Mercury, fisheries, and health in four Caribbean countries

Mercurio, pesca y salud humana en cuatro países del Caribe

Mercure, pêcheries et santé humaine dans quatre pays des Caraïbes

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EXTENDED ABSTRACT

Mercury (Hg) is a nonessential, toxic trace element that bioaccumulates in marine organisms and biomagnifies in marine food webs. Exposure to high levels of Hg, often through seafood consumption, can have negative effects on human health (Rice et al. 2014). The dietary cultures of the Southern Caribbean region include a wide range of seafood consumption patterns, with different species consumed at different rates. Therefore, human exposure to Hg is expected to vary by country.

In terms of health risk from Hg exposure, the Environmental Protection Agency (USA) considers a hair Hg concentration of <1µg/g as low risk, 1-5µg/g as medium risk, and >5 µg/g as high risk (EPA 1997). Implementing a novel, community-engaged research method, this study partnered with local barbershops and hair salons in Barbados, Grenada, St. Lucia, and St. Vincent & the Grenadines (SVG) to collect human hair samples from volunteer adult (18+) participants, along with responses to a survey with questions pertaining to participants' demographics, diets, and health histories. In each country, five barbershops and/or hair salons were selected as sample-collection sites, resulting in twenty total sites across the region (Figure 1). Barbers and hairstylists were trained to collect and store hair samples and to guide participants when needed through self-administered paper survey questionnaires. At their request, study participants received their own Hg concentrations by mail or email after the study concluded. The study attracted 434 participants. For 23 of these, an insufficient quantity of hair was collected, or the survey was not completed correctly. These were eliminated from the study, leaving 411 hair samples with corresponding survey responses for analysis.

Hair samples were analyzed for total Hg concentrations—a well-established standard method to measure human Hg exposure (Katz & Katz 1992)—using a modified Nippon MA-3000 direct Hg analyzer with an atomic absorption spectrometer. Due to the failure of the assumption of normality, a Kruskal Wallis ANOVA on Ranks and Dunn's pairwise comparison was used to determine if there was a significant difference in hair Hg concentrations among countries. All human-subject research in this study was approved by the Institutional Review Board at Coastal Carolina University (protocols #2021.170 and #2023.202) and the respective research oversight board in each country.

Findings indicate patterns of wide variation in Hg exposure across the four countries in the study area (Figure 2). The highest Hg concentration in the entire dataset was 1135.87 µg/g, measured in a sample from Barbados. While we are confident in the accuracy of this datum, we removed the outlier from statistical analysis owing to its skewing effect on the dataset. With this outlier removed, the mean Hg concentration measured across all samples with the outlier included was 4.59 µg/g; with the outlier removed, the mean was 1.8 µg/g. This value is comparable to the mean values reported in several other, similar studies and compiled by Katz & Katz (1992), as follows: China, 0.9 µg/g; Canada, 1.2 µg/g; United Kingdom, 1.6 µg/g; United States, 2.4 µg/g; Australia, 2.5 µg/g; and Japan, 3.9 µg/g. Considering the data by country, again with the Barbados outlier removed from the analysis, two groupings become apparent: Barbados and SVG with higher Hg concentrations, and Grenada and St. Lucia with lower Hg concentrations.

The high mean value of Hg exposure in samples from SVG was expected, owing to that country's reliance upon whaling for high trophic-level odontocetes (toothed whales and dolphins) as a significant part of its food system (Fielding et al. 2020). St. Lucia also supports a whaling operation targeting odontocetes and reported consumption of odontocetes in the

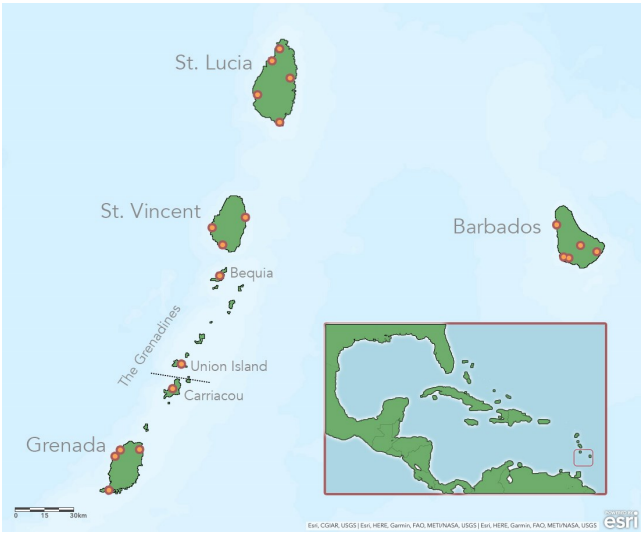

Figure 1. Map of study sites in Barbados, Grenada, St. Lucia, and St. Vincent & the Grenadines

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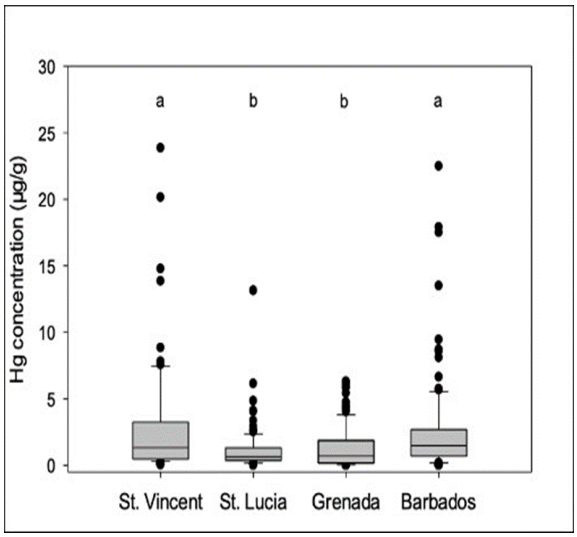

Figure 2. Box and whisker plots showing the hair Hg concentrations in St. Vincent & the Grenadines (n = 77, max = 23.84, median = 1.32, mean = 2.74), St. Lucia (n = 126, max = 13.13, median = 0.63, mean = 1.10), Grenada (n = 91, max = 6.29, median = 0.69, mean = 1.22), and Barbados (n = 116, max = 22.48, median = 1.47, mean = 2.52). The minimum Hg concentration for each country was at or near zero. An outlier of 1136 (Barbados) was removed from the dataset for this figure. The whiskers extend to 1.5-times the interquartile range and dots are outliers. Lowercase letters represent countries grouped by similar hair Hg concentrations. All Hg concentrations measured in µg/g.

two whaling countries were similar (2.11 meals per person per year in St. Lucia and 2.56 in SVG, as compared with 0.02 in Barbados and none in Grenada), however, mean and median Hg concentrations in St. Lucia were significantly lower than in SVG. The divergence between the St. Lucia and SVG data are difficult to explain from reported dietary data alone. The high mean and median values for Barbados, both comparable to values from SVG, as well as the presence of the extreme outlier, are also difficult to explain. These may be due, partially, to the relative popularity of high trophic-level marine fishes in Barbados.

In 2020, St. Vincent's main active volcano, La Soufrière, entered an eruptive phase and in 2021, large ash clouds were emitted that fell over St. Vincent and Barbados (Robertson et al. 2024). Since Hg can be emitted from volcanic eruptions, the possibility of Hg exposure to participants from those two countries from the volcanic ejecta, in addition to Hg exposure from their diets, cannot be ruled out at this time. Future research is planned to investigate this possibility.

These findings suggest the need for additional research to better understand patterns of Hg exposure in these countries, as well as better public dietary recommendations to assist consumers in making informed, health-conscious choices about their seafood consumption.

KEYWORDS: biomagnification, environmental health, methylmercury, nutrition, whaling

LITERATURE CITED

EPA [United States Environmental Protection Agency]. 1997. Mercury Study Report to Congress. Office of Air Quality Planning and Standards and Office of Research and Development. EPA-452/R-97-003. https://www.epa.gov/mercury/mercury-study-report-congress

Fielding, R., J. Kiszka, C. Macdonald, M.A. McCormack, J. Dutton, A. Ollivierre, J.A. Arnett, M. Elkins, N.A. Darby, H.-M. Garcia, S. Skinner, H. Tucker, and V. Reid. 2021. Demographic and Geographic Patterns of Cetacean-based Food Product Consumption and Potential Mercury Exposure within a Caribbean Whaling Community. Human and Ecological Risk Assessment 27(6): 1671-1695.

Katz, S.A., and R.B. Katz. 1992. Use of Hair Analysis for Evaluating Mercury Intoxication of the Human Body: a Review. Journal of Applied Toxicology 12(2):79-84.

Rice, K.M., E.M. Walker, Jr., M. Wu, C. Gillette, and E.R. Blough. 2014. Environmental Mercury and Its Toxic Effects. Journal of Preventive Medicine & Public Health 47(2):74-83.

Robertson, R.E.A., E.P. Joseph, J. Barclay, and R.S.J. Sparks. 2024. The 2020-21 Eruption of La Soufrière Volcano, St Vincent. Geological Society, London. Special Publication 539.