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# Polychlorinated biphenyls and omega-3 fatty acid exposure from fish consumption, and thyroid cancer among New York anglers

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## ABSTRACT

Fish from the Great Lakes contain polychlorinated biphenyls (PCBs) which have been shown to disrupt endocrine function and mimic thyroid hormones, but they also contain beneficial omega-3 fatty acids that may offer protection against endocrine cancers. The purpose of this study was to examine the effects of Lake Ontario fish consumption and the estimated consumption of PCBs and omega-3 fatty acids on the risk of thyroid cancer in a group of sport fishermen. Anglers from the New York State Angler Cohort Study were followed for cancer incidence from 1991–2008. Twenty-seven cases of incident thyroid cancer and 108 controls were included in the analyses. Total estimated fish consumption, estimated omega-3 fatty acid consumption, and estimated PCB consumption from Lake Ontario fish were examined for an association with the incidence of thyroid cancer, while matching on sex, and controlling for age and smoking status. Results from logistic regression indicate no significant associations between fish consumption, short-term estimated omega-3 fatty acids, or estimated PCB consumption from Great Lakes fish and the development of thyroid cancer, but it was suggested that long-term omega-3 fatty acid from Great Lakes fish may be protective of the development of thyroid cancer. In conclusion, fish consumption, with the possible concomitant PCBs, from the Great Lakes does not appear to increase the risk of thyroid cancer in New York anglers. Further research is needed in order to separate the individual health effects of PCBs from omega-3 fatty acids contained within the fish.

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## Introduction

Polychlorinated biphenyls (PCBs) are a group of 209 synthetically produced compounds that have been shown to disrupt endocrine function and mimic thyroid hormones

(Cunningham, 2012). PCBs are persistent, lipophilic, and are metabolized very slowly, resulting in a bioaccumulation in the fat stores of fish and other animals, including humans that consume contaminated fish (Cunningham, 2012).

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PCBs are known endocrine disruptors, and have potential consequences on thyroid function, although studies examining the association between thyroid dysfunction and PCB exposure have produced inconsistent results (Bloom et al., 2009; Dallaire et al., 2009; Turyk et al., 2008). Even with evidence that higher concentrations of thyroid stimulating hormone (TSH), a resulting condition of thyroid dysfunction, are associated with a greater risk and more advanced stages of thyroid cancer (Boelaert et al., 2006; Haymart et al., 2008), there is a paucity of research examining the association between thyroid cancer and PCBs. One study reported a higher standardized incidence ratio for thyroid cancer among women living in an area that had previously had extensive contamination from a PCB production site (Pavuk et al., 2004), although the association was not found in men, which illustrates the complex relationship between environmental PCBs and endocrine diseases, such as thyroid cancer. Thyroid cancer is of notable concern because both the incidence and mortality of thyroid cancer in the United States have been increasing in recent years (2001–2010; Howlader et al., 2012). With its increasing incidence, understanding the risk factors for thyroid cancer is important for the prevention and treatment of this disease, and PCB exposure may be one potential preventable predictor of thyroid cancer that warrants further investigation.

Because PCBs were banned in the United States in 1979 (US EPA, United States Environmental Protection Agency, 2013), exposure since that time has come primarily from residual PCB concentrations in the environment. The consumption of fish living in polluted waters has been a notable concern, especially in regard to the development of cancer (Johnson et al., 1999). However, the association between fish consumption and cancer is complex. One study found that the incidence of breast cancer was higher for each additional 25 g of fish consumed per day (Stripp et al., 2003); while another study found that the risk of breast cancer was lowest among individuals in the highest quartile of total fish/shellfish consumption, compared to the lowest quartile of total fish/shellfish consumption (80 vs. 25 g fish per day; Gago-Dominguez et al., 2003). Similarly, another study found that the risk of colorectal cancer was lower among those in the highest quartile of fish consumption than those in the lowest quartile (Kato et al., 1997). Other studies have found no associations, positive or negative, between fish consumption and cancer incidence (Holmes et al., 2003; McElroy et al., 2003; Tomasallo et al., 2010; Willett et al., 1990). Several of these studies looked specifically at the association between Great Lake fish consumption and cancer (McElroy et al., 2003; Tomasallo et al., 2010), while most considered fish from all sources, including store-bought. Benefits of fish consumption may be due, in part, to their content of omega-3 fatty acids, which have been observed to be protective of certain types of cancers, including breast, colon, and esophageal (Tavani et al., 2003). Conversely, fish from the Great Lakes may have higher concentrations of PCBs, which are known endocrine disruptors (Cunningham, 2012), and may have an adverse effect on thyroid cancer incidence. To our knowledge, no published studies have examined the effects of fish consumption on the risk of thyroid cancer in humans. The need for research into these associations may be greater in populations with high Great Lake fish consumption patterns. Specifically, New York residents were

between three and eight times more likely to consume fish more than twice a week than other states in the Great Lakes region (Imm et al., 2005). Therefore, the purpose of this study was to examine the effects of Great Lakes fish consumption, and the estimated PCB consumption or omega-3 fatty acids from these fish, on thyroid cancer incidence among sport fishermen of the New York State Angler Cohort Study.

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## 1. Methods

### 1.1. Study population

Participants were recruited from the New York State Angler Cohort Study, which is a longitudinal cohort study that was designed to examine the potential health risks in sport fishermen (anglers) and their spouses. For these analyses, a case-control design was employed. A more detailed description of the original methods and study design can be found elsewhere (Vena et al., 1996). A roster of fishing license holders residing in the 16 New York counties bordering Lakes Ontario and Erie provided names of 30,000 subjects for the sampling frame. In 1991, a baseline questionnaire queried demographics, health status, and fish consumption, along with informed consent, was completed by 18,076 anglers and their spouses.

Cases of first primary incident thyroid cancer, diagnosed and histologically confirmed between June 1, 1991 through December 31, 2008, were identified through a linkage with the New York State Cancer Registry — which requires the reporting of cancer cases from hospitals and physicians — matching on social security number, date of birth, first name, last name, soundex of first and last names, address, sex, and race. The New York State Cancer Registry has received a gold certification, which means that case ascertainment is at least 95% complete (New York State Cancer Registry, 2014). A proprietary web-based public records search tool was used to determine whether participants had moved out of the state of New York and the year they moved. Loss to follow-up was 9.8% ( $n = 1672$ ), and average length of follow-up was  $16.4 \pm 3.1$  years. Twenty-seven cases of incident thyroid cancer were identified through the search. Additionally, there was active follow-up with mailed questionnaires to identify non-reportable endpoints. In addition, vital status was ascertained by linkage with the Social Security Administration ( $n = 422$ ). SAS statistical software (SAS version 9.3; SAS Institute, Cary, NC, USA) randomly selected controls from the cohort of sport anglers and spouses. There were four controls randomly selected and frequency matched on sex for every case, resulting in a total of 108 controls.

### 1.2. Fish consumption

Fish consumption was measured using the food frequency method. A mailed questionnaire during the fall of 1991 asked both detailed and general questions regarding fish consumption. Detailed questions asked about types and patterns of Great Lakes fish consumption during the years 1990–1991; general questions asked about Great Lakes fish consumption during the years 1955–1991. The specific species asked about in the baseline survey included catfish, lake trout, Chinook

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