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O. Drescher<sup>a</sup>, E. Dewailly<sup>a,b</sup>, L. Sandy<sup>c</sup> & M. Forde<sup>d</sup>

<sup>a</sup> Laval University CHUQ Research Center, Québec, Canada

<sup>b</sup> Institut National de Santé Publique, Québec, Canada

<sup>c</sup> University of the West Indies, Cave Hill Campus, Barbados

<sup>d</sup> Department of Public Health & Preventive Medicine, St. George's  
University, St. George's, Grenada

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## Mercury Levels in Barbadian Fisher Folk and Commonly Caught Fish Species

O. Drescher,<sup>1</sup> E. Dewailly,<sup>1,2</sup> L. Sandy,<sup>3</sup> and M. Forde<sup>4</sup>

<sup>1</sup>Laval University CHUQ Research Center, Québec, Canada; <sup>2</sup>Institut National de Santé Publique, Québec, Canada; <sup>3</sup>University of the West Indies, Cave Hill Campus, Barbados; <sup>4</sup>Department of Public Health & Preventive Medicine, St. George's University, St. George's, Grenada

### ABSTRACT

Ocean fish are an important staple food for many Caribbean persons. Some species, however, have high Hg concentration levels and represent a significant source of Hg exposure. This study assessed Hg concentrations in fish species commonly caught and consumed in Barbados as well as Hg exposure of those who work in the fishing industry. Total Hg concentrations were measured in 100 fish samples. Human Hg concentrations were determined from hair snippets taken from 46 fisher folk and fish consumption habits evaluated using interview-administered questionnaires. Mercury levels varied by fish species with predatory fish species having the highest concentrations. Low Hg concentrations were found in dolphinfish (*Coryphaena hippurus*) and flyingfish (*Hirundichthys affinis*). Reported fish consumption rates were high and varied significantly between men and women,  $2675 \pm 1600$  and  $1275 \pm 600$  (g/week), respectively ( $p = 0.01$ ). The median hair Hg concentration was  $3.1 \pm 2.3$   $\mu\text{g/g}$  (range: 0.01–15.6  $\mu\text{g/g}$ ) and significantly associated with consumption of “high-risk” fish species ( $p = .02$ ). These results show that it is possible to make informed choices concerning fish consumption habits in order to maximize benefits while minimizing the effect of Hg exposures, especially for sensitive groups such as pregnant women and infants.

**Key Words:** mercury, fish species, fish consumption, Caribbean, Barbados.

### INTRODUCTION

Mercury is a global pollutant causing adverse environmental and human health effects not only in the areas of major emission but also at non-source locations such as the Caribbean and Arctic regions (Van Oostdam *et al.* 2004). Mercury has always been present in the environment due to natural geological processes of deposition

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Address correspondence to E. Dewailly, Public Health Research Unit, CHUQ, 2875 Boulevard Laurier, Édifice Delta 2, Bureau 600, G1V 2M2, Québec, Canada. E-mail: eric.dewailly@crchul.ulaval.ca

and atmospheric transport, but in the last century due to the industrialization of many countries environmental Hg loading has significantly increased (Walsh *et al.* 2008; AMAP 2011).

The Hg released into aquatic surroundings can be converted to methylmercury (MeHg) by microorganisms in sediments. Methylmercury accumulates in animal tissues and increases in concentration at each trophic level of the food chain. As a result of this biomagnification process, predator fish can have very high Hg concentrations with up to 80 to 90% of total Hg found in fish flesh in the form of MeHg (Hall 1974; Goyer *et al.* 2000; Storelli *et al.* 2002). Humans are exposed to MeHg primarily through the consumption of contaminated fish, particularly large predatory ocean fish species such as tuna, swordfish, shark, marlin, and large marine mammals such as whale (Goyer *et al.* 2000).

Evidence based on the findings of large MeHg poisoning outbreaks such as in Japan in the 1950–60s in the Minimata Bay area and in Iraq in 1970 have clearly indicated that neurotoxicity resulting from *in utero* exposure is one adverse health outcome of great concern (Legrand *et al.* 2010). Additionally, a spectrum of other adverse health effects have been observed following exposure to MeHg, particularly to the nervous system and the developing brain, and more recently to the cardiovascular system (Roman *et al.* 2011).

In the absence of unusual exposures to elemental or inorganic Hg, the main form of Hg deposited during hair growth is generally methylmercury (Lindberg *et al.* 2004) and hair analyzed in segments reflects temporal exposure patterns (Schoeman *et al.* 2010). Based on the onset of clinical disease associated with certain blood and hair MeHg levels, a provisional tolerable weekly intake (PTWI) of 1.6  $\mu\text{g}/\text{kg}$  bodyweight has been suggested as a safe exposure limit (FAO/WHO 2011). The PTWI corresponds to a hair Hg level of 2.2  $\mu\text{g}/\text{g}$  and was set at the 61st meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA) and reaffirmed at the latest 72nd meeting.

In 2007, the estimated per capita consumption rate of fish in Barbados was 43 kg/year, which is significantly greater than the world average of 18 kg/year (FAO 2011). Given that consumption of contaminated fish (especially large pelagic fish) is a major source of human exposure to MeHg, the high fish consumption of Barbadians raises concern of potential exposure to this contaminant, especially for fisher folk and their families.

Apart from an investigation of Hg levels in fish species that are commonly found in and around Bermuda (Dewailly *et al.* 2008), there are very few available data for other Caribbean islands on fish Hg burden by fish species. The objectives of this present study were twofold: (1) to measure Hg concentrations in fish species commonly landed and consumed in Barbados and (2) to evaluate fish consumption habits of a subgroup of the population made up of Barbadians working in the fishing industry (fishermen, fish market vendors, processors, helpers) and their family members by using hair as a biomarker of mercury exposure (H-Hg).

## METHODS AND MATERIALS

The study was conducted in Barbados by the Centre Hospitalier Universitaire de Québec (CHUQ) research center of Laval University, Quebec, Canada, with

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the assistance of the Institut National de Santé publique du Québec (INSPQ), and in partnership with the Caribbean EcoHealth Programme (CEHP)—a Canadian Global Health Research Initiative (GHRI) funded initiative (Forde *et al.* 2011)—and the University of the West Indies (Barbados). The study protocol was approved by the Barbados Ministry of Health Research Ethics Committee (2010). All individuals who agreed to participate in the study signed a written consent form. In the case of minors (<18 years old), parents were allowed to sign the consent form and answer for their children.

### Sampling of Fish Species

Fish samples were collected at the main Barbados fish markets located at Bridgetown and Oistins from species regularly sold for local consumption. Samples were collected over a 3-months period from multiple fish vendors and processors working in the fish market. Samples were also collected from local sport fishermen who usually keep their catch for personal consumption and sell the excess to local restaurants. Samples were taken from white muscle tissue in the abdominal area next to the gills or near the caudal fin. Samples were frozen and stored at  $-20^{\circ}\text{C}$  until analyzed for their Hg content. Fish weights were determined for the whole fish in flyingfish and queen snappers. Spinny lobsters were also weighted intact. Tunas, swordfish, sailfish, Caribbean reef shark, and blue marlins were weighed without head and viscera, while all other fish species were weighed with head intact but without viscera.

### Recruitment of Participants

Barbadians working in the fishing industry (fishermen, vendors, processors, helpers) and their family members were recruited at the two main fishing complexes on the island—Bridgetown and Oistins fish market—using a snowball sampling strategy. This choice of sampling technique was based on the premise that individuals working in the fishing industry know each other and can therefore identify potential eligible participants within their small informal networks. Persons that had been living in Barbados for less than 1 year of the participation date were excluded from the study.

### Questionnaires

Interview-administered questionnaires in the responders' native language (English) were used to collect information on each consenting participant's age, profession, and fish consumption per week by fish species. Fish meal portion sizes (grams) were determined by presenting to each participant pictures of cooked fish meals with utensils for size reference. The questionnaire was administered at the same time that the hair sample was taken.

### Hair Sampling and Hg Analysis

Hair samples were cut with stainless steel scissors from the occipital region of the scalp, the roots stapled on a length of cardboard, and stored in Ziploc bags. Total Hg was measured by cold vapour atomic absorption mass spectrometry using

a Pharmacia Hg monitor (model 100), using standard methods (M-111 and M-222) developed by the INSPQ for analysing total Hg in hair and in biological tissue samples (Ebbestadt *et al.* 1975). For both fish and hair samples, approximately 10 mg of fish or hair (first cm) were digested with nitric acid in pressured vials and the digests then vaporized through a cell crossed by a light beam. Mercury concentrations were calculated by comparing the absorbance at 254 nm with that obtained with a Hg standard curve. Each run of fish samples included two reference standards, DOLT-2 (3.4  $\mu\text{g/g}$ ) and DORM-3 (4.6  $\mu\text{g/g}$ ), and a blank. The same was true for each run of hair samples with two sets of powdered hair reference standards (1.1 and 5.2  $\mu\text{g/g}$ ) provided by the INSPQ. The results for the fish samples are expressed on a wet weight basis and the limit of detection was 0.02  $\mu\text{g/g}$  wet-weight. For each batch of specimens analyzed, approximately 10% of the fish sample digests were selected for a repeat analysis.

The limit of detection for the hair analysis was 0.1  $\mu\text{g/g}$ . For each batch of hair specimen analyzed, approximately 10% of the hair sample digests were selected for a repeat analysis. Any specimen that had Hg concentrations of  $\geq 20$   $\mu\text{g/g}$  were re-analyzed and sent to the INSPQ for confirmation of total Hg levels and for inorganic Hg analysis.

### Statistical Analysis

Descriptive analyses were used to describe the distribution of Hg concentration levels in the fish flesh, hair-Hg (H-Hg) concentration levels, and fish consumption frequencies. Four extreme H-Hg values (361, 1404, 4012, and 5617  $\mu\text{g/g}$ ) were removed from the analysis and analyzed separately (Drescher *et al.* 2013). The fish consumption rate, recorded as grams per week (g/week), was determined for each participant by multiplying the number of fish meals reported per week (all species combined) by portion size. A “high-risk” fish consumption rate was also calculated by eliminating fish species that were found to be very low in Hg (flyingfish, dolphinfish, lobster, and shrimp) and presumably having a low impact on the total Hg body burden from the number of fish meals reported per week. Given that H-Hg concentration levels were asymmetrically distributed, measures less sensitive to outliers such as the median and median absolute deviation (MAD) were calculated and used instead of the mean and standard deviation. Kruskal-Wallis tests were used to compare H-Hg and fish consumption between men and women participants. Quantile regression analysis, also less sensitive to outliers, was used to examine the association between H-Hg concentrations and “high-risk” fish consumption rates. All statistical analyses were performed using SAS 9.2 software with the significance level set at  $p < .05$ .

## RESULTS

### Hg Levels in Barbadian Fish Species

A total of 100 samples were collected from 15 fish species commonly found in the marine waters that surround the island of Barbados. The mean Hg concentrations and weights of all fish samples are given in Table 1. The local fish species with the highest Hg concentrations were blue marlin ( $5.28 \pm 6.56$   $\mu\text{g/g}$  w.w.), tiger shark

**Table 1.** Mercury concentration levels ( $\mu\text{g/g}$  w.w.)<sup>†</sup>, and bodyweights (kg), in the flesh of fish and crustacean species caught in Barbadian waters, Bermudian waters (Dewailly *et al.* 2008), and U.S. waters (FDA 1990–2010).

Common name	Scientific name	Barbados					Bermuda			U.S. FDA		
		N	Total Hg ( $\mu\text{g/g}$ )		Bodyweight (kg)		N	Total Hg ( $\mu\text{g/g}$ )		N	Total Hg ( $\mu\text{g/g}$ )	
			Mean $\pm$ SD	Range	Mean $\pm$ SD	Range		Mean $\pm$ SD	Range		Mean $\pm$ SD	Range
Albacore tuna	<i>Thunnus alalunga</i>	1	0.55		14.5					43	0.36 $\pm$ 0.14 ND–0.82	
Amberjack	<i>Seriola lalandi</i>	7	1.01 $\pm$ 0.93	0.19–2.31	6.5 $\pm$ 4.3	2.3–13.4	8	0.55 $\pm$ 0.46	0.2–1.55			
Barracuda	<i>Sphyraena barracuda</i>	3	0.25 $\pm$ 0.05	0.20–0.30	6.8 $\pm$ 0.0	6.8–6.8	7	0.73 $\pm$ 0.38	0.18–1.4			
Blue marlin	<i>Makaira nigricans</i>	6	5.28 $\pm$ 6.56	0.14–14.44	162.7 $\pm$ 133.4	34.2–313	3	3.1 $\pm$ 0.17	3.0–3.3	16	0.49 $\pm$ 0.24*	0.1–0.92*
Dolphinfish	<i>Coryphaena hippurus</i>	25	0.25 $\pm$ 0.15	0.04–0.57	7.7 $\pm$ 2.6	3.6–14.5	1	0.05				
Flyingfish	<i>Hirundichthys affinis</i>	10	0.11 $\pm$ 0.09	0.04–0.35	0.1 $\pm$ 0.01	0.11–0.14	6	0.35 $\pm$ 0.016	0.05–0.19			
Kingfish	<i>Acanthocybium solandri</i>	1	0.49		8.2							
Queen snapper	<i>Etelis oculatus</i>	12	0.34 $\pm$ 0.18	0.19–0.87	3.0 $\pm$ 0.7	2–4.6	1	0.52		67	0.17 $\pm$ 0.24	ND–0.27
Sailfish	<i>Istiophorus albicans</i>	1	0.08		17.2							
Caribbean reef shark	<i>Carcharhinus perezii</i>	1	0.9		14.7		1	0.92				

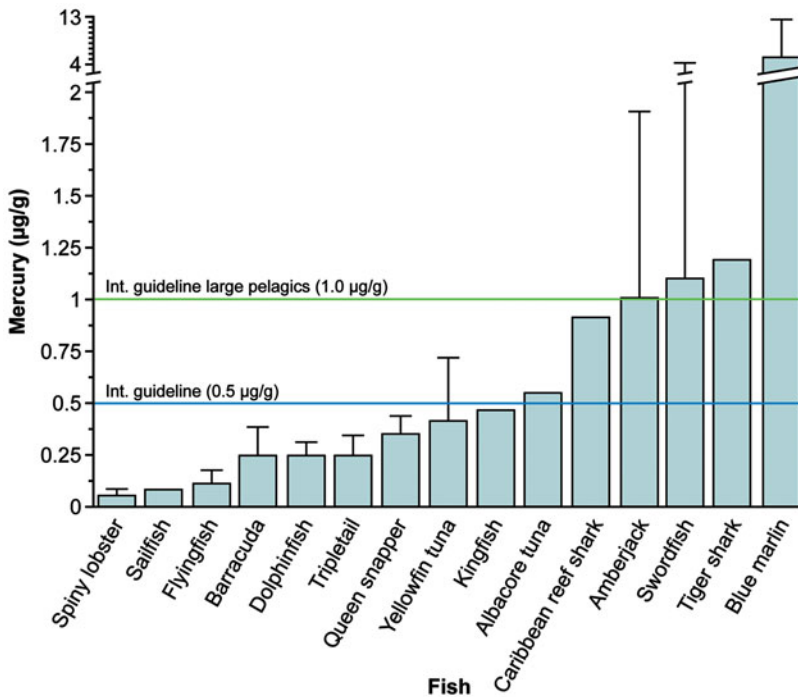
*(Continued on next page)*

**Table 1.** Mercury concentration levels ( $\mu\text{g/g}$  w.w.)<sup>†</sup>, and bodyweights (kg), in the flesh of fish and crustacean species caught in Barbadian waters, Bermudian waters (Dewailly *et al.* 2008), and U.S. waters (FDA 1990–2010). (*Continued*)

Common name	Scientific name	Barbados					Bermuda			U.S. FDA		
		N	Total Hg ( $\mu\text{g/g}$ )		Bodyweight (kg)		N	Total Hg ( $\mu\text{g/g}$ )		N	Total Hg ( $\mu\text{g/g}$ )	
			Mean $\pm$ SD	Range	Mean $\pm$ SD	Range		Mean $\pm$ SD	Range		Mean $\pm$ SD	Range
Spiny lobster	<i>Panurilus argus</i>	8	0.06 $\pm$ 0.02	0.04–0.09	0.2 $\pm$ 0.04	0.14–0.25				13	0.09 $\pm$ 0.1	ND–0.27
Swordfish	<i>Xiphias gladius</i>	2	1.09 $\pm$ 0.35	0.84–1.09	26.7 $\pm$ 23.3	10.2–43.1	1	3.31		636	1.0 $\pm$ 0.54	ND–3.22
Tiger shark	<i>Galeocerdo cuvier</i>	1	1.18		40.8							
Tripletail	<i>Lobotes surinamensis</i>	16	0.26 $\pm$ 0.18	0.11–0.84	2.6 $\pm$ 0.7	1.8–4.5						
Yellowfin tuna	<i>Thunnus albacares</i>	6	0.41 $\pm$ 0.29	0.16–0.95	35.9 $\pm$ 12.5	17.7–49	17	0.37 $\pm$ 0.18	0.18–1.1	231	0.35 $\pm$ 0.23	0.01–.48

<sup>†</sup>Total mercury concentrations are expressed on a wet weight (w.w.) basis. \*Results are expressed in concentrations of methylmercury. ND—Mercury concentration was less than detection level (Level of Detection = 0.01  $\mu\text{g/g}$ ).

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**Figure 1.** Fish mean total Hg concentration levels with upper 95% error bars and guideline recommendations determined by the USFDA and used by the U.S. and Canadian governments as legal limits for the maximum allowable Hg concentrations for the importation of commercial fish and/or fish to be sold on the market (0.5–1.0 µg/g). (Color figure available online.)

(1.18 µg/g w.w.), and swordfish (1.09 ± 0.35 µg/g w.w.). The local fish species with the lowest mean Hg concentration levels were flyingfish (0.11 ± 0.09 µg/g w.w.), sailfish (0.08 µg/g w.w.), and spiny lobster (0.06 ± 0.02 µg/g w.w.). Weights of blue marlin specimens varied greatly, ranging from 34.2 to 313 kg, as well as amberjacks: 10.2–43.1 kg, and yellowfin tunas: 17.7–49 kg. Shown in Figure 1 are the local fish species according to increasing concentrations of Hg in their flesh with 95% confidence limit top error bars. These recorded mean Hg concentration levels are compared with the two action limits determined by the U.S. Food and Drug Administration (FDA) and used by the U.S. and Canadian governments as legal limits for the maximum allowable Hg concentrations for the importation of commercial fish and/or fish to be sold on the market (WHO/UNEP 2008). The 1.0 µg/g limit has been adapted for large pelagic fish while all other fish should be less than 0.5 µg/g. The mean Hg concentration level was less than the 0.5 µg/g action level for a number of locally caught species, however, when referring back to Table 1, the range of recorded values indicate that some of these same fish specimens (*e.g.*, yellowfin tuna, tripletail, and queen snapper) were well above this level. Only

**Table 2.** Mercury concentration levels ( $\mu\text{g/g}$ ) in the hair of Barbadian participants and fish consumption rates (g/we).

	Men			Women			<i>p</i> -value <sup>‡</sup>
	N	Median $\pm$ MAD	Range	N	Median $\pm$ MAD	Range	
Age	26	46 $\pm$ 6.5	3–83	20	44 $\pm$ 7	3–63	.79
Hair mercury ( $\mu\text{g/g}$ )	26	4.30 $\pm$ 2.74	1.04–15.62	16 <sup>†</sup>	2.46 $\pm$ 0.89	0.01–7.29	.02
Fish consumption (g/we)	26	2675 $\pm$ 1600	200–12375	20	1275 $\pm$ 600	600–6500	.01
High-risk* fish consumption (g/we)	26	1875 $\pm$ 1087.5	0–5775	20	862.5 $\pm$ 437.5	0–5200	.01

MAD—Median Absolute Deviation. <sup>‡</sup>Kruskal-Wallis test. <sup>†</sup>Four extreme values were removed from the analysis and analyzed separately (Drescher *et al.* 2013).

\*High-risk fish consumption—calculated by eliminating fish species low in Hg (flyingfish, dolphinfish, lobster, and shrimp).

flyingfish, barracuda, and spiny lobster had all recorded Hg concentration levels less than the WHO 0.5  $\mu\text{g/g}$  action level.

### Hg Levels in Barbadian Fisher Folk

The study group was composed of 46 Barbadian fisher folk and family members: 26 men (median age: 46 yrs) and 20 women (median age: 44 yrs). Four women were found to have extremely high hair-Hg (H-Hg) levels (361, 1444, 4012, and 5617  $\mu\text{g/g}$  [inorganic Hg]) and were excluded from the study group to investigate alternative possible sources of Hg exposure in a separate case report. For these four women, Hg-containing skin lightening creams were eventually identified as the most probable source of their high Hg exposure (Drescher *et al.* 2013).

The median H-Hg concentration for the study group was 3.1  $\pm$  2.3  $\mu\text{g/g}$ , ranging between 0.8–15.6  $\mu\text{g/g}$  (excluding the four outliers). As shown in Table 2, the women had a median H-Hg concentration of 2.5  $\pm$  0.9  $\mu\text{g/g}$  and ate 1275  $\pm$  600 g/week of fish (all species included). The men had approximately twice the H-Hg concentration (4.3  $\pm$  2.7  $\mu\text{g/g}$ ) as the women, which may be related to the fact that they also reported eating twice as much fish (2675  $\pm$  1600 grams,  $p = 0.01$ ) compared to what the women reported. The fish species most consumed by the study participants were flyingfish, followed by marlin and tuna.

Hair-mercury concentration of the study participants increased according to “high-risk” fish consumption rate ( $\beta = 0.0015$   $p = .02$ ). Hence, a 100 g increase in “high-risk” fish consumption per month was associated with an increase of 0.15 ppm in H-Hg. The relation between H-Hg concentrations and fish consumption rate (all species included) was not statistically significant ( $\beta = 0.0006$   $p = .06$ ).

## DISCUSSION

This study measured the Hg burden of 15 locally available fish species in Barbados. In addition, the H-Hg content of 46 individuals working in the fishing industry was determined and found to be correlated with “high-risk” fish consumption rates ( $p = .02$ ).

The fish Hg concentration levels measured in this study were very similar to those found for the same species in a similar investigation conducted in Bermuda (Dewailly *et al.* 2008) and in the United States (FDA 1990—2010) as shown in Table 1. The small variations observed between mean Hg concentration levels could be due in part to the different sample sizes utilized by the respective studies. Additionally, in concordance with the findings of other studies, the high-end predatory fish species such as marlin, swordfish, and shark had high Hg concentration levels in their flesh, for the most part owing to their top positions in the food web (Storelli and Marcotrigiano 2000; Mahaffey *et al.* 2004).

In Barbados, blue marlin and amberjack fish samples had especially high levels of Hg and showed the highest variations in concentrations and bodyweights. During the lifetime of fish, Hg is considered to show a continued rise because of the long biological half-life of this element (Amlund *et al.* 2007). Accordingly, among individuals of the same species, fish with higher bodyweights (aged fish) are expected to have higher Hg accumulations than those with lower bodyweights (younger fish). Also contributing to variations in muscle Hg levels within individuals of the same species are the heterogeneity of food sources, and migration patterns.

Based on the provisional tolerable weekly intake (PTWI) for methylmercury of 1.6  $\mu\text{g/g}$  bodyweight, recommended for pregnant women or women intending to get pregnant, infants, and children by the Food and Agricultural Organization/World Health Organization (FAO/WHO 2006), Dewailly and colleagues created categories of suggested consumption frequencies to help ensure the PTWI would not be exceeded (Dewailly *et al.* 2008). Based on these categories, six of the 15 fish species caught in Barbadian waters—flyingfish, barracuda, dolphinfish, tripletail, queen snapper, and yellowfin tuna—can be consumed under *limited or little restriction* (between once per day and once per week). Spinny lobster and sailfish can be consumed *without restriction*. Six fish species—tiger shark, swordfish, amberjack, Caribbean reef shark, albacore tuna, and kingfish—caught in Barbadian waters fall under the category of *strong or severe restriction* (species that can be consumed once per week to once per month). For blue marlin, dietary recommendations are complicated by the wide range of Hg concentrations measured in this species—likely related to the wide range of bodyweights—and by a potential lower ratio of MeHg to inorganic Hg in its flesh (Shultz *et al.* 1976). In addition, marlins are commonly already cut into steaks when reaching the consumers, making it very hard for anyone to choose smaller marlins, which would presumably contain less Hg. Because of this, we recommend that women during their pregnancy or women intending to get pregnant avoid consumption of this fish species since only one portion (from one of the larger individuals) will very likely exceed the total Hg tolerable dose for at least 1 month.

The median H-Hg concentration for the study group ( $3.1 \pm 2.3 \mu\text{g/g}$ ) was similar to other populations with a fish-based diet. Nonetheless, the median H-Hg concentration for the women ( $2.5 \pm 0.9 \mu\text{g/g}$ ) was 12 times greater than the geometric mean H-Hg concentration levels reported for U.S. females 16–49 years of age ( $0.20 \pm 0.04 \mu\text{g/g}$ ) during the 1999–2000 National Health and Nutrition Examination Survey (NHANES) (McDowell *et al.* 2004). Notably, 65% of the participants in this study exceeded the PTWI hair-equivalent concentration of  $2.2 \mu\text{g/g}$ .

The fish consumption frequency questionnaire revealed that the species of fish most consumed by the Barbadian study participants were flyingfish, followed by marlin and tuna. The popularity of flyingfish was expected as a report by the United Nation's Food and Agriculture Organization (FAO) found that 65% of the total yearly fish catch for the island of Barbados was flyingfish (FAO 2001). As reported above, in contrast to other high-end predatory species that have high Hg concentration levels, consumption of flyingfish, which were found to have low Hg levels will have a minimal impact on Hg body-burden regardless of the consumption rate. Given that Barbadians benefit from a wide variety of fish species to choose from, they would profit (especially pregnant women, women intending to get pregnant, and children) from appropriate guidelines advising and encouraging the consumption of fish species that have low Hg concentration levels in order to minimize Hg exposure while still maintaining the multiple nutritional benefits such as selenium and omega-3 fatty acids that can be gained from eating fish.

An evaluation of two such key nutrients in the Bermuda fish species study (De-wailly *et al.* 2008) revealed that selenium concentrations were relatively high in all fish species and omega-3 polyunsaturated fatty acids (PUFA) were particularly high in mackerel (*Euthynnus alletteratus*) and wahoo (*Acanthocybium solandri*) fish species. These two fish species are also found in Barbadian waters and are very popular species caught by those involved in the sport charter fishing industry. When available, they are not typically sold at the local fish markets, but are sold directly to restaurants or consumed by the fisher folk and their families. In addition, small pelagic fish such as anchovies (*Sardinella anchovia*) and flyingfish (*Cypselurus heterurus*) had some of the highest percentages of omega-3 PUFA concentrations in relation to total fatty acid contents while concomitantly containing low Hg concentration levels. Therefore, looking at the Barbadian context, due to the traditional predominance of pelagic fishing (FAO 2001) as well as the cultural popularity of flyingfish as a local delicacy, this small pelagic species offers great nutritional and commercial benefits and should continue to be promoted for consumption.

This study is the first in the Caribbean to simultaneously evaluate Hg concentration levels in fisher folk and in commonly caught fish species, however, there are some limitations. Recruitment from a single sub-group of the island's population limits generalizability of results, though we minimized selection bias by selecting participants who worked in the same institution to decrease potential differences such as socioeconomic status. Further, while snowball sampling limits one's ability to give an accurate assessment of whether the sample obtained is indeed representative of the target population, for this study, participants were recruited from the two sole main fish processing and marketing complexes in Barbados thus maximising the potential that the sample of participants obtained was representative of Barbadian fisher folk. Additionally, while self-reported assessment of variables such as the

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type and quantities of fish species consumed may be inaccurate due to recall bias, attempts were made to address these concerns by using easy, user-friendly recall techniques as well as using only one trained interviewer. It is still possible, however, that these aforementioned variables might have suffered from some over-reporting as was similarly observed by others when using species-specific fish consumption questionnaires (Lincoln *et al.* 2011). This occurrence would tend to decrease the measure of association. As for the fish samples collected, while there are no obvious reasons to believe the Hg concentrations of the specimens sampled were not representative of the ones not sampled, this study would nonetheless have benefited from a larger sample size. Finally, direct measurements of selenium and omega-3 PUFA would have provided additional insights into determining which locally caught fish species would provide the maximum nutritional benefit while minimizing the harm from high Hg exposure.

### CONCLUSIONS

This study offers a snapshot of Hg exposure from fish caught in marine waters around Barbados for fisher folk and their families. Further research is needed to generalize these study findings to the wider Barbadian population. By clarifying the Hg content of commercially available fish, suitable and appropriate recommendations can be drafted to inform the public about the importance of selecting fish species that have low Hg loads in order to minimize Hg exposure, especially for pregnant women or women intending to get pregnant, infants, and children, while maintaining the nutritional benefits that can come from consuming fish. In particular, the already popular flyingfish, which was found to be low in Hg yet rich in key nutrients, should be emphasized as a superior choice of fish for the general population of Barbados.

### ABBREVIATIONS

CHUQ	Centre Hospitalier Universitaire de Québec
H-Hg	hair mercury
JECFA	Joint FAO/ WHO Expert Committee on Food Additives
MeHg	methylmercury
PUFA	polyunsaturated fatty acids
SG	specific gravity
US FDA	United States Food and Drug Administration
R <sup>2</sup>	coefficient of determination
n	sample size
Hg	mercury
INSPQ	Institut National de Santé publique du Québec
MAD	median absolute deviation
PTWI	provisional tolerable weekly intake
RfD	reference dose
U-Hg	urinary mercury
WHO	World Health Organisation

*p*                    *p*-value  
95% CI        95% confidence interval

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