International Journal of Hygiene and Environmental Health 219 (2016) 184–194

Contents lists available at ScienceDirect

International Journal of Hygiene and Environmental Health

journal homepage: www.elsevier.com/locate/ijheh

Levels of persistent contaminants in relation to fish consumption among older male anglers in Wisconsin

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ARTICLE INFO

Article history:
Received 13 August 2015
Received in revised form 12 October 2015
Accepted 3 November 2015

Keywords:
Fish consumption
Great lakes
Anglers
Persistent
Pollutant

ABSTRACT

Fish are an important source of nutrients which may reduce risk of adverse health outcomes such as cardiovascular disease; however, fish may also contain significant amounts of environmental pollutants such as mercury, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and perfluorinated compounds (PFCs, also called perfluoroalkyl compounds), which confer increased risk for adverse health effects. The Wisconsin Departments of Health Services and Natural Resources developed a survey instrument, along with a strategy to collect human biological samples to assess the risks and benefits associated with long-term fish consumption among older male anglers in Wisconsin. The target population was men aged 50 years and older, who fish Wisconsin waters and live in the state of Wisconsin. Participants provided blood and hair samples and completed a detailed (paper) questionnaire, which included questions on basic demographics, health status, location of catch and species of fish caught/eaten, consumption of locally caught and commercially purchased fish, and awareness and source of information for local and statewide consumption guidelines. Biological samples were used to assess levels of PCBs, PBDEs, PFCs (blood), and mercury (hair and blood). Quantile regression analysis was used to investigate the associations between biomarker levels and self-reported consumption of fish from the Great Lakes and other areas of concern, other locally caught fish, and commercially purchased fish (meals per year). Respondents had a median age of 60.5 (interquartile range: 56, 67) years. The median fish consumption was 54.5 meals per year, with most fish meals coming from locally-caught fish. Participants had somewhat higher mercury levels compared with the US general population, while levels of other contaminants were similar or lower. Multivariate regression models showed that consumption of fish from the Great Lakes and areas of concern was associated with higher levels of each of the contaminants with the exception of PBDEs, as was consumption of locally caught fish from other water bodies. All commercial fish consumption was also associated with both hair and blood mercury. When looking at specific PCB, PBDE and PFC analytes, consumption of fish from the Great Lakes and areas of concern was associated with higher levels of each of the individual PCB congeners examined, as well as higher levels of all of the PFCs examined, with the exception of PFHxS. Among the PFCs, locally caught fish from other water bodies was also associated with higher levels of each of the congeners examined except PFHxS. Finally, all commercial fish was associated with higher levels of PFHxS.

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Introduction

Fish represent a dietary source of lean protein and important nutrients such as omega-3 fatty acids. However, fish may also contain high levels of contaminants, including persistent compounds such as mercury, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and perfluorinated compounds

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http://dx.doi.org/10.1016/j.ijheh.2015.11.001
1438-4639/Published by Elsevier GmbH.

(PFCs, also called perfluoroalkyl compounds). Given the increasing importance of fish in the US diet (Loke et al., 2012) and the health effects which have been associated with these compounds, monitoring contaminant levels in fish and fish consumers is important for preventing adverse health effects through appropriate fish consumption guidelines, monitoring exposures, and tracking health impacts in the population.

Mercury has long been recognized as a neurotoxicant, and has also been associated with increased risk for cardiovascular disease (ATSDR, 1999, 2013). Polychlorinated biphenyls are a group of 209 different compounds formerly used in electronic equipment manufacturing for their insulative and conductive properties. Although production in the US was banned in 1979 due to health concerns, PCBs persist in the environment, and have been linked to a wide range of adverse health effects including certain cancers, endocrine and reproductive disorders, and neurodevelopmental delays (ATSDR, 2000, 2011). Polybrominated diphenyl ethers are used as flame retardants in a variety of consumer products; like PCBs, they are persistent and lipophilic (ATSDR, 2004). Although there are fewer studies of human health effects compared with PCBs, there is some evidence that thyroid and neurodevelopmental effects could be of concern. Perfluorinated compounds are also found in a variety of consumer products, used for non-stick/non-stain applications (ATSDR, 2009b; Steenland et al., 2010). Similarly to PBDEs there are fewer studies of human health effects available, but some evidence for health effects including changes in liver enzymes, and lower birth weight.

Fish from many waters, including the Great Lakes, may be contaminated with each of these pollutants, although levels vary by specific location, age and type of fish, and other factors (EPA, 2009a).

The Wisconsin Department of Natural Resources (DNR) state waters monitoring program has noted declines in mercury concentrations in fish on the whole, but also that the rate of decline is different depending the latitude of the specific water body (Rasmussen et al., 2007). Wisconsin DNR data have also shown that PCB concentrations have decreased dramatically in Lake Michigan salmon species from 1975-2010, but the rate of decline is much less in recent years compared with the earliest years of data collected (Rasmussen et al., 2014). Similarly, longitudinal biomonitoring among a group of Great Lakes fish consumers has shown a decreased in serum PCBs over time, although the rate of decline was relatively slow at 3.5% per year (Knobeloch et al., 2009). PBDE concentrations in Great Lakes walleye and trout have been decreasing from 1980 to 2009 (Crimmins et al., 2012); however, the congener composition of PBDEs is also changing, with larger proportions of the highly brominated PBDEs in more recent years, which may reflect changing industrial use patterns. Biomonitoring among Great Lakes fish consumers has shown a similar phenomenon—total PBDE body burden increased from 1994–1995 to 2004–2005, and the composition also changed with an increasing proportion of the more highly brominated PBDE 153, relative to PBDE 47 (Turyk et al., 2010). Regarding PFCs in the Great Lakes region, there are fewer data available, partly because these chemicals have been in use for a shorter time compared with PCBs or PBDEs, but limited data suggest that the concentrations of many PFC congeners are increasing over time (Furdui et al., 2008). Recent data collected by the Environmental Protection Agency provide a baseline for future monitoring of PFC levels in the Great Lakes (Stahl et al., 2014); these data showed high detection frequency for certain PFCs including PFOS (100%), PFDA (92%), and PFUnA (90%). Thus, contaminants in Great Lakes fish remain a concern for consumers.

Anglers and their families are a particularly vulnerable population because they tend to consume more locally caught Great Lakes Basin fish. Given the increased risk of exposure to persistent contaminants and potential for adverse health, current fish consumption guidelines in Great Lakes states are designed to encourage consumption of fish that is high in nutrients yet low in contaminants. In Wisconsin, such guidelines were first issued in 1976, by the Departments of Health Services (DHS) and Natural Resources (DNR) and targeted licensed, mostly male anglers. As fetal exposure adverse impacts became known there was a shift in focus to emphasize advice to women of childbearing age. Older male fish consumers may have increased vulnerability to adverse health effects due to higher body burden of contaminants (Knobeloch et al., 2006, 2009; Turyk et al., 2012), and increased risk of stroke and heart disease (de Goede et al., 2012; He et al., 2002; Salonen et al., 1995). Accordingly, the Wisconsin Fish Consumption Advisory Program (WFCAP) has renewed efforts to reach aging male anglers, developed a survey instrument, along with a strategy to collect biological samples, which will be used to assess the risks and benefits associated with long-term fish consumption among older male anglers in Wisconsin. Our goal in this study is to examine the association between fish consumption and biomarkers of exposure to persistent contaminants in this angler cohort.

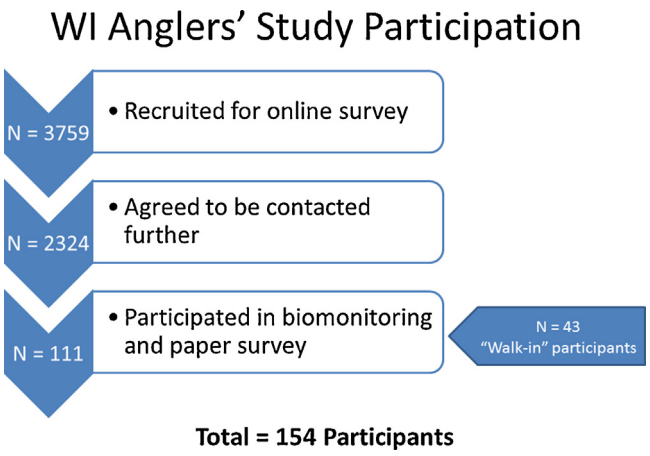

Fig. 1. Participation for the Wisconsin Anglers' Study.

Materials and methods

Participants were recruited from those who previously participated in an online survey administered by the DHS, and had indicated they would be interested in future studies ($n = 111$; see (Christensen et al., 2015; Imm et al., 2013) for details). An additional 43 persons (who had not participated in the online survey) were recruited via flyers and other methods (Fig. 1). The study was conducted in 2012–2013.

The target population was men aged 50 years and older, who fish Wisconsin waters and live in the state of Wisconsin. Participants provided blood and hair samples and completed a detailed (paper) questionnaire, which included questions on basic demographics, current health status, location of catch and species of fish caught/eaten, consumption of locally caught and commercially purchased fish, awareness of local and statewide consumption guidelines, and source of information on consumption guidelines. The Survey of the Health of Wisconsin program conducted follow-up phone calls and coordinated bio-sample collection in the homes of study participants (Nieto et al., 2010). The study was reviewed by the University of Wisconsin Human Subjects Review Board and determined to be exempt, as it was conducted for the purpose of public health research.

Biological samples

Biological samples were used to assess serum levels of contaminants PCBs, PBDEs, PFCs, and mercury in blood, and mercury in hair.