CONTRIBUTION OF POPULATION SURVEYS 
TO THE STUDY OF CARDIOVASCULAR DISEASE 
AND DIABETES IN GREENLAND

ABSTRACT

Two population surveys with focus on cardiovascular disease and diabetes were carried out among the Greenland Inuit in 1993-94 and 1999-2001. The number of participants was 264 (1993-94 study) and 2056 (1999-2001 survey) Inuit living in Denmark, towns in Greenland, and villages. Compared with the general population of Denmark, the Inuit had a high consumption of marine food, but regional and demographic variation was marked. Smoking prevalence was high, being approximately 70% among adults in 1999-2001. Blood pressure was lower than in Denmark and the serum lipid profile was healthier (high HDL cholesterol and low triglyceride). The risk factor pattern is consistent with neither an increased, nor a decreased cardiovascular risk profile. Longitudinal studies are needed to determine the incidence of cardiovascular diseases and diabetes, and to establish causal links between traditional risk factors and disease in this non-European population.

Keywords: Cardiovascular risk factors, Diabetes, Greenland, Inuit
INTRODUCTION

Routine mortality statistics have shown that mortality from coronary heart disease is low in Greenland compared to Denmark, while mortality from other heart diseases and stroke is high (1). The scientific evidence for the low mortality from coronary heart disease is, however, weak and its accuracy has recently been challenged (2). The prevalence of diabetes was found to be very low in the 1960s (3), but, in spite of an increasing number of type 2 diabetes cases in clinical practice, research on diabetes has been scarce. During the 1990s, two population surveys were carried out in Greenland with focus on cardiovascular disease and diabetes. Some of the main results are outlined below.

The population of Greenland is 56,000, of which an estimated 90 percent are ethnic Greenlanders (Inuit). Further, an estimated 8,000 ethnic Greenlanders live in Denmark permanently, or for shorter periods for educational purposes. The Greenlandic language is closely related to the Inuktitut and Inupiaq languages spoken in Canada and Alaska, respectively. It is spoken as the first language by almost all Greenlanders living in Greenland. Living conditions are considerably different in Greenland and Denmark. The towns and villages in Greenland are small, hunting and fishing are important leisure time activities, and traditional Greenlandic food makes up a significant proportion of the diet. In Denmark, the Inuit migrants are well integrated into the Danish society and their life style is similar to that of the general population in a western industrialized country.

The 1993-94 Health Interview Survey in Greenland

The study was an interview survey of 1728 adult Greenlanders and Danes from all parts of Greenland. Among these, 352 Inuit from three representative towns and four villages on the west coast of Greenland were invited to participate in a clinical study with blood samples. The response rate for the interview was 67%, and 75% of those invited for the clinical study accepted (50% overall participation). In addition to questions about socio-demographic factors, disease, smoking, diet and physical activity, blood pressure and anthropometric variables were measured, and fasting blood samples were analysed for cholesterol fractions, triglyceride, glucose, free fatty acids, mercury and organochlorines (4).
The Greenland Population Health Survey 1999-2001

This study was a population survey with special focus on cardiovascular disease and diabetes in Greenland and among Inuit living in Denmark. The population and methods have recently been described in a supplement to the Journal (5).

The overall aim of the project was to study health and disease among Greenlanders living under different living conditions ranging from traditional to European. The basic design of the study is a cross-sectional study of a randomly selected Inuit population from Denmark and four areas in West Greenland, with a view to perform a follow-up after a suitable period of time. The data collection served as an umbrella for studies with several topics, including a general health interview survey, cardiovascular disease and diabetes, lung disease and allergy, alcohol and liver disease, and thyroid disease. Only the results on cardiovascular disease and diabetes are included in the present article.

Figure 1. Map of Greenland with study areas.
Data were collected from 1999 to 2001 among adult Greenlanders living in Greenland and Denmark. In Greenland, Nuuk, Qasigiannguit, and four villages in the district of Uummannaq (Ikerasak, Saattut, Qaarsut, and Ukkussissat) were surveyed. The study areas in Greenland are shown in figure 1. Living conditions varied considerably among the study areas, ranging from the European conditions in Denmark, to the traditional Inuit conditions in the villages of the Uummannaq district.

From Greenland and Denmark, a total of 3337 Greenlanders aged 18 and above was invited to participate in the study. A total of 2056 Greenlanders participated in the cardiovascular part of the study (62%). The participation rate was 54% in Denmark and 66% in Greenland (p<0.001).

**Interviews and questionnaires**

Data was collected by face-to-face interviews, self-administered questionnaires, clinical examinations, anthropometric measurements, and sampling of biological specimens (blood, urine, and fat biopsies). Questionnaire data was collected by structured interviews and self-administered questionnaires. The survey questionnaires were developed in Danish and subsequently translated into Greenlandic. The translation procedure included translation by two, or more interpreters, followed by an independent back translation into Danish and revision of the translation as needed. In Denmark, almost all information was obtained using the survey instruments in the Danish language, while in Greenland, almost all information was obtained in the Greenlandic language. In Denmark, the socio-demographic background information was obtained by mailed questionnaires, while in Greenland, both mailed questionnaires and interviews were used. Genetic Inuit heritage was estimated from questions on the ethnicity of the four grandparents and, if this information was missing, of the parents. Dietary information was obtained from short questionnaires (15-17 items) about food frequency without portion sizes. Physical activity was self-assessed on a five-point scale for summer and winter separately. Detailed information was obtained about smoking habits including type and amount of tobacco smoked, and about the age the participant started (and perhaps stopped) smoking.
Clinical data
Clinical data were collected by interviews, physical examinations and blood sampling. The clinical examinations consisted of sampling of (fasting) blood and urine, a 75g 2-hour oral glucose tolerance test, a fat biopsy, anthropometric measurements, blood pressure, ECG, a general physical examination for signs of alcohol-related disease, a skin prick test, a lung function test and an ultrasound examination of the thyroid gland and carotid artery. The procedures applied varied according to the study area and the age of the participant. For the cardiovascular and diabetes sub-study, blood analyses included cholesterol fractions, triglyceride, fasting and 2-hr glucose and insulin, C-peptide, and HbA1c. Samples, stored at –20 °C, await further analyses.

The clinical examinations were performed by a team of investigators consisting of trained staff from Denmark and staff from the local hospitals trained on the job. The data collection was arranged by stations between which the participants rotated. In all study areas, the clinical examination took place in localities assigned to the project by the local hospital. In some of the villages, however, they were conducted in schools, or health centres.

Ethics
The studies were approved by the relevant ethical review committees. In the case of Greenland, they were approved by the Commission for Scientific Research in Greenland. All subjects had been informed about the study, both in writing and orally, and had given their informed consent, in writing, prior to enrolment.

RESULTS

Diet, physical activity, and smoking
Both surveys revealed a high consumption of fish and marine mammals, with marked regional, age- and gender-related differences (6). This has been confirmed by studies of biochemical markers (7) and a detailed dietary survey, including 24-hour recall, as well as a questionnaire on food frequency with portion sizes (8). There is a decreasing trend in the consumption of marine mammals from the first to the second study (unpublished results). In Greenland, the marine diet is
the source of anthropogenic contaminants with relevance for cardiovascular health, such as mercury and organochlorines (7, 9, 10).

Physical activity was assessed in a rather simple way, by asking participants about their levels of summer and winter activity and, subsequently, recoding the responses into low, moderate and high physical activity. In the second survey, 15% of men and 18% of women were characterized as mostly sedentary, while 28% and 10%, respectively, were physically very active (5). As expected, physical activity decreased with age. This crude measure has not shown associations with any of the other cardiovascular risk factors.

Smoking was very prevalent in all age groups, regardless of gender. In the first survey, 80% and 75% of men and women, respectively, were smokers, while these figures had decreased to 71% and 70% in the second survey (unpublished results). In 1999-2001, 22% of men and 13% of women were heavy smokers, smoking 15 cigarettes, or more, per day. Heavy smoking was most pronounced in the 25-64 age group (5).

**Blood pressure**

Previous studies of blood pressure among the Inuit have yielded inconsistent results and studies comparing Inuit migrants with those living in traditional Inuit areas are absent. Our first survey indicated that blood pressure was similar in Greenland and Denmark and showed no association between consumption of a marine diet and blood pressure (4, 7).

The second survey compared the blood pressures of the Inuit in Greenland with those of Inuit migrants in Denmark (11). Age and gender adjusted blood pressures were 117/72 mm Hg in Greenland and 127/81 mm Hg among the migrants (p<0.001). In both populations, blood pressure increased with age and body mass index, and was higher among males and non-smokers. In Greenland, blood pressure increased with the level of school education. The associations with Inuit genetic heritage, alcohol, diet and physical activity were not significant. The difference between the two populations persisted after adjusting for age, gender, body mass index, education and smoking. Among those who had completed high school, there was no difference between the systolic blood pressure of the two populations, while the difference for diastolic blood pressure was much less than for those with less education. It was concluded that blood pressure was lower among the Inuit in Greenland than among the Inuit migrants in Denmark, but that the difference was absent (systolic pressure), or reduced (diastolic pressure), among
the better educated. The results suggest that the blood pressure of the Inuit, especially Inuit men, may be responsive to factors related to the modern western way of life.

Most studies of Inuit blood pressure have reported lower blood pressure among the Inuit as compared with the predominantly white national populations. This has been attributed to traditional subsistence practices and lifestyle. In addition to the data from Greenland, we analysed three Inuit populations from Alaska and Canada (12). A total of 2509 adults were randomly selected from 31 villages across the Arctic. Mean systolic blood pressures ranged from 116 to 124 mm Hg among men and from 110 to 118 among women in the four populations. Mean diastolic blood pressures ranged from 75 to 78 mm Hg among men and from 71 to 73 among women. Adjusted for age, body mass index and smoking, blood pressure differed among the populations (p < 0.001). Systolic blood pressure increased with age. Male gender, obesity and being a non-smoker, were all associated with high systolic and diastolic blood pressure. Mean systolic blood pressure was low among the Inuit compared with most European populations of the INTERSALT study, but higher than in several Asian populations and the Amazonian Indians. It was concluded that Inuit blood pressures rank intermediate on a global scale, but are low in comparison to most European populations. The Inuit population is not homogeneous, and this is reflected in blood pressure differences among the four regional subgroups. The roles of the traditional diet, a rural lifestyle with a low level of psycho-social stress, and genetics, must be further explored.

**Obesity**

In one study, overweight, obesity and central fat patterning, and their relation to westernisation, were analysed among the Inuit of Greenland and Inuit migrants in Denmark (13). The proportions of obese participants were 16% and 22% among men and women in Greenland (p=0.004), and 12% and 11%, respectively, in Denmark (n.s.). Westernisation was accompanied by a decrease in the proportion of obese people, particularly among women. Adjusted for BMI and age, waist circumference decreased with westernisation (among women), while hip circumference increased (men and women). The differences were particularly pronounced for migrants compared with residents of Greenland. In conclusion, BMI and central fat patterning decreased with westernisation among Greenland Inuit women contrary to most
studies of migrants. The changes were less prominent among men. This suggests a reduced cardiovascular risk profile with westernisation among Greenland Inuit. The changes in waist and hip circumference indicates that these anthropometric measurements are influenced by environmental factors.

One major question is whether the association between obesity and metabolic risk factors is similar for the Inuit and for a European population. Our results showed that the Inuit had lower levels of 2-hour glucose and insulin, blood pressure and triglyceride, and higher levels of HDL cholesterol, than the Danish participants at any given level of obesity (14). Fasting glucose and fasting insulin levels within obesity categories were not different in the two populations. Adjustment for physical activity, smoking, school education and alcohol consumption did not change these findings. It was concluded that the trends in the association between obesity and metabolic effects among the Inuit and a Northern European population were the same, but the levels of the risk factors were significantly different.

Blood lipids
Plasma cholesterol and triglycerides were measured in both surveys, but the scientific reporting has not been completed for the second survey. High density lipoprotein (HDL) and low triglyceride were found among the Greenlanders, compared with the general population in Denmark, while total cholesterol was similar in the two populations (4). HDL cholesterol was positively associated with a marine diet, while low density lipoprotein (LDL) and triglyceride were negatively associated (7) with marine diet.

Diabetes and impaired glucose tolerance
Diabetes and IGT were diagnosed by a standard 75g oral glucose tolerance test in 917 randomly selected adult Inuit (15). The age-standardised prevalences of diabetes and IGT were respectively 10.8% and 9.4% among men, and 8.8% and 14.1% among women. Of those with diabetes, 70% had not been previously diagnosed. Significant risk factors for diabetes included a family history of diabetes, age, BMI and high alcohol consumption, whereas frequent intake of fresh fruit and seal meat were inversely associated with diabetic status. Age, BMI, family history of diabetes, sedentary lifestyle and place of residence were significant predictors of IGT.
We concluded that the prevalence of diabetes is high among the Inuit of Greenland. Heredity was a major factor, while obesity and diet were important environmental factors. The high proportion of unknown cases suggests a need for increased diabetes awareness in Greenland.

**Genetics**
DNA has been processed and stored from the participants in the second study. Analyses are currently ongoing for genes suspected to be related to cardiovascular risk among the Canadian Inuit (16), but results are not yet available.

![Figure 2. Cardiovascular risk factors among Inuit in Greenland (5) and the general population in Denmark. Figures from Denmark were based on a survey from 1991-92 (17) and were age-adjusted to the Greenland study.](image-url)
In conclusion, figure 2 shows cardiovascular risk factors among Greenland Inuit compared with published figures for the general population in Denmark (17). The figures from Denmark were adjusted to the age composition of the Greenland study, but, since the design and methods were not fully comparable, the comparisons must be made with caution. Furthermore, there was almost 10 years between the study in Denmark and that in Greenland. Blood pressures were slightly lower among Inuit men compared with Denmark, body mass index was higher among Inuit women, while the most pronounced differences were found for serum lipids; high HDL and low triglyceride among Inuit men, and high LDL among Inuit women, compared with the general population of Denmark.

**DISCUSSION**

The two studies have given a comprehensive cross-sectional description of risk factors for cardiovascular disease and diabetes in the Inuit population of Greenland and, to some extent, also of the prevalence of diseases. The possibilities for analyses of the second survey are far from exhausted and the stored serum and plasma samples, as well as DNA, offer the possibilities for a series of publications. Among those directly in line are analyses of serum lipids and the metabolic syndrome in relation to westernisation and migration, and studies of genetic markers for cardiovascular risk.

The studies have given a solid cross-sectional description of risk factors for cardiovascular disease among the Greenland Inuit. It appears that some risk factors (blood pressure, HDL cholesterol, triglycerides) put the Inuit at less risk than the European population with which they are compared, while others put them at greater risk (smoking). Thus, neither the Inuit phenotypes as described in this article and in the papers cited, nor their genotypes (16), are consistent with a reduced cardiovascular risk. Furthermore, considering the scant evidence for a low incidence of cardiovascular disease (2), it is fair to conclude that the relationship between cardiovascular risk and marine diet among the Inuit is far from explained. Further studies with a longitudinal design are needed to throw further light on these issues.

A longitudinal study of cardiovascular disease and diabetes among the Inuit should include Inuit from all major Inuit areas and should
consist of not less than 8-10,000 participants to be followed for at least 10-20 years. At baseline, the participants should be well characterised with respect to their diet, physical activity, other risk factors and confounders, and prevalent disease. Our 1999-2001 study was designed as the baseline for a cohort that will be followed with regard to disease incidence and mortality. The cohort is, however, rather small and not all of the data is comparable to that gathered from similar surveys in Canada and Alaska. A Pan-Arctic study of Inuit Health in Transition will provide information useful for local health planning, will allow nested preventive studies, and will answer many basic scientific questions related to the effects of diet and life style on cardiovascular disease and diabetes.

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