

# Blood pressure among the Inuit (Eskimo) populations in the Arctic

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*Aims:* Studies of blood pressure among various Inuit (Eskimo) populations in the Arctic have given inconsistent results. Most studies 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. This study compared the blood pressure among the major Inuit population groups with other populations and examined the associations with factors like age, gender, obesity and smoking. *Methods:* The study comprised four Inuit populations from Alaska, Canada, and Greenland with participation rates ranging from 51% to 73%. In a cross-sectional design, 2,509 randomly selected adults from 31 villages were examined. Blood pressure, anthropometric measurements, smoking, and medication were recorded. *Results:* Mean systolic blood pressures ranged from 116 to 124 mm Hg among men and 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. Systolic blood pressure increased with age. Male gender, obesity, being a non-smoker, and being on anti-hypertensive treatment were associated with high systolic and diastolic blood pressure. Adjusted for age, body mass index, smoking, and anti-hypertensive treatment, blood pressure differed among the populations ( $p \leq 0.001$ ). 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. *Conclusions:* Inuit blood pressures rank intermediate on a global scale but low in comparison with most European populations. The Inuit population is not homogeneous, and this is reflected in blood pressure differences among the four regional subgroups. The role of the traditional diet, a rural lifestyle with a low level of psychosocial stress, and genetics must be further explored.

*Key words:* Alaska, blood pressure, Canada, Greenland, Inuit, obesity, smoking.

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## INTRODUCTION

The recorded mortality rate from coronary heart disease is low among Inuit (Eskimo) populations in Alaska, Canada, and Greenland, while the mortality rate from stroke among the Inuit is similar to or higher than among the general populations of the USA, Canada, or Denmark (1–3). Hypertension is an important risk factor for both conditions. Several studies of blood pressure have been conducted among the Inuit during the last 40 years but they are difficult to compare because study protocols varied considerably or were not explicitly reported, because the age composition of the populations studied differed, and because of random variation due to small study populations. The conclusions of the studies have ranged from significantly lower (3–7) to similar (8–11) or even

slightly higher (12, 13) blood pressures among the Inuit compared with the general European or North American populations or, in a few cases, with neighbouring American Indian populations (6, 7, 13). The Inuit population comprises several regional subgroups. Epidemiological studies conducted among the Inuit usually disregard the variation in lifestyle, culture, history, and genetics among regional subgroups and few studies have compared the health patterns among these groups. However, in a study conducted in Alaska in the 1950s, the Central Yupik Eskimos were found to have higher blood pressure than the Inupiaq Eskimos (6).

In a number of studies from all over the world, blood pressure has been shown to vary with obesity, physical activity, diet, alcohol, smoking, and stress. Among the

Inuit of Northern Québec (Nunavik) there was no association of blood pressure with modernization (6), but the prevalence of hypertension was significantly higher among obese than among non-obese Inuit (14). Among Inuit in the Kivalliq region of Canada the expected increase in blood pressure with increasing cholesterol and triglyceride was not observed (15). Among the Siberian Yupik, diastolic blood pressure was positively associated with fasting insulin (16). Among Alaskan Eskimos, blood pressure increased with increased consumption of store-bought food relative to traditional food, increased body mass index, increased mechanized activity, and glucose intolerance (7). In Greenland, there was no association of systolic or diastolic blood pressure with the consumption of traditional marine food (11).

The purpose of the present study was to compare the blood pressure among the major Inuit population groups with other populations and to examine the associations of age, gender, obesity, and smoking with blood pressure.

## METHODS

### *Study population*

Data were collected in four separate surveys conducted among the Inuit (Eskimo) of Alaska, Canada, and Greenland. The study areas are shown in Figure 1. Ethnologists describe 20 traditional regional groups of Inuit currently totalling approximately 167,000 persons (17). There are two major linguistic subdivisions: Yupik speakers and Inuit/Inupiaq speakers. Inuit/Inupiaq represents a continuum of dialects from Alaska to Greenland. Yupik speakers inhabit the Alaska coast south of Norton Sound, St Lawrence Island, and the easternmost tip of Siberia, while the Inupiaq inhabit the Alaska coast north of Norton Sound, and the Inuit the Canadian Arctic and Greenland. In many circumstances, in particular in Canadian usage and in political language, the word Inuit has replaced Eskimo as a common term for Yupik and Inupiaq/Inuit, Eskimo being perceived as derogatory. In this paper, Inuit is used for the combined population while the individual populations are referred to by their geographical origins (Figure 1).

### *Samples and study designs*

The studies were carried out between 1990 and 2001 and similar protocols were used for the measurement of blood pressure. In the Bering Strait Region, Alaska, data were collected in 1994 among the adult indigenous population of four villages (two Siberian Yupik, one Central Yupik, one Inupiaq). A total of 454 individuals aged 25 and above participated in the survey (51% of

the total eligible population) (18). In the Kivalliq Region, Nunavut Territory, Canada, data were collected in 1990–91 among the population of eight villages. A total of 380 adults (73% of a random sample) participated in the survey (19). In Nunavik, Québec, Canada, data were collected in 1992 in a random sample of Inuit from 14 villages. Information was obtained from 400 adults (54% of the sample) (14). In Greenland, data were collected during 1999–2001 in a random sample of indigenous Greenlanders (Inuit) from two towns and four villages on the west coast. A total of 1,316 individuals aged 18 and above participated in the survey (67%) (20). After the exclusion of 41 participants with less than two valid measurements of blood pressure, the study population numbered 2,509 participants, 453 from Alaska, 364 from Kivalliq, 397 from Nunavik, and 1,295 from Greenland. For comparison, data from a survey conducted among the general population of Québec (Canada) in 1990 were included (21). This survey was performed by the same researchers who conducted the survey in Nunavik, and the same protocol was used. All studies were approved by the relevant ethical review committees and all subjects had given their informed consent in writing prior to enrolment.

### *Physical measurements*

The clinical examinations took place at the local hospital, health centre, or school. Participants had fasted overnight and examinations usually took place between 8 a.m. and noon. Height and weight were measured with the participants stripped to their underwear and socks. On the standing participant, waist circumference was measured 1 cm above the iliac crests (in Alaska at the level of the umbilicus), hip circumference at its maximum. Blood pressure was measured on the right arm of the sitting participant after at least five minutes of initial rest. Using an appropriate size cuff, the blood pressure was read to the nearest mm Hg two (Kivalliq, Nunavik) or three (Alaska, Greenland) times with one minute's interval. Systolic and diastolic blood pressures were determined at the first and fifth Korotkoff sounds. The two first measurements were averaged for the analyses in this paper.

### *Data analysis*

The questionnaires were coded and double entered on the computer. Values outside the permitted range were corrected against the questionnaires. Chi-square, one-way ANOVA, and normal tests were used to compare proportions and means. General linear models (the UNIANOVA procedure of SPSS) were used to compare blood pressure among the four Inuit population

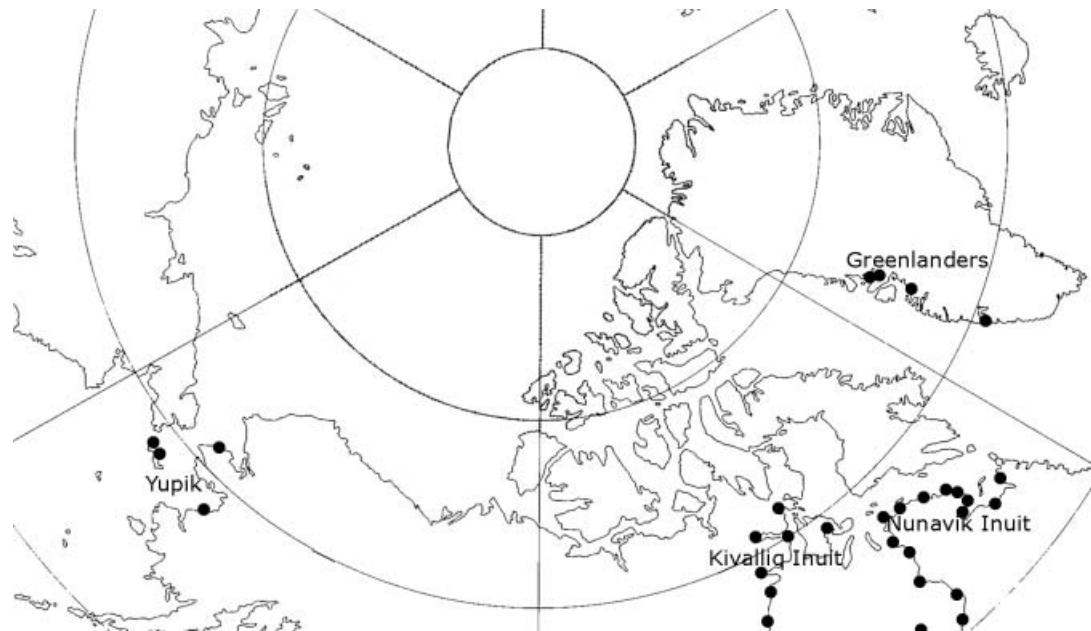


Fig. 1. Map of study areas and populations.

groups adjusted for age, gender, body mass index, smoking, and treatment for hypertension, and to estimate adjusted blood pressure values. The data in Figure 2 were standardized by calculating mean blood pressure for 20- to 39-year-old men, 20- to 39-year-old women, 40- to 59-year-old men, and 40- to 59-year-old women and averaging over age and gender categories. Data processing and statistical analysis were performed using standard statistical software (SAS and SPSS).

## RESULTS

The distribution of the independent variables and of the systolic and diastolic blood pressure among the four Inuit populations and the general population of Québec are shown in Table I. Age, body mass index, waist-hip ratio, and the percentage of smokers as well as blood pressure, except diastolic pressure among women, varied significantly among the four Inuit populations. The population of Québec was younger, had lower body mass index and waist-hip ratio than the Inuit, and showed the lowest prevalence of cigarette smoking ( $p < 0.001$ ). For men, the blood pressure was higher in Québec than among the Inuit while there was no difference for women.

The proportion of participants aged 45 and above who were under current treatment with anti-hypertensive drugs varied significantly from only a few per cent in Kivalliq to 6% in Nunavik, 9% in Greenland and 16–17% in Alaska and Québec. Blood pressure  $\geq 140/90$  was significantly more prevalent in Kivalliq (among men) and in Greenland (among women) than

in the other regions. The patterns persisted after age adjustment.

Systolic blood pressure increased significantly with age among men as well as women in all four population groups and, except in Alaska, the systolic blood pressures were higher among men than among women. The pattern was slightly less clear for diastolic blood pressure, which for all four population groups together showed an increase by age and higher pressure among men than among women. The exceptions included a significantly decreasing diastolic blood pressure by age among Alaska men.

Age, male gender, body mass index, being a non-smoker, and being on anti-hypertensive treatment were positively associated with high systolic blood pressure in a general linear model with similar results for men and women separately. Male gender, body mass index, being a non-smoker and being on anti-hypertensive treatment were positively associated with high diastolic blood pressure. Age was negatively associated with diastolic blood pressure among men but not among women. Waist circumference and waist-hip ratio were slightly less predictive than body mass index in the multivariate models.

The general linear models were repeated for all four population groups, separately for men and women, and similar results were observed. However, age was not associated with systolic blood pressure among Alaska males and neither smoking nor anti-hypertensive treatment were associated with blood pressure in Kivalliq and Nunavik. Adjusted for age, body mass index, smoking, and treatment blood

pressure still varied significantly among the four populations (Table 2). The highest blood pressures were found among the Kivalliq Inuit closely followed by the Greenland Inuit.

Values of systolic blood pressure observed in the present study and in Québec were compared with those observed in the INTERSALT study, which was conducted among various populations of Africa, Asia, Europe, and the Americas, including several indigenous peoples (Figure 2) (22). Systolic blood pressure of the Inuit populations was lower than those of most European populations but higher than those of other populations, especially the Amazonian populations of Brazil and several Asian populations. The comparison of body mass index between populations indicated that the Inuit ranked in the highest quartile of body mass index. In particular, the average body mass index observed among the Inuit populations was considerably higher than that of the Amazonian and Asian populations.

## DISCUSSION

Although the blood pressure varied significantly among the four Inuit populations, the Inuit group ranked lower than most of the European populations included in the INTERSALT study. This cannot be explained by differences in body mass index, since the Inuit ranked among the populations with the highest body mass index. Also, compared with the population of Québec the blood pressure of the Inuit was low, although the former were younger and had lower mean body mass index. The high proportion of smokers among the Inuit explains part of their low blood pressure since several population studies have observed lower blood pressure among smokers than non-smokers (23).

The measurement of blood pressure is influenced by numerous factors and strict standardization of procedures is necessary to obtain comparable results. Similar written guidelines for blood pressure measurement were followed in our four studies and meticulous training of persons responsible for measuring the blood pressure was instituted. Nevertheless, it cannot be ruled out that part of the difference among the Inuit populations could be due to measurement errors. The four studies were performed 10 years apart but there was no systematic variation in blood pressure with this parameter. The participation rates ranged from 51% to 73% and the studies with the two highest participation rates (73% and 67%) also had the highest blood pressure measured. In Greenland there was a similar variation between areas with high and low participation rates and it cannot be ruled out that there

is a differential participation rate according to blood pressure.

Age, male gender, body mass index, non-smoking, and anti-hypertensive treatment were determinants for high blood pressure among the Inuit as in other populations. The adjustment for these determinants did not remove the differences in blood pressure among the four Inuit populations. Adjusted mean systolic blood pressures were 5–10 mm Hg higher and diastolic blood pressure 2–3 mm Hg higher in Kivalliq than in Nunavik and Alaska. While in our study central adiposity had slightly less predictive value than body mass index, little is known about the significance of fat distribution among the Inuit.

The prevalence of anti-hypertensive treatment influences the population mean blood pressure but it also reflects the level of blood pressure. In this study, the pronounced variation in the proportion of participants on anti-hypertensive medication among the study populations probably reflects variations in the accessibility of health services rather than differences in the prevalence of hypertension. Accordingly, the proportion of treated participants should be inversely associated with mean blood pressure. We included treatment in the multivariate model and did not observe a clear association between treatment and blood pressure at the population level. However, Kivalliq with the lowest proportion of participants on anti-hypertensive medication ranked highest with regard to blood pressure, while Alaska with a five times higher proportion of participants on medication ranked lowest.

Some of the variation in blood pressure both among the Inuit populations and between the Inuit and other populations may be due to genetic differences. The Yupik and the Inuit speaking population groups differ with regard to a number of genetic markers while the Inuit, despite their extremely broad geographic distribution, form a tight cluster (24). Genetic research has identified some common variants in candidate genes that appear to be determinants of blood pressure in the general population. The specific genes are those encoding angiotensin converting enzyme (ACE), adducin (ADD1), the G protein beta3 subunit (GNB3), and angiotensinogen (AGT) (25). Some of these genetic variants have been studied in Canadian Inuit, but their association with blood pressure is still unclear. For instance, angiotensinogen, the hepatically secreted precursor for angiotensin I, is encoded by AGT. A common amino acid variant in AGT, namely M235T, has been associated with elevated plasma concentrations of angiotensinogen and elevated blood pressure, perhaps through linkage disequilibrium with a functional variant in the AGT promoter (25). Canadian Inuit have one of the highest frequencies of the AGT T235 allele of any population in the world

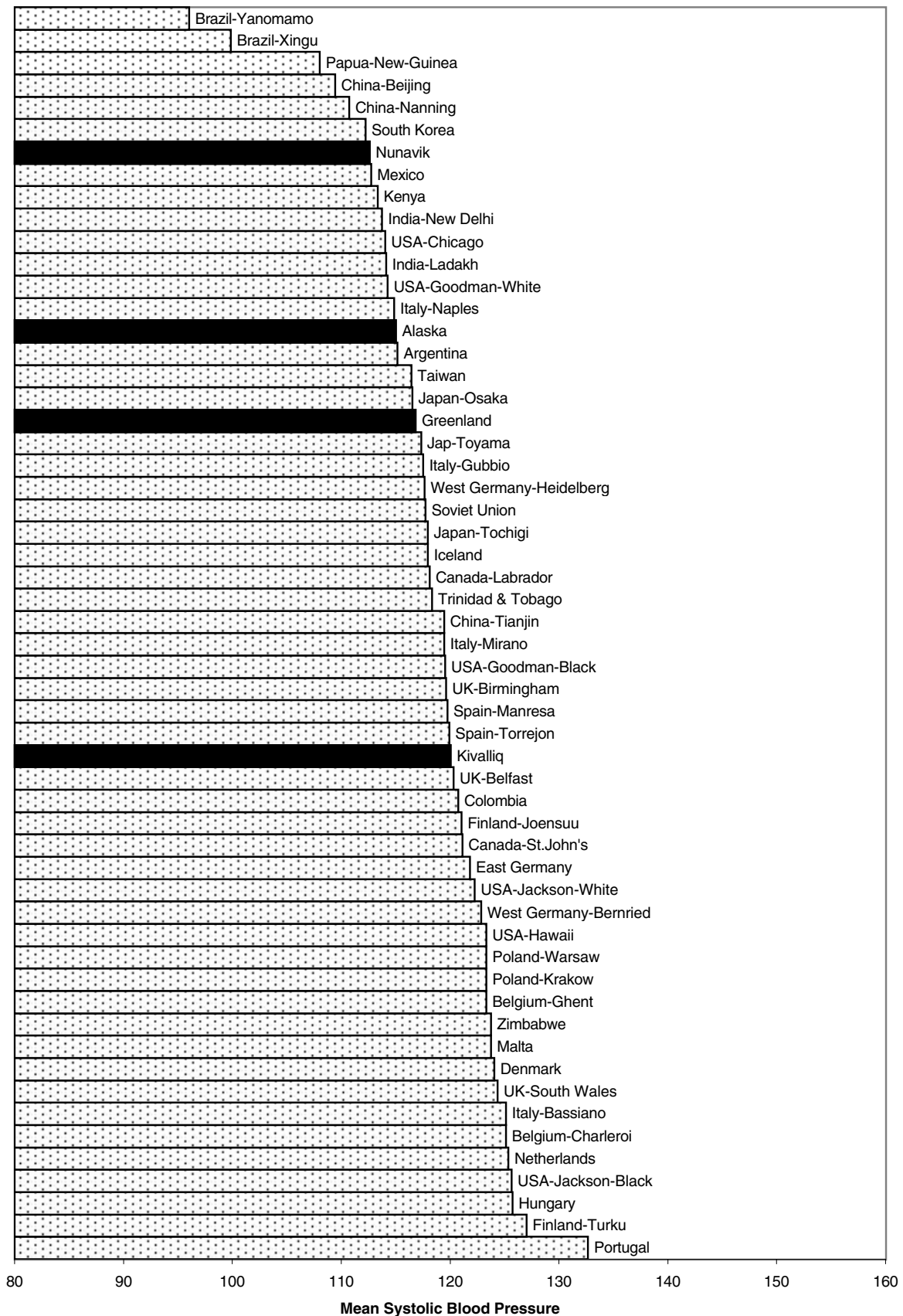


Fig. 2. Systolic blood pressure in four Inuit populations, Québec, and populations that participated in the INTERSALT study. Mean blood pressures calculated for men aged 20–39, men aged 40–59, women aged 20–39, and women aged 40–59, and then averaged over age and gender groups.

Table I. Distribution of blood pressure and determinants for blood pressure in four Inuit populations (1990–2001) and the general population of Québec (1990)<sup>a</sup>

	Alaska	Kivalliq	Nunavik	Greenland	<i>p</i> <sup>b</sup>	All Inuit	Québec	<i>p</i> <sup>c</sup>
<b>Men</b>								
Number of participants	214	158	151	571		1094	713	
Mean age (years)	47	36	39	44	<0.001	42	39	<0.001
Age range (years)	25–91	18–80	18–73	18–85		18–91	18–74	
Body mass index (weight/height <sup>2</sup> )	26.1	25.7	26.5	25.9	n.s.	26.0	25.3	<0.001
Waist–hip ratio	0.96	0.89	0.90	0.93	<0.001	0.93	0.90	<0.001
Smokers (%)	60	74	65	69	<0.001	68	27	0.03
Systolic blood pressure (mm Hg)	117	124	116	121	<0.001	120	124	<0.001
Diastolic blood pressure (mm Hg)	75	78	77	75	<0.001	76	77	0.002
Anti-hypertensive treatment (%) <sup>d</sup>	14	2	6	5	0.02	7	13	0.02
<b>Women</b>								
Number of participants	239	206	246	724		1415	724	
Mean age (years)	49	37	38	44	<0.001	43	38	<0.001
Age range (years)	25–88	18–84	18–73	18–86		18–88	18–74	
Body mass index (weight/height <sup>2</sup> )	27.4	26.9	27.4	26.5	0.02	26.9	23.9	<0.001
Waist–hip ratio	0.93	0.85	0.87	0.88	<0.001	0.88	0.78	<0.001
Smokers (%)	51	70	67	67	<0.001	65	30	<0.001
Systolic blood pressure (mm Hg)	118	116	110	118	<0.001	117	116	n.s.
Diastolic blood pressure (mm Hg)	72	73	71	72	n.s.	72	72	n.s.
Anti-hypertensive treatment (%) <sup>d</sup>	19	3	5	12	0.004	11	18	0.007
<b>Men and women</b>								
Number of participants	453	364	397	1295		2509	1437	
Mean age (years)	48	37	38	44	<0.001	43	38	<0.001
Age range (years)	25–91	18–84	18–73	18–86		18–91	18–74	
Body mass index (weight/height <sup>2</sup> )	26.8	26.4	27.0	26.2	0.01	26.5	24.6	<0.001
Waist–hip ratio	0.94	0.87	0.88	0.90	<0.001	0.90	0.83	<0.001
Smokers (%)	55	72	66	68	<0.001	66	28	<0.001
Systolic blood pressure (mm Hg)	118	119	112	119	<0.001	118	120	<0.001
Diastolic blood pressure (mm Hg)	73	75	73	73	0.007	74	74	n.s.
Anti-hypertensive treatment (%) <sup>d</sup>	17	3	6	9	<0.001	10	16	<0.001

<sup>a</sup>Arithmetic mean and percentages.

<sup>b</sup>*P* value for differences between Inuit populations.

<sup>c</sup>*P* value for differences between Inuit and Québec populations.

<sup>d</sup>Age group 45+.

(26). However, the allele was not itself associated with elevated blood pressure or hypertension in individual Inuit subjects, nor was the high allele frequency correlated with elevated blood pressure or hypertension at the population level (26). This suggests either that variation in AGT is not a genetic determinant of blood pressure in the Inuit, or that other factors, such as background genetic variation or environmental factors,

attenuate the possible relationship between blood pressure and AGT variation.

The living conditions and health behaviour of the Inuit are in many aspects very different from those of Western populations. They vary from one population group to the other and are greatly influenced by the living conditions in the USA, Canada, and Denmark, respectively. The communities included in this study

Table II. Mean blood pressure adjusted for age, body mass index, smoking, and anti-hypertensive treatment in four Inuit population groups

Population groups	Systolic blood pressure		Diastolic blood pressure	
	Mean	95% CI	Mean	95% CI
<b>Men</b>				
Alaska	116	(114, 118)	75	(73, 76)
Kivalliq	126	(124, 129)	78	(77, 80)
Nunavik	117	(114, 119)	76	(74, 78)
Greenland	121	(120, 122)	75	(74, 76)
<i>p</i>	<0.001		0.005	
<b>Women</b>				
Alaska	114	(112, 115)	71	(70, 73)
Kivalliq	119	(117, 121)	74	(72, 75)
Nunavik	112	(110, 114)	71	(70, 72)
Greenland	119	(118, 120)	73	(72, 73)
<i>p</i>	<0.001		0.01	

were generally small and rural. In Greenland, however, one-third of the participants lived in an urban community with *c.* 13,000 inhabitants and a sizeable white (Danish) population while in Canada and Alaska all participants lived in small villages with few white inhabitants. The ranking of the adjusted blood pressures with the lowest pressures in Nunavik and Alaska and the highest in Kivalliq and Greenland was not consistent with these aspects of the living conditions.

It is debatable whether n-3 fatty acids can lower blood pressure among normotensives but several studies have shown a significant reduction among hypertensives (27). Diet was recorded in all four studies that are part of the present article but the data could not be compared because of different methodologies. Previous studies among the Inuit in West Greenland did not show significant effects of the amount of marine diet on blood pressure (11), while studies from Alaska showed a positive association between non-indigenous fat intake and the intake of milk and cheese and high blood pressure (7).

Psychosocial factors contribute to the regulation of blood pressure (29) and many studies have demonstrated lower blood pressure among rural populations than among migrants to urban areas (30). This was also the case for Greenlanders who had migrated to Denmark (20). It is probable that the rural life of the Inuit protects them against high blood pressure. We conclude that age, male gender, and obesity are risk factors for high blood pressure among the Inuit, that the blood pressure differences among Inuit populations are rather small but statistically significant, and that Inuit blood pressures rank intermediate in an international comparison and low compared with European populations.

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