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Climate Change and Contaminants in Subsistence Foods: A Tribal Program to Monitor the Health of Alaska Yupik Women and Children

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Overview

“Climate Change and Contaminants in Subsistence Foods: A Tribal Program to Monitor the Health of Alaska Yupik Women and Children” is the fourth webinar conducted under EPA’s STAR Research Grants Program/National EPA–Tribal Science Council webinar series in 2009.

Dr. James E. Berner directs the Alaska Native Traditional Food Safety Monitoring program, which assesses contaminant and micronutrient levels in pregnant Alaska Native women, and evaluates health effects in mothers and newborn infants. In this webinar, Dr. Berner describes the climate changes taking place in Alaska and the contaminants these changes are bringing to Alaska. He discusses the impacts climate change and contaminants are having on the health of pregnant Alaska Yupik women and on subsistence food safety. Dr. Berner noted that his group has been working on this project since 1999, primarily with support from EPA, but also from the Centers for Disease Control and Prevention, Alaska Native Tribal Health Consortium, and the State of Alaska.

Background

The Alaska Native population is 130,000, representing 19% of the State of Alaska’s population, which is the highest Native American population percentage of any State in the country. The Native Alaska population is comprised mostly of very young children and people up to the age of 54, after which the population drops off substantially. Approximately 65% of the Alaska Native population lives in rural areas, 35% in urban areas, and 58% in villages of 200 or less. Most of the rural communities have no road connection with major population centers and depend entirely on air or, in the summer months, on river and ocean transport.

Alaska has five major language groups and five major cultural groups. The languages are not mutually intelligible among the groups. This project focuses on the Yupik Eskimos of the Yukon-Kuskokwim River Delta area in Western Alaska.

According to Dr. Berner, two of the most serious challenges facing Alaska Natives are the health impacts of climate change and the subsequent issue of subsistence food safety. Furthermore, the transport of contaminants by ocean, river, and atmospheric mechanisms may be increased by a warming climate.

Climate Change

Dr. Berner discussed how the Arctic climate is warming more rapidly than other parts of the globe, and larger changes are projected. The climate is changing more rapidly in the northern part of the western hemisphere and in the adjacent region of Siberia, than anywhere else, and more of the warming is occurring in the winter than in the summer. Some regions, however, are cooling. From 1954-2003, the annual average temperature change ranged from a 2–3°C warming trend in Alaska and Siberia, to a cooling trend of up to 1°C in southern Greenland. During the winter months, temperature change maps show temperature changes ranging from a warming of up to 4°C in Siberia and Northwest Canada to a cooling of 1°C over southern Greenland. Dr. Berner pointed out, however, that despite the amount of information available on temperature changes in the Arctic, there are vast areas in the highest Arctic latitudes where no climate data are available, which makes it difficult for scientists to model climate change accurately.

Climate Change and Contaminants in the Arctic

The Polar Vortex (PV) is key to the atmospheric processes in the Arctic. The PV is a cyclonic wind pattern around the North Pole that is strongest in the troposphere above 15,000 ft. and far stronger in the winter. The strength of the PV profoundly influences temperature, barometric pressure, movement of Arctic ice, and surface water circulation, as well as Arctic and Northern hemisphere weather. The PV is partly reflected by the Arctic Oscillation (AO) Index, which measures the difference in Sea Level Pressure (SLP) between the Arctic high pressure field and the northern hemisphere mid-latitude low pressure field in the middle of the Atlantic Ocean (37–45°N).

- A positive AO increases wind currents into the Arctic, raises the mean Arctic temperature, decreases sea ice, and increases precipitation.
- A negative AO increases sea ice, decreases mean temperature, and increases cold air movement into northern latitudes.
- Dr. Berner says the Arctic is currently in a negative AO phase.

Some ocean issues cause significant changes in both weather and contaminant transport, according to Dr. Berner. In terms of how and to what extent the influence that the AO has on the transport of contaminants in the Arctic Ocean, a strong, positive AO causes increased cyclonic movement of surface water and ice in the Arctic Ocean. A strong, positive AO also diverts Russian Arctic river inflow (1000 km³/yr) into the Canada Basin, and the Canadian Archipelago. According to Dr. Berner, a strong, positive AO also results in an atmospheric flow of contaminants from the Russia into the Arctic Ocean. In contrast, a strong, negative AO causes Russian River water to be diverted to eastern Greenland.

The Southern Oscillation (SO) Index also affects the flow of contaminants into the Arctic Ocean. Cyclic changes in equatorial Pacific Ocean surface temperatures, as expressed by the surface water temperature gradient between Darwin, Australia and Tahiti. Cold surface water in the western Pacific, and warm surface waters in the eastern Pacific result in El Niño Southern Oscillation (ENSO) events. Warm surface water in the western Pacific and cold surface water in the eastern Pacific result in La Niña events. Strong ENSO events increase atmospheric transport of lower latitude contaminants to eastern Arctic Canada and the U.S.

Another ocean oscillation discovered in the past 15–20 years, Dr. Berner says, is the Pacific Decadal Oscillation (PDO), which describes sea surface temperatures in the North Pacific Ocean, and their cyclic characteristic distribution of warm and cold surface waters, which affect sea level pressure, and surface wind stress anomaly patterns during PDO warm and cool phases. The monthly values for the PDO index from 1900–2008 showed positive-negative-positive changes over time periods ranging from 20–40 years and have now turned negative, or cool, again.

The difference between ENSO and PDO is that the El Niño is only a cycle of a year or two, whereas PDOs are 20- to 40-year cycles. Dr. Berner showed a chart illustrating Fairbanks Annual Time Series 1908–2008 Data for temperature, precipitation, and snowfall during the PDO time period described above. Comparison of Fairbanks average annual temperature trends show an association with the phase of the PDO for the same time period, with cool PDO phases associated with somewhat cooler air temperatures, and warm phase PDO associated with generally warmer Fairbanks air temperatures.

The land temperature in Alaska, according to Dr. Berner, is strongly influenced by the PDO. As already noted, the warming trend has turned negative again in Alaska. Dr. Berner asked, “What does this mean for us? Does it mean that all the things we saw in the warming phase will disappear?” Threats such as emerging zoonotic disease-causing organisms have the ability to adapt to cooler temperatures, and may well now become permanent features in the Arctic. Dr. Berner cited the Arctic Council’s Arctic climate impact assessment (ACIA) model, which projects:

- Increase mean temperature of 1.6–5.8°C by 2100.
- Increase precipitation, mostly as rain.
- Decreased sea ice, decreased snow cover, and albedo.
- Increase in sea level ~20cm.
- Possible increase river output in some, but not all, Arctic rivers.
- Decrease in permafrost in some regions.

Dr. Berner said the ACIA has significant, and crucial, limitations because it lacks the required information necessary to predict climate change. Furthermore, he noted that scientists have no alternative except to use this incomplete model regardless of the information it lacks. Specifically, Dr. Berner says the model has no ability to model ocean processes; AO, SO, and PV; or clouds.

Health impact mechanisms on the Native Alaska people because of climate change and contaminants in the Arctic include:

- The effect of contaminant transport on subsistence foods.
- The spread of zoonotic disease (diseases animals can give to people).
- Damage to permafrost-dependent infrastructure.
- Unintentional injury (e.g., hunters going through the ice, which is a significant issue).
- Extreme weather events.

Subsistence food safety is essential to the Alaska Native population in the following ways:

- Rural Alaska Natives are the most subsistence dependent population in the U.S.
- Accumulation of organic contaminants in the food web biomagnifies and bioaccumulates, and the developing fetus and pregnant women are most sensitive to the toxicologic effects of contaminants and heavy metals.
- Traditional food has public health and culture benefits.
- Transport of contaminants by ocean, river, and atmospheric mechanisms may be increased by a warming climate.

The Alaska Subsistence Food Harvest (from most to least harvested) consists of fish, marine mammals, terrestrial mammals, plants, birds, and shellfish. By far, salmon is the most commonly consumed species in the Native Alaskan diet. Dr. Berner noted that the warming trend leads to more salmon reaching the Alaskan coastline and being harvested, as well as salmon steadily returning to more northern rivers on the Bering Sea coast.

Food safety issues surrounding contaminants include:

- Persistent organic pollutants:
 - Highly persistent, fat soluble, and easily transportable.
 - Industrial origin (polychlorinated biphenyls [PCBs] and polybrominated diphenyl ethers [PBDEs])
 - Agricultural pesticides (dichlorodiphenyltrichloroethane [DDT], toxaphene, mirex, hexachlorocyclohexane [HCCH]).
 - Industrial by-products (dioxins, furans, hexachlorobenzene [HCB]).
- Heavy metals that are present and threaten food safety:
 - Mercury (Hg), lead (Pb), arsenic (As), and cadmium (Cd).
 - All are naturally occurring, easily transported.
 - Hg, As, and Cd exist in forms that vary greatly in toxic potential.

The human toxicological effects of climate change and contaminants in the Arctic on subsistence food safety include negative effects on Native people in terms of growth, neurologic development; endocrine disruption; immunologic effects; and adult chronic disease, which might turn out to be the most common effect of all.

The effects of contaminant transport in the Arctic on subsistence food safety are influenced by the facts that air currents are hemispheric; ocean currents are global; and all local sources are eventually distributed globally.

Dr. Berner stated that the warming climate in the north might be increasing contaminant transport from lower latitudes to the Arctic, citing the arctic influence on ocean circulation. Specifically, the polar region influences global ocean currents. The Arctic plays a fundamental role in the circulation of water in the oceans of the world. When warm, salty water of the Thermohaline Circulation, referred to as the Gulfstream in the north Atlantic, reaches the cold Arctic around Greenland and Iceland and in the Labrador Sea, it becomes denser as it cools, and therefore sinks to deeper layers of the ocean. Every winter, several million cubic kilometers of water sink to deeper layers, which move water slowly south along the bottom of the Atlantic Ocean south around the tip of Africa, across the Indian Ocean, north along the coast of Asia, into the North Pacific, where it warms and rises, then starts the reverse trip back as a warm surface current.

Dr. Berner provided a general conceptual model of seasonal distribution and movements of Pacific salmon in the open ocean. Salmon are distributed in both the Bering Sea and North Pacific Ocean in the summer and primarily in the North Pacific in the winter. Salmon generally move to the south and east in winter and to the north and west in summer. According to Dr. Berner, The contaminants in salmon consumed by Alaska Natives on the Yukon-Kuskokwim Delta are transported to the region by the Western Boundary Current of the Pacific Ocean, which receives the contaminants in the outflow of the large Asian rivers, such as the Mekong, and Yangtze.¹

In a chart depicting Yukon River Chinook Salmon Muscle Contaminant Levels² (parts per billion [ppb], wet weight), results ranged from the high mean of over .06 for toxaphene, about 0.025 for PCBs, over 0.02 for all DDT-related compounds, less than 0.01 for DDE, and 0.01 for chlordanes. Dr. Berner pointed out that toxaphene is a good crop pesticide and very easy to make, but it's not supposed to be used anymore, but there are indications that, perhaps, that it may still be being used somewhere in Asia.

According to the same study, the contaminant level for methyl-mercury was low enough that the salmon could be sold in a grocery store (0.15 ppb). The salmon was also very high in selenium (Se), which may decrease the risk of prostate cancer in men.

Alaska Native Environmental Health

Dr. Berner moved on to discuss the Alaska Native's traditional diet. One of the first things he mentioned was that a lead isotope ratio comparison of blood and solid lead shot samples discovered that some of the lead found in pregnant women came from buckshot used in hunting.

¹ Quinn, 2005.

In a comparison of women in the Yukon-Kuskokwim Delta to other populations in the Arctic Coast, the blood levels of persistent organic compounds in circumpolar pregnant women were less than or about average for the group. However, the Yupik population had substantially higher omega-3 fatty acid levels than any other pregnant Inupiat women on Alaska's Arctic Ocean coast,³ and Dr. Berner says that future studies will consider the risk and balance of these levels of fatty acids in the diet of pregnant women.

Additional findings on the health status of Alaska Natives that may be related to diet include the following:

- Low Weight Births, CY 1999-2001⁴
 - U.S. all races equals 7.6% of total births; Indian Health Service (IHS) total is 6.6%; Alaska total is 5.6%, which is a “good” finding, according to Dr. Berner.
- High Weight Births, CY 1999-2001⁵
 - U.S. all races equals 9.8%; IHS total is 12.2%; Alaska total is 19.3%.
 - Alaska had the highest rate of the 12 areas studied.
 - Dr. Berner pointed out that many high-weight births (over 9 lbs.) are due to gestational diabetes mellitus, and that raises the question as to whether that might be a factor in the Alaska Native rate of high birth weight infants.
- Percentage of Alaska Adults Who Are Obese⁶ (major risk factor for diabetes)
 - Alaska Natives: rate fluctuates, but is on a definite upward trend, from 1993 when the percentage was about 18% to approaching 30% in 2001, which is about a 12% total increase.
 - For Non-Natives, the rate has steadily increased from approximately 12% in 1993 to a little more than 21% in 2001 (less than a 10% total increase).
 - According to Dr. Berner, the rate of Alaska Native adults who are now obese is about 44% to 45% in the Yukon-Kuskokwim Delta.
- Birth Rates Among Mothers with Diabetes CY 1999-2001⁷
 - U.S. all races: 29.3 per 1,000 live births
 - IHS total: 49 per 1,000 live births
 - Alaska: 32.2 per 1,000 live births
 - The strikingly high levels of omega-s fatty acids in the blood of pregnant Yupik women may be reducing the risk for gestational diabetes, compared to other Native American women, who have equal rates of obesity, but do not have a high intake of marine fish and sea mammal.

Research into chronic disease in the Native Alaska population as it is affected by climate change and contaminants in the Arctic is investigating the following factors:

² U.S. Fish and Wildlife Service, 2001, A. Matz, personal communication.

³ Alaska Native Traditional Food Safety Monitoring Program – 1999-2003.

⁴ Regional Differences in Indian Health, 2002-2003 Edition.

⁵ Regional Differences in Indian Health, 2002-2003 Edition.

⁶ ISER, Status of Alaska Native Report, 2004.

⁷ Regional Differences in Indian Health, 2002-2003 Edition.

- High intake of omega-3 fatty acids reduces risk of cardiac arrhythmia may theoretically increase bleeding risk; increases insulin sensitivity; and may well decreases risk for metabolic syndrome and diabetes.
- Selenium may decrease the risk of prostate cancer.
- Contaminant exposure may increase risk for Type 2 diabetes and osteoporosis.
- Zoonotic diseases are a traditional food safety issue because as these diseases start to affect the subsistence animals, the way that the Alaska Native people have to treat the meat before it is eaten may have to change. Furthermore, zoonotic disease may not be readily apparent when the seal or caribou is killed.
 - Climate warming has resulted in northward spread of zoonotic diseases.
 - West Nile Virus is steadily extending northward into cold regions of Canada and there is concern that the caribou might provide a natural host for the progression of this disease.
 - Zoonotic diseases are a major health issue and should receive significant attention from EPA, according to Dr. Berner. The diseases may be hard to test for, but reducing the risk of zoonotic disease is the single most important thing that can be done to reduce the potential negative impact of climate change on the health of Alaska Natives.
 - Dr. Berner works with Alaska Tribal Nations to keep current on new zoonotic processes and try to stay ahead of the curve on emerging threats.

Climate change and contaminants in the Arctic result in mechanisms of multiple interactions, including:

- Increased tissue levels of contaminants in subsistence species will have a negative impact on animal immune response to current endemic zoonotic diseases (e.g., brucella, toxoplasma).
- Decreased numbers of key subsistence species (e.g., sea mammals, caribou), which could adversely affect diet, by exposing Alaska Native consumers to risks associated with unhealthy food choices in store-bought foods. .
- Increased contaminant transport, with increased tissue levels of contaminants in Arctic wildlife may increase susceptibility to active infection with endemic or new pathogens, and possibly increased risk of exposure in human consumers to zoonotic diseases, and increased human levels of contaminants.
- Increased temperature increases volatilization of persistent organic pollutants (POPs) and Hg.
- Increased solar radiation on open Arctic Ocean water speeds gaseous evasion of volatile contaminants.
- Increased precipitation increases atmospheric scavenging of contaminants, and decreases rate of transport to the Arctic.

The ecosystem interactions resulting from climate change and contaminants in the Arctic include:

- Increased deposition of atmospheric Hg (which may be coming from China's coal burning power plants to Northern Canada and Alaska) in a warmer Arctic will result in

increased bacterial methylation of Hg, which is very toxic, and may increase the local Hg burden on food webs.

- Increased temperature speeds bacterial uptake and chemical reaction with contaminants.

The Study: The Alaska Native Traditional Food Safety Monitoring Program

The overarching goal of this program is to ensure the continued safety of traditional foods. Its objectives are to monitor trends in dietary intake of subsistence foods, exposure to organic pollutants and heavy metals, the health of pregnant women and their infants; and develop useful data for Alaska Native communities to develop strategies to ensure traditional food safety.

The program also has a number of sub-objectives:

1. Monitor trends in dietary intake of subsistence foods in an effort to reduce their risks, but maintain the healthful aspects of their subsistence food.
 - Document seasonal and regional trends in subsistence species use.
 - Document maternal and newborn blood levels of micronutrients.
 - Look for associations between high levels of micronutrients and maternal/newborn outcomes.
2. Monitor trends in exposure to organic pollutants and heavy metals. (Make distinction between legacy contaminants and new contaminants [e.g., Teflon-like chemicals]).
 - Document seasonal and regional trends in contaminant exposure.
 - Look for associations between contaminant exposure and maternal/infant health outcomes.
3. Monitor trends in the health of pregnant women and their infants.
 - Document incidence and prevalence of health outcomes in pregnancy and infancy, including glucose intolerance, which is a risk factor for both mothers and infants.
4. Develop useful data for Alaska Native communities to develop strategies to ensure traditional food safety. (Some communities are developing strategies to maintain their traditional diets while reducing risk.)
 - Track trends in diet for use in Regional Health Corporation programs (e.g., anemia, diabetes).
 - Provide data for use in negotiations with international pollution sources.
 - Provide data for U.S. and international agencies that fund Arctic health initiatives.
 - Provide data to communities so that village-specific exposure reduction strategies can be developed, if needed.

Methods

1. Enrollment of 200 pregnant women ≥ 18 years old, preferably ≤ 20 week's gestation.
2. Obtain health, dietary nutrient, and tissue exposure data on enrolled women.

- Routine prenatal history/physical.
 - Serum and whole blood specimen obtained at prenatal lab draw.
 - Maternal urine at enrollment. (looking for heavy metals).
 - Maternal health record review after delivery.
 - Maternal subsistence dietary assessment.
3. Obtain micronutrient and tissue exposure data on infants of enrolled women.
 - Routine newborn history and physical exam and neonatal hospital course.
 - Cord blood (serum and whole blood) for POPs, heavy metals, and micronutrients.
 - Health record review after the first year of life.
 - Blood pressure at 4–7 years of age (some regions have found that those born with higher prenatal exposure to mercury are at risk for higher blood pressure in childhood).

Analytes to be examined in women:

1. Whole blood—Pb, Hg, Se, and Cd
2. Serum—PCBs, polychlorinated dibenzofurans (PCDDs/Fs), hexachlorocyclohexanes (HCHs), chlordanes, DDT, dieldrin, aldrin, endrin, mirex, HCB, toxaphene, heptachlor, fatty acids, polybrominated diphenyl ethers (PBDEs) and perfluorooctane sulfonate (PFOS).
3. Urine—urine radionuclides, phthalates, arsenic, Hg.

Analytes to be examined in newborns:

1. Whole blood—Pb, Hg, and Se.
2. Serum—PCBs, PCDD/Fs; HCHs, chlordanes, DDT, dieldrin, aldrin, endrin, mirex, HCB, toxaphene, heptachlor, fatty acids, BFRs, and Hg.

Conclusions

Dr. Berner ended his presentation by providing the following conclusions:

- Climate-contaminant interaction is complex, and poorly understood.
- Impact of climate change, and the temperature trends over the Arctic are not uniform.
- Some contaminants (e.g., HCH) appear to be decreasing in Arctic environmental specimens while others are increasing.
- Only serial measurements, over time, in the environment, biota, and human residents, will eventually allow understanding of mechanisms and impacts. According to Dr. Berner, these serial measurements over time are the only way to understand the effects of climate change and contaminant transport on the Native Alaska population.
- The Native Alaskan traditional diet confers significant public health benefits. There may be some risks associated with it, but that is being investigated.
- The traditional diet is the source of contaminant exposure for Yupik Alaska Natives and has theoretical risks even at low exposure levels.
- Global climate regime change has increased risk in traditional marine and terrestrial food species in Alaska.

Question & Answer Session

Question:

Have there been any major barriers to participation from any of the women?

Dr. Berner:

No, they are quite familiar with health research. Over the years, they've had multiple intervention trials with health researchers. In fact, the community came to me and said, "Don't you think we should do this?" It's not a top-down research project. From the start, it was a community-driven, community-based, completely participatory initiative. We have a really nice, iterative interaction, and if the community thinks a protocol needs to be changed, we talk about it. From my perspective, it's an ideal way to do health research.

Question:

Have you considered extending the omega-3 and Hg monitoring to adult males?

Dr. Berner:

There are datasets like that already in Alaska. We are the only ones doing a serial maternal monitoring program in Alaska.

Suzanne Fluharty, Yurok Tribe Environmental Program:

I'm curious about the work that might be done beyond the native diet and the consumption of other things interacting with the obesity. What kinds of things are happening to look at the whole health picture?

Dr. Berner:

There is a longitudinal study of nine villages in the Yukon-Kuskokwim Delta that is looking at risk factors for cardiovascular disease and cancer and deals with diet, but it does a lot of what we do in looking at micronutrients. The diet everywhere in the North has been westernized (not just in Alaska), but the traditional diet is still stronger in Alaska, but nowhere near where it was forty years ago. From a public health standpoint, we don't want it to go any lower. We'd like to replace some of these unhealthy Western choices with traditional food.

Vi Waghiyi, Alaska Community Action on Toxics:

We've been trying to get the Institutional Review Board (IRB) to do our pilot study on breast milk in the Norton Sound region. We've had challenges in getting IRB approval. Do you have any suggestions for us on how we can get IRB approval?

Dr. Berner:

IRB approval is always a challenge. There are turnovers on the board all the time. New people can have different perspectives and that can make it a lengthy process. If you have a strong letter from the Tribal Health Board and sound science to back it up, they're more likely to take you seriously.

Nigel Fields, EPA:

In terms of the women who participate—do you have any idea what the percentage is of women in rural areas who participate? Also, is there a difference between those who receive prenatal care and those who don't?

Dr. Berner:

Prenatal care is available in every village. The Health Aide identifies the pregnancy and refers the woman to the Yukon-Kuskokwim Health Corporation in Bethel, Alaska, where she receives a full prenatal exam. If we are out recruiting, she hears from us. It will take us about a year and a half to recruit 200 women, recruiting one week every month. About 75% of the pregnant women get care in their first trimester.

In every other Arctic country, the maternal monitoring programs get the blood from the woman and the baby at the time of delivery. My concern is that we miss everything that happens in early pregnancy and only get the uncomplicated survivors. But, we wanted to look at women with the POPs level they have when they enter prenatal care. That's why we do things differently. Our data is not highly comparable with the rest of the Arctic, but what has been done well is looking at POPs concentrations during early pregnancy, to look for associations of contaminants with maternal and prenatal complications in early and mid pregnancy.

Question:

Have you encountered opposition from those who don't believe in the effects of climate change?

Dr. Berner:

My position on whether there has been warming in the Arctic is pretty clear: There has been. We have gathered great data in Alaska, which shows that it is undeniably warmer over the past 40 years, and that most of the change has been in average winter temperature. There's no question that when you get warmer, it changes the ecosystem, and when you change the ecosystem, you change the risks. Some diseases tend to disappear and others tend to appear. It's the same with contaminant transport. Sometimes you get a benefit, sometimes you don't. We're not worried about the cause of the warning, but the adaptation to what's happening.

Question:

What criteria did you use to determine gestational diabetes?

Dr. Berner:

The O'Sullivan criteria.

Question:

Do the women receive any compensation for participating?

Dr. Berner:

We give them an hour's worth on a long-distance calling card. It's what they wanted.

Dr. Berner:

My take home message is that everyone should figure out a way to think about their own Tribal nation and ask, "Where are the threats? Where are the chokepoints in your ecosystem?" That way you don't have to look at the whole universe, and you can monitor the ecosystem in the most efficient, cost-effective way.

