Active and passive smoking increase blood cadmium concentrations in Canadian newcomers and Canadian-born participants; a preliminary report.

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Introduction

High cadmium exposure is a population health hazard, which may cause a decrease in long-term bone mineral density and act as a risk factor for osteoporosis.[1-4] Moreover, a high cadmium body burden is associated with increased excretion of beta 2-microglobulin from urine, which is a nonspecific biomarker of future kidney disease.[5-7] Finally, zinc[8-11] and iron[12,13] absorption have shown to be negatively affected by cadmium, and conversely could affect the rate of cadmium absorption.

Smoking has been attributed to cadmium exposure.[19] Moreover, recent reports suggest smoking is a greater contributor for Cadmium exposure in First Nations communities of Canada, versus consumption of cadmium-accumulating organ meats.[20] Cadmium concentrations were positively associated with the number of cigarettes smoked daily.[21]

In this study, we hypothesized that smoking would increase the bodily cadmium burden, and that Canadian newcomers may harbour different heavy metal concentrations, in comparison to the Canadian-born population, leading to health inequities across the nation.

Methods

Data from the Canadian Health Measures Survey was used to examine groupings of newcomers (Caucasian (CN) and non-Caucasian (NCN)) and Canadian-born (CB) participants. Smoking, as one of the sociodemographic variables, was assessed to examine the influence of exposure on heavy metal burden within the body. Smoker type (e.g., never, daily), and whether or not there were daily smokers within the home, categorically characterized participant smoking exposure. Finally, time since quitting daily smoking was additionally examined as a continuous variable. Canadian newcomers and Canadian-born were compared.

Results

Active smoking

- **Cadmium**

Smoking significantly increased cadmium concentrations for both CN and NCN ($p<0.0001$), and CB ($p<0.0001$).

Smoking elevated concentrations of cadmium for all subgroups.

Passive smoking

- **Cadmium**

Having smokers inside of the home significantly increased cadmium, as well, for both CN (0.0002) and NCN (0.0002) newcomers, and CB ($p<0.0001$).

Living with members that smoke inside the home elevated cadmium for all subgroups.

Lastly, all significant associations of metal concentrations and time since quitting smoking daily were negatively directed ($p<0.0001$).

Quitting daily smoking reduced cadmium for all subgroups.

Discussion

This study found that both active and passive smoking is related to increased body burden of cadmium that could be a risk factor for osteoporosis and kidney diseases. These findings are consistent with similar studies.[19,21-23]

We also found that newcomers have higher total blood cadmium levels, in comparison to CB participants, which NCN exhibiting the highest cadmium levels. The observation of elevated metal concentrations in newcomers, compared to native-born individuals, is consistent with prior research conducted on this topic.[24,25] And more specifically, differing exposure concentrations between CN and NCN is also consistent with prior studies conducted where the researchers found regional variations in the dioxin and the aflatoxin exposure burden [26], similar to our results on metals.

Although cadmium can be measured in blood, urinary cadmium levels better reflect total body burden.[14-17] Normal urine levels should generally be less than 1 mcg/g of creatinine.[18] If higher levels are observed, long-term exposure to cadmium is likely. The limited access to urinary cadmium is a limitation for this study.

Conclusion

The results of this investigation suggest that active and passive smoking are both a predictor of elevated blood cadmium, supporting the concept that smoking is detrimental to health.

The strength of the association between, both, active and passive smoking is a relationship that smokers should be aware of. Smokers, or those exposed to second-hand smoke frequently, may require lifestyle advice on preventing other risk factors of osteoporosis and kidney diseases, such as mobility. They may also require awareness towards diet modifications, and supplementation, to minimize risk of cadmium exposure.

Moreover, this study provides insight on the necessity to identify important distinctions amongst newcomer subgroups when examining health, allowing us to move past the Canadian-born/newcomer dichotomy. Because of the lengthy half-lives of particular metals such as cadmium, it is expected that mono tonic and non-monotonic health burdens may persist for an extended period of time amongst heavily exposed newcomers.

The results of this investigation are unique and have provided a starting point for the development of forthcoming targeted interventions and risk management strategies for particular subgroups, disproportionately exposed to cadmium.

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References

1. Wallin, M. et al. Kidney cadmium levels and associations with urinary calcium and bone mineral density: a cross-sectional study in Sweden. Environ Health 12, 22, doi:10.1186/1476-069x-12-22 (2013).

2. Nambunmee, K. et al. Bone resorption acceleration and calcium reabsorption impairment in a Thai population with high cadmium exposure. Toxicol Mech Methods 20, 7-13, doi:10.3109/15376510903452941 (2010).

3. Kazantzis, G. Cadmium, osteoporosis and calcium metabolism. Biometals 17, 493-498 (2004).

4. Kido, T. et al. The renal handling of calcium and phosphorus in environmental cadmium-exposed subjects with renal dysfunction. J Appl Toxicol 13, 43-47 (1993).

5. Cai, S. et al. A judgment of attribution of increase in urine beta 2-microglobulin after environmental cadmium exposure. Biomed Environ Sci 5, 130-135 (1992).

6. Ellis, K. J., Cohn, S. H. & Smith, T. J. Cadmium inhalation exposure estimates: their significance with respect to kidney and liver cadmium burden. J Toxicol Environ Health 15, 173-187, doi:10.1080/15287398509530644 (1985).

7. Chaumont, A., De Winter, F., Dumont, X., Haufroid, V. & Bernard, A. The threshold level of urinary cadmium associated with increased urinary excretion of retinol-binding protein and beta 2-microglobulin: a re-assessment in a large cohort of nickel-cadmium battery workers. Occup Environ Med 68, 257-264, doi:10.1136/oem.2009.054122 (2011).

8. Vance, T. M. & Chun, O. K. Zinc Intake Is Associated with Lower Cadmium Burden in U.S. Adults. J Nutr 145, 2741-2748, doi:10.3945/jn.115.223099 (2015).

9. McCarty, M. F. Zinc and multi-mineral supplementation should mitigate the pathogenic impact of cadmium exposure. Med Hypotheses 79, 642-648, doi:10.1016/j.mehy.2012.07.043 (2012).

10. Banni, M., Chouchene, L., Said, K., Kerkeni, A. & Messaoudi, I. Mechanisms underlying the protective effect of zinc and selenium against cadmium-induced oxidative stress in zebrafish Danio rerio. Biometals 24, 981-992, doi:10.1007/s10534-011-9456-z (2011).

11. Vidal, A. C. et al. Maternal cadmium, iron and zinc levels, DNA methylation and birth weight. BMC Pharmacol Toxicol 16, 20, doi:10.1186/s40360-015-0020-2 (2015).

12. Suh, Y. J. et al. Prevalence and Relationships of Iron Deficiency Anemia with Blood Cadmium and Vitamin D Levels in Korean Women. J Korean Med Sci 31, 25-32, doi:10.3346/jkms.2016.31.1.25 (2016).

13. Lee, B. K., Kim, S. H., Kim, N. S., Ham, J. O. & Kim, Y. Iron deficiency increases blood cadmium levels in adolescents surveyed in KNHANES 2010-2011. Biol Trace Elem Res 159, 52-58, doi:10.1007/s12011-014-9982-y (2014).

14. The ToxGuide™ is developed to be used as a pocket guide. Tear off at perforation and fold along lines. ATSDR. https://www.atsdr.cdc.gov/toxguides/toxguide-5.pdf (accessed Nov 05, 2018).

15. Sun, H. et al. Association of cadmium in urine and blood with age in a general population with low environmental exposure. Chemosphere 156, 392-397, doi:10.1016/j.chemosphere.2016.05.013 (2016).

16. Mascagni, P., Consonni, D., Bregante, G., Chiappino, G. & Toffoletto, F. Olfactory function in workers exposed to moderate airborne cadmium levels. Neurotoxicology 24, 717-724, doi:10.1016/s0161-813x(03)00024-x (2003).

17. Kowal, N. E., Johnson, D. E., Kraemer, D. F. & Pahren, H. R. Normal levels of cadmium in diet, urine, blood, and tissues of inhabitants of the United States. J Toxicol Environ Health 5, 995-1014, doi:10.1080/15287397909529809 (1979).

18. Cadmium. IBM Micromedex ®.

19. Satarug, S. Long-term exposure to cadmium in food and cigarette smoke, liver effects and hepatocellular carcinoma. Curr Drug Metab 13, 257-271 (2012).

20. Ratelle, M., Li, X. & Laird, B. D. Cadmium exposure in First Nations communities of the Northwest Territories, Canada: smoking is a greater contributor than consumption of cadmium-accumulating organ meats. Environ Sci Process Impacts 20, 1441-1453, doi:10.1039/c8em00232k (2018).

21. Charania, N. A. et al. An examination of traditional foods and cigarette smoking as cadmium sources among the nine First Nations of Eeyou Istchee, Northern Quebec, Canada. Environ Sci Process Impacts 16, 1422-1433, doi:10.1039/c4em00064a (2014).

22. Satarug, S. & Moore, M. R. Adverse health effects of chronic exposure to low-level cadmium in foodstuffs and cigarette smoke. Environ Health Perspect 112, 1099-1103, doi:10.1289/ehp.6751 (2004).

23. McElroy, J. A., Shafer, M. M., Trentham-Dietz, A., Hampton, J. M. & Newcomb, P. A. Urinary cadmium levels and tobacco smoke exposure in women age 20-69 years in the United States. J Toxicol Environ Health A 70, 1779-1782, doi:10.1080/15287390600754953 (2007).

24 . Curren, M. S. et al. Comparing plasma concentrations of persistent organic pollutants and metals in primiparous women from northern and southern Canada. The Science of the total environment 479-480, 306-318, doi:10.1016/j.scitotenv.2014.01.017 (2014).

25. Wu, W. T. et al. Changing blood lead levels and DNA damage (comet assay) among immigrant women in Taiwan. The Science of the total environment 407, 5931-5936, doi:10.1016/j.scitotenv.2009.07.025 (2009).

26. Gibb, H. et al. World Health Organization estimates of the global and regional disease burden of four foodborne chemical toxins, 2010: a data synthesis. F1000Research 4, 1393, doi:10.12688/f1000research. 7340.1 (2015).