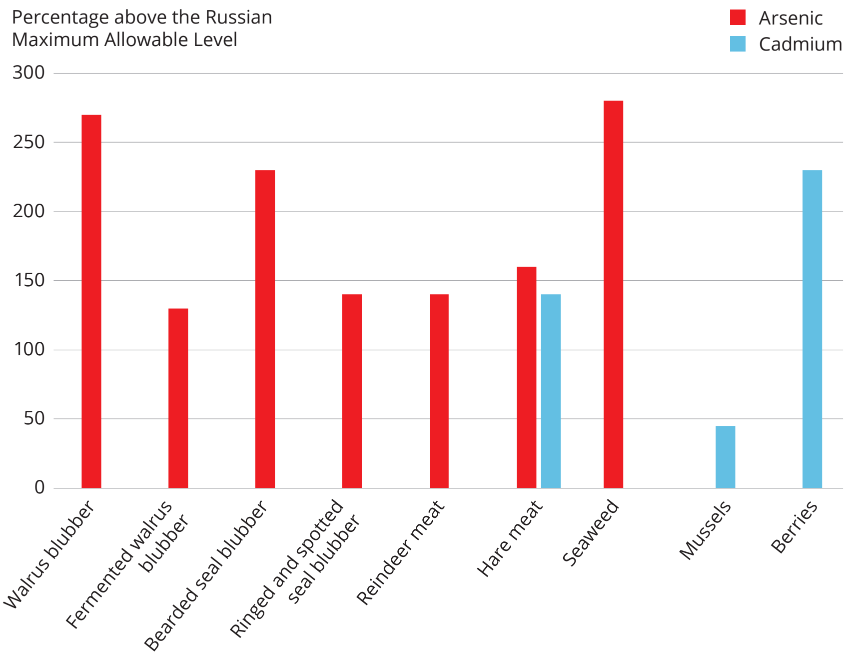

Figure 6. Exceedances above Russian Maximum Allowable Levels (MAL) for highest concentrations of arsenic and cadmium measured in food samples from coastal Chukotka, Russia. The 0% line represents the MAL.

ACTIONS UNDER WAY TO REDUCE HEALTH RISKS

Governments in Arctic nations use public health advisories and other forms of communication to inform Arctic peoples about contaminant risks as well as the benefits of traditional/country and local diets—especially the benefits of eating foods low on the marine food chain and consuming land-based foods. Most of the risk communication in Arctic countries focuses on mercury levels in fish and other marine foods due to the risks posed by mercury exposure to fetal development and the health of young children. Some countries, such as Finland, Iceland, and Sweden, distribute consumption guidelines based on other contaminants.

Successful risk communication requires partnerships to build trusted relationships between communicators and their intended audiences. To be effective in raising and maintaining awareness, messaging should be clear, timely, consistent, repeated, regionally and culturally appropriate, balanced, and customized to target populations. Risk messaging should be developed and tested with members of the intended audiences, and should be provided in an open, transparent, and non-technical manner. Messages and communications channels should be objectively evaluated through surveys or other means to gauge their effectiveness and fine-tune as necessary.

Risk communication initiatives on controversial topics such as health risks from traditional/country and local foods should build strong, evidence-based justifications. If not, target audiences may increase their skepticism and resistance to change.

Social media may be a useful tool in risk communication, enabling informal two-way communication and helping to build relationships with target audiences. Although risk communication can be undermined by misleading, sensationalized, and alarmist messages on social media and other channels, social media—if monitored properly—could be an effective tool for quickly clarifying rumors and quelling false medical advice.

Few studies have evaluated the effectiveness of health risk communication efforts in Arctic countries. Studies in Denmark and the United States found that targeted and personalized messaging was effective in reducing mercury exposure among pregnant women. Experience in Canada suggests that public health messaging that is developed in partnership with Indigenous Peoples and strikes a balance between the risks and benefits of consuming traditional/country and local foods is most effective.

Communication alone cannot ensure reductions in the levels of contaminants in Arctic populations. International agreements and national regulations to reduce releases of contaminants to the environment are more effective and sustainable over the long term.

ONE ARCTIC, ONE HEALTH

The One Health concept, which recognizes that human health, animal health, and environmental health are interrelated and interdependent, has become a useful holistic approach to addressing multiple challenges related to environmental change in the Arctic.

The Arctic Council's One Arctic, One Health project, launched in 2015, is designed to strengthen regional knowledge-sharing and coordination across a variety of Arctic One Health concerns with a goal of advancing Arctic regional resilience and reducing health risks. To date, the project has developed a research network, joint scientific projects, and a series of workshops, tabletop exercises, and conferences. Traditional ecological knowledge and local observations are essential components of the One Health approach, and the One Arctic, One Health project includes a focus on participatory community-based approaches.

Figure 7. The One Health paradigm.
Source: University of Alaska, Fairbanks

KNOWLEDGE GAPS AND RESEARCH PRIORITIES

The *AMAP Assessment 2021: Human Health in the Arctic* identified a number of key gaps in knowledge and areas that should be priorities for further research.

ROUTES OF EXPOSURE

- Conduct risk-benefit analyses to compare traditional foods with store-bought Western foods while considering health, economics, local contexts, cultural resilience, and sustainability.
- Conduct more studies on the impacts of dietary transitions among specific demographic, geographic, and social subgroups. The need to expand monitoring and research is especially evident in Russia, where only a few dietary studies have evaluated Arctic Indigenous populations.
- Develop priorities for dietary research in partnership among academics and Arctic Indigenous communities and organizations, and an approach based on co-production of knowledge should be used in this research. There is also a need to examine the overall food system, including both traditional and market-food components.
- Harmonize methods for assessing dietary intake, food security, health outcomes, and northern food environments to enable comparisons that are more accurate across populations and over time; they also need to consider gender- and age-based differences in consumption.
- Monitor vitamin D and iodine levels in Arctic populations and evaluate the need for supplements and fortification.
- Improve understanding on sources of exposure (including consumer products) for PBDEs and PFASs.

BIOMONITORING

- Continue and expand biomonitoring efforts, including in pregnant women, to establish time trends for POPs, metals, and chemicals of emerging Arctic concern.
- Take seasonality into account when determining the timing of sampling in biomonitoring efforts, as traditional foods with elevated levels of contaminants are often consumed in greater quantities during certain seasons.
- Expand biomonitoring studies to include new chemicals of Arctic concern.

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HEALTH IMPACTS

- Support and expand the use of cohort studies, which are important for making links between exposures and health outcomes in Arctic populations.
- Conduct more studies to identify the mechanisms through which exposure can lead to health impacts. Many studies show associations between exposure to contaminants and adverse health outcomes, but associations do not necessarily indicate sole causation.
- Identify prenatal and postnatal windows of vulnerability—the periods in which the fetus and infant are most vulnerable to impacts from exposure. Research should continue to focus on the effects of contaminants on pregnant women and women of childbearing age whose diets involve significant consumption of marine mammals.
- Increase the focus of research on mixtures of POPs and their effects on reproductive health and the immune system.

RISK ASSESSMENT

- Conduct more studies to reduce uncertainties in the estimates of health risks from exposure to contaminants, including studies to better identify the sources of contamination and improve the overall process of risk assessment.
- Develop new risk assessment methods and models, and improve the harmonization of study protocols for estimating the links between health effects and exposure.

INTERDISCIPLINARY RESEARCH

- The One Health concept has emerged as a useful approach to addressing multiple challenges related to environmental change in the Arctic. Human, animal, and environmental health are interrelated and interdependent, and the One Health concept brings together knowledge on these interrelated health issues and how they are affected by stressors such as climate change.
- Conduct new, collaborative studies to investigate levels of chemicals of emerging Arctic concern, routes of exposure, health effects, lifestyle implications, and interactions with other stressors outside the field of contaminants (such as climate change).
- Improve understanding of the health impacts of contaminants on wildlife, including possible immunosuppressive effects that could lead to increase of active zoonotic infections in exposed wildlife and increased risk to human consumers. The warming Arctic climate and permafrost thaw may influence contaminant exposure as well as an increase in spread of zoonotic infectious diseases in the Arctic.
- Conduct multidisciplinary research on critical questions related to lifetime contaminant accumulation, lifetime exposure to zoonotic pathogens, and the health consequences to wildlife and human consumers.

ACTIONS TO REDUCE HEALTH RISKS

- Evaluate the impact of combinations of medium and messenger for a variety of health messages to improve understanding of optimal communication strategies for different types of communities. Studies on the effectiveness of social media in risk communication would be useful.
- Gather more data on health communication and risk perception to compare results with those from other regions and across Arctic countries. Data from multiple regions would help identify best practices, including cultural appropriateness, that could be used and adapted to specific regional and community needs.

Calf marking in a mountain herding district on the Swedish side of Sápmi. This is the highlight of the annual reindeer herding cycle and is done during cold summer nights.

Jannie Staffansson

RECOMMENDATIONS

Based on the findings of the *AMAP Assessment 2021: Human Health in the Arctic*, and building on earlier AMAP assessments of human health impacts in the Arctic, AMAP recommends the following:

1 REDUCE OR ELIMINATE CONTAMINANTS AT THE SOURCE

- Arctic States and all parties to the Stockholm and Minamata Conventions should strengthen and accelerate measures to eliminate POPs and human-made mercury emissions globally.
- Arctic States should take steps to reduce or eliminate chemicals of emerging Arctic concern such as PFASs through national policies and international agreements.

2 PROMOTE HEALTHY FOOD CHOICES

- To get the best out of traditional/country and local and store-bought Western diets, governments can, for example, promote consumption of foods low in contaminants. Effective communication can increase the use of healthy traditional/country and local foods (e.g., fish and terrestrial animals such as reindeer/caribou, musk ox, and sheep) and reduce intake of foods that are likely to have high levels of contaminants or that are otherwise unhealthy.
- Vitamin D and iodine levels should be monitored in Arctic populations and the need for supplements and fortification should be evaluated.

3 MONITOR AND ADDRESS FOOD INSECURITY IN ARCTIC COMMUNITIES

- Food insecurity is a growing problem in some Arctic Indigenous populations as diets transition toward expensive store-bought food and environmental factors such as climate change affect the availability of traditional/country and local foods. Governments and non-governmental organizations should take an active role in monitoring food insecurity in Arctic communities and collaboratively develop proactive approaches to address it, building on and learning from existing best practices and models.

4 EXPAND EFFORTS TO COLLECT DATA ON EXPOSURE, DIETARY TRANSITIONS, AND HEALTH IMPACTS

- Arctic States and research funding bodies should work to fill information gaps, such as the need for more data on lifelong human health impacts in the Arctic related to exposure to contaminants, dietary transitions, and nutrition. There are also geographical gaps in Arctic data on contaminant levels and trends in humans: the need to expand monitoring and research is especially evident in Russia, where only a few dietary studies have evaluated Arctic Indigenous populations.
- Research should continue to focus on the effects of contaminants on pregnant women and women of childbearing age whose diets involve significant consumption of marine mammals. New, collaborative studies are required to study levels of chemicals of emerging Arctic concern, routes of exposure, health effects, lifestyle implications, and interactions with influences outside the field of contaminants for these specific groups. There should be more focus on mixtures of POPs to which people are exposed and their effects on reproductive health and the immune system.

ADDRESSING NEW FINDING

REINFORCING MESSAGE

ADDRESSING KNOWLEDGE GAPS

AMAP, established in 1991 under the eight-country Arctic Environmental Protection Strategy, monitors and assesses the status of the Arctic region with respect to pollution and climate change. AMAP produces science-based policy-relevant assessments and public outreach products to inform policy and decision-making processes. Since 1996, AMAP has served as one of the Arctic Council's six working groups.

The basis for this summary, the **AMAP Assessment 2021: Human Health in the Arctic** report, is one of several reports and assessments published by AMAP in 2021. Readers are encouraged to review this, and the reports below, for more in-depth information on climate and pollution issues:

- *AMAP Assessment 2020: POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change*
- *AMAP Assessment 2021: Mercury in the Arctic*
- *AMAP Assessment 2021: Impacts of Short-lived Climate Forcers on Arctic Climate, Air Quality, and Human Health*
- *AMAP Arctic Climate Change Update 2021: Key Trends and Impacts*

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Cover image: Bryan & Cherry Alexander Photography *A bowl of wild mushrooms collected near a Selkup camp in the forest. They will be dried & stored for the winter. Krasnoselkup, Yamal, Western Siberia, Russia*