

# Conclusions and Recommendations

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In this chapter the conclusions and recommendations from the report on AMAP Phase I (AMAP, 1998) are repeated (shown in italics) in order to allow comparisons with the conclusions and recommendations resulting from AMAP Phase II (shown in bold). This chapter also reviews progress since AMAP Phase I and provides concluding remarks on the combined effects 'multiple environmental stressors'.

## 11.1. Conclusions

In some areas, the indigenous peoples enjoy the same level of health as the non-indigenous populations, but in most areas their health is significantly poorer. Among indigenous peoples, lifestyle-related conditions such as obesity, diabetes, and circulatory disease have been more frequent than previously reported. Suicides and injuries also remain a significant cause of death in some parts of the circumpolar region.

### 11.1.1. General

*(1) Contaminants of anthropogenic origin, such as POPs, metals and radionuclides, are spread globally, and contaminate the Arctic. The combination of environmental conditions and biomagnification in the marine and freshwater aquatic food webs results in accumulation of certain persistent contaminants in local food at levels which are often in excess of contaminant concentrations in the mid-latitudes where these contaminants originate. Consumed fish, marine mammals, terrestrial mammals, and birds are the major sources of human exposure to environmental contaminants in the Arctic and, as a consequence, several Arctic population groups are much more highly exposed through the diet than most populations in the developed world.*

**Conclusion (1) is still valid.**

*(2) The social, cultural, spiritual and physical health of Arctic indigenous peoples depends on the collection and consumption of country foods. A diet based on traditional foods is of high nutritional benefit. Consumption of n-3 fatty acids found in marine mammals and fish has been suggested as the component responsible for the lower incidence of cardiovascular disease in Alaska, Greenland, Canada and Japan. However, other nutrients may also influence the rate of cardiovascular disease. The consumption of local fish, meat, wild greens and berries provides the necessary dietary intake of most vitamins, essential elements and minerals. When market foods are purchased to supplement current country food diets, they should be selected for their nutrient quality. It is unlikely that market foods currently available to most Arctic indigenous populations can provide the nutritional equivalent of traditional food.*

**Conclusion (2) is still valid.** In addition, there is still difficulty in scientifically comparing the benefits and risks of consuming a traditional or subsistence diet. These are important to quantify as dietary intakes are changing across the Arctic due to social pressures, perceived threats of contaminants, the availability of traditional food, and the availability and acceptability of store-bought foods.

*(3) The influence of contaminants on fetal and neonatal development is of special concern. Preliminary results indicate that POPs and methylmercury concentrations are two- to ten-fold higher in breast milk and cord blood in some Arctic areas than in breast milk and cord blood from regions south of the Arctic. The fetus and the neonate are very vulnerable to the effects of many of these contaminants during this critical period of development.*

**Conclusion (3) is still valid and has been strengthened by new findings.** For mercury, studies in the Faroe Islands indicate an association between fetal and neonatal exposure on the one hand and neurobehavioral deficits in children or development of hypertension in later life on the other. Similarly, preliminary findings from a larger cohort study comparing breast-fed with bottle-fed babies have strengthened concern for fetal and neonatal exposure to POPs in relation to respiratory infections in highly exposed children.

There is still a paucity of population health effects data (reproductive health outcomes, neurobehavioral development, immune system response, hypertension and cardiovascular diseases, etc.) for the Arctic. It is essential to complete the current cohort studies in Quebec, the Faroe Islands, Greenland and Finland. Meta-analyses of these studies may be possible and this would considerably increase the power of the individual cohort studies. Additional studies may be warranted when these are completed.

Fetal exposure to environmental contaminants may also result from occupational exposure experienced by the mother. All Arctic countries have, to a greater or lesser degree, tried to give special benefits for working in the north. Special attention is now focused on the health effects of workers in heavy industries of the Arctic, and the general trend is to decrease fetal exposure to harmful substances by removing pregnant women from difficult and contaminated working places when (or even before) a pregnancy is recognized.

### 11.1.2. Persistent organic pollutants

*(4) There is both scientific and public concern about the possible adverse effects of POPs on pregnancy outcome, fetal development, child development, reproduction, male and female fertility, and the immune system. Sev-*

*eral of these effects may be mediated through endocrine disrupting properties of some POPs. DDT and its metabolites and some dioxin and PCB congeners have been implicated.*

Conclusion (4) is still valid. In addition there is strong evidence from analyses of banked blood samples from Norway (non-Arctic donors) of an exponential increase in polybrominated diphenylethers since 1977. It is necessary to include these compounds and other 'new chemicals of concern' in future studies in order to evaluate concentrations in relation to findings on biomarkers.

*(5) Despite the number of controls on several POPs imposed during the 1970s and 1980s, there is no evidence that levels in Arctic peoples have decreased. The persistence of POPs, their presence throughout the ecosystem, and the continued use of some POPs for disease vector control, all contribute to the constant influx of POPs into the Arctic environment and sustained levels of human exposure. There is very little information on temporal trends of POPs in Arctic populations. Monitoring of POPs in blood over the next decade is essential to establish whether or not risk management strategies for POPs are effective.*

Conclusion (5) is still valid. Continued monitoring has provided new data, but significant temporal trends can not yet be observed due to the short period of observation. There are also few available banked (archived) Arctic population samples for retrospective studies. Further prospective monitoring of blood (and other biological samples as per AMAP protocols) and tissue banking are essential to establish these time trends in various Arctic populations. To assess changes in dietary patterns, information needs to be obtained from continued dietary surveys.

*(6) Elevated levels of toxaphene and chlordanes, coupled with current intake scenarios, suggest some indigenous groups are exposed to levels of these contaminants significantly above the Tolerable Daily Intake (TDI). Information on the levels of toxaphene in human tissues is limited.*

No new information on dietary intake of toxaphene has appeared since Phase I. Conclusion (6) is still valid. New information on toxaphene concentrations in blood and breast milk confirms a high dietary intake of toxaphene.

*(7) There is insufficient information to conclude whether the TDI for dioxins and furans and dioxin-like PCBs is being exceeded in Arctic populations. Also, there is as yet little conclusive scientific information directly linking harmful human effects to low levels of exposure to these contaminants.*

New calculations of dioxin toxic equivalents from data provided in Phase I indicate that human intake of substances with dioxin-like effects (dioxins/furans, dioxin-like PCBs, and some organochlorine pesticides) is a matter of concern. Analyses of dioxin and dioxin-like compounds should be included in future human effect studies in order to enable a further assessment of the risks posed.

*(8) While current levels of exposure to POPs in the Arctic are unacceptable, it is not always clear what public health measures should be taken to reduce the exposure of Arctic populations who rely on traditional foods for spiritual, cultural, physical, and nutritional benefits. Decision-making would be greatly aided by studies of the interactive effects of current levels of mixtures of POPs found in the traditional food supply. In the interim, the risks associated with a shift in dietary preference need to be considered along with the risks associated with the presence of contaminants in Arctic wildlife consumed as traditional food. Weighing the uncertainty in some of the TDI values (e.g., toxaphene) against the benefits of traditional food gathering and consumption, it has been recommended in most Arctic jurisdictions that consumption continue.*

Although far from complete, progress has been made in studies on the interactive effects of current levels of mixtures of POPs in the traditional diet. Also, information on concentrations found in species used for food and in their various organs has improved. These scientific findings have improved the basis for dietary advice aimed at reducing exposure. Communication of public health advice and information differs in different areas of the Arctic due to different exposures, cultures, and public health practices, and is not commonly evaluated for its effectiveness. There is a need for an evaluation of the type, role and impact of public health advice or interventions.

*(9) The concentrations of some POPs in breast milk have raised justifiable concern among mothers in the Arctic. The health benefits to newborns of breast feeding are substantial, e.g. mother-child bonding, immunological benefits transferred from mother to child, nutritional value, and reduced risk of bacterial contamination from poorly prepared formulas. Breast feeding should continue since the benefits of breast feeding outweigh the currently known risks attributed to infant exposure to contaminants through breast milk.*

The substantial health benefits of breast feeding justify the development of programmes to inform mothers how adjustments within their traditional diets can significantly reduce levels of some contaminants in their milk without compromising nutritional value.

*(10) Existing epidemiological evidence on the adverse effects of POPs in human is inconclusive and needs to be replicated because of the specific context in the Arctic in which there are differences in genetics, climate, food consumption patterns, and lifestyle among population groups.*

Epidemiological evidence on the adverse effect of POPs on humans is emerging in Arctic and non-Arctic regions. The high exposure levels found in some Arctic communities are suspected to have a negative influence on human health. At the population level there is still no direct evidence of adverse effects on health status (mortality and morbidity). However, based on the weight of all available evidence within and outside the Arctic, there is reason for concern and a need to continue to reduce human exposure.

### 11.1.3. Heavy metals

(11) Existing data from the literature do not allow a valid estimate of spatial and temporal trends of exposure of Arctic peoples to mercury and cadmium, while for lead, a declining trend is observed. There is some evidence that the general decline in lead exposure parallels the decline in lead levels in industrialized areas.

Conclusion (11) is still valid for temporal trends during the period of review by AMAP (1997 to 2002). However, analyses of historical human and animal hair samples from the Arctic have shown a three-fold increase in mercury concentration and a ten-fold increase in lead from the 1400s to 2000.

(12) The high exposure of indigenous peoples to methylmercury in some Arctic areas is a matter of concern because of its neurotoxic effects on the fetus. Further investigation of both the levels and the influence of mercury on fetal development is warranted.

Dose-related, subtle neurotoxic effects of methylmercury have been observed in children in some regions of the Arctic. This emphasizes the concern for methylmercury exposure *in utero* and warrants local public health strategies in some regions to reduce the exposure of women of child-bearing age and especially those that are pregnant. The success of carefully developed public health strategies has been demonstrated in the Faroe Islands where interventions related to consumption of pilot whale meat have resulted in an 80% reduction in mean mercury body burdens.

(13) Lead levels in Arctic indigenous peoples have declined since the implementation of controls on lead emissions. Concentrations of lead in blood currently reported are below a level of concern, however, continued monitoring is warranted because of the potent effects of lead on neurological development in the fetus and children.

Conclusion (13) is still valid. In addition, recent data have shown that lead shot can be a significant source of human lead exposure.

(14) As elsewhere in the world, cadmium intake in the Arctic is mostly through smoking. However, as with mercury, the dietary exposure level will vary according to choice of food. Recent research indicates that kidney tubular dysfunction may occur at lower levels than previously considered.

The main source of cadmium exposure is smoking. Depending on food consumed, dietary intake in some Arctic regions is above the WHO provisional tolerable weekly intake (PTWI) and adds significantly to blood cadmium concentrations. The health consequences are at present unknown. Reduced smoking among Arctic residents will significantly reduce cadmium exposure.

(15) Arsenic and nickel exposures are mainly related to local industrial activities. The impacts on health of organo-arsenicals in marine food is at present not well understood. Studies of speciation of the naturally-occurring arsenicals in various animals and organs and

their potential interactions with essential trace elements are needed.

Conclusion (15) is still valid. Ongoing epidemiological studies of occupationally exposed populations working in the nickel industry of the Kola Peninsula might reveal new information about the impact of nickel on fetal malformations and pregnancy outcomes in general.

### 11.1.4. Essential elements

(16) In general, ample supplies of selenium are provided through the diet in populations depending on marine food. Muktuk (whale skin) is the richest source. Populations predominately depending on food of terrestrial origin may have a marginal deficit in selenium supply. While animal experiments indicate selenium protects against the effects of some heavy metals (i.e., mercury, lead, and cadmium), its role as an antidote for metal toxicity in humans is at present hypothetical. The role of selenium as a protective factor against lipoprotein peroxidation and its purported beneficial effects in protecting against cancer and cardiovascular disease remain to be elucidated.

Most essential elements are amply supplied through food of marine origin while populations predominantly depending on food of terrestrial origin may have a marginal deficit. Recent data have shown that transition from a marine food to a market food diet reduces the intake of most trace elements to a level below the recommended daily intake.

### 11.1.5. Radiation

(17) The level of human exposure to anthropogenic radionuclides such as radiocesium in the Arctic has declined dramatically since the cessation of above-ground weapons testing. However, some Arctic populations still have higher exposures from anthropogenic radionuclides in the environment than those in the temperate zone because of unique features of Arctic terrestrial and freshwater ecosystems and the people's use of traditional foods. The cumulative dose to which a population is exposed must also include an estimate of the natural radionuclides. In some geographical areas, levels of natural radionuclides (derived from, e.g., radiopolonium) have resulted in certain indigenous peoples being exposed to higher levels of radiation than the general population.

Human health effects associated with radioactivity are not addressed in this report – readers should consult the AMAP 2002 assessment on radioactivity in the Arctic (AMAP, 2003a).

(18) Increased UV radiation due to ozone depletion is not a major concern in terms of skin cancer because of the amount of clothing worn in Arctic environments. The primary health concern is the reflection of UV from snow and ice causing snow blindness. In addition, there is growing concern about the development of cataracts.

Conclusion (18) is still valid but this issue has not been further considered in this report.

### 11.1.6. Estimates of exposure and effects

(19) Food is the major exposure route for contaminants in the Arctic. The type and amount of human exposure to environmental contaminants varies throughout the circumpolar region according to the level of contaminants in the food, the amount and type of food consumed, and the method of food preparation. For these reasons, wildlife monitoring data provide a very uncertain basis for precise human exposure estimates. However, they are of great value for risk characterization as they identify the contaminants present in wildlife used as traditional food, and the most contaminated species, and can, therefore, contribute to the basis for dietary recommendations. Uniform methodology for dietary intake studies applied across the circumpolar region would greatly assist risk assessment.

Conclusion (19) is still valid. However, in addition to dietary intake, recent studies have shown that uptake, metabolism, and excretion of xenobiotic substances are under genetic influence, also lifestyle factors, e.g., smoking and body mass index influence the body burden. These factors should be considered in future studies.

(20) Determining adverse health effects in human populations due to the presence of contaminants in traditional foods and human milk is extremely difficult for methodological and ethical reasons. Results are also difficult to interpret because of a wide range of confounding factors (socio-economic, lifestyle and gender/age related). Monitoring contaminant concentrations in human tissues and using these data to estimate exposures will continue to be necessary as will a general reliance on animal studies of the effects of mixtures of contaminants and nutrients found in Arctic foods. Tissue banks would greatly assist the requirements for retrospective comparative studies of contaminant levels and effects.

Conclusion 20 is still valid. Progress in molecular biology has provided tools to identify biomarkers of effect for contaminants in human samples. Implementation of the human health effects programme combined with continued monitoring of exposure (including new contaminants of concern) would allow identification of early effects at the molecular level. It will also act as a warning system to signal increases in exposure to levels where overt signs of poisoning may appear. Little attention has been paid to the possible variation associated with the collection of blood samples from fasted versus non-fasted individuals. There is a need to set clear protocols for the collection and analysis of human tissue samples to minimize biological and analytical variability.

(21) Risk assessments are, in general, conducted for individual contaminants and not mixtures of contaminants. They are based upon extrapolations from single compound animal studies combined, when possible, with data from occupational exposure or accidental intoxication events. These assessments do not adequately account for the metabolic transformations of contaminants in the food chain, the possible interactions between contaminants concomitantly present in the environment, or the modifying influences of nutrients, such

as trace elements and antioxidants, naturally present in Arctic traditional food. Consequently, the accepted guidelines for exposure are not necessarily applicable to Arctic communities.

Risk assessments have in general been conducted for individual contaminants and not mixtures of contaminants. New methodologies can integrate epidemiological and mechanistic biomarker effect studies on human samples making it possible to estimate the effects of current exposure levels of the actual mixture of contaminants (and metabolites), possible interactions, and the modifying effects of nutrients (combined effects). Guidelines on exposure levels in the Arctic should be based on recommendations from national or regional public health authorities.

(22) Very few studies of the effects of environmental contaminants on Arctic populations have been completed, therefore, existing literature does not provide convincing evidence of adverse health effects. On the other hand, the health-promoting effects of traditional diets have been well documented. This has led to a reluctance to recommend changes to current patterns of traditional food consumption. Based on this review, there may be a need to consider providing food consumption advice to some people in some areas in order to protect the fetus from exposure to mercury and some POPs. It would be prudent for local health care providers to consider giving dietary advice to young women and pregnant women in order to help them reduce exposure levels prior to and during pregnancy. The consumption of less contaminated traditional food items that provide the nutritional needs of women of child-bearing age should be promoted.

Conclusion (22) is still valid. Evidence of subtle effects of contaminants in traditional food is emerging in some Arctic populations. On the other hand, the nutritional and physiological benefits of traditional diets are well known. This supports the need for dietary recommendations to be based on risk-benefit analyses. Carefully considered and balanced dietary advice that takes risks and benefits into account is needed for children and adults of reproductive age for both genders.

(23) Contamination of the Arctic is part of a global process. While human exposures in the Arctic can be moderately reduced with some dietary modifications (provided these are culturally, socially and nutritionally suitable for the specific communities involved), it must be recognized that long-term exposure reductions can only be accomplished through international conventions resulting in bans and restrictions on production and use of the most toxic chemicals.

Conclusion (23) is still valid. There has been substantial effort to evaluate the weight of evidence for effects on human populations exposed to POPs and metals (from cellular effects to epidemiological outcomes) through various AMAP and national activities. There is a need to continue this process and to conduct the research needed to support this approach. Now that two international agreements on POPs (the Stockholm Convention on POPs and the POPs Protocol to the LRTAP Convention) and one on metals (the Metals Protocol to the LRTAP

Convention) have been successfully negotiated, it is essential that they be promptly ratified and so enter into force. These agreements will only succeed in reducing environmental burdens and human exposures if they are implemented and monitored. In addition, the global assessment of mercury initiated by UNEP in 2000 provides an opportunity to ensure that Arctic concerns are reflected in the considerations for global action on mercury.

## 11.2. Recommendations

### 11.2.1. At the scientific assessment level

(1) *Continue monitoring contaminants in human blood and tissues in order to reveal temporal and spatial trends.*

Recommendation (1) is still valid. It has been five years since the completion of most of the original circumpolar blood monitoring survey. Re-sampling during AMAP Phase III would enhance the ability to determine whether or not human exposures are declining.

(2) *Combine experiences from the rapidly expanding disciplines of biomarker research and molecular epidemiology with existing monitoring programs.*

Recommendation (2) is still valid. The AMAP Human Health Expert Group has developed a human health effects programme that should be more extensively applied.

(3) *Develop uniform methods and initiate studies which will allow objective dietary assessments and exposure estimations.*

Continue the process and apply uniform methods for the objective assessment of diets and estimation of exposure. In addition, promote studies on the nutrient content of traditional food items.

(4) *Complete human populations studies of contaminant-related effects on reproduction and fetal and child development.*

Continue to support human population studies of contaminant-related effects on reproduction and fetal and child development, immune and hormone status, and cancer.

(5) *Revise existing guidelines for tolerable intakes of contaminants based upon studies of interactions among individual contaminants present in Arctic foods, and between contaminants and nutrients.*

Guidelines for tolerable intakes of contaminants should be based on regional and local needs and should strike a balance between benefits from traditional foods and potential negative effects from exposure to contaminants.

(6) *Create and manage tissue/specimen banks in the circumpolar region.*

Recommendation (6) is still valid. In addition, support is necessary for the implementation of laboratory harmonization programmes to enhance the inter-comparability

of data; and to ensure the collection of blood samples that are based on standard protocols, including the collection of samples from fasted subjects.

### 11.2.2. At the public health policy level

(7) *Apply communication and consultation approaches that enhance the development of local information and advice for indigenous peoples about contaminant exposures and effects.*

Apply communication and consultation approaches that enhance the development of local information and advice for indigenous peoples about benefits of traditional food, contaminant exposure and effects.

(8) *Advise Arctic peoples to continue to eat traditional food and to breast feed their children, and develop dietary advice for girls, women of child-bearing age and pregnant women which promotes the use of less contaminated food items while maintaining nutritional benefits.*

Advise Arctic peoples to continue to eat traditional food and to breast feed their children taking dietary recommendations into consideration. Where necessary, as a means of reducing exposure, ensure that the combination of traditional food and market food provides similar nutritional value to the original diet.

### 11.2.3. At the national and international policy level

(9) *Initiate measures to reduce and control regional industrial emissions of contaminants.*

Recommendation (9) is still valid. Strengthen international efforts to control production, use and emissions to the environment of persistent organic pollutants and mercury. Support the UNEP Global Mercury Assessment.

(10) *Strengthen international effort to control production and use of persistent organic pollutants.*

Ratify and implement the Århus Protocols on POPs and Heavy Metals and the Stockholm Convention on POPs, including participating in the global monitoring of human exposure to be established under the latter.

Support a global assessment of the linkages between health and the environment.

## 11.3. Progress since AMAP Phase I

During AMAP Phase I the Human Health Expert Group prepared a comprehensive review of existing information on the health implications of exposure to a defined list of priority contaminants and included evidence of exposure in various parts of the Arctic. Exposure was predominantly dietary. The objectives of the first phase of the AMAP Human Health sub-programme, developed in Nuuk in 1992, were however not fully met due to logistical and financial problems. Thus the first phase of the programme effectively became a pilot programme, i.e., the first study of blood contaminant levels for most of the eight Arctic countries in which sampling proce-

dures and analyses were standardized to allow comparisons between countries and regions.

During AMAP Phase II a more extensive human health programme was undertaken. The outcome of the Phase II programme confirms the exposure levels found during the pilot study and has extended the geographical coverage such that it is almost circumpolar. Owing to the length of the monitoring period (1994 to 2001) temporal trends in human exposure to contaminants can not yet be established. Statistically significant trend estimates will require a sustained monitoring programme over several decades. Such a programme is important as current exposure levels in certain areas and for certain contaminants exceed existing health guidelines.

During AMAP Phase II more information on contaminant concentrations in species relevant to human diets was obtained from data produced by the AMAP Heavy Metal and POPs Assessment Groups. This allows more detailed and more specific dietary guidance. Progress in procedures for dietary assessment and validation of dietary indicators (e.g., n-3 : n-6 fatty acid ratios) has also improved the basis for advice.

The mandates of AMAP Phases I and II defined the priority contaminants to be monitored. However, as described in chapter 4, new contaminants of concern have since appeared. There is an urgent need to include such contaminants in future monitoring programmes.

The main achievement of Phase II has been the development and implementation of a human health effects monitoring programme (see chapter 6). Although implementation is now almost circumpolar, the process should be continued and expanded in a continuous, co-ordinated programme.

#### 11.4. Concluding remarks on combined effects

Human health status is determined by an interaction between genetic endowment and the influence of environmental factors. Genetic factors can exert an influence through entire ethnic populations, in families, and at an individual level. As a consequence, studies of genetic susceptibility (genetic epidemiology) are important for assessing the impacts of environmental exposure at all levels of the population.

In terms of health, environmental factors may be either positive (e.g., nutrients) or negative (e.g., contaminants and radiation). While the genetic determinants of health at the level of the individual are stochastic, the environmental influences are dose-related and as such include both qualitative and quantitative aspects. As a consequence, a holistic approach to describing the health–environment relationship is a huge task and one which the current state of scientific knowledge cannot support, despite considerable progress in this field over the last ten years. Although the problems are mainly of a methodological nature, it is the current lack of understanding within the scientific community of the need for a multidisciplinary approach that is of most importance.

Environmental health determinants are chemical, physical, biological, psychological, and societal in nature. This means that besides geneticists, epidemiologists and toxicologists, natural scientists, sociologists, psycho-

logists, medical experts and anthropologists must also be involved if a holistic approach to the description of the health–environment relationship is to be developed.

During AMAP Phase I the mandate was to monitor the specified priority contaminants and to evaluate the potential risks to human health. In Phase II the mandate was expanded through the Alta Declaration to an evaluation of the influence on human health of ‘multiple environmental stressors’. This expanded mandate has been the focus of the present report. As the scientific background required to fulfill the Alta mandate is currently insufficient, the work is not yet complete. Nevertheless, it is generally agreed that significant progress has been made and the work is headed in the right direction.

Recent scientific advances have improved the ability to address the impacts of multiple stressors. Classical epidemiology can identify the combined effects of environmental exposures in a given population. However, this is insufficient under Arctic conditions owing to small population sizes, the lack of specificity concerning which exposure causes which effect, and its capacity to measure only overt effects. An improvement has been the coupling of epidemiological methods to sub-clinical endpoints, e.g., neurophysiological effects such as evoked nerve potentials (see chapter 9). In this manner, lower exposure levels can be related to effects. Further resolution of low-exposure related effects will come from a coupling of epidemiological methods with the experience obtained in molecular biology and genetics (see chapter 6). While the effect that is measured may be of decreasing immediate clinical significance, its early detection will, in the long-term, be of increasing significance for the development of disease prevention policies.

The identification of new contaminants in the environment often complicates and confounds efforts to identify causal agents. Many of these new contaminants have poorly defined acute, chronic and multi-generational toxicity. These uncertainties notwithstanding, the finding of effects at a sub-clinical level is a strong rationale for immediate reduction of the actual exposure level. They also call for a more intensive focus of the AMAP Human Health Effects Programme on the nature and extent of the adverse effects that may already be present in Arctic populations.

Exposure to contaminants in Arctic populations is almost exclusively the result of consuming traditional food. This food, at the same time, is of great importance to sustained physical health and cultural and spiritual integrity. Therefore, there is an essential need to balance risk assessments with evaluations of the nutritional benefits of traditional food.

The main conclusion of this report is that current human exposure to the existing level and mixture of contaminants in the Arctic influences the health of some Arctic populations in a negative manner. Subtle effects have been demonstrated to be present at a sub-clinical level. In relation to potential effects on future generations, efforts to reduce the input of persistent substances to ecosystems world-wide should be accelerated. Furthermore, the process initiated through AMAP Phases I and II should be continued and expanded to include all relevant disciplines with the aim of pursuing a more holistic assessment of the health of Arctic peoples.

