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Association of blood polychlorinated biphenyls and cholesterol levels among Canadian Inuit

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ABSTRACT

Background: It has generally been thought that Inuit populations have low risk of cardiovascular disease due to high consumption of omega-3 fatty acids found in traditional marine-based diets. However, results of recent surveys showed that Inuit populations are experiencing increasing rates of cardiovascular disease and related risk factors.

Objective: The purpose of this study was to investigate if blood polychlorinated biphenyls (PCBs) are associated with high cholesterol and related parameters in Canadian Inuit, known risk factors for cardiovascular disease.

Methods: The Adult Inuit Health Survey (IHS, 2007–2008) included 2595 Inuit participants from three regions of the Canadian Arctic, of which 2191 could be classified as with or without high cholesterol. The high cholesterol outcome was defined by LDL-C > 3.36 mmol/L or taking medication(s) that reduce cholesterol, and was examined in adjusted logistic regression models with individual blood levels of PCB congeners, sum of dioxin-like PCBs (ΣDL-PCBs), or sum of non-dioxin-like PCBs (ΣNDL-PCBs). Statistically significant covariates for high cholesterol were ranked in importance according to the proportion of the model log likelihood explained. Continuous clinical parameters of total cholesterol, triglycerides, LDL-C, and HDL-C were examined in multiple linear regression models with ΣDL-PCBs or ΣNDL-PCBs.

Results: A total of 719 participants had high cholesterol (32.8%). PCBs were associated with increased risk of high cholesterol, and higher levels of serum triglycerides, total cholesterol, and LDL-C. No association was observed between PCBs and serum HDL-C. With respect to other statistically significant covariates for high cholesterol, the log likelihood ranking of PCBs generally fell between body mass index (BMI) and age.

Conclusion: Further work is needed to corroborate the associations observed with PCBs and lipids in Canadian Inuit and to examine if they are causal in the direction anticipated.

1. Introduction

It has generally been thought that Inuit populations have low risk of cardiovascular disease due to consumption of omega-3 fatty acids found in traditional marine-based diets. However, based on the results of recent surveys, Inuit populations are experiencing high rates of cardiovascular disease and related risk factors. In the Canadian region of Nunavik, the *Qanuippitaa* Survey found that 16.7% of Inuit adults have high blood pressure, 7.9% high cholesterol, 4.1% cerebrovascular disease, 2.3% coronary artery disease, and 6.7% other cardiovascular disease (PHAC, 2009). In the Aboriginal Peoples Survey 2012 of Canada, 12% of Inuit 15 years of age or over reported having high blood pressure and 5% reported diabetes (excluding gestational diabetes) (Wallace, 2014). The Inuit diet, therefore, does not seem to provide full protection against cardiovascular morbidity. Non-modifiable and modifiable factors both play important roles in contributing to the prevalence of cardiovascular disease in Inuit communities (Tvermosegaard et al., 2015).

The presence of high blood cholesterol is an important risk factor for the development of atherosclerosis and myocardial infarction. Cholesterol travels in the blood stream bound mainly to low-density lipoprotein cholesterol (LDL-C), which carries up to 70% of total serum cholesterol and is highly atherogenic, and to high-density lipoprotein cholesterol (HDL-C), which carries up to 30% of total serum cholesterol (NCEP, 2002). The very low density lipoproteins (VLDL) and chylomicron lipoproteins are rich in triglycerides and also have potential to promote atherosclerosis (NCEP, 2002). According to clinical practice guidelines, cholesterol lowering therapy should be initiated for secondary prevention in those with clinical atherosclerotic cardiovascular disease and for primary prevention in those with LDL-C ≥4.9 mmol/L, with diabetes 40–75 years of age, or with 10-year atherosclerotic cardiovascular disease risk ≥7.5% and 40–75 years of age (Stone et al.,

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2014). The risk of atherosclerotic cardiovascular disease is reduced by 20% for every 1.0 mmol/L reduction in LDL-C (Stone et al., 2014).

Although risk factors for high cholesterol, such as diets high in saturated and trans-fatty acids and obesity, are well recognized among the medical community, the contribution of persistent organic pollutant (POP) exposure is unclear. Persistent organic pollutants accumulate in the circumpolar Arctic region primarily by long-range transport from southern latitudes and resist environmental degradation (AMAP, 2015a). These chemicals bioaccumulate and biomagnify in food chains. The Inuit are especially susceptible to POP exposures from the consumption of marine mammals. They have been shown to have higher body burden of polychlorinated biphenyls (PCBs) and organochlorine pesticides compared to the general Canadian population (Laird et al., 2013). Only a few studies in Inuit populations have investigated the effect of POPs on cardiovascular disease risk factors (Château-Degat et al., 2010; Valera et al., 2013a, 2013b). In a cross-sectional study of Inuit adults from Nunavik, PCBs and p,p′-dichlorodiphenyldichloroethylene (p,p′-DDE) were found to be associated with higher risk of hypertension (Valera et al., 2013a). Among Inuit from Greenland, dioxin-like PCBs and p,p′-dichlorodiphenyltrichloroethane (p,p′-DDT) were associated with higher risk of hypertension in younger respondents 18–39 years of age, but not in older respondents ≥ 40 years (Valera et al., 2013b). Perfluorooctanesulfonate (PFOS) plasma levels were negatively associated with triacylglycerol and ratio of total cholesterol to HDL-C in Nunavik (Château-Degat et al., 2010).

The purpose of this study was to investigate the association of PCBs, a ubiquitous group of POPs, on high cholesterol and related clinical parameters. This area of investigation has received little attention in Inuit, although studies have been conducted in other populations (Aminov et al., 2013; Goncharov et al., 2008). An investigation of PCBs and high cholesterol in Canadian Inuit will add to our understanding of potentially novel risk factors for this important condition.

2. Methods

2.1. Participants and data collection

The Adult Inuit Health Survey (IHS, 2007–2008) was a cross-sectional survey of Canadian Inuit across 33 coastal communities and three inland communities in the Inuvialuit Settlement Region, Nunavut Territory, and Nunatsiavut and was conducted as part of the International Polar Year program (Saudny et al., 2012). The survey included questionnaires about health status, chronic diseases, and behaviours such as exercise, smoking and alcohol intake. Also included in the survey were tests of clinical parameters and blood levels of PCBs. A total of 2595 Inuit who were 18 years of age or older participated in the survey (68% participation rate) and 2191 were classified as with or without high cholesterol. Pregnant women were excluded. All work was approved by the research ethics boards of the University of Northern British Columbia, McGill University and the University of Ottawa. Scientific Research Licenses for the IHS were obtained from relevant northern research institutions (the Aurora Research Institute, Northwest Territories and Qaujisaqtulirijikkut, Nunavut).

2.2. Exposures

The association with high cholesterol and related measures was explored with individual plasma PCB congeners (PCB-99, 105, 118, 138, 153, 156, 170, 180, 183, and 187) and PCB groupings of sum of dioxin-like PCBs (ΣDL-PCB) and sum of non-dioxin like PCBs (ΣNDL-PCB). Details of analytic methods and quality control procedures have been described previously (Laird et al., 2013). Samples were analyzed by the Laboratoire de Toxicologie at the Institut National de Santé Publique du Québec. ΣDL-PCB and ΣNDL-PCB were calculated according to the following:

Table 1
Quartile concentration cut-off values.

	Lipid-Based (μg/g lipid)	Wet-Weight (μg/L)
PCB-99		
Q1	[0.0016, 0.0059]	[0.015, 0.0362]
Q2	(0.0059, 0.0189]	(0.0362, 0.12]
Q3	(0.0189, 0.0509]	(0.12, 0.33]
Q4	(0.0509, 0.648]	(0.33, 4.9]
PCB-105		
Q1	[0.0004, 0.0011]	[0.004, 0.005]
Q2	(0.0011, 0.0032]	(0.005, 0.02]
Q3	(0.0032, 0.0092]	(0.02, 0.057]
Q4	(0.0092, 0.111]	(0.057, 0.78]
PCB-118		
Q1	[0.0007, 0.0063]	[0.005, 0.038]
Q2	(0.0063, 0.0176]	(0.038, 0.11]
Q3	(0.0176, 0.0475]	(0.11, 0.31]
Q4	(0.0475, 0.631]	(0.31, 4.9]
PCB-138		
Q1	[0.0007, 0.0184]	[0.005, 0.1]
Q2	(0.0184, 0.0541]	(0.1, 0.32]
Q3	(0.0541, 0.135]	(0.32, 0.88]
Q4	(0.135, 1.99]	(0.88, 15]
PCB-153		
Q1	[0.0007, 0.0429]	[0.005, 0.25]
Q2	(0.0429, 0.134]	(0.25, 0.79]
Q3	(0.134, 0.352]	(0.79, 2.3]
Q4	(0.352, 6.18]	(2.3, 48]
PCB-156		
Q1	[0.0005, 0.0025]	[0.005, 0.0163]
Q2	(0.0025, 0.00795]	(0.0163, 0.048]
Q3	(0.00795, 0.0202]	(0.048, 0.13]
Q4	(0.0202, 0.412]	(0.13, 3.2]
PCB-170		
Q1	[0.0006, 0.00688]	[0.005, 0.04]
Q2	(0.00688, 0.0219]	(0.04, 0.13]
Q3	(0.0219, 0.0607]	(0.13, 0.39]
Q4	(0.0607, 1.37]	(0.39, 10]
PCB-180		
Q1	[0.0007, 0.0211]	[0.005, 0.12]
Q2	(0.0211, 0.0667]	(0.12, 0.4]
Q3	(0.0667, 0.186]	(0.4, 1.2]
Q4	(0.186, 4.77]	(1.2, 37]
PCB-183		
Q1	[0.0005, 0.0019]	[0.005, 0.01]
Q2	(0.0019, 0.0063]	(0.01, 0.038]
Q3	(0.0063, 0.0163]	(0.038, 0.11]
Q4	(0.0163, 0.291]	(0.11, 2.2]
PCB-187		
Q1	[0.0007, 0.0089]	[0.005, 0.049]
Q2	(0.0089, 0.026]	(0.049, 0.15]
Q3	(0.026, 0.0642]	(0.15, 0.42]
Q4	(0.0642, 0.94]	(0.42, 7.3]
ΣDL-PCB		
Q1	[0.0021, 0.0113]	[0.015, 0.064]
Q2	(0.0113, 0.0306]	(0.064, 0.182]
Q3	(0.0306, 0.0775]	(0.182, 0.509]
Q4	(0.0775, 1.14]	(0.509, 8.88]
ΣNDL-PCB		
Q1	[0.0331, 0.148]	[0.24, 0.822]
Q2	(0.148, 0.367]	(0.822, 2.2]
Q3	(0.367, 0.93]	(2.2, 6.02]
Q4	(0.93, 15.4]	(6.02, 120]

Abbreviations: DL-PCB = dioxin-like polychlorinated biphenyl; NDL-PCB = non-dioxin like polychlorinated biphenyl; PCB = polychlorinated biphenyl; Q = quartile.

$$\sum \text{DL} - \text{PCB} = \text{PCB} - 105 + \text{PCB} - 118 + \text{PCB} - 156$$

$$\sum \text{NDL} - \text{PCB} = \text{PCB} - 28 + \text{PCB} - 52 + \text{PCB} - 99 + \text{PCB} - 101 + \text{PCB} - 128 + \text{PCB} - 138 + \text{PCB} - 153 + \text{PCB} - 170 + \text{PCB} - 180 + \text{PCB} - 183 + \text{PCB} - 187$$

All contaminants were divided into quartile level on both wet-weight and lipid basis and the first quartile set as the reference category (Table 1 provides concentration ranges of each quartile for each