FOLLOW-UP SAMPLING OF SERUM DIOXIN LEVELS AND AN ANALYSIS OF POTENTIAL ENVIRONMENTAL ASSOCIATIONS IN A SMALL POPULATION IN SOUTHWESTERN LOUISIANA

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Introduction

In 1998 and 1999 the Agency for Toxic Substances and Disease Registry (ATSDR) evaluated blood levels of dioxins, furans, and coplanar polychlorinated biphenyls (collectively referred to as dioxin in this report) in a small community located near a highly industrialized area in Calcasieu Parish, Louisiana [1,2]. These assessments reported elevated levels of dioxin in some participants. Following the public release of these documents, community members continued to express concern regarding the potential for ongoing exposure to dioxin in their current environments.

In order to address questions raised in the first two reports and to determine whether exposure was still ongoing in the community, ATSDR initiated a follow-up analysis of blood dioxin levels in those persons who were described in the 1998 and 1999 reports. This follow-up investigation also incorporated more extensive residential environmental sampling of soil, indoor dust, attic dust, well water, and food sources including locally caught fish, and home-grown fruit, vegetables, and nuts. Congener specific analyses were conducted on all biological and environmental samples in order to assess potential sources of exposure associated with participants' blood serum levels.

Twenty two individuals participated in the follow-up sampling conducted in November of 2001. Five of these participants were initially sampled in June 1997 and the other 17 were sampled in December 1998. Initial recruitment of these individuals was intentionally biased towards residents with the highest exposure potential as determined by either occupational history or residential proximity to local petrochemical facilities and a vinyl chloride monomer plant.

Methods and Materials

Follow-up sampling for congener specific, serum dioxin levels was performed on 22 individuals in this investigation. Most participants (95%, 21/22) provided an 80-ml blood sample that was allowed to clot at room temperature for 1-2 hours and then placed on ice and shipped overnight for laboratory analysis. The initial sampling and analysis of these participants in 1997 and 1998 was conducted using similar methods [1,2]. The time between the initial and follow-up sampling for participants ranged from 2.96 to 4.46 years. Blood serum dioxin concentrations were analyzed using gas chromatography/isotope dilution-high resolution mass spectroscopy and reported as either lipid adjusted concentrations or as lipid adjusted WHO-TEQs [3].

Nineteen household environments were sampled in this follow-up investigation. Samples were collected from surface soil in the yard (n=20), indoor dust (n=14), attic dust (n=13), private well water (n=3), and homegrown vegetables (n=3), fruit (n=3), and nuts (n=3). Locally caught fish (n=8) were also provided by some participants. Samples were placed on ice and shipped overnight for laboratory analysis at the end of each sampling day. Water, soil, indoor dust and attic dust samples were analyzed using EPA Methods 8082 and 8290. Fish and edible plant material were analyzed using EPA Method 1613 as amended.

Statistical analyses were conducted using SPSS version 8. Serum, surface soil, indoor dust, and attic dust dioxin results were log normally distributed. However, 'zero' values were lost when data were log transformed. Therefore, changes in participants' serum dioxin levels were analyzed using both parametric and nonparametric methods. The Student's t-test compared mean differences in log transformed serum

dioxin congener levels between sampling periods. The Wilcoxon signed-rank test was the nonparametric method used to detect significant differences in serum dioxin levels between sampling events. A general linear model for repeated measures determined associations between the changes in participants' log transformed congener levels and environmental sampling results. Spearman rank correlation coefficients tested for associations between the 2001 serum dioxin and environmental sampling results.

Finally, serum dioxin levels were evaluated against two comparison populations; a randomly sampled control group in Southern Louisiana and national data documented in the Centers for Disease Control and Prevention's (CDC) recently released *Second National Report on Human Exposure to Environmental Chemicals* [4]. The control group from Southern Louisiana included 120 residents in Lafayette Parish who had congener specific serum dioxin sampling performed in 2002 as part of an ATSDR investigation. Congener data were also compared with CDC's newly released exposure report. However, due to the lack of reporting a total TEQ value and a majority of congeners below the limit of detection in the CDC analysis, only a few congener comparisons at the 95th percentile level were feasible. Blood sample volumes collected in both the CDC and the Lafayette Parish comparison groups were smaller than in the follow-up cohort. These lower volumes resulted in a much higher percentage of non-detect values in the two comparison groups. Therefore, caution should be used in directly comparing central tendency and percentile data between the follow-up cohort and two comparison groups.

Results and Discussion

There were thirteen male and nine female participants sampled in this investigation. The majority of these subjects were African-American (77%, 17/22) and the cohort had a mean age of 57.4 and an average length of residency in Calcasieu Parish of 47.5 years. Many members of the cohort were overweight (77%, 17/22) based on a body mass index (BMI) above 25 and over half of these individuals were obese (59%, 10/17) based on a BMI above 30.

Overall, there was a non-significant ($p>0.05$) decrease in mean serum dioxin concentrations for the cohort (1380.91 pg/g lipid vs. 1128.34 pg/g lipid) resulting in a similarly small, non-significant decrease in mean WHO-TEQ levels (62.5 pg TEQ/g lipid vs. 61.0 pg TEQ/g lipid). There was a substantial gender difference in mean dioxin TEQs (89.90 pg TEQ/g lipid in women and 41.07 pg TEQ/g lipid in men). However, when the data were log transformed, differences in gender were not significant ($p>0.05$). Congener profiles were similar between genders except for three congeners (2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 1,2,3,4,7,8-HxCDD/1,2,3,6,7,8-HxCDD) that were two to threefold higher in females. These congeners accounted for over 90% of the difference in mean TEQ between genders.

Most congener concentrations decreased between sampling events although, in many cases, these decreases were not statistically significant ($p>0.05$). A large portion of the total serum TEQ in this population was due to the contribution of a select few congeners including 1,2,3,7,8-PeCDD (42.7%), 1,2,3,4,7,8-HxCDD and 1,2,3,6,7,8-HxCDD (20.7%), and 2,3,7,8-TCDD (11.4%). The mean values of these congeners did not significantly decrease. Contributions of these congeners to total serum TEQ were similarly distributed in both sampling events.

When directly compared to a control population in Southern Louisiana, many individuals in this investigation were elevated. All descriptive measures of serum dioxin level in the investigation cohort were higher than those documented in the comparison group (Table 1). However, the congener profiles for these two groups were quite similar.

Congener specific data from the 2001 sampling were compared to CDC's national report on human exposure to environmental chemicals released in January, 2003 [4]. Unfortunately, comparisons could only be made between six congeners at the 95th percentile since most results were below the limit of detection in the CDC report. However, for the six congeners where comparisons were feasible, between 15-30% of the participants in this investigation were above the national 95th percentile.

Repeated measures analyses using log transformed data revealed a significant ($p<0.05$) relationship between the change in serum TEQ and current surface soil TEQ. Self-reported weight change was significantly ($p<0.001$) associated with the change in serum TEQ and many of the congeners (p-values

ranging from <0.05 to <0.001). Spearman rank correlation coefficients for 2001 serum results showed a strong correlation between serum TEQ and age (r=0.71, p<0.01).

There are many limitations associated with this investigation. The most prominent limitation is the introduction of selection bias by intentionally recruiting participants who lived close to potential sources of dioxin and were older than the general population. The purpose of an ATSDR exposure investigation is to determine if exposure is actually occurring so that appropriate public health actions can be taken to address the exposure. Therefore, selection bias is a necessary component to these investigations since they are designed to identify "worst case" exposure scenarios. As discussed previously, another major limitation involves the differences in detection limits between this investigation and the two comparison populations.

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Table 1: Serum Dioxin TEQs in both sampling events and a Louisiana comparison population

	N	Geometric Mean	Arithmetic Mean	Median	Range	95th Percentile
Initial sampling (1997/1998)	22	43.65	62.50	51.31	3.83 - 166.66	164.85
Follow-up sampling (2001)	22	40.74	61.04	39.88	4.14 - 245.15	234.25
Louisiana comparison (2002)	120	13.39	21.12	15.02	0.11 - 146.00	64.85

Table 2: 2001 Serum Dioxin TEQs by age quartiles

Age Category	N	Geometric Mean	Arithmetic Mean	Median	Range	95th Percentile
15-29	2	--	10.20	--	10.20-10.21	--
30-44	3	10.93	13.97	12.46	4.14-25.31	25.31
45-59	6	40.62	44.97	35.38	29.63-98.70	98.70
60+	11	75.27	91.89	69.13	27.64-245.15	245.15

References

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