

LAY ABSTRACT – FINAL 9/24/2013

Serum Concentrations of Polyfluoroalkyl Compound Exposure in Young Girls in Greater Cincinnati and the San Francisco Bay Area, USA

Susan M. Pinney¹, Frank M. Biro^{2,3}, Gayle C. Windham⁴, Robert L. Herrick¹, Antonia M. Calafat⁵, Paul Succop¹, Kayoko Kato⁵, Lawrence H. Kushi⁶, Robert Bornschein¹

¹University of Cincinnati College of Medicine, Dept. of Environmental Health, Cincinnati, OH, USA; ²University of Cincinnati College of Medicine, Dept. of Pediatrics, Cincinnati, OH, USA; ³Cincinnati Children's Hospital Medical Center, Cincinnati, OH, USA; ⁴Division of Environmental and Occupational Disease Control, California Department of Public Health, Richmond, CA, USA; ⁵Division of Laboratory Sciences, National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, GA, USA; ⁶Division of Research, Kaiser Permanente, Oakland, CA, USA.

Background: Perfluorochemicals (PFCs) are surfactants that have wide consumer use and industrial applications. They are used in metal plating, computer semi-conductors, film processing, fire-fighting foams and in producing grease and water resistant coatings. Perfluorooctanoic acid (PFOA or C-8) can be found as a residual impurity in some paper coatings used on containers for processed food. PFCs have been detected in breast milk, infant formula and food and are correlated with maternal serum concentrations. In this report, we describe the serum concentrations of PFCs measured among young girl participants of the BCERP puberty studies in Greater Cincinnati and the San Francisco Bay Area. We conducted this analysis to determine if factors such as location and years of residence, drinking water source and being breastfed were predictors of the girl's serum PFC concentration.

Methods: Through the NIH Breast Cancer and the Environment Research Program (BCERP), we conducted a study of PFC biomarkers in serum of 6-8 year-old girls in Greater Cincinnati (N=353) and the San Francisco Bay Area (N=351), collected in 2005-2009. The biomarkers were measured at the CDC Environmental Laboratory. Parents or guardians provided questionnaire information, including information about where the girl had lived throughout her lifetime and whether she drank bottled water. Mothers reported the duration of breast feeding their daughters. At the Greater Cincinnati site, municipal water departments provided information about their water distribution systems and the zones serviced by each of the water treatment plants.

Results: We were able to detect the presence of five of the PFCs in serum of at least 95% of the girls. PFOA serum concentrations were lower in the San Francisco Bay Area girls than in the Greater Cincinnati girls (median 5.8 vs. 7.3 ng/mL). PFOA serum concentrations were higher than the NHANES 2005-2006 95th percentile value in 38.6% of the Greater Cincinnati site girls (136/352) and in 14% of the San Francisco Bay Area girls (50/351). Girls from the Greater Cincinnati site lived in either Southwestern Ohio (SWO) or in Northern Kentucky (NKY). Girls living in NKY had much higher concentrations of PFOA in serum (22.0 ng/mL) than those in Southwestern Ohio (6.8 ng/mL); 48/51 NKY girls had concentrations above the NHANES 2005-2006 95th percentile value. Girls in NKY also had higher levels of PFOS (17.7 ng/mL vs. 13.2 ng/mL; p=0.02) but not other PFCs (Me-PFOSA-AcOH, PFNA, PFDeA or PFHxS). PFOA serum

concentration was highly associated ($p < 0.001$) with cumulative years of drinking water from the NKY water distribution zone but not associated with years of drinking water from either of the other two Cincinnati water distribution zones using granular activated charcoal filtration. The duration of being breast fed was associated with higher serum PFOA concentrations at both sites and with higher concentrations of other PFCs (PFOS, PFHxS and Me-PFOSA-AcOH) in GC.

Serum concentrations of PFOA in Greater Cincinnati girls, in both southwest Ohio and northern Kentucky, appear to be decreasing over time in a one year period from 2005-2006, and in similar proportions, 26% and 32% respectively ($N=22$ girls). For the 22 San Francisco Bay Area girls, the serum concentration increased 14% or 0.7 ng/ml ($p = 0.007$).

Conclusions: The findings from this study suggest that exposure to PFCs is widespread in our population of young girls, and varies by race or ethnic group. Our results suggest that a source upriver from the GC area may have contributed to exposures in girls from NKY through their drinking water, while girls in SWO had lesser exposure because of the use of granular activated carbon filters for water treatment. The higher serum concentrations that were discovered in the NKY girls probably are representative of all persons in the NKY water district during the same time period. Despite the many health benefits of breast feeding to both child and mother, our study is the first to report that length of time the child was breast fed is associated with higher serum PFC concentrations in the child. PFOA has been identified as an emerging drinking water contaminant, and water treatment systems able to remove PFOA and other PFCs will reduce body burdens of both mother and child and may decrease the risk of health effects.

Public Health Translation: This project represents a success story of research findings being translated to public health. Funding for the research provided by NIEHS and NCI ultimately led to changes in water treatment practice in the Greater Cincinnati area. Girls then enrolled in the study, and 353 in Greater Cincinnati and 351 in the San Francisco Bay Area provided blood serum which was used for these analyses. In 2005, early in the puberty study, Dr. Antonia Calafat at the CDC wisely suggested that PFCs (and other relevant environmental biomarkers) be added to those included in the feasibility study. When we discovered that about half of the girls in the feasibility study from the Cincinnati site (all from NKY), age 6-8 years, had serum concentrations above the 95th percentile value for US children 12-19 years (NHANES 2005-2006), NIEHS, NCI and CDC agreed to measure the serum concentration in all of the study participants from the NKY area. Using those preliminary data, in 2007 the study investigators in Greater Cincinnati visited the water departments in both Cincinnati and NKY to inform them of the findings, and held a meeting with the parents of the NKY study participants. Over the next five years, the NKY water department implemented granular activated carbon filtration at both of their plants to meet new federal regulations and prepare for future regulations, and the Greater Cincinnati Water Works considered the

biomarker information in determining the appropriate frequency for re-activating their granular activated carbon filters. Prior to publication of the study in September 2013, the study investigators again met with the leadership of the water departments, sharing slides of findings that had been presented at the ISEE meeting in Basel in August 2013.