Community Exposure to PFCs in Washington County, Minnesota:
The East Metro Perfluorochemicals Biomonitoring Pilot Project

Jean Johnson PhD, Adrienne Kari MPH, Carin Huset PhD, Allan Williams PhD

Background and Purpose
Perfluorochemical (PFC) contamination of groundwater from nearby waste disposal facilities was first discovered in Washington County, Minnesota, located east of the Minneapolis-St. Paul metropolitan area (also referred to as “East Metro”), in 2004 by the Minnesota Pollution Control Agency (MPCA) and the Minnesota Department of Health (MDH). Further investigation revealed widespread contamination of ground water that supplied drinking water to residents in the City of Oakdale and other communities. The 3M Company began research and development of PFCs at its Cottage Grove facility in southern Washington County in the 1940s; commercial production started in the early 1950s. Wastes from the production process and wastewater treatment plant sludge were disposed of at the facility and at several disposal sites in Washington County between 1956 and 1971 (estimated dates).

This biomonitoring project was conducted by MDH to measure the range and distribution of PFC exposure in a population sample from each of two communities identified as likely to be exposed. The work was conducted in accordance with 2007 Minnesota Legislation that established a pilot program to build MDH capacity for a state biomonitoring program.

Participant Recruitment Methods
Two communities located in Washington County were selected, each defined based on their household drinking water supply:
1. People currently living in households served by the Oakdale Municipal Water Supply
2. People currently living in households served by private wells in Lake Elmo and Cottage Grove with known PFOA and/or PFOS contamination.

To be eligible, individuals had to be at least 20 years of age and lived in their current residence prior to January 1, 2005 (a date before most remediation efforts were initiated). In August 2004, a household survey was mailed to 500 households randomly selected from Oakdale municipal billing records and to all 169 homes identified from well sampling records with a private well contaminated with > 0.1 ppb of PFOA or PFOS. From a list of eligible adults identified in the survey, individuals were randomly selected and recruited. A total of 196 adults were enrolled, 98 individuals from each community. Each completed a brief survey and provided a blood serum specimen for analysis. Specimen collection was completed on December 31, 2008.

Laboratory Analysis Methods
Serum samples were analyzed for seven PFCs by the Public Health Laboratory at MDH using solid phase extraction and liquid chromatography tandem mass spectrometry with stable isotopically labeled internal standards used for quantification. One ml of serum was extracted using Oasis HLB cartridges with a modified wash step. We prepared matrix matched calibration curves from bovine calf serum daily for quantification. Separations were performed using an Agilent 1200 HPLC and a water/acetonitrile mobile phase (modified with 1% formic acid). An Applied Biosystems 4000 Qtrap tandem mass spectrometer operated in negative ESI mode was used for detection, with two MRM transitions monitored per analyte (when possible). The precision and accuracy of this method, as determined through spike and recovery experiments, are 1-8% and 99-115% respectively.

Biomonitoring Results
We found measurable levels of PFOA, PFOS, and PFHxS in specimens from all 196 participants. PFHxS was detected in 28% of the population and PFHxS was detected in 3%. PFHFA and PFHxA were below the limit of detection (0.1 ng/ml) for all specimens. Mean serum concentrations were significantly higher in males for PFOA (>0.001) and for PFHxS (p=0.004), but not for PFOS. PFOA, PFOS, and PFHxS were found to be significantly different (p=0.05) across age categories and increased with age. Similar increases in PFOA and PFHxS levels were observed with increased length of residence in the home. The difference in mean PFOA concentrations observed between the municipal water and private well communities was of borderline significance (<0.06), while community differences accounted for approximately 43% of the variability in PFOA levels found in blood. For PFOS and PFHxS levels in blood ranged from 0.04-1.87 ng/ml for PFOA and 0.04-2.47 ng/ml for PFOS. The analysis also took into account the participant’s age, gender, and years living in the home. PFOA and PFOS levels in water were strongly correlated with levels found in the blood (r=0.70 and 0.31 respectively). For PFOS, age, and water concentration together accounted for approximately 43% of the variability in PFOS levels found in blood.

Table 1. Study Participant Characteristics

<table>
<thead>
<tr>
<th>Municipal Water Community (N=98)</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant age</td>
<td>53.1</td>
<td>25</td>
<td>85</td>
</tr>
<tr>
<td>Years living in house</td>
<td>17.8</td>
<td>4</td>
<td>62</td>
</tr>
<tr>
<td>Years lived in Oakdale (years)</td>
<td>20.7</td>
<td>3.5</td>
<td>62</td>
</tr>
<tr>
<td>Private Well Community (N=98)</td>
<td>53.0</td>
<td>20</td>
<td>86</td>
</tr>
<tr>
<td>Years lived in house</td>
<td>19.8</td>
<td>4</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 2. PFC Serum Concentrations by Gender and Drinking Water Community

<table>
<thead>
<tr>
<th>PFC Analyte</th>
<th>Study Population (N)</th>
<th>Geometric Mean Serum Conc. (ng/ml)</th>
<th>Median Serum Concentration (ng/ml)</th>
<th>Range (ng/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFOA Total</td>
<td>Females (106)</td>
<td>15.4</td>
<td>16</td>
<td>1.6-177</td>
</tr>
<tr>
<td></td>
<td>Males (98)</td>
<td>19.0</td>
<td>20</td>
<td>20-39</td>
</tr>
<tr>
<td>PFOS Total</td>
<td>Females (106)</td>
<td>35.9</td>
<td>41</td>
<td>3.2-448</td>
</tr>
<tr>
<td></td>
<td>Males (98)</td>
<td>32.9</td>
<td>35</td>
<td>3.2-448</td>
</tr>
<tr>
<td>PFHxS Total</td>
<td>Females (106)</td>
<td>8.4</td>
<td>8.9</td>
<td>0.32-316</td>
</tr>
<tr>
<td></td>
<td>Males (98)</td>
<td>10.6</td>
<td>10.9</td>
<td>1.3-316</td>
</tr>
<tr>
<td></td>
<td>Municipal community</td>
<td>8.6</td>
<td>9.8</td>
<td>0.32-72</td>
</tr>
<tr>
<td></td>
<td>Private well comm.</td>
<td>8.3</td>
<td>7.1</td>
<td>0.37-316</td>
</tr>
</tbody>
</table>

Discussion
Individuals living in the East Metro area prior to Jan. 1, 2005 were exposed to PFCs through their drinking water. Serum levels were elevated in comparison with results reported for the US general population, 2 to 4 times that reported in NHANES samples collected in 2003-2004, but comparable to or lower than levels found in other studies of communities exposed via drinking water. Past well water levels were strongly correlated but only partially explained variability in the blood serum levels, indicating that other sources likely contribute to exposure in this population.

Based on these findings, a follow-up study is recommended to measure changes in blood levels over time. Levels are expected to decrease due to the remedial actions taken since 2005 to remove PFCs from the drinking water in these communities.

Acknowledgements
We gratefully acknowledge the contributions to this project of numerous MDH staff and the Environmental Health Tracking and Biomonitoring Advisory Panel and Workgroup. We also thank the East Metro area community members, elected representatives, medical professionals and local public health officials for their support and cooperation. The East Metro PFC Biomonitoring Pilot Project was funded by the Minnesota State Legislature as part of the Environmental Health Tracking and Biomonitoring Program at the Minnesota Department of Health.

For more information, please call the MDH Environmental Public Health Tracking and Biomonitoring program at: 651-201-5900 or email: health.tracking@state.mn.us.