E4G

Arctic Monitoring and Assessment Programme

under the
Arctic Environmental Protection Strategy

PROPOSAL FOR THE HUMAN HEALTH SUBPROGRAMME

30 October 1992

LIST OF CONTENT

1. PREFACE

This proposal for the monitoring and assessment of human exposure to environmental hazards in the Arctic has been prepared according to the decisions taken at the AMAP Task Force (AMAPTF) Meeting in Tromsø, Norway, December 1991.

The proposal has been prepared by a Danish/Greenlandic Working Group in cooperation with experts from the other AMAP countries and after consultations during an international workshop meeting October 29-30, 1992, in Nuuk, Greenland, hosted by the Home Rule Authorities of Greenland. Written comments have been received from Canada, Finland, Norway, Russia, Sweden and the U.S.A. A list of participants in the workshop meeting is given in chapter 13.

The individual components of the proposal have as far as possible been kept nonspecific from a geographical point of view in order to be applicable to all national and regional monitoring programmes.

2. SUMMARY

The evaluation of the risk to human health from environmental pollution in the Arctic can be made on the basis of environmental monitoring, assessment of the exposure to anthropogenic contaminants from food, water and air, existing toxicological data and biological monitoring.

For persistent organic contaminants, heavy metals, and radionuclides, which are the substances identified as requiring primary attention, the following should be carried out

- data on the occurrence in the environment should be registered from the AMAP environmental monitoring programmes and other sources. It is important that these programmes include monitoring on local food sources, water and air;
- investigations on the exposure from food sources, water and air, including dietary assessments, should be carried out. Combinations of dietary assessment methods should be used.

  It should be recognized that some groups of people including children are at a higher risk because of special dietary habits. The dietary assessments of such groups may therefore influence the risk management;
- toxicological data, preferentially from reviews and evaluations made by recognized national or international institutions, should be collected;
- biological monitoring should be based on blood samples from mothers and the umbilical cord at delivery because fetal life is the period of greatest susceptibility to toxic substances. These kinds of specimens are the only ones, which for practical reasons can be easily obtained in the Arctic, and they meet requirements for comparability and represen-tativity within a well-defined population group.

Specific proposals

Overall Strategy

- Plans should be made for an initial 5 year core monitoring programme.
- The monitoring programme should be reviewed annually and consideration given to extension of the programme after 5 years. The core monitoring elements should be implemented by all nations annually. Other monitoring components may be added by individual countries to reflect national or local needs.

Population Sampling

- The core programme should focus on the effects of contaminants on the fetus and the newborn.

- sampling by all nations should include blood obtained from mothers and the umbilical cord of newborns;
- placental tissue should be collected at the time of delivery and archived for retrospective analyses;
- a minimum of 150 blood and placental tissue samples from newborns and mothers should be collected at birthing centres per year in each nation in a way that is representative of the predetermined study population;
- consideration of the need to collect breast milk samples should be based on national and regional concerns/existing monitoring programmes.

Collection of Data on Individuals and their Diet

- Short questionnaries that identify a minimum number of key information items should be administered by all nations to all individuals from whom samples are obtained;
- exposure assessment based on food, water and air intake should be conducted by all nations and focus on national and local concerns;
- collection of food items when required should be coordinated whenever possible with other AMAP subprogrammes (terrestrial, marine and fresh water).

Contaminants and Essential Elements

The core monitoring programme should address

- chlorinated organic contaminants including OC pesticides and PCBs in newborns (cord blood) and mothers (plasma);
- other halogenated aromatic hydrocarbons ("co-planar" PCBs, PCDDs/PCDFs), on a congener-specific basis, measured on a subset of samples (pooled plasma);
- methyl mercury and lead in whole blood from newborns and mothers; cadmium in whole blood from mothers;
- an essential trace element screen (Zn, Se, Cu, etc.) in plasma from newborns and adults;
- radionuclides in food and human tissues (whole body counts where possible).

In addition, the following components should be considered on the basis of national/regional needs:

- polycyclic aromatic hydrocarbons (PAHs) in whole blood combined with possible adduct quantification in whole blood (lymphocytes) and placenta;
- inorganic arsenic in urine;
- cadmium in urine in combination with biological monitoring (i.e. microproteinuria);
- delta-ALAD activity (whole blood) and protoporphyrin measurements (RBC) to supplement blood lead analysis.

- analysis of hair for methyl mercury

Analytical Quality Control and Assurance

- All nations will use their laboratories that have attained a satisfactory standard of analytical proficiency, quality control and quality assurance.
- Arrangements could be negotiated between nations for samples collected by one country to be analyzed by another country's appointed laboratory.
- A sample exchange programme will be put in place as required to ensure interlaboratory comparability.

Ethics

- All participants in human biomonitoring programmes should be fully informed of the objectives and scope of the programmes and have provided written and informed consent prior to their participation.
- All biomonitoring and individual-based epidemiological studies should be approved in accordance with national and local requirements (e.g. scientific-ethical committees).
- Communities should be involved to the extent possible in the issue identification, study design and implementation and reporting of results.

Programme Implementation

A programme implementation group of member nations involved in the human health subprogramme should meet annually to

- report on study design, implementation and results;
- consider quality control and quality assurance issues;
- assess the significance of the results and harmonize recommendations;
- prepare an annual evaluation of activities for the AMAP Taskforce.

3. INTRODUCTION

The charge given to the Human Health Subprogramme is to monitor and assess the effects on human health of anthropogenic pollutants, including radioactive substances, in the Arctic in order to evaluate the need for reduction of the contamination. After considering the guidance provided by the AMAPTF, the Human Health Subprogramme has identified the following objective.

General Objective for the Human Health Subprogramme

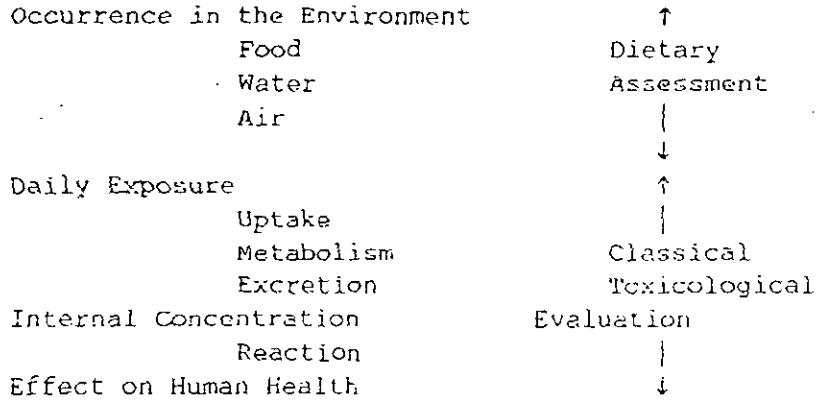
To protect and promote the health of Northern peoples with respect to their exposure to environmental contaminants (anthropogenic contaminants and radionuclides).

To achieve this general objective, the following specific approaches need to be adopted:

(a) evaluation of the risk to human health associated with exposure to environmental contaminants by:
   - evaluating human exposure;
   - evaluating the risk on the basis of toxicological and epidemiological studies.

(b) contribution to the basis for risk-management associated with human exposure to environmental contamination. This management could imply:
   - developing and implementing long-term strategies to reduce sources of environmental contaminants at the local and international level;
   - developing and providing short-term advice at a local or regional level to Northerners on ways of reducing contaminant intakes while preserving traditional ways of living.

The Human Health Subprogramme Proposal emphasizes the occurrence of the pollutants and essential elements in the environment and their effects on human health. This relationship consists of several steps as shown in the following scheme:



1. From Environment to Exposure

Monitoring the environment gives data on the occurrence of the pollutants in the environment, including water and air. Estimating the daily intake from food, water and air gives the daily exposure.

2. From Exposure to Effect

Knowledge about this step is available from numerous epidemiological investigations and/or laboratory animal experiments.

3. From Exposure to Internal Concentration

Data exist only for a few substances. Often a simple relationship does not exist between exposure and internal concentration. Measurement of internal concentration (or biological monitoring) has been used only in a few cases to control estimates of exposure.

4. From Internal Concentration to Effect

Data exist only for a few substances. Often a simple relationship cannot be found between internal concentration and effect.

Thus, the use of the internal concentration or biological monitoring of humans for assessing the effects of anthropogenic pollutants requires extensive scientific investigations to elucidate the relationships between exposure and internal concentration and between internal concentration and effect, respectively. However biological monitoring may play an important role as control of dietary assessment, and indicator of the trend of the exposure.

4. BACKGROUND

Human exposure to chemical compounds can be determined either by environmental monitoring (concentrations in food, air, water etc.) or by biological examination, which is the detection of the compounds or their metabolites in human index media (blood, urine, hair, breast milk, etc.). These methods will give information on the external dose and internal concentration, respectively. However, these measures do not give precise information on the biological effect of the exposure. In contrast measures of biological effects do not give any information on the specific source of exposure responsible for the biological effect.

The first objective in a monitoring programme is to establish a dose response relationship in such a way that effects can be predicted from a measurement of internal concentration. The second is to form a basis for risk assessment and risk management. This will mean that risk can be assessed from external dose (concentration in food, air etc.). To fulfil the aims of the programme it must involve not only biological monitoring, but also to some extent environ-

mental monitoring and effect studies.

In accordance with its objective, the AMAP Subprogramme for Human Health will determine the usefulness of particular monitoring approaches, assess the applicability of effect measurements in populations at risk, and link indicators of environmental quality with indicators of human health. It may identify the need for a reduction in human exposure and the need for a reduction in emissions to the environment. This is of special importance in the Arctic where risks and benefits must be balanced. For example, due to traditional dietary habits, a considerable number of individuals are exposed to certain compounds (e.g. methyl mercury) above the level considered safe but at the same time benefit from these traditional foods (e.g. low risk of heart disease).

Fetal life is the period of greatest susceptibility to the effects of toxic chemicals. It is proposed that the AMAP Human Health Subprogramme be primarily aimed at protecting the fetus and childhood development.

5. OVERALL STRATEGY

There are some basic strategical considerations which must be addressed before going into the technical details of the monitoring programme.

The programme can be an ongoing monitoring programme or a one-time effort limited to a few years. In order to monitor long term contaminant trends and effects and provide an early warning system, a running programme is clearly preferable. It is probably advisable to propose a phased plan, aiming at a long-term programme but with the final decision about the duration to be taken after practical experience has been obtained.

Consideration can also be given to whether the programme should consist of a number of identical national programmes, or whether there should be a common core with possibilities for individual countries to add items of specific interest that address national or local needs. As long as countries can agree on a sufficiently large core of common items the latter solution is preferable.

Proposal on Overall Strategy

Plans should be made for an initial 5 year core monitoring programme. The monitoring programme should be reviewed annually and consideration given to extension of the programme after 5 years. The core monitoring elements should be implemented by all nations annually. Other monitoring components may be added by individual countries to reflect national or local needs.

6. POPULATION SAMPLES

Monitoring of a representative sample of the whole population has some theoretical advantages. Information of exposure can be obtained for the whole population and previously unidentified high risk groups might be detected. The sample would, however, have to be large and include persons from various geographical locations, indigenous people as well as immigrants, persons with different lifestyles (e.g. dietary habits, smoking), both sexes and several age groups. It would be difficult to establish a long term monitoring programme in a large number of geographical locations and the logistic and administrative problems in connection with this approach outweigh its advantages. Despite our ability to predict some high risk population groups, the sampling of these groups alone will not give a general picture of the exposure levels in the whole population.

Combining elements of both approaches may be the most cost effective basic study design. For example sampling mothers and newborns at birthing centres enables informed consent, medical follow-up and procedures, centralization of sampling, addressing a potentially at risk group (i.e., newborns) and general population sampling through maternal blood. Sampling at birthing centres also permits the collection of breast milk samples and placental tissues. Both can be readibly stored for future analysis (including biomarkers). This proposal recommends a minimum of 150 samples be collected per year from mothers and their infants from each country. The actual number must take into consideration the heterogeneity of the population and the regional distribution of ethnic populations. This will result, in 5 years, in a comprehensive view of residues in circumpolar populations. The need to sample other population groups (males, older adults) and to establish time-trends can follow this programme and be based on national and local needs.

Proposal for Population Sampling

The core programme should focus on the effects of contaminants on the fetus and the newborn.

- sampling by all nations should include blood obtained from mothers and the umbilical cord of newborns;
- placental tissue should be collected at the time of delivery and stored for retrospective analyses;
- a minimum of 150 blood and placental tissue samples from newborns and mothers should be collected at birthing centres per year in each nation in a way that is representative of the predetermined study population;
- consideration of the need to collect breast milk samples should be based on national and regional concerns and existing monitoring programmes.

7. COLLECTION OF DATA ON INDIVIDUALS AND THEIR DIET

Basic demographic and lifestyle information on individuals volunteering as subjects for biological monitoring is essential. Data should as a minimum include age, gender, number of breastfed children, alcohol and tobacco consumption, consumption of native and processed foods, birthweights and birthlengths, and length of gestation.

Detailed dietary interviews can yield information on high, medium and low exposure groups, but most often must be validated with measurements of blood, breastmilk, hair, etc. Several methods exist and need to be evaluated carefully to ensure they adequately address local and regional lifestyles and seasonal feeding patterns.

The collection of native foods is expensive and should be coordinated with scientists working in the field with wildlife and fish, and local hunters. The scientists must be informed of the type of food samples required (amounts, type of tissues consumed, species consumed, location of species hunted, hunting seasons, etc.). Cooperative studies with local hunters enable the combination of traditional knowledge on wildlife movements and eating habits with sample collection.

Proposal for Collection of Data on Individuals and their Diet

- short questionnaries that identify a minimum number of key information items should be administered by all nations to all individuals from whom samples are obtained;
- exposure assessment based on food, water and air intake should be conducted by all nations and focus on national and local concerns.
- collection of food items when required should be coordinated whenever possible with other AMAP subprogrammes (terrestrial, marine and fresh water).

8. POLLUTANTS AND ESSENTIAL TRACE ELEMENTS TO BE MEASURED

The AMAPTF has decided that the monitoring programme should address organic contaminants, heavy metals and radionuclides. The Human Health Subprogramme Working Group has concluded that acidification per se, oil and noise should not be part of the programme. However, exposures to essential elements that can mitigate the deleterious effects of exposure to some contaminants should be determined.

Persistent Organic Contaminants

Chlorinated organic contaminants include pesticides (e.g., DDT, mirex, chlordane, etc.), industrial chemicals (e.g., PCBs, hexachlorobenzene, etc.) and industrial byproducts (e.g., polychlorinated dibenzodioxins and furans). All of these chemicals are lipophilic and accumulate in the aquatic food chain. Individuals living in the Arctic who consume large quantities of sea mammals can be exposed to undesirably high levels of these contaminants. Although several of these chemicals are carcinogenic in animal studies, their carcinogenic potential for humans remain unclear. Regardless, other toxic effects of these chemicals are of a major public health concern-especially for the fetus and breastfed infant.

Fetal exposure is best measured via collection of maternal blood and umbilical cord blood at birth. Because individual PCB and PCDD/F congeners exert different toxic effects and their relative levels in the Arctic differ from those in the South, specific congener analysis needs to be performed. Due to their low concentration in plasma, pooling of samples is frequently required.

The major concern over polyaromatic hydrocarbons (PAHs) exposure is associated with

genotoxic effects and carcinogenic potency. Because of the metabolism of high molecular weight PAHs by wildlife, it is unlikely that individuals consuming aquatic and terrestrial animals are highly exposed to the most dangerous PAHs. However, human exposures may need to be assessed in specific regions of the Arctic where high levels PAH emissions are occurring.

Heavy Metals

Mercury

Mercury has the highest priority among the heavy metals present in the Arctic environment, as it is converted to the neurotoxic methyl mercury which is biomagnified in the marine food chains. As a result of this the highest concentrations are found in predatory species such as seals and cetaceans.

Accumulation of methyl mercury in the marine environment results in increased human exposure to this compound in populations with a high daily intake of marine food. In the Arctic human exposure to methyl mercury at a level in excess of the provisional tolerable intake proposed by FAO/WHO has been identified. Methyl mercury crosses the placental barrier and both experimental and epidemiological evidence demonstrate that the fetus has an increased susceptibility to methyl mercury toxicity compared to adults. Furthermore, the effects may not be apparent until the nervous system has reached a sufficient degree of maturity.

Cadmium

In the Arctic environment less attention has been paid to cadmium as compared to mercury, in spite of the fact that this toxic element also bioaccumulates in the marine food chains.

Blood is not the best matrix for evaluation of cadmium exposure. Urine may be a better indicator of body burden. However, 24 hour collections of urine in the Arctic are difficult unless obtained in a hospital setting. In addition, cadmium does not extensively pass the placental barrier, even though it indirectly can affect fetotoxicity by reducing the placental transfer of zinc. For these reasons it is proposed that cadmium be measured in adult (maternal) blood samples only and that urine collections be made only when feasible.

Lead

Studies on atmospheric transport of aerosols indicate that a combination of midlatitude pollution and meteorological conditions can influence the lead deposition in the Arctic. Certain

characteristics of Inuit food such as low calcium and high protein and iron intake will probably facilitate lead absorption, but the pathway from aerosol deposits to the human organisms awaits explanation.

Lead passes the placental barrier and is found at relatively high levels in maternal and cord blood samples in regions without local sources of pollution. Lead exposure levels in Arctic populations can be used as an indicator of trends in global pollution.

Essential Trace Elements

Some essential trace elements interact with toxic heavy metals in biological systems and modify their toxic effects. Selenium acts as an antioxidant in the body and probably reduces the neurotoxic effects of methyl mercury.

Selenium is supplied together with mercury from food items of marine origin. Other essential trace element levels, for example copper and zinc, should also be determined in Arctic populations.

Radionuclides

Radionuclide exposure occurs mainly through consumption of contaminated foods. Exposure levels have declined in the Arctic food supply since the moratorium on nuclear testing. Internal concentrations of radionuclides in human tissues can be readily measured using portable whole body counting devices. While radionuclides are not likely to present a major health risk in the Arctic, characterization of whole body levels and dietary intakes are not complete throughout the circumpolar region. Several major sources of radionuclides do exist in parts of the Arctic and need to be evaluated together with changes in human body burdens.

Proposal on Contaminants and Essential Elements

The core monitoring programme should address:

- chlorinated organic contaminants including OC pesticides and PCBs in newborns (cord blood) and mothers (plasma);
- other halogenated aromatic hydrocarbons ("co-planar" PCBs, PCDDs/ PCDFs), on a congener-specific basis, measured on a subset of samples (pooled plasma);
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- an essential trace element screen (Zn, Se, Cu, etc.) in plasma from new borns and adults;
- radionuclides in food and human tissues (whole body counts where possible).

In addition, we recommend that the following components be considered on the basis of national/regional needs:

- polycyclic aromatic hydrocarbons (PAHs) in whole blood combined with possible adduct quantification in whole blood (lymphocytes) and placenta;
- inorganic arsenic in urine;
- cadmium in urine in combination with biological monitoring (i.e., microproteinuria);
- δ-ALAD activity (whole blood) and protoporphyrin measurements (RBC) to supplement blood lead analysis;
- analysis of hair for methyl mercury.

9. Analytical Control and Assurance

Analytical quality control and quality assurance are essential to ensure comparability between results obtained in the various countries.

Several nations have already developed expertise in the analysis of persistent organic contaminants, metals, essential elements, biomarkers and other biological measurements. Their laboratories have undergone assessment to assure adequate QA/QC and several have participated in international sample exchanges. It is most expedient to have each nation conduct its own analysis in its own laboratories provided sample exchanges are incorporated for interlaboratory comparisons. These laboratories could provide analytical services to countries without adequate expertise at this time. It is also most cost effective to have one country volunteer to coordinate sample exchanges for each group of pollutants.

Proposal on Analytical Quality Control and Assurance

- All nations will use their laboratories that have attained a satisfactory standard of analytical proficiency, quality control and quality assurance.
- Arrangements could be negotiated between nations for samples collected by one country to be analyzed by another country's appointed laboratory.
- A sample exchange programme will be put in place as required to ensure inter-laboratory comparability.

10. COST ESTIMATE

The analyses proposed for the Human Health Subprogramme are summarized in Table 1 with the estimated cost in US dollars.

Compound	Maternal Blood		Cord Blood			Estimated Cost/Sample
	Whole Blood	Plasma	Whole Blood	Plasma		
Mercury	+		+			50
Cadmium	+					20
Lead	+		+			40
Essential Trace Elements		+		+		115
Organochlorine Compounds		+		+		250
Congener Specific PCBs and PCDD/Fs		+				1500*
Radionuclides						NE
Questionaire Administration						NE
Data Evaluation and Communication						NE

* Cost per pool of 10 samples = 1500

NE: Not estimated

The costs of measurements of radionuclides, dietary assessment, questionnaire interviews and data evaluation and communication have not been evaluated and are not negligable. In

general terms these aspects differ between nations and can cost as much as the total laboratory analysis.

11. ETHICS

No biomedical studies can be undertaken without full consideration of their ethical implications. Community concerns and the provision of study results are especially important in the Arctic because of the isolated and closely knit nature of the settlements.

PROPOSAL ON ETHICS

- All participants in human biomonitoring programmes must be fully informed of the objectives and scope of the programme and have provided written and informed consent prior to their participation.
- All biomonitoring and individual-based epidemiological studies should be approved in accordance with national and local requirements (e.g. scientific-ethical committees).
- Communities should be involved to the extent possible in the issue identification, study design and implementation, and reporting of results.

12. IMPLEMENTATION OF THE PROGRAMME

In order to implement the components of the programmeme, all nations will need to coordinate their efforts, compare their data, evaluate their results etc., to ensure that the objective of promotion and protection of health of Northern peoples is met in a cost-effective fashion. It is essential that a steering group be established and include experts from all member nations.

Proposal for Programme Implementation

A programme implementation group of member nations involved in the Human Health Subprogramme should meet annually to

- report on study design, implementation and results;
- consider quality control and quality assurance issues;
- assess the significance of the results and harmonize recommendations;
- prepare an annual evaluation of activities for the AMAP Taskforce.

13. PARTICIPANTS IN WORKSHOP MEETING

Nils O. Alm, MD, Norwegian National Insurance Administration, Oslo, Norway, representing the Nordic Council for Arctic Medical Research;

Peter Bjerregaard, MD, DMSc, Danish Institute for Clinical Epidemiology, Copenhagen, Denmark, representing the Society for Medical Research in Greenland (Danish/Greenlandic Working Group);

Anders Carlsen, MD, Danish Environmental Protection Agency, Copenhagen, Denmark (Danish/Greenlandic Working Group);

Eric Dewailly, MD, PhD. Environmental Health Service, Community Health Department, Laval University Hospital, Quebec, Canada;

Ingmar Egede, MA, Vicepresident, Inuit Circumpolar Conference, Nuuk, Greenland;

Mark Feeley, PhD, Health Protection Branch, Department of Health and Welfare, Ottawa, Canada;

Andy Gilman, Ph.D., Health Protection Branch, Department of Health and Welfare, Ottawa, Canada;

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Marianne Lykke Thomsen, MA, Inuit Circumpolar Conference, Nuuk, Greenland.