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National estimation of seafood consumption in Mexico: Implications for exposure to methylmercury and polyunsaturated fatty acids

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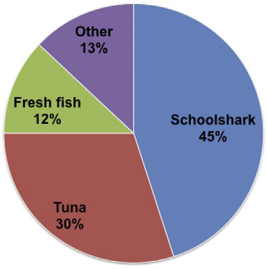
HIGHLIGHTS

- Seafood is a good source of polyunsaturated fatty acids but contains the contaminant mercury.
- We analyzed data from the National Health and Nutrition Survey of Mexico (n = 10,096).
- Tuna, sunfish, shrimp, mullet, carp, schoolshark constituted 60% of seafood intake.
- Canned tuna and schoolshark contributed 75% of the population's mercury exposure.
- Salmon, sardine, trout, anchovies offered the best balance of fatty acids and mercury.

GRAPHICAL ABSTRACT



75% of Mexico's exposure to mercury comes from schoolshark and tuna

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ABSTRACT

Background: Seafood is a good source of Omega-3 polyunsaturated fatty acids (ω3-PUFA) but also contains the toxic contaminant methylmercury (MeHg). National estimates of exposure to both compounds through seafood intake in Mexico are not known. The objective of the current study was to describe national seafood consumption habits and to estimate seafood-based exposure to ω3-PUFAs and MeHg.
Methods: We analyzed data from a 24-h dietary recall extracted from the 2012 National Health and Nutrition Survey of Mexico (n = 10,096 subjects aged 1y and older). National per capita seafood intake as well as information on age, sex, socioeconomic status, and geographic region was obtained. The contribution of each seafood item to the total MeHg exposure was estimated, as was the balance between estimated exposures to ω3-PUFAs and MeHg.
Results: A mean daily seafood intake of 10 g/day was estimated. The top species consumed in decreasing order were: canned tuna, sunfish, shrimp, mullet, carp and schoolshark (constituted 60% of seafood intake). Canned tuna and schoolshark contributed 75% of the population's estimated exposure to MeHg. The best balance of population-level exposures to ω3-PUFAs and MeHg was found in salmon, sardine, trout and anchovies.
Conclusion: Environmental dietary exposure to MeHg is a public health concern and thus a good understanding of seafood consumption is needed to create national consumption guidelines. The current study provides nationally-representative data in Mexico from which decisions can be made (e.g., UN Minamata Convention) and future studies conducted.

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Abbreviations

DHA	Docosahexaenoic Acid
ENSANUT	National Health and Nutrition Survey
EPA	Eicosapentaenoic Acid
Hg	mercury
MeHg	methylmercury
SES	Socio Economic Status
ω3-PUFA	Omega-3 polyunsaturated fatty acids
U.S. EPA	United States Environmental Protection Agency
U.S. FDA	United States Food and Drug Administration

1. Introduction

Fish and shellfish (herein referred to as seafood) represent a dietary source that consists of high quality protein, is low in saturated fats and cholesterol, and also provides a wide range of essential micronutrients (Ababouch, 2014; Smith and Sahyoun, 2005). In particular, seafood contains Omega-3 polyunsaturated fatty acids (ω3-PUFAs) which have demonstrated a potential role in terms of promoting brain development and protecting against coronary heart disease, stroke, age-related macular degeneration, and mental disease (Ruxton et al., 2007, 2016; Torpy et al., 2006). The importance of ω3-PUFAs lies in the fact that humans cannot synthesize them, and their accumulation in the body depends on the amounts and types in the diet, with a major dietary source being fatty fish (Innis, 2008).

In contrast to the aforementioned benefits, seafood is contaminated with methylmercury (MeHg) (Mergler et al., 2007). Mercury (Hg) is a toxic chemical of global concern due its wide ranging of adverse human health effects particularly towards children's neurodevelopment (Clarkson et al., 2003; Ha et al., 2017). Its presence in seafood poses a dilemma for individual consumers and for public health agencies; weighing the benefits of seafood consumption versus the risks posed by MeHg contamination is not trivial. This is of particular global concern given that more than one billion people worldwide rely on seafood as their main protein source (Swain et al., 2007). Global per capita seafood consumption has increased from an annual average intake of 9.9 kg in the 1960's to 19.2 kg in 2012, and some of the greatest increases are being experienced in countries with rapidly developing economies (Food and Agriculture Organization, 2014).

A recent study made by us in Mexico found that Hg exposure levels were approximately 3–5 fold higher in women and children from México City than average levels found in biomonitoring programs in the U.S. (Basu et al., 2014). The same study showed that the amount of MeHg in seafood sold in Mexican markets varied from one species to another, and that MeHg content in 7 of 23 seafood species and 5 of 9 canned tuna brands purchased exceeded the U.S. EPA guidance value of 0.3 μg/gram, and that 11 of the 23 seafood species and 6 of the 9 canned tuna brand exceeded the U.S. FDA guidance value of 0.1 μg/g (U.S.Food and Drug Administration, 2017). These results raise concern about Hg exposure in Mexico though several knowledge gaps exist which limit future public health actions. Foremost is the lack of a nationally-representative study in Mexico that characterizes seafood consumption (i.e., what specific seafood varieties are consumed and in what amounts?), and relates this dietary information to exposures to MeHg (i.e., is the current intake of seafood exceed the U.S. EPA value of MeHg?). In addition, such analyses should always consider the potential co-exposure to ω3-PUFAs which afford tremendous health benefits.

The objective of the current study was two-fold. First, it aimed to describe national seafood consumption habits in Mexico. This was achieved by analyzing relevant data extracted from the 2012 National Health and Nutrition Survey. And second, it aimed to estimate population-level, seafood-based exposures to MeHg and ω3-PUFAs. In doing so, the work provides the first comprehensive assessment of seafood consumption, as well as the associated risks and benefits to the population of Mexico.

2. Methods

2.1. Participants

The 2012 National Health and Nutrition Survey (ENSANUT) is a cross-sectional, multi-stage probabilistic survey representative of the national population of Mexico (Romero-Martinez et al., 2013). It was carried out between October 2011 and May 2012. The main objective of the survey was to quantify the frequency, distribution and trends of the health and nutrition status of Mexican population. The survey collected information from 50,528 households, from which 96,031 individuals were selected for participation. A household response rate of 87% was obtained. Informed consent was obtained from each subject or subject's parent/guardian. The survey protocol was revised and approved by the Ethics Committee of the Mexican National Institute of Public Health.

A 24-h dietary recall was collected in a subsample (~11%) of the ENSANUT representative of the national, regional, and urban/rural population (Lopez-Olmedo et al., 2016). In the current analyses we excluded children <1 year old and breastfed children >1 year old because it was not possible to estimate their total energy and nutrient intake, and their eating patterns differ from the rest of the family. Furthermore, pregnant and lactating women (n = 154) were also excluded because their energy and nutrient requirements are different from those of other women, and their sample size was not large enough to make population inferences. Additionally, we excluded 119 subjects with implausible energy intake (outside ±3 SD of the log of the energy intake/energy requirements ratio). The resulting analytic sample size for this study consisted of 10,096 subjects aged 1y and older.

2.2. Seafood intake

Seafood intake was estimated from ENSANUT's 24-h dietary recall. Trained interviewers collected information using a multiple 5-pass probing method to obtain more accurate dietary information (Moshfegh et al., 2008). The 5-pass method consisted of the following steps: 1) develop a preliminary food ingestion list in which the participant recalls all food consumed in an entire day, with no special attention in the order or time of consumption; 2) ask specifically about consumption of items frequently forgotten; 3) for each identified item, gather information on the time and occasion of consumption; 4) for each item, obtain details such as specific ingredients, amounts, cooking method, purchase of processed food, etc.; and 5) conduct a final review of the data obtained with the participant.

Respondents, particularly those younger than 15 y, were assisted by the person who cooked and prepared their meals in the household. To estimate the quantity of food consumed, interviewers used scales or common household measuring items such as spoons and cups. After the interview, for all items reported, the amount consumed was converted to grams by using the estimated weight of common portion sizes of each food item. Additionally, the amount consumed was multiplied by each food's edible portion, in order to obtain net grams consumed. In the case when mixed dishes and recipes were reported, these were disaggregated into their ingredients, so that we could obtain a better