Predictors of serum PCDF concentrations in people from Michigan, USA

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Introduction and Methods

- The University of Michigan Dioxin Exposure Study (UMDES) was undertaken in an area in which there was widespread contamination of soils and river sediments in Midland and Saginaw, Michigan from the Dow Chemical Company operations in Midland. The Tittabawassee River floodplain was believed to have been contaminated from past chloralkali operations which spilled waste materials into the river. Polychlorinated dibenzofurans (PCDFs) predominated in soil and sediment samples from the river downstream of Dow's facilities.
- We studied factors that predict serum concentrations of the PCDFs for which World Health Organization Toxic Equivalency Factors (TEFs) exist: 2378-TCDF, 12378-PeCDF, 23478-PeCDF, 123478-HxCDF, 123678-HxCDF, 123789-HxCDF, 234678-HxCDF, 1234678-HpCDF, 1236789-HpCDF, and OCDF.
- Participants were interviewed regarding potential exposure pathways (sport caught fish and game, diet, activities in the contaminated area, occupations, residential locations), demographics, smoking, and breast feeding. Samples of blood, soil, and household dust were analyzed for PCDFs using HRGC/HRMS. Important factors were identified using forward stepwise selection.
- Data from 946 UMDES participants were analyzed in SAS 9.1 using linear regression for complex survey data where log10(serum PCDF) was a linear function of predictors.

Results

- Serum PCDF concentrations were detectable in at least 95% of subjects for 23478-PeCDF, 123478-HxCDF, 123678-HxCDF, and 1236789-HpCDF.
- Serum PCDF concentrations were detectable in only a small proportion of subjects for 2378-TCDF (32%), 12378-PeCDF (25%), 123789-HxCDF (1%), 234678-HxCDF (44%), 1234789-HpCDF (1%), and OCDF (11%), even though the limits of detection for these congeners were below 1 part per trillion.
- The most important congener was 23478-PeCDF because it is typically associated with wastes from chloralkali operations.

Table 1: Percent variation in serum concentrations (adjusted R^2) explained by category of factors

Contribution to Adjusted R^2	23478 PeCDF	123478 HxCDF	123678 HxCDF	1234678 HpCDF
Overall (Stable only)	**61.59**	**46.79**	**34.89**	**11.01**
Demographic and Health factors	41.69	35.51	34.94	6.38
Residence factors	0.00	0.00	0.00	0.00
Soil/House dust	0.00	0.00	0.00	0.00
Property use factors	0.87	0.61	0.00	0.00
Work history factors	0.08	0.00	0.00	0.72
Water activity factors	0.00	0.26	0.00	0.00
Fish consumption and fishing	3.44	0.54	0.08	0.15
Meat/dairy consumption and hunting	0.00	2.56	0.00	4.44

- **The overall model** explained 62% and 47% of the variation in the serum concentration for 23478-PeCDF and 123478-HxCDF, respectively, indicating the variables we studied included important predictors of the serum level. In contrast, the models for 123678-HxCDF and 1234678-HxCDF explained only 35% and 11%, respectively.
- **Demographic and health factors** (age, age^2, sex, BMI, change in BMI in the past year, and breastfeeding) explained most of the variation
- **Soil and household dust** explained no appreciable amount (< 0.01%) of the variation.
- **Fish consumption and fishing** explained 3% of the variation in serum 23478-PeCDF and less than 1% for 123478-HxCDF, 1234678-HpCDF, and 1234678-HpCDF.
- **Meat/dairy consumption and hunting** explained 3-4% of the variation in 123478-HxCDF and 1234678-HpCDF, but no appreciable amount for 23478-PeCDF and 123678-HxCDF.

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Results, cont.

Linear Regression Results

- Age was positively associated with serum 23478-PeCDF (Figure 1), 123478-HxCDF (Figure 2), and 123478-HxCDF (Figure 3) levels, but not 1234678-HpCDF.
- A significant interaction between age and sex for 23478-PeCDF and 123478-HxCDF, showed serum levels increased with age more so for females than males (Figure 1&2).
- A significant interaction between BMI and sex for 123478-HxCDF and 123678-HxCDF, showed obese males had higher levels of these congeners at all ages than females or thin males (Figure 2&3).
- BMI was positively associated with 123478-HxCDF and 1234678-HpCDF. In addition, BMI loss in the past 12 months was positively associate with all four PCDF congeners suggesting total body fat and loss of body fat are both important predictors of PCDF concentrations in serum (Figures 1-3).

Figure 1: Relationship between serum 23478-PeCDF and age and sex

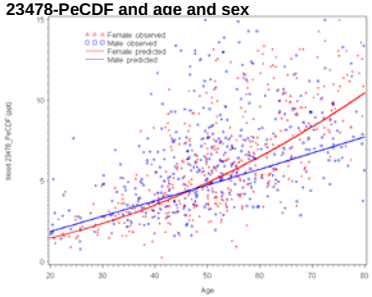


Figure 2: Relationship between serum 123478-HxCDF and age, sex, and BMI

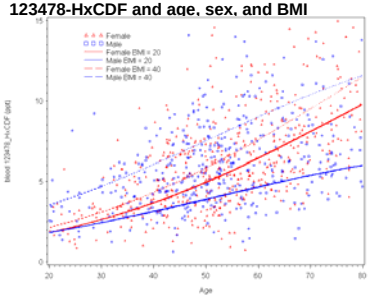
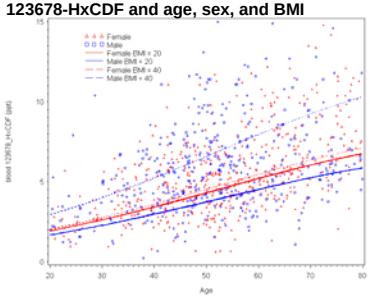


Figure 3: Relationship between serum 123678-HxCDF and age, sex, and BMI



- Breast feeding was inversely associated with serum 23478-PeCDF.
- Smoking was inversely associated with 123478-HxCDF and 1234678-HpCDF.
- Neither living on contaminated soil, contaminated household dust, living in or near the Tittabawassee River flood plain, nor living downwind of the Dow facilities was associated with increased serum levels for any PCDF congener.
- Working at Dow Chemical Company was not associated with serum levels of any PCDF congener.
- Eating fish in general (store bought, sport caught, or restaurant) was not associated with increased serum levels of any PCDF congener, nor was eating walleye or perch caught from the contaminated areas. Eating any fish other than walleye or perch from Saginaw River or Bay in the last 5 years was inversely associated with serum levels of 123478-HxCDF, 123478-HxCDF, 1234678-HpCDF, and 23478-PeCDF. Fishing in the Saginaw River or Saginaw Bay more than once per month after 1980 was associated with increased serum 23478-PeCDF. The lack of a consistent pattern among these findings does not indicate that these are important sources of PCDF exposure and is consistent with the modest contributions of fish consumption to the model R^2.
- No significant associations between any PCDF congener and meat or game consumption from the contaminated areas.

Conclusions

This study was large and capable of finding small statistically significant associations. Inferences should include consideration of the magnitude of the effect, the statistical significance of the estimate, and the variance in serum PCDF explained by the factor.