Chapter 3 – Health
in strategic environmental assessment report

(SEA 2007 report – US)

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Chapter 3 Health

1.0 Summery

1.1 Introduction

It will be endeavoured to split a contribution to a strategic environmental assessment (SEA) from Health into three sections. First of all, an account of our present knowledge about health conditions in Greenland in general, and in three specific areas–Nuuk, Maniitsoq and Sisimiut municipalities—in particular, as these three municipalities have been picked as potential sites for establishing an aluminium smelting plant. A good deal of data material is available from the period 1993–2007, which can be used to shed light on health conditions in Greenland for both children and young people as well as the adult population, exemplifying the kind of knowledge that can be extracted from these. The focus is particularly on the occurrence of chronic disorders, mental health and mortality in Greenland. Coupled to this is the empirical knowledge that is lacking in the area in order to draw a comprehensive picture of health conditions in Greenland, then an overview of the factors we need to be particularly aware of when setting up an aluminium smelting plant, while the third section will deal with some recommendations emerging on the basis of the preceding two sections.

1.2 SIF

This review of the data material that will be available to SIF for analysing health conditions in Greenland shows that data have been gathered from a broad section of the country's population. Data thus include information from both towns and settlements; pregnant women, infant neonates, children aged 0-12, schoolchildren aged 15-17 and adults 18 or above. All data material includes sociodemographic background information, health, living conditions and lifestyle, making it possible to shed light on the scope and distribution of illness and risk factors for chronic disorders. The bulk of the data material additionally contains information collected through clinical studies supplemented with blood and urine sample measurements, making it possible for adults aged 18 and above in particular to shed additional light on e.g. chronic disorders like asthma, cardiovascular disease and diabetes as well as the extent of pollution from environmental contaminants.

What all the data material has in common is that the information obtained in a study has generally also been sourced from other data material describing similar health conditions in Greenland, Denmark or other Inuit populations, so

that it will be possible to make comparative analyses. In addition, most data material sets enable follow-up studies of the participants to be undertaken, either by re-examining them or by merging the data with information from the Mortality Registry or the National Patient Registry. The latter, however, requires validation by the National Patient Registry.

Unfortunately, there is a lack of data elucidating health conditions in Sisimiut, as these are not included in SIF's population study 2005-2007, which should be made available before the construction of any aluminium smelting plant. Furthermore, it will be essential to follow up the possible derived effects of construction work and plant operations on health conditions. It may be expedient to obtain knowledge from other countries that have similar aluminium smelting work projects; among others, Norway and Iceland have had an aluminium smelting industry for some years.

1.3 Collecting new knowledge – SIF

The population studies done to date draw a picture of public health development since the beginning of the 1990s, and in connection with the Public Health Programme ongoing monitoring of the programme's goals and targets has been planned from 2009 to 2012. It is recommended coordinating any future monitoring programme relating to the creation of an aluminium smelting plant and other industries with general monitoring of the population's state of health. Future population studies should therefore adopt previous protocols' recommendation as a stepping stone to which data to collect as well as which health conditions it is particularly wished to monitor in the relevant study.

1.4 CAM

Under a joint programme, based on the work af AMAP (Arctic Monitoring and Assessment Programme), which is the international monitoring programme aimed at the Arctic region and approved by the Ethics Committee for Scientific Studies in Greenland (under the Commission for Scientific Research in Greenland (KVUG)), the Centre for Arctic Environmental Medicine has undertaken a series of population studies in Greenland to the following main ends:

1. To monitor blood levels of persistent organic pollutants (POPs)
2. To monitor blood levels of heavy metals
3. To evaluate the differences in levels found between different population groups in Greenland
4. To measure and evaluate any quantifiable health effects.

In order to obtain larger and more representative study groups, men and women in Greenland have been extracted for the studies in a systematic and randomizing fashion over the past nine years. Tests were done here for a series of heavy metals in blood and plasma, including Cd (cadmium), Hg (mercury), Pb (lead), Cu (copper) and Zn (zinc) as well as Se (selenium). In addition, analyses were done for fourteen different types of PCB (polychlorinated biphenyls), a number of organic pesticides: Aldrin, Chlordane, Dieldrin, DDT, Endrin, Heptachlor, Hexachlorbenzene, Mirex and Toxaphene. The study has since been extended with blood lipids, including fatty acid composition, triglycerides and cholesterol–both HDL and LDL cholesterol, which could act as dietary markers like health markers. While analysing the participants' blood for a variety of parameters, a standardized questionnaire study was also conducted at the same time, containing information about demographic, anthropometric and lifestyle factors including smoking, alcohol and dietary habits. In order to confirm or refute the smoking information given, subjects were also screened for Cotinine, a nicotine metabolite. In addition, examinations were done for contaminants as well as collecting nutrients in dietary samples.

1.5 Collecting new knowledge – CAM

To draw up an SMV study population: a "cohort" of 50 younger, healthy men aged 25-35 in each of the 3 towns of Nuuk, Sisimiut and Maniitsoq is suggested formed. These are chosen from a randomized draw from the national registration office in each town. A preliminary condition for inclusion is that the individuals experimented with are willing to participate in follow-up investigations for instance every 3 or 5 years. The size of the population has been chosen from earlier statistical power calculation conducted in relation to CAM's AMAP projects in Greenland 1999-2006. To achieve this size of cohort it may be necessary to draw up to dubble as many via the national registration office, as others' experience shows that follow-up investigations have a low percentage of commitment of max 40-50 %, however, this is not our experience in Greenland. Plan and budget are based on district medical officer Ph.D. Henning Sloth Pedersen conducting the investigation under the auspices of CAM.

Questionnaire common: same wording as in CAM's AMAP questionnaire is used in case of comparison/co-ordination. The questionnaire contains demographic questions and lifestyle questions: questions concerning smoking and alcohol. Total expected expenditure for drawing up the SMV study population: 1.1 million DKK.

2.0 Introduction

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3.0 SIF

The Centre for Health Research in Greenland (SIF), an offshoot of the National Institute of Public Health, has supplied a wealth of material on various aspects of health in Greenland over the past twelve years, including descriptions of the pattern of disease in Greenland, analyses of psychosocial health, environmental medicine, diet, cardiovascular disease, diabetes and mortality analyses.

Thus, since 1993, SIF has conducted a large number of population surveys and studies, with the last one, the fifth in the series, extending from 2005 to 2007, with data collection that has just ended in early October 2007.

SIF's data material relating to health conditions in Greenland

Project (year)	Participants	Geographical area	Study
Greenland I (1993-94)	1,728 people aged 18 or above	All towns and 21 settlements	Nationwide interview study supplemented with self-completed questionnaires about living conditions, lifestyle and health. Women (661 in total) were additionally interviewed about well-being and health in children aged 0-12 living at home. Clinical study with lab tests (subsample) to identify risk factors for cardiovascular disease and environmental exposure to pollution (264 people from Nuuk, Ilulissat and Uummannaq)
Greenland II (1997-99)	2,108 Greenlanders aged 18 or above	Denmark	Study of migration, living conditions, lifestyle and health among Greenlanders residing in Denmark (self-completed questionnaire) Clinical study with lab tests (subsample) to identify risk factors for cardiovascular disease and environmental exposure to pollution (739 people)
Greenland III (1999-2001)	1,961 Greenlanders aged 18 or above	Three towns on the west coast and four settlements in Uummannaq Municipality: Nuuk, Sisimiut, Qasigiannguit, Ikerasak, Saattut, Qaarsut, Ukkussissat	Interview study supplemented with self-completed questionnaires (all individuals) on health, disorders and lifestyle to elucidate diabetes and cardiovascular risk factors. Clinical study with lab tests (except in Sisimiut, in total 1,317)
Greenland IV (2002)	256 Greenlanders aged 34 or above	Denmark	Interview study with self-completed questionnaire about health, disorders and lifestyle that can elucidate diabetes and cardiovascular risk factors etc. among Greenlanders residing in Denmark. Clinical study with lab tests.
Greenland V (2005-07)	2,350 people aged 18+	West Greenland: 7 towns and 8 settlements	Interview study supplemented with self-completed questionnaires on living conditions, lifestyle and health. Clinical study with lab tests to identify risk factors for diabetes and cardiovascular disease.
Mortality registry (1968-2002)	14,209 deaths, incl. 13,368 with information about cause of death	Whole country	Register of deaths and causes of death among people whose address is recorded with the national register in Greenland.
Young people's well-being (2004-05)	508 schoolpupils aged 15-17 (odd 18-year-olds)	From ten schools in seven towns: Nuuk, Qaqortoq, Narsaq, Maniitsoq, Ilulissat, Upernavik, Tasiilaq	Anonymous cross-section study. Self-completed computer-based questionnaire on health and well-being. Particular focus on sexual assault.
The Ivaaq child cohort (1999-2005)	403 pregnant women and their newborn children	Nuuk, Ilulissat and Maniitsoq	Interview and blood samples with special focus on long-term effects of exposure to alcohol, tobacco and environmental pollution in the fetal state.
Mental health in the primary sector (1997)	376 patients aged 18-64 and their doctors	Nuuk and Qasigiannguit	Questionnaire study (self-completed) to shed light on mental health and reasons for seeking medical advice in patients at the Health Clinic and practice in Qasigiannguit (all patients and their GPs). Psychiatric interview (100 patients)

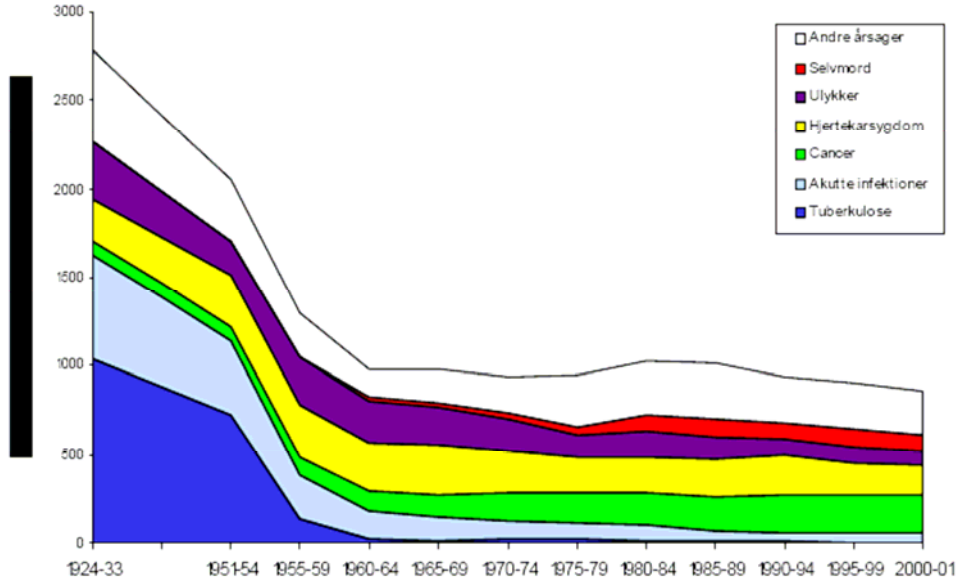
Number of participants or registrees from Nuuk, Maniitsoq and Sisimiut Municipality

Data	Nuuk	Maniitsoq	Sisimiut
Greenland I (1993-94)	352	79	162
Clinical study with blood sampling (subsample of Greenland I)	92		
Greenland III (1999-2001)	700		430
Greenland V (2005-07)	526	358	
Mortality registry(1968-2002)	2,193	1,092	1,090
Young people's well-being (2004)	157	84	
Ivaaq child cohort (1999-2005)	311	17	
Mental health in the primary sector (1997)	277		

Selected topic areas in the population studies Greenland I, III and V

Topic areas	Greenland I	Greenland III	Greenland V
Sociodemographic background information	X	X	X
Health status			
Self-evaluated health status	X	X	X
Health status measured by questionnaire SF-12			(X)
Self-reported illness, e.g. diabetes, cardiovascular disease, asthma	X	X	X
Cardiovascular disease (Rose Questionnaire)	X	X	X
Mental health incl. question about suicide	X	X	X
Use of health services	X		X
Lifestyle and behaviour			
The diet questions in Greenland V have been considerably expanded in relation to Greenland I and III, and include intake of 70 foods incl. portion size.	(X)	(X)	X
Smoking	X	X	X
Hash	X		X
Alcohol, incl. modified CAGE questionnaire and MAST	X	X	X
Exercise	X	X	
Physical activity level (International Physical Activity Questionnaire tailored to Greenland)			X
Living conditions (work, working environment, housing)	X	X	X
Clinical study			
Height, weight, waist measurement based on MONICA standard (WHO)	X	X	X
Blood pressure (seated) based on MONICA standard (WHO)	X	X	X
ECG (12 leads)		X	X
Oral glucose load		X	X
Lung function test (Vitalograph®) and prick test		X	
Ultrasound study of the carotid		X	X

Ultrasound study of fat in the abdominal region (Utrecht University)			X
Determination of fat percentage vs bioimpedance			X
Measurement of motion pattern and pulse for 3-4 days (Actiheart®, Cambridge University)			X
Lab tests			
Blood samples			
Serum, plasma, blood and urine for biobank		X	X
DNA		X	X
Cholesterol, triglyceride	X	X	X
Mercury, selenium, PCBs and pesticides	X	X	X
Other			
Nails (stable isotopes)			X
Urine albumin, creatinine		X	X

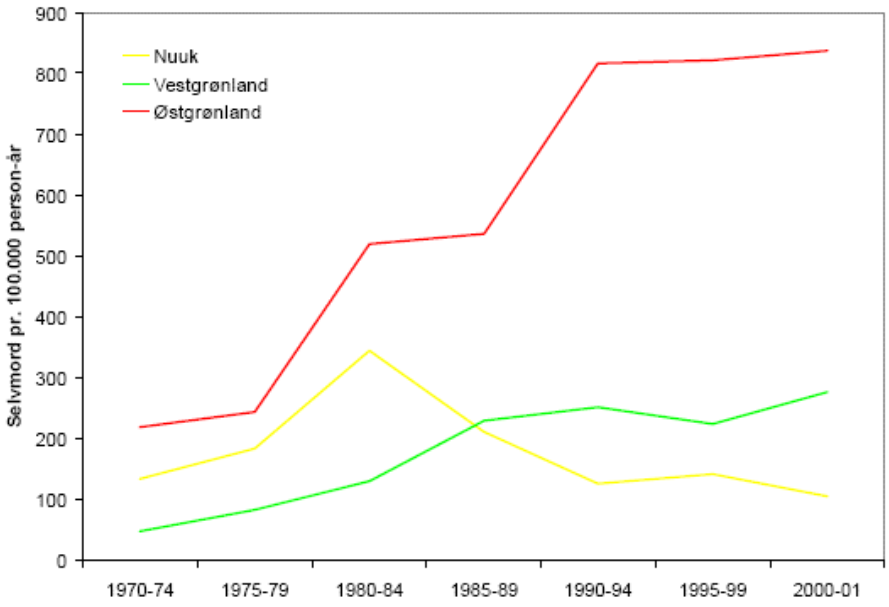


Figur 1. Aldersjusteret dødelighed pr 100.000 i Grønland. Baseret på Landslægens årsberetninger og siden 1968 på det grønlandske dødsårsagsregister

Figure 1: Age-adjusted mortality per 100,000 in Greenland. Based on the Chief Medical Officer's annual reports and, since 1968, on the Greenland Mortality Registry.

[Skema/diagram:]

Key:
Other causes
Suicide
Accidents
Cardiovascular disease
Cancer
Acute infections
TB



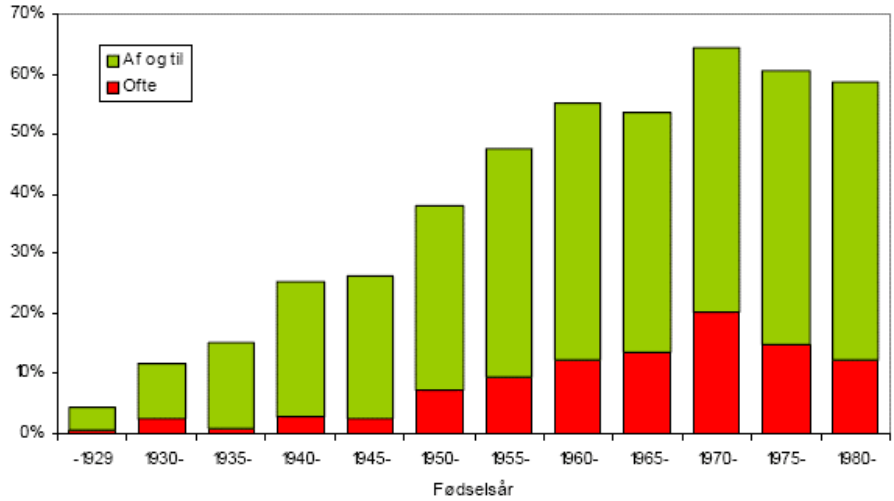
Figur 2. Dødelighed af selvmord i tre grønlandske regioner. Baseret på det grønlandske dødsårsagsregister.

Figure 2: Mortality from suicide in three regions of Greenland. Based on the Greenland Mortality Registry.

[Skema/diagram:]

Key:
Nuuk
West Greenland
East Greenland

Suicide per 100,000 person-years



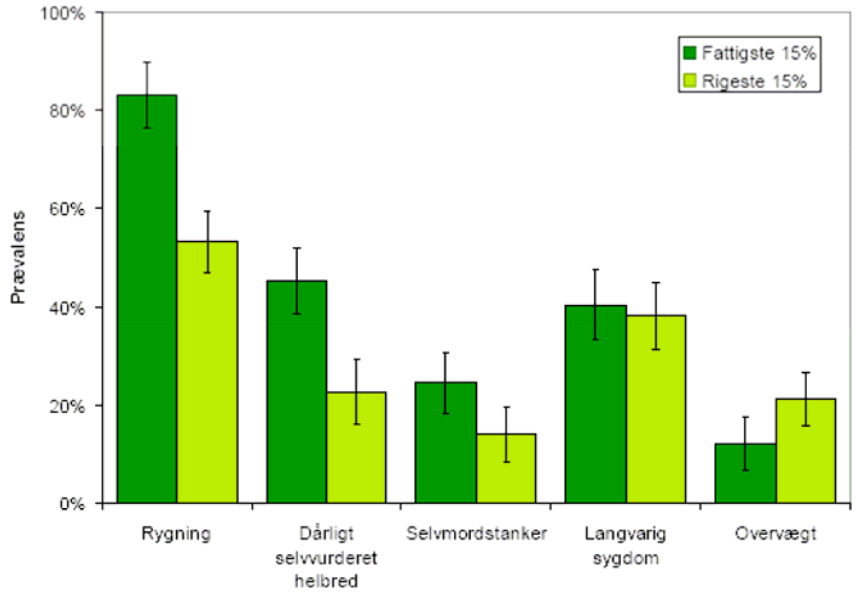
Figur 3. Andel deltagere i befolkningsundersøgelserne 1999-2006, der oplyser at have oplevet alkoholproblemer i barndomshjemmet. Efter fødselsår.

Figure 3: Proportion of participants in the 1999-2006 population studies stating that they have experienced alcohol problems in their childhood home. By year of birth.

[Skema/diagram:]

Key:
Occasionally
Often

Year of birth



Figur 4. Social ulighed i sundhed og forekomst af sygdom. Sammenligninger mellem de fattigste og rigeste 15% af befolkningen.

Figure 4: Social inequality in health and incidence of disease. Comparisons between the poorest and the richest 15%of the population.

[Skema/diagram:]

Key:
Poorest 15%
Richest 15%

Prevalence

Smoking

Poor self-evaluated health

Suicidal thoughts

Long-term illness

Obesity

Occurrence of selected health conditions in Greenland, 2005-07

	Nuuk and Maniitsoq N=553 (%)	Towns in the rest of West Greenland N=884 (%)
Smokes daily	297 (53.7)	532 (60.2)
Eats own or family member's haul/quarry every week	147 (26.5)	370 (41.9)
Poor self-evaluated health status	191 (34.5)	277 (31.3)
Back pains	220 (39.7)	344 (38.9)
Suicidal thoughts ever	109 (19.8)	131 (14.8)
Often alcohol problems in childhood home	113 (20.5)	115 (13.0)
Obesity (BMI 30+)	129 (23.3)	217 (24.5)
High blood pressure	177 (32.0)	332 (37.5)

Occurrence of selected health conditions in Nuuk, Maniitsoq and Sisimiut in the studies Greenland I and Greenland III

	1993-94 N=416 (%)	2005-07 (Nuuk and Maniitsoq only) N=553 (%)
Smokes daily	260 (62.5)	297 (53.7)
Eats own or family member's haul/quarry every week	250 (60.2)	147 (26.5)
Poor self-evaluated health status	64 (15.4)	191 (34.5)
Back pains	69 (16.6)	220 (39.7)
Suicidal thoughts ever	79 (19.0)	109 (19.8)
Often alcohol problems in childhood home	38 (9.1)	113 (20.5)
Obesity (BMI 30+)	50 (12.1)	129 (23.3)
High blood pressure	69 (16.7)	177 (32.0)

4.0 Future analyses of health conditions in Greenland

There are many factors that directly and indirectly influence the disease pattern in a population, incl. lifestyle, education, economic climate, pollution and the derived consequences of investments in construction and infrastructure. There are several options for collecting data to monitor a population's state of health. Register follow-up of routinely collected data on causes of death and causes of hospitalization are one way of capturing data. However, many data items can only be obtained by means of population studies, e.g. lifestyle factor trends, which provide information about risk factors that should be homed in on for preventive purposes.

The strong point about population studies is that information is also collected from people who have not been in contact with the health services. The threshold for seeking medical advice and access to health services are not identical for everyone. An astonishing number of people with persistent disorders do not go to their GP, and an insight into these people's health behaviour, living conditions and health can therefore be obtained exclusively by collecting information from the individual. Where the participants make up a representative section of the population, demographic studies provide a sound insight into health behaviour, state of health and illness patterns among the population. Demographic studies can be an excellent means of monitoring health initiatives and offering a snapshot of the population's state of health. Demographic studies can provide advance warning of the disorders that will assume importance for the illness pattern in future, and therefore contribute information about both present and future use of health services. Thus, results from population studies are also relevant to health policy agenda and can thereby have a derivative effect on the health services' function and organization. The population studies done to date draw a picture of public health development since the beginning of the 1990s, and in connection with the Public Health Programme ongoing monitoring of the programme's goals and targets has been planned from 2009 to 2012. It is recommended coordinating any future monitoring programme relating to the creation of an aluminium smelting plant and other industries with general monitoring of the population's state of health. Future population studies should therefore adopt previous protocols' recommendation as a stepping stone to which data to collect as well as which health conditions it is particularly wished to monitor in the relevant study.

4.1 Knowledge that is lacking, in both the current and the longer term

Prior to creating and operating an aluminium smelting plant in Greenland, it is expedient to have a comprehensive picture of health conditions available; this requires certain data to be collected.

The Greenland V population study includes both Nuuk and Maniitsoq with two settlements, but not Sisimiut. Thus there are no new, comparable health data for Sisimiut, which is unfortunate, were Sisimiut Municipality to be selected as the site for establishing an aluminium smelting plant. So no status report is available on the state of health prior to the construction of any aluminium smelting plant, which is essential in order to be able to evaluate whether there is

any development in the state of health of Sisimiut over time. It is of some urgency, therefore, to conduct a population study in Sisimiut Municipality with a similar protocol to that for Nuuk and Maniitsoq. The study should include 350-500 adults from both the town and settlements, and should be conducted as soon as possible. The budget for a population study in Sisimiut Municipality, including 300 participants from Sisimiut and 150 participants from the settlements, totals some DKK 1.8 million, cf. Appendix 2.

4.2 Studies of the population's health status during the construction phase

The construction of an aluminium smelting plant calls for the building of hydroelectric power stations, transmission lines, ports and roads as well as the actual smelting works. The building phase is expected to take 4-5 years and involve 3-4,000 people [IMN Working Group, 2007], primarily foreign manpower with specialist know-how—mainly men. Such a massive increase in the number of foreign men in the townscape compared to the number of Greenland men and thus a preponderance of men in relation to women may, as conditions in the 1960s did, create social problems [Bjerregaard, 2004], impacting on health, including several episodes of violence, suicide, alcohol-related illness and poor psychosocial well-being. Both the construction phase and the operating phase will also pose a considerable challenge to the health services in the relevant municipality.
During the construction phase it might be expedient to monitor violence, suicide, alcohol-related illness, poor psychosocial well-being and abortions with data from sources incl. the health services, the police and the department of medical officers and health.

4.3 Studies of the population's health status during the operating phase

The operating phase of the aluminium smelting plant requires taking on about 750-1,000 people, the majority of whom are expected to consist of unskilled women and men. There is expected to be an increase in the number of inhabitants owing to people moving there to take up residence, which in turn will require a certain volume of public works (health services, day-care facilities, schools etc.). All other things being equal, the creation of jobs will result in increased health, with several studies confirming that occupational activity has a

beneficial effect on people's state of health. People not in gainful employment have a 2-3 times' higher mortality rate than people in employment.
It will be essential to monitor the development of chronic disorders, living conditions and mental health in the population directly or indirectly affected by the knock-on effects of creating the aluminium smelting plant.

4.4 Occupational-medicine studies of the workers at the aluminium smelting plant

Studies of the work at an aluminium smelting plant indicate that some working processes may be associated with exposure to ultrafine dust particles [Thomassen et al., 2006] (e.g. fluorine, aluminium oxide, cryolite [Hoflich et al., 2005]) and other forms of air pollution (e.g. sulphur dioxide, tar-like substances). However, such pollution depends on the design of the project, for which reason the specific impact on the working environment will depend on this. Results from research into the possible health consequences of work in an aluminium smelting plant indicate that, depending on the length and extent of exposure to pollution, the work may involve an increased risk of developing respiratory problems [Larsson et al., 2007; Fritschi et al., 2003], e.g. in the form of asthma [Barnard et al., 2004; Taiwo et al., 2006; Kongerud et al., 1994; Mapp et al., 2005] and cancer (e.g. bladder cancer [Gaertner and Theriault, 2002]). It suggests that an increase in the extent of exposure to tar-like substances is reflected in increased bladder cancer occurrence [*Aluminiumindustriens Miljøsekretariat* (Environmental Secretariat of the Aluminium Industry) (AMS), 2000]. It should be noted here that modern plants primarily make use of so-called pre-bake technology, in which the anodes are pre-baked so that exposure to tar-like substances will be radically eliminated during aluminium electrolysis as compared to the somewhat older "Søderberg technology".
In order to monitor the occurrence of symptoms and illness, therefore, it will be appropriate to collect knowledge about the state of health among workers at the smelting plant on a regular basis, including data that can shed light on the occurrence of medically diagnosed asthma, respiratory symptoms and pulmonary function, in both potentially exposed and non-exposed individuals. More detailed guidelines for monitoring are to be developed in accordance with the project design as well as regional/national legislation and agreements. In this context it may be relevant to use the experience gained from monitoring health among workers at aluminium smelting plants in other countries as a springboard; among others, Iceland and Norway have many years' experience of constructing and operating aluminium smelting plants.

5.0 Summary

This review of the data material that will be available to SIF for analysing health conditions in Greenland shows that data have been gathered from a broad section of the country's population. Data thus include information from both towns and settlements; pregnant women, infant neonates, children aged 0-12, schoolchildren aged 15-17 and adults 18 or above. All data material includes sociodemographic background information, health, living conditions and lifestyle, making it possible to shed light on the scope and distribution of illness and risk factors for chronic disorders. The bulk of the data material additionally contains information collected through clinical studies supplemented with blood and urine sample measurements, making it possible for adults aged 18 and above in particular to shed additional light on e.g. chronic disorders like asthma, cardiovascular disease and diabetes as well as the extent of pollution from environmental contaminants.

What all the data material has in common is that the information obtained in a study has generally also been sourced from other data material describing similar health conditions in Greenland, Denmark or other Inuit populations, so that it will be possible to make comparative analyses. In addition, most data material sets enable follow-up studies of the participants to be undertaken, either by re-examining them or by merging the data with information from the Mortality Registry or the National Patient Registry. The latter, however, requires validation by the National Patient Registry.

Unfortunately, there is a lack of data elucidating health conditions in Sisimiut, as these are not included in SIF's population study 2005-2007, which should be made available before the construction of any aluminium smelting plant. Furthermore, it will be essential to follow up the possible derived effects of construction work and plant operations on health conditions. It may be expedient to obtain knowledge from other countries that have similar aluminium smelting work projects; among others, Norway and Iceland have had an aluminium smelting industry for some years.

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In order to obtain larger and more representative study groups, men and women in Greenland have been extracted for the studies in a systematic and randomizing fashion over the past nine years. Tests were done here for a series of heavy metals in blood and plasma, including Cd (cadmium), Hg (mercury), Pb (lead), Cu (copper) and Zn (zinc) as well as Se (selenium). In addition, analyses were done for fourteen different types of PCB (polychlorinated biphenyls), a number of organic pesticides: Aldrin, Chlordane, Dieldrin, DDT, Endrin, Heptachlor, Hexachlorbenzene, Mirex and Toxaphene. The study has since been extended with blood lipids, including fatty acid composition, triglycerides and cholesterol–both HDL and LDL cholesterol, which could act as dietary markers like health markers. While analysing the participants' blood for a variety of parameters, a standardized questionnaire study was also conducted at the same time, containing information about demographic, anthropometric and lifestyle factors including smoking, alcohol and dietary habits. In order to confirm or refute the smoking information given, subjects were also screened for Cotinine, a nicotine metabolite. In addition, examinations were done for contaminants as well as collecting nutrients in dietary samples.

Heavy metal contaminant	Occurrence	Toxicity	Pollutants/ pathways
Mercury (Hg)	Natural occurrence Industrial use Increasing in the environment	Accumulates, severely toxic, damage to central nervous system	Flesh from fish and meat from large marine mammals
Cadmium (Cd)	Industrial use On decline in the environment	Accumulates in kidneys, kidney damage, possibly	Organs from large marine animals, cereals and

		carcinogenic	especially smoking

Lead (Pb)	Industrial, tanks, water pipes, lead shot, petrol additives; on decline in the environment	Accumulates, neurotoxic, especially to infants	Rub-off effect from plumbiferous containers, tobacco, lead shot
Selenium (Se) – non-contaminating	Natural occurrence, soil, plants, especially in meat and skin from large marine animals	Nutrient only toxic at very high doses	Certain soil types, ingesting *mattaq*[1] can produce high levels

Contaminant	Occurrence	Toxicity	Pollutants/pathways
PCB, covers 209 different related substances	Man-made chemical, industrial use, now banned, on decline in the environment	Accumulates; varying toxicity. Immune and hormone disrupting effects; long-term effects	Accumulates in ocean food chains; oily fish and marine animals
DDT and DDE	Man-made insecticide, pesticide, now banned. On decline in the environment	Long-term effects, immune and hormone disrupting	As above
Chlordanes, hexachlorbenzene, HCH, mirex, toxaphenes	Chemically manufactured insecticides and fungicides. Restricted or banned in most countries	Accumulates, varying toxicity, some are carcinogenic	As above

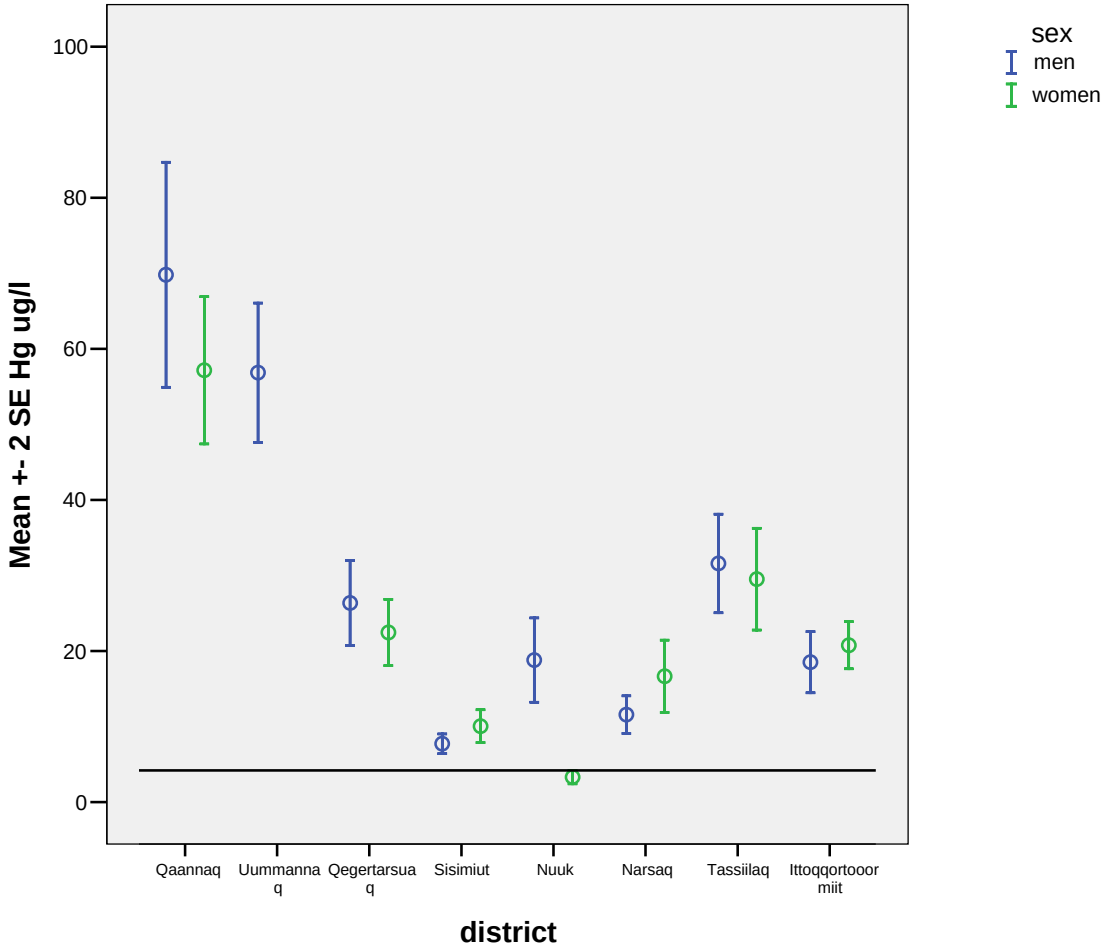
[1] *Mattaq* is a Greenlandic delicacy from the skin of the narwhal or beluga, generally served with the fat on.

6.1 Heavy metals

Both among pregnant women, non-pregnant women and their male peers, the same general picture emerged with regard to blood levels of total mercury (Hg), cadmium (Cd) and lead (Pb). The lowest mercury values were found among pregnant women in Nuuk and Disko Bay, and as a rule the non-pregnant women came higher than pregnant women but lower than men from the district. The highest levels were found in Uummannaq at 52 microgrammes/litre and Qaannaq (64 microgrammes/litre).

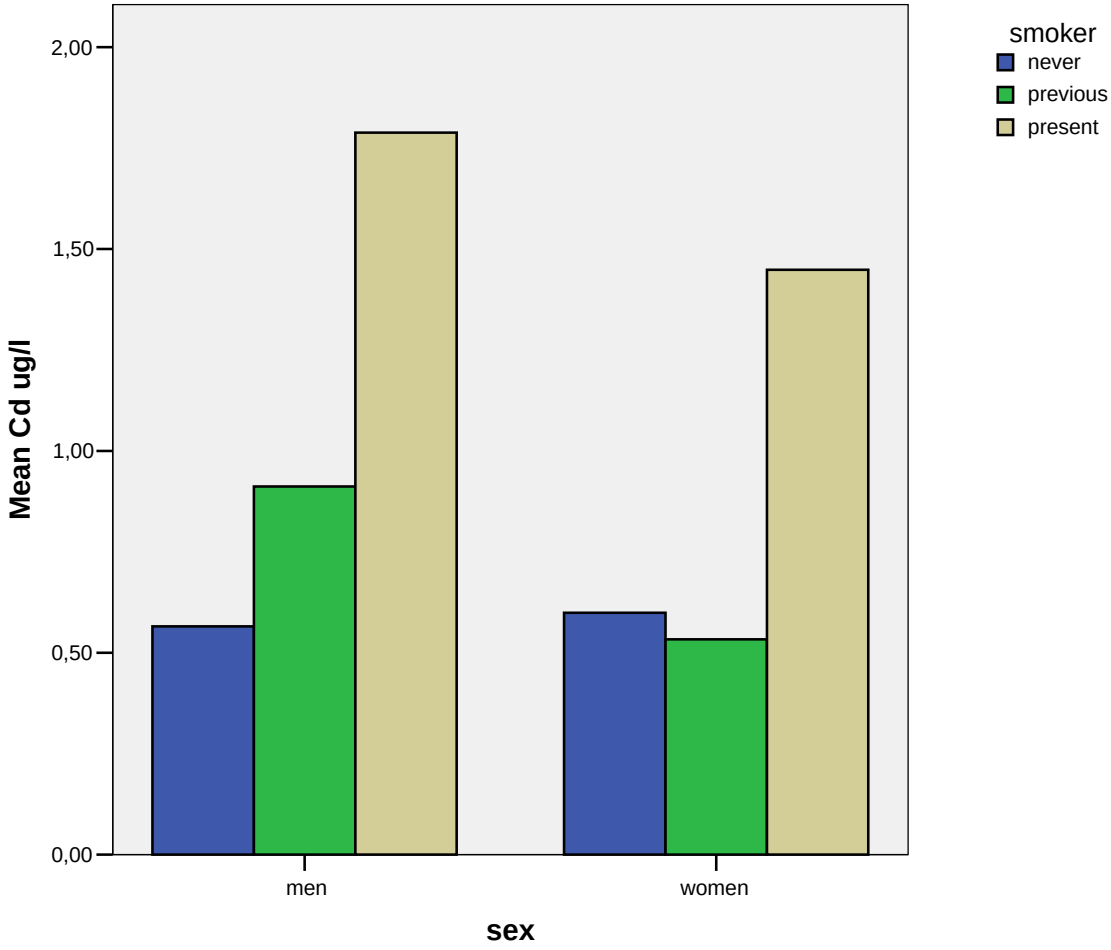
Qaannaq and Uummannaq also rank high with regard to selenium, which is not a contaminant but a naturally occurring mineral found in large amounts in *mattaq* and elsewhere. The above-average blood levels for Hg also corresponded to the number of people whose blood level exceeded US-EPA blood mercury threshold values of 4.4 microgrammes per litre. Among pregnant women in Nuuk (1997), 44% exceeded the threshold values (not shown in the figure) but in 2005 90% of women from Nuuk were under the threshold value, while in all the other population groups 80-100% exceeded the threshold values.

Average levels of mercury in the blood (microgrammes/litre) among 20 to 50-year-old men and women in 8 Greenland districts, 1999-2006, as compared with US-EPA reference line of 4.2 microgrammes/litre.



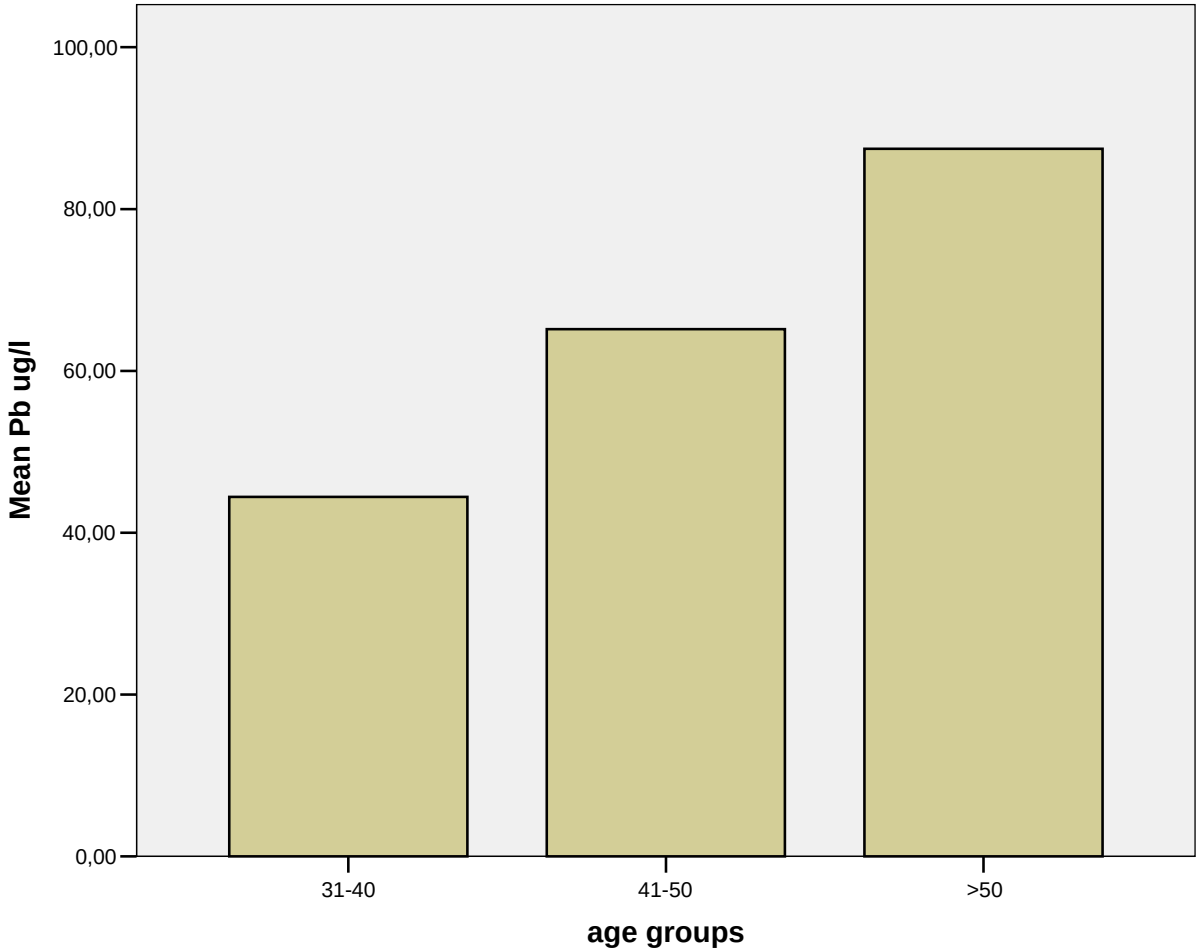
Geometrical mean values for cadmium and lead were only moderately raised. Cd levels ranged from 0.98 microgrammes/litre in Sisimiut to 2.13 microgrammes in Ittoqqortoormiit. The higher Cd values indicated smoking among the subgroups; on average, Cd in smokers was approximately double that in non-smokers.

Figure 2. Mean values for cadmium in the blood (microgrammes/litre) among men and women, and in relation to smoker status. There is no clear age accumulation of Cd and no systematic difference between individual districts.



The lead content in the blood was not particularly high, averaging between 20 and 77 microgrammes per litre; the threshold value of 100 microgrammes per litre was exceeded by only 2-3% of the women and 3-10% of the men. However, there were a few outlying values: for instance, a 20-year-old woman from Narsaq had a blood lead value of 404 microgrammes/L and concurrently had a high Cd value of 6.8; she claimed never to have smoked, which sounds unlikely. But there is no ruling out industrial or occupational pollution or contamination from local drinking water, as Narsaq is an area very rich in minerals.

Lead content in the blood (microgrammes/litre) among men in Nuuk in relation to age group; the older age group is characterized by a high intake of wildfowl shot with lead shot.



6.2 Other metals

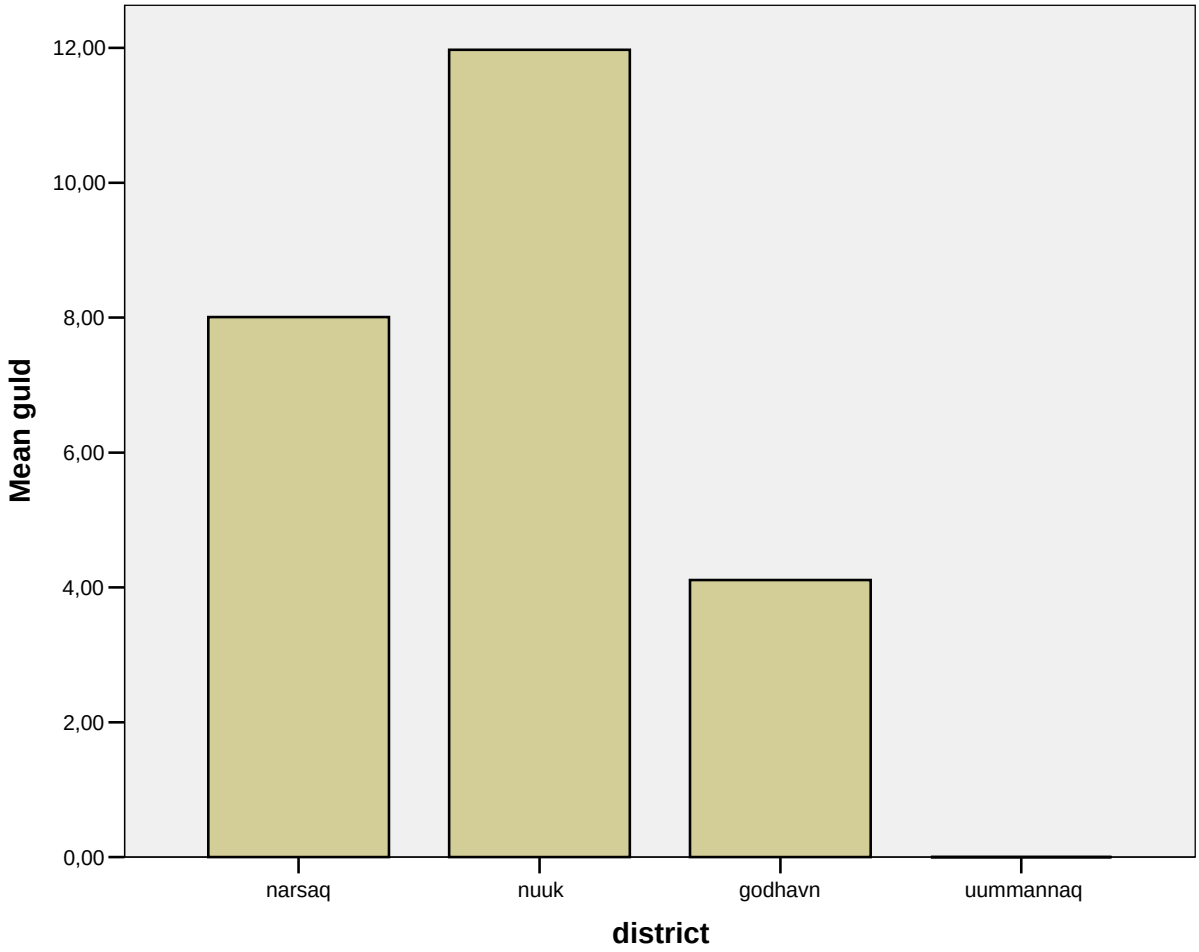
Since 2004 DMU (the Danish National Environmental Research Institute (NERI)) has introduced a new method for determining metals in blood and other tissue, enabling virtually all metals in the periodic system to be measured.

This has also been undertaken for blood samples from Uummannaq, Nuuk, Godhavn and Narsaq, and for food samples from Uummannaq and Narsaq, resulting in a total of 45 elements originally measured, not all of which were above the detection limit. Moreover, some are so rare as to be of no interest in terms of human biology. For the time being, therefore, we have opted to include 15 elements in the population study. But that does not preclude us from including more if there proves to be interest.

The calculation showed that Greenland blood levels for Ca, Cu, Fe, Mg, P and Zn can be regarded as being within the normal range for international studies (despite a low intake of Ca). The blood values for Se, on the other hand, were significantly higher than in other countries. An interesting fact that emerged was that there were detectable levels of both precious metals and uranium, which

varied from town to town and were apparently not related to dietary make-up. We can only assume, therefore, that this was a soil-related phenomenon.

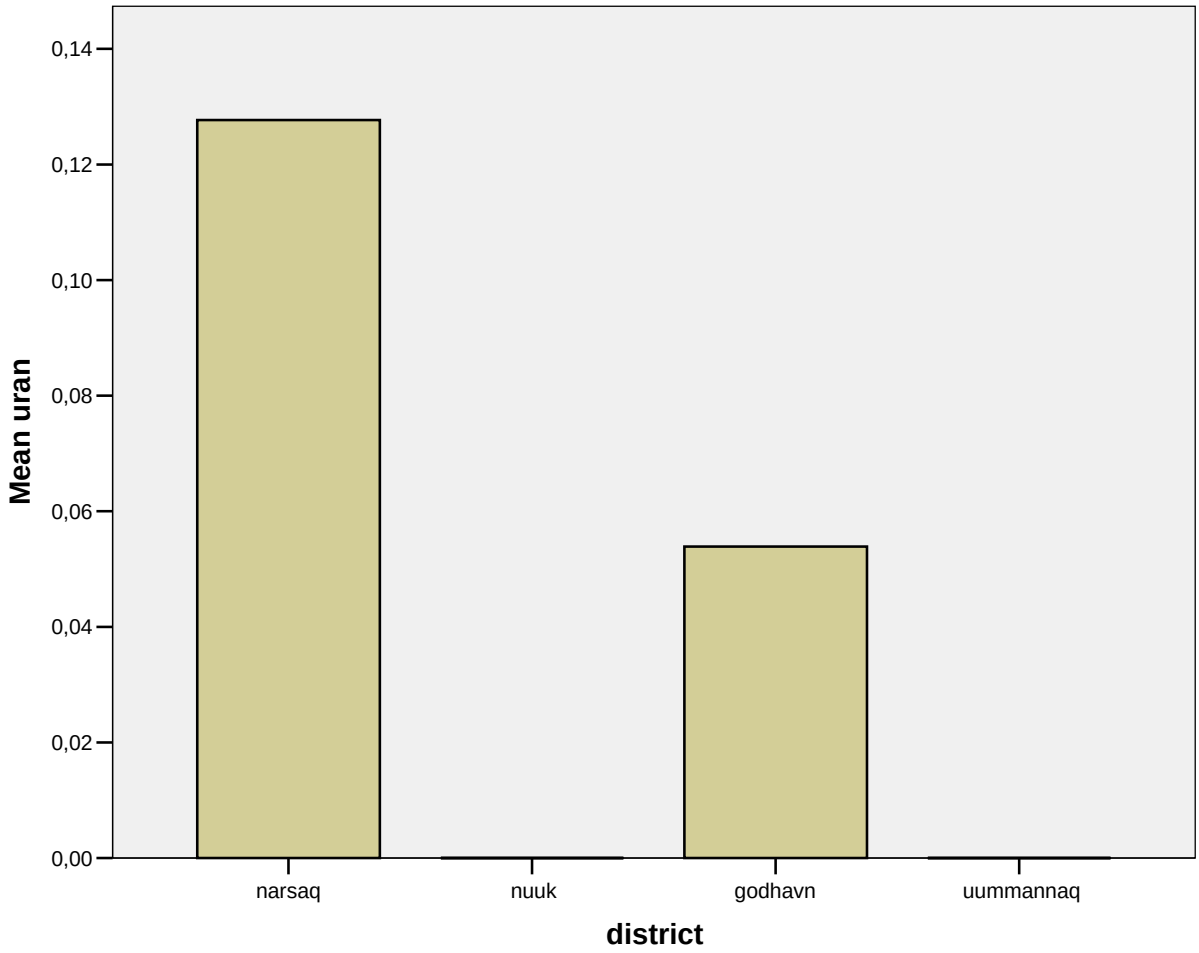
Figure 4, showing the blood's content of gold (microgrammes/litre) in four districts. Uummannaq is below the detection limit.



Function	Element	Presumed source
Nutrients	Ca,Cu,Fe,Mg,P,Se,Zn	Foodstuffs and drinking water
Heavy metals, toxic	Cd,Hg,Pb (Ba)	Foodstuffs and tobacco
Precious metals	Ag,Au,Pt	Geology of the local area
Radioactive metals	Th,U	Geology of the local area

The correlation analysis shows that the presence of silver and uranium was significantly associated and that gold, copper and platinum were mutually associated; this too points to geologically determined sources.

The uranium content in the blood (microgrammes/litre) in four districts. Nuuk and Uummannaq are below the detection limit.



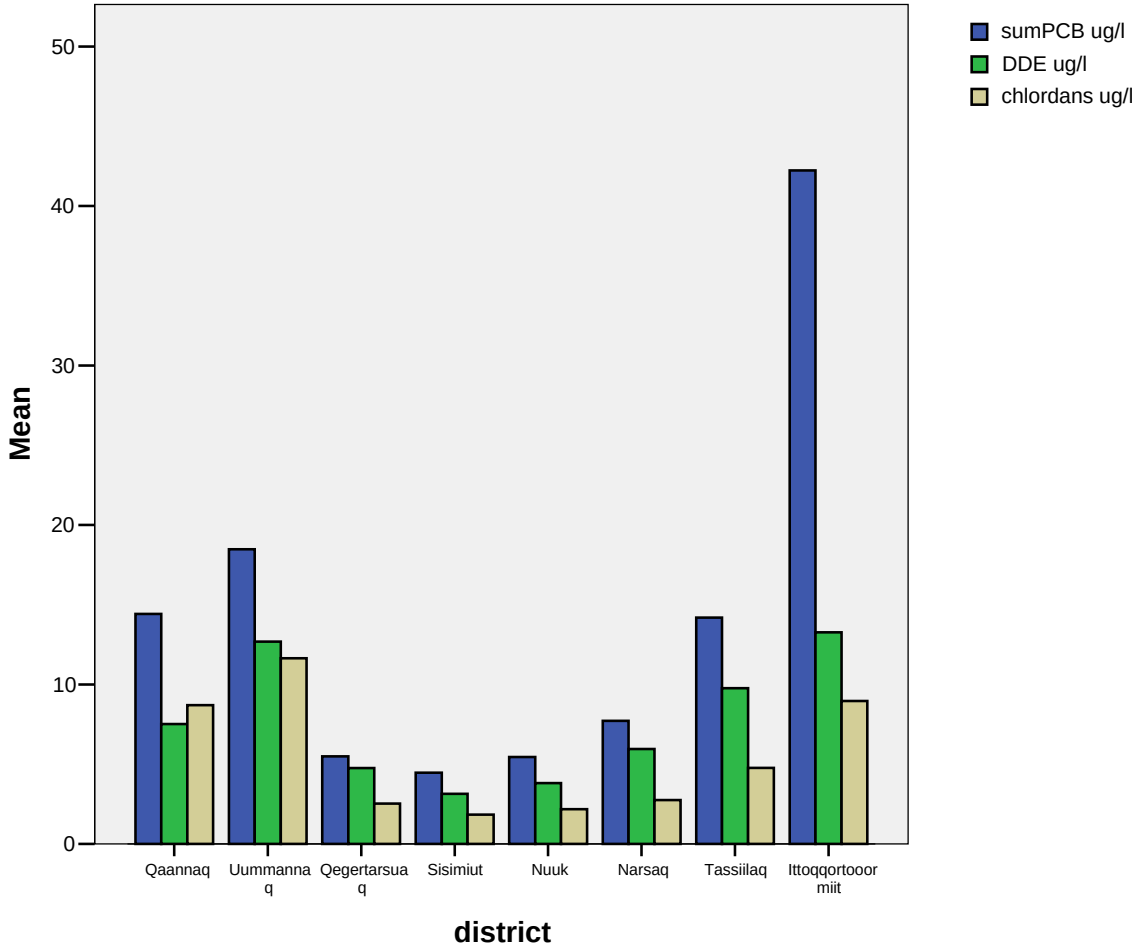
6.3 Organochlorines (POP): pesticides, PCBs and toxaphenes

The geographical pattern for blood levels of persistent organic contaminants differed very slightly from the pattern for heavy metals. The blood values generally highest for POP were found in Ittoqqortoormiit, particularly among men. This was first shown in a pilot study from 1997 and later confirmed among a larger study group in 1999-2000.

Hexachlorphene, beta-HCH and toxaphenes (not shown) were relatively uniformly distributed geographically, while chlordanes, DDT and particularly PCB were at very high levels in Ittoqqortoormiit.

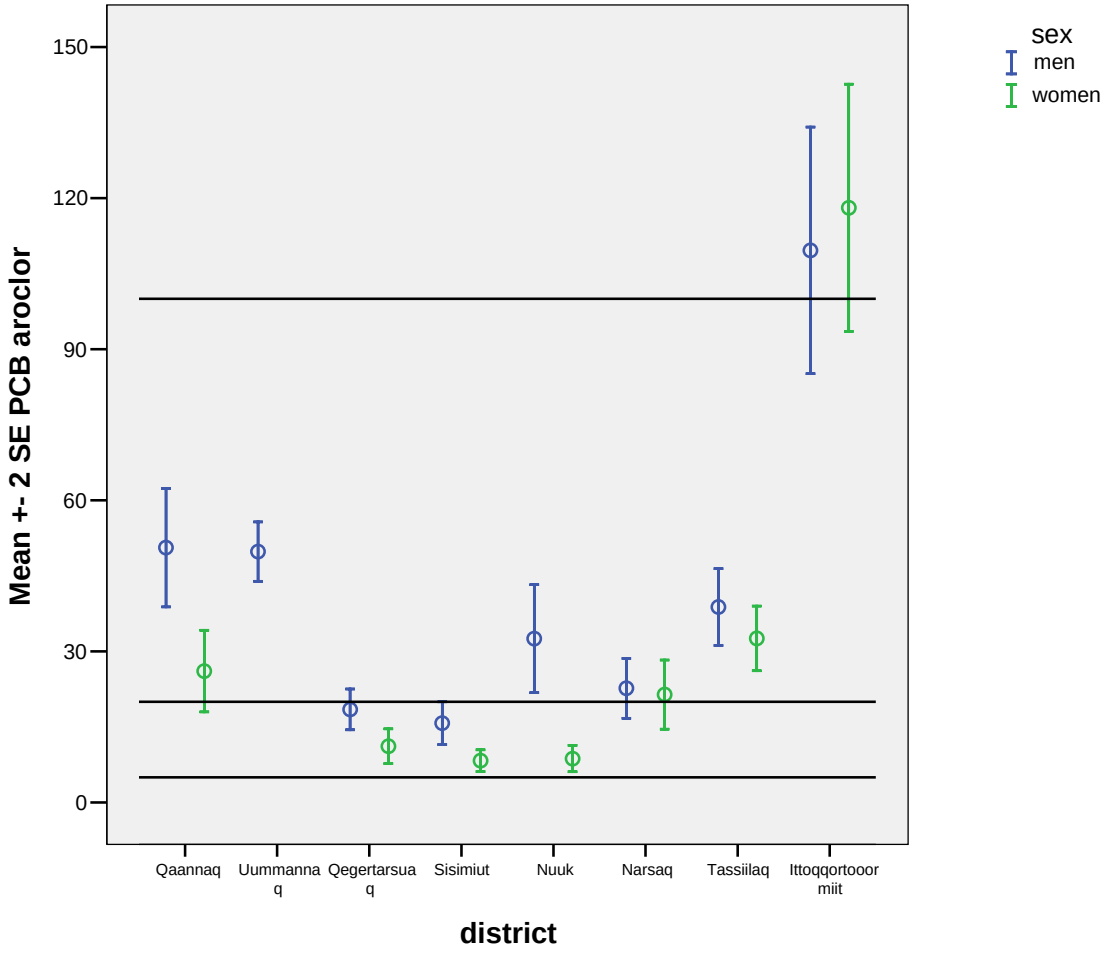
PCB values here were up to 3-4 times higher than those from the other locations and can also be regarded as the highest concentrations measured among Arctic populations.

Plasma POP levels in Greenland, 1999-2006, by district, µg/litre



The mean values for PCBs were also indicative of the number of blood samples that exceeded the Canadian threshold values for PCB-Arochlor 1260.
Here 93-100% from all districts exceeded 5 microgramme/L, which is the threshold value for ”concern”—the ”level of concern” for pregnant women and fertile women. In Qaannaq, Uummannaq, Nuuk and Tasiilaq all men exceeded the 20 microgramme ”concern” threshold value for men. Both men and women in Ittoqqortoormiit exceeded the 20 microgramme ”concern” threshold value for men and among men 43% exceeded the “level of action” threshold value of 100 microgrammes/Litre.

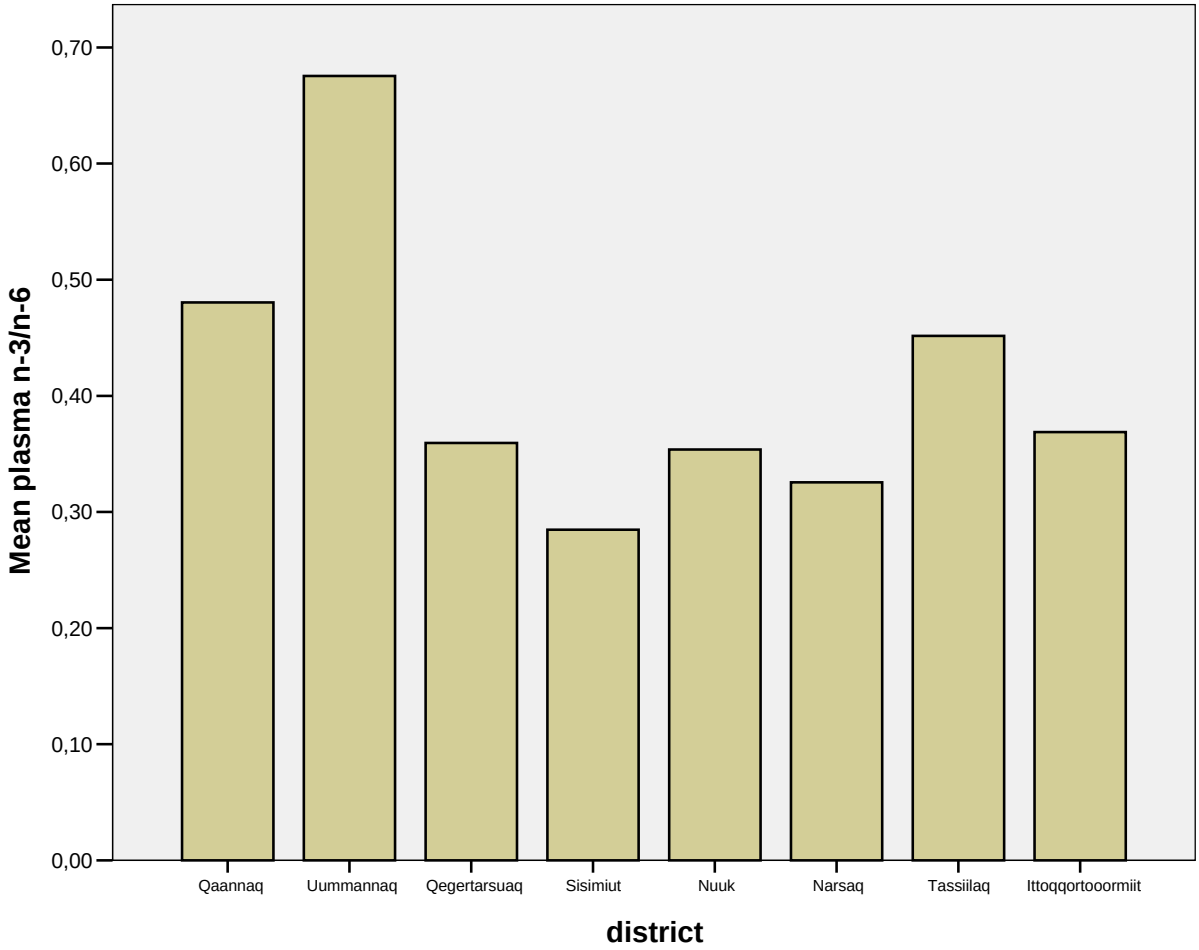
Plasma levels of PCB in relation to Canadian threshold values of 5, 20, and 100 microgrammes/Litre, respectively



6.4 Fatty acids in phospholipids

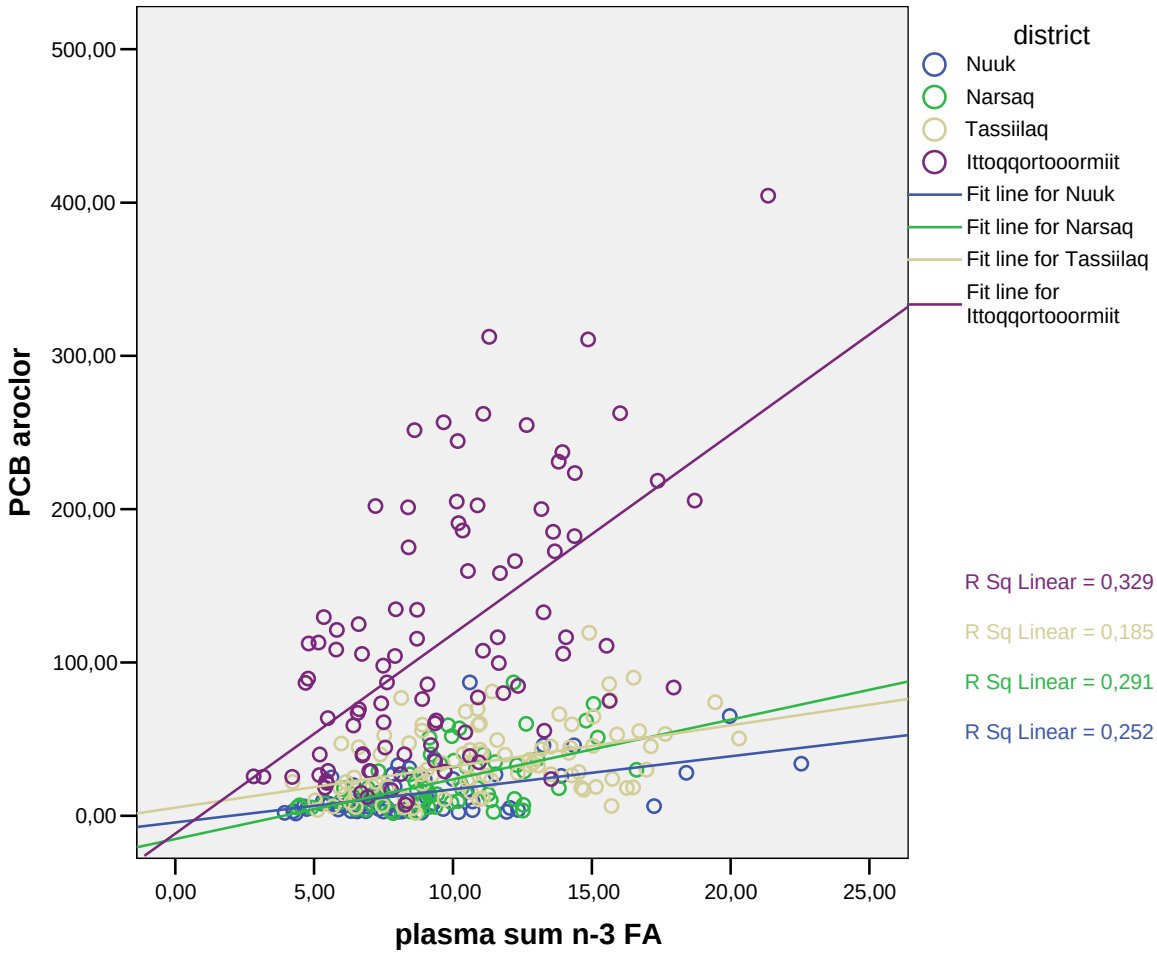
The n-3 fatty acid content in plasma lipids and the ratio between n-3 and n-6 fatty acids indicates the relative intake of traditional and imported food, where a high n-3:n-6 ratio indicates a high intake of local produce, particularly marine mammals and fish.

The lowest average is seen in Sisimiut, reflecting a diet with the least content of traditional foodstuffs, while Uummannaq has the highest average, even higher than both Qaanaaq and Ittoqqortoormiit, both of which are located further north. However, this may be due to the fact that among the study population in Uummannaq there was a relatively greater number of hunters, whalers and sealers and the population consisted exclusively of men.



By comparing the different figures showing, respectively, fatty acids and contaminants in blood and serum, it is immediately possible to see that there is some correlation between these results, as high n-3/n-6 values accompany high contaminant levels, particularly mercury and PCB and vice versa. But although there is a strong link between n-3 and PCB in plasma, there is a great difference in the gradient for the individual districts, with Ittoqqoortoormiit in particular standing out for a much higher PCB content per gramme of n-3 fatty acid. To put it another way, the fat of animals is more contaminated there than elsewhere. This is also found in direct measurements of the animals' content of contaminants. But the ratio is further amplified by the fact that the people of Ittoqqoortoormiit eat a considerable amount of polar bear, which is high up in the food chain.

Comparison between plasma content of n-3 fatty acids and PCBs for different districts. Only four districts have been included for the sake of clarity



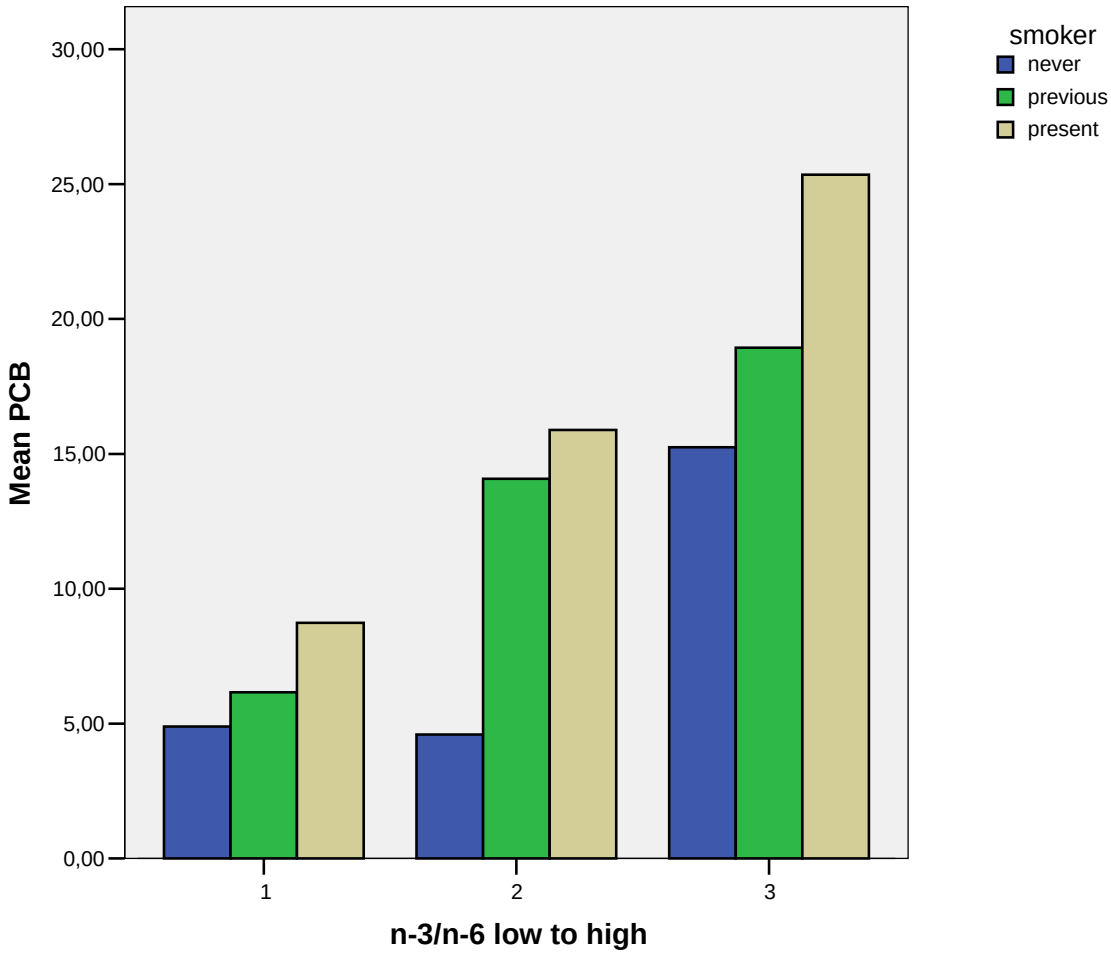
These parameters, which indicate a firm link between contaminant load and consumption of local marine produce, can additionally be documented by statistical, so-called multiple regression analysis, showing that the most important predictors for high contaminant load are as follows:

1. Advanced age, as contaminants are only excreted particularly slowly and therefore accumulate with age.

2. Smoking, as smokers have higher contaminant levels than non-smokers (presumably due to slower breakdown or excretion of the toxins).

3. High plasma ratio between n-3 and n-6 fatty acids, indicating a high intake of n-3 fatty acids from marine fish and mammals found in the traditional diet.

PCB content in plasma shown as a function of n-3 intake, 3 groups, and smoking, 3 groups, for the whole of Greenland. N=650.



7.0 Recommendations

On the basis of the population studies described above and supplementary studies of the nutrient and contaminant content in Greenlandic meals, we would like to offer some advice that addresses both the contaminant problem, nutritional considerations and the potential health problem connected with overweight.
In 2007 Greenland's Nutrition Council sent out a revised diet and lifestyle advice sheet, which very closely approximates that below, albeit in a slightly different order of priority.

1. The advice about "eating a varied diet" should apply both to diet in general and to the Greenlandic products eaten as part of it, because by varying the kinds of local products you also vary the differential contaminant load.

2. The intake of marine mammals should not be increased beyond the present level, but nor should it be substantially lowered, owing to its valuable fatty acids, vitamins and minerals. Certain large animals ranking high in the food chain, such as the polar bear for example, should only be consumed as an extremely rare delicacy.

3. Although a relatively large amount of fish is already eaten in Greenland, we can certainly recommend an increase in fish intake, preferably varied, again. Fish is far less contaminated than larger marine animals and contains all the good fatty acids and vitamins.

4. Terrestrial mammals like reindeer and musk oxen have healthy meat rich in protein with a low content of contaminants, so the use of these hunted animals can be increased without risk.

5. Since, apart from its other harmful effects, smoking increases contaminant levels, the level of smoking should be reduced.

6. Intake of fruit, vegetables and potatoes that do not contain contaminants but contain important vitamins and antioxidants should be increased, and the supply situation should accommodate this possibility.

7. Intake of sugar and sweetened products in particular is on the increase in Greenland, particularly among the young, and should be reduced through advice, counselling and even control measures.

8. As a countermove to the increased incidence of obesity, the level of physical activity should be increased and facilities improved. From the point of view of maintaining a healthy lifestyle with appropriate physical activity, therefore, it may be desirable for the population to continue hunting and fishing, preparing local products and retaining these as an essential component of their diet.

9. Drink water (instead of soft drinks and pop etc.). There is ample water and ice in Greenland, but not everyone is privileged to have a good, fresh, tasty water supply and the situation ought to be improved.

8.0 Collecting new knowledge – CAM

To draw up an SMV study population: a ”cohort” of 50 younger, healthy men aged 25-35 in each of the 3 towns of Nuuk, Sisimiut and Maniitsoq is suggested formed. These are chosen from a randomized draw from the national registration office in each town. A preliminary condition for inclusion is that the individuals experimented with are willing to participate in follow-up investigations for instance every 3 or 5 years. The size of the population has been chosen from earlier statistical power calculation conducted in relation to CAM's AMAP projects in Greenland 1999-2006. To achieve this size of cohort it may be necessary to draw up to dubble as many via the national registration office, as others' experience shows that follow-up investigations have a low percentage of commitment of max 40-50 %, however, this is not our experience in Greenland. Plan and budget are based on district medical officer Ph.D. Henning Sloth Pedersen conducting the investigation under the auspices of CAM.
Questionnaire common: same wording as in CAM's AMAP questionnaire is used in case of comparison/co-ordination. The questionnaire contains demographic questions and lifestyle questions: questions concerning smoking and alcohol.
Total expected expenditure for drawing up the SMV study population: 1.1 million DKK.

9.0 Konklusion

Health is undoubtedly the most precious possession of any living being by far, taking precedence over everything else in this life. Thus the World Health Organization (WHO) defines health as *“a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”.*

In order to gain some impression of the consequences that an aluminium smelting plant may assume for health, one needs to look at the individual components that go to make up the overall picture of health. In this connection one needs to look, above all, at health conditions for those whose working and day-to-day lives are localized around the smelting works, then health conditions for the residents and the environment in the areas neighbouring the smelting works. By its very nature an aluminium smelting works will affect everything and everyone around it with:

GAS escape: The gases that cause the greatest concern by far are:

Fluorides, especially hydrogen fluorides, which are extremely toxic and have a destructive effect on plant growth and decalcification in mammals, with brittleness of the bones as a result. In addition, fluorine damages the teeth and, furthermore, the fluorides accumulate in marine animals with migration up through the food chain.

PAHs (polycyclic aromatic hydrocarbons) such as benzopyrenes, which generate serious air pollution and are severely carcinogenic, causing cancer of the lung and bladder.

SO_2 (sulphur dioxide), which is converted into the caustic and toxic sulphuric acid. This gas forms the prime constituent of acid rain, resulting in the poisoning of plants and animals. An escaping discharge of sulphur dioxide can spread across an area with a radius of up to 100 kilometres.

CO_2 (carbon dioxide) with the well-known greenhouse effect, with which the whole wide world is currently so preoccupied.

LIQUID WASTE: Dissolved organic compounds as well as suspended solids, resulting in impaired visibility in the area.

Oils and lubricating oils: detrimental to health either as a result of direct contact or through pollution of the surroundings.

SOLID WASTE: generated from the linings of large vessels. These substances are highly toxic to both plants and animals, as well as the environment.

In order to achieve the best possible protection, safeguarding everything and everyone, including the staff at the aluminium smelting plant and the environment, regard should certainly be had to the experience gleaned elsewhere on similar plants, and to the measures evolved in this context. A textbook example is Canada, where their gigantic aluminium smelting works, for instance, are run in accordance with a well-structured occupational health service and in-house safety plan.

This plan contains several elements, including:

- Prevention in various forms
- On-the-job injuries, both somatic and psychological
- Working accidents
- Occupational injuries
- Occupational disorders
- Occupational injury, occupational accident, industrial injury and occupational illness insurance.
- Rehabilitation and retraining
- Any compensation that may be triggered by the initiatives above

As a point of curiosity, it is worth mentioning that, particularly for the purpose of deaths giving rise to damages, the employee's "spouse" is regarded as someone who is married to, has a registered partnership with or cohabits with the employee; the person actually lives together with the employee, irrespective of whether the cohabitee is of the same or the opposite sex; the person has lived together with the employee for a period of no less than three years or for just one year if the couple has or is expecting a child within the relationship; the person is otherwise recognized by the public authorities as the employee's spouse. In other words, there is no regard for the individual employees' sexuality, and it is therefore of no importance whether one is a heterosexual or a homosexual man or woman.

The synopsis of the health input for the SEA can be expressed as follows:

There is a whole body of knowledge about the current state of health in Greenland, thanks to the population health study which has been in progress for a great many years, including monitoring of the occurrence of persistent organic contaminants and heavy metals in the blood. Particular focus is directed on the occurrence of chronic disorders and mental health. However, there is still a lack of some empirical knowledge in the health field in order to better allow a comprehensive picture of health conditions to be drawn in this country.

The creation of an energy-intensive industrial plant like an aluminium smelting works will foreseeably have a powerful impact on people and the environment, and we must therefore be alert to, take account of and be prepared for the measures needed to counter such adverse effects as will invariably arise in connection with it.

These adverse effects have been referred to in the text and include the emission of gases, including carbon dioxide with its now all too familiar greenhouse effect, hydrofluorides, hydrocarbons and sulphur dioxide, which is converted to caustic and the toxic sulphuric acid with acid rain as a result, samt sundhedsskadelige og miljøtoksiske flydende og fast affald.

Luckily for us, we have an opportunity to keep one eye on and benefit from the experiences that have been gleaned in other places where aluminium smelting plants like the one it is intended to establish here in Greenland are already in operation. Continuous monitoring of the state of health and of the environment is therefore needed throughout the process—both during the planning phase and during the construction and operating phases once the aluminium smelter is running at full power.

Finally, we must be particularly mindful of the need to put in place a smooth-functioning and entirely independent occupational health service and in-plant safety plan, which will act as a watchdog for the benefit of the employees, their families, the environment, the plant owners—indeed, the whole of society and posterity.