Blood Cadmium, Game Consumption and Tobacco Smoking in Southern Ontario Anglers and Hunters

Donald C. Cole, MD,¹ Jill P. Kearney, MSc²

Cadmium is a toxic metal currently on the Canadian Environmental Protection Act Priority List for reduction in the environment.¹ Public health concerns arose among the James Bay Cree² due to bioaccumulation of cadmium through the food chain into caribou, deer and moose meat, particularly the organs.^{3,4} The Ontario Ministry of Natural Resources currently warns hunters not to eat deer and moose organs.⁵ Along with occupational exposure, smoking also raises blood cadmium (CdB) levels due to high cadmium concentrations in Canadian cigarettes.⁶ We investigated the determinants of CdB in Southern Ontario anglers and hunters.

METHODS

Recruitment was through a multistage sampling design. Fish and wildlife consumption questionnaires were mailed to anglers listed in a datafile of 1988 Ontario sport fishing licence holders from two communities chosen because of their active fish populations: Cornwall (C, n=1,989) and Mississauga (M, n=2,288). Women were oversampled because of concerns about reproductive effects of contaminants in Great Lakes fish.⁷ The respondents (C, n=992, M, n=776, 41% overall) were generally older than those mailed questionnaires. An additional number of personal interviews were conducted in the Cornwall

area using the same questionnaire (n=94). We calculated PCB intake indices based on species-locations reported in respondents' questionnaires and Ontario Ministry of Environment and Energy PCB fish contaminant data (C, n=841, M, n=687). For biological sampling and more detailed interviewer-administered questionnaires, we invited approximately equal numbers of those with high to medium indices and those with no known consumption of Great Lakes fish (C, n=400, M, n=305). Consenting participants (C, n=141, M, n=91, 33% overall) were more frequently male and reported significantly higher yearly consumption of wildlife and game than non-respondents, but smoking patterns were the same.⁸

The questionnaire included items on current and former smoking, current and former home and occupational exposures

to metal fumes or dusts, and game organ meat consumption. CdB level was chosen to indicate current versus lifetime exposures to cadmium. One blood sample was drawn through a disposable, stainless steel needle into a vacuumized 7 mL metal-free vacutainer with sodium heparin as anticoagulant; the vacutainer was repeatedly inverted to assure mixing. CdB was determined by graphite furnace atomic absorption spectrophotometry,⁹ with a limit of detection (LOD) of 0.05 µg/L and limit of quantification (LOQ) of 0.2 µg/L. If control samples of known cadmium concentrations were >10% from the target value, all samples in a batch (n=12) were reanalyzed. Follow-up with the family physician was recommended for those above the U.S. Occupational Safety and Health Administration's (OSHA) recommended action level of 5 µg/L.¹⁰

1. Environmental Health Program, McMaster University

2. Environmental Health Directorate, Health Canada

Correspondence and reprint requests: Donald C. Cole, McMaster University, 1200 Main St. W., HSC 2C1, Hamilton, ON L8N 3Z5, Tel: 905-525-9140 ext. 22037, Fax: 905-577-0017

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TABLE I
Model of ln (cadmium in whole blood µg/L) ($r^2=0.76$)

Variable	Coefficient (ßi)	Standard error (ßi)	P-Value	e ^{ßi}
Intercept	-2.202	0.235		0.111
Gender (1=female)	0.253	0.118	0.033	1.288
Age (years)	0.012	0.005	0.017	1.012
Current smoker (1=yes)	2.453	0.231	0	1.162
Number of cigarettes or pipes smoked/day	0.025	0.01	0.013	1.025

All variables went through stages of data description, summary statistics and natural log transformations for the CdB data with corresponding geometric means. In subsequent statistical analyses, non-detectable/quantifiable values were replaced with a value equal to one-half LOD. Potential exposure (e.g., game consumption) and confounder (e.g., smoking) variables were included in a stepwise regression model using SAS.¹¹ A p-value of 0.10 was used for inclusion of main effect variables. No two-way interaction terms of these selected main effect variables were significant at $p=0.05$.

RESULTS

Sample clotting occurred for 13% of participants (31/232). Seventy-four samples were below the LOQ, considerably skewing the distribution among the remaining 201 participants. Only 12/232 (10/201 usable CdB samples) reported consumption of game organ meats. Exposure to metal dust and fumes was reported at work by 44.1% and at home by 25% of participants but none reported exposure to cadmium specifically. Although increasing age and female gender played a role, CdB levels were most strongly related to smoking status descriptively (Figure 1) and in regression modelling (Table I). Neither deer and moose meat consumption nor exposure to metal dust or fumes entered the model.

The geometric mean CdB was 0.14 µg/L ($n=59$) for non-smokers, compared with 3.94 µg/L for current smokers ($n=65$) and 7.54 µg/L for those smoking more than 31 cigarettes/day ($n=6$) (Figure 1). Twenty-five participants (38.5% of all smokers) had CdB levels above the OSHA guideline.

The maximum CdB value was 14.6 µg/L in a 54-year-old woman with no reported exposures to metal dusts or fumes, who smoked 50 cigarettes/day and consumed 50 moose meals per year, including 3-4 moose livers. Based on the Table I regression model, her predicted CdB value would have been 10.8 µg/L, three quarters of that observed, leaving 14.6-10.8=4.2 µg/L of her observed value to be attributed to her game consumption.

DISCUSSION

A strong dose-response relationship between tobacco smoking and CdB has previously been found in two Canadian populations. The geometric mean CdB for families with commercial fishing licences on the St. Lawrence River's north shore increased from 0.31 µg/L (95% CI, 0.24-0.39) for non-smokers to 8.08 µg/L (95% CI, 7.32-8.93) for those smoking >30 cigarettes per day.¹² Among Quebec Inuit families who hunted game, non-smokers had a geometric mean of 0.26 µg/L, former smokers, 0.75 µg/L and current smokers, 6.78 µg/L.¹³ In other countries, CdB levels are generally lower, e.g., in Wisconsin, Great Lakes anglers who smoked >30 pack years had arithmetic means of 1.03 µg/L (fish eaters) and 0.65 µg/L (controls).¹⁴ For Japan, geometric means were 4.18 µg/L in male and 4.29 µg/L in female smokers, but geometric means in non-smokers were similar at 3.04 µg/L (men) and 3.50 µg/L (women), likely indicating cadmium sources other than smoking.¹⁵

This study found low levels of CdB in non-smokers even though our population was older and included proportionately more game consumers than among the overall angler population. Despite these

selection biases, smoking status was similar, which allowed for an analysis of the role of game consumption in affecting CdB levels. It was determined that the contribution to CdB levels of game consumption was overwhelmed by that of smoking. Canadian smokers are particularly at risk of reaching CdB levels at which the risk of kidney damage,¹⁶ reductions in bone density¹⁷ and lung cancer¹⁸ are conceivable on the basis of cadmium exposure alone. Given the nutritional and financial benefits of harvested game consumption for moderate consumers, emphasis should be on counselling hunters to reduce cigarette consumption before urging them to eat less game.

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