Persistent Organic Pollutants (POPs) and Heavy Metals:
Health Effects in Circumpolar Populations

The Alaska Community Action on Toxics

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Contaminants and Health Effects

The new 2015 AMAP Arctic Human Health Assessment will soon be published online, and has the very latest information on this topic.

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Exposure Characteristics in Arctic Populations

- Most exposure is to contaminants in subsistence foods.
- Highest contaminant burdens, in general, are in marine species that are at the top of the food web.
- Terrestrial species, especially herbivores, generally have very low levels of POPs.
- Large, long-lived carnivorous fresh water fish may acquire significant amounts of methyl mercury.

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Exposure Characteristic in Arctic Population

- Variations in ocean and atmospheric transport create large differences in seawater levels of contaminants and metals throughout the Arctic.
- Changing socioeconomic conditions, and media messaging change the subsistence patterns of Arctic residents.

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Challenges in Arctic Human POPs and Metal Effect Studies

- Very small populations
- Exposure is chronic, starts with conception, is low-level and is always a mixture of many compounds, along with dietary micronutrients.
- Most laboratory toxicology studies are single-agent studies. Much of the published human toxicology data is from accidental exposure to very high levels, or they are from industrial exposure to much higher levels than the low-level food exposure in Arctic residents.

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Challenges in Arctic human POPs and Metals Effects Studies

- Causal relationships have been established for single agent exposures in some circumstances, such as asbestos and mesothelioma, PCB and chloracne, lead neurotoxicity, Hg and Minimata disease. Mixture exposure has occasionally been successfully associated with disease outcomes, like tobacco smoke and certain types of lung cancer, but that has required huge populations, and many years of longitudinal follow-up.

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Challenges in Arctic POPs and Metals Effects Studies

- Mixture of toxicants that act on the same organs or tissues, even if individual levels are lower than the lowest level of observed effect could possibly act in an additive toxicity, or even synergistically.
- Toxicants with different mechanisms could possibly have additive effects when combined, if they affect the same tissue.

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Challenges in Arctic POPs and Metals Effects Studies

- An example may be the differing findings in the Faroe Island Hg and Seychelles Islands Hg studies of neurodevelopmental outcomes of prenatal Hg exposure. The Faroe Islands cohort showed subtle but significant neurodevelopmental effects, which were not present in the Seychelle Islands cohort. Explanations include the fact that the marine source of Hg in the Faroe Islands cohort also contained significant amounts of POPs and PCBs, characteristic of Arctic marine predators, while the Seychelle Islands marine species were much lower in the food web, and there was no significant POPs or PCB exposure.

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Challenges in Arctic POPs and Metals Effects Studies

- These two cohorts also point out the difficulty of comparing outcomes in populations that may be genetically very different.
- Arctic populations differ in lifestyle, culture and socioeconomic status, and these are often accompanied by prenatal exposure to toxicants with known prenatal toxicity, such as alcohol and tobacco.

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Challenges in Arctic POPs and Metals Effects Studies

- In remote isolated communities, studies that depend on developmental assessment at specific post-birth time intervals can lose observations due to problems in travel, availability of examiners fluent in indigenous languages, and movement of families between villages.

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Current Studies on Populations exposed to POPs, PCBs and Metals in Arctic Marine Diets

- On-going studies are in progress in the Faroe Islands, Greenland, Canada, and Alaska
- Alaska, Greenland and Arctic Canada are longitudinal studies of the residents in small rural communities, with varying degrees of marine subsistence diet. They do not usually sample the same participants in each cycle of testing, and they are cross-sectional studies of the same population, but not necessarily the same participants. These studies give a good measure of a population's trends in diet, and tissue levels. They are more difficult to analyze, as numbers are smaller, and confounding factors are frequent.

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Health Effect Study Results

- All studies deal with mixture exposure, multiple confounders, and marine subsistence diets or fresh water fish diets.
- A few studies have more then one observation over time, in the same individuals, but most are serial observation in the same population, but not the same individuals.
- All are studies of effects with known prenatal exposure to POPs and metals.

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PCB Exposure

- Neurological effects in infancy including mild abnormalities of muscle tone, reflexes, and newborn activity level, persisting at 18 months (1, 2).
- Prospective studies on prenatally exposed infants at the highest levels show a predictable group of neurocognitive effects (3).
- Most prenatal low-level exposure studies show no impact on prenatal growth or duration of pregnancy, and only inconsistent effects on childhood growth parameters (4, 5).
- The effect of PCB is attributable to the prenatal exposure, and seems most significant in non-breastfed infants(6

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Organochlorine Pesticide (OCP) Exposure

- Effects on growth and development have been studied prospectively in New York (5), North Carolina (4), Michigan, the Netherlands and Germany. The impact of OCP exposure is inconsistent between studies and sometimes transient in the non-Arctic populations (6). In Arctic populations, OCP and PCB and Hg are found together, and these populations show decreased growth in highest levels of OCP exposure (7).
- The OCPs and PCB are both associated with increased risk of Type 2 Diabetes

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Brominated Flame Retardants (BFR) Exposure Prenatal Exposure

- BFRs have been implicated in laboratory studies with neurological, and other developmental effects, but human population studies are still in early stages.
- In the Alaska Native Yupik women monitored, these compounds are not associated with the subsistence diet, but are likely acquired form indoor environmental sources, as is the case with the general US population.
- It is not clear whether the most commonly consumed northern marine Subsistence species are a major source of these compounds. They are commonly found in many consumer products, and are much higher in human blood studies in the U.S. and Canada, and are highest in California (10).

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Perfluorinated Compounds (PFC)

- These are highly persistent, and are becoming widely distributed in the Arctic, as well as elsewhere. They are bound to albumin, and usually measured in plasma (17).
- These compounds are present in marine species, and prenatal exposure is associated with lower levels of antibodies to vaccines. It is not clear that this results in any increase in likelihood of developing infections.

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Mercury (Hg) Exposure

- Mercury is a well known neurotoxin, and the developing brain is the most sensitive stage.
- Changes in cardiac automaticity have been found in adult and child populations with higher exposure to mercury, but the relationship to prenatal exposure is not always clear (12).

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Mercury Exposure

- Longituinal exposure studies of children with known levels of prenatal exposure have been carried out in Canada and Greenland, Faroe Islands, New Zealand, the Phillipines, South America, and the Seychelle Islands. Comparable neurodevelopmental testing has been done in the Canadian, Faroe Islands, and Seychelles Islands cohort.
- The results show neurological effects in the most highly exposed children in Canada (13), Faroe Islands (14), but not in the Seychelles (16).

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Mercury Exposure

- The difference may be due to the very low levels of POPs in the Seychelles fish that form the major marine food intake.
- Further follow-up of these cohorts is needed to see whether the neurodevelopmental and cardiovascular associations with prenatal Hg exposure persist.

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Mitigating Factors

- Breast feeding reduced the impact of PCBs in breast fed children, compared to similarly exposed non-breast fed children (6, 18, 19).
- Higher cord levels of omega-3 fatty acids also improved cognitive and motor development in Inuit children (19).
- Age may attenuate, or be associated with disappearance of early effects, for example, mild BP elevation associated with prenatal Hg in Faroe Islands male children at age 7 years, resolved by age 14 years (20).

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Conclusions

- Hg and Pb have very well documented prenatal exposure effects.
- PCBs have well documented effects, but they are best seen at high exposure levels, and are more difficult to separate when seen in mixtures of other compounds and metals.
- The organochlorines pesticides are usually seen in mixtures in the Arctic food web, and in human residents, and effects are difficult to separate.
- Mixture toxicology is poorly understood, and analysis of low dose mixture exposure needs much more research, and longitudinal population studies.

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