

The University of Michigan Dioxin Exposure Study Progress Report

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Progress Since August 2006

- ❖ Re-impute the dataset to include missing dust variable.
- ❖ Recalculation of TEQs for blood, dust, and soil dioxins to take into account the 2005 WHO TEFs.
- ❖ Use of quantile estimation methods to determine the 50th, 75th, 90th percentiles of blood dioxin levels by age and sex in the reference (Jackson/Calhoun) population.
- ❖ Use of logistic regression to model the probability of having blood dioxin values above the 90th percentile in Jackson/Calhoun



TEQs and TEFs changed in 2005

- ❖ During the last 15 years, the World Health Organization has established and regularly re-evaluated toxic equivalency factors (TEFs) for dioxins and related compounds through expert consultations.
- ❖ New TEF values were adopted in 2005 and replace the previous 1998 values.
- ❖ We have calculated the TEQ using the 2005 TEFs for the blood, household dust, and soil in the UMDES.
- ❖ We have also calculated the TEQs based on the 1998 TEFs so we can compare the UMDES values to published values based on the 1998 TEFs.



TEQs and TEFs changed in 2005

Now the story gets complicated.

- ❖ Different researchers around the world use different subsets of the dioxin congeners to calculate the TEQ.
 - 29 congeners (dioxins, furans, and PCBs)
 - 21 of the congeners (all dioxins and furans, but only some of the PCBs)
 - 17 dioxins and furans and exclude the PCBs.
- ❖ So, we have to calculate the TEQ 6 ways:
 - 1998 TEFs x 3 different sets of congeners
 - 2005 TEFs x 3 different sets of congeners

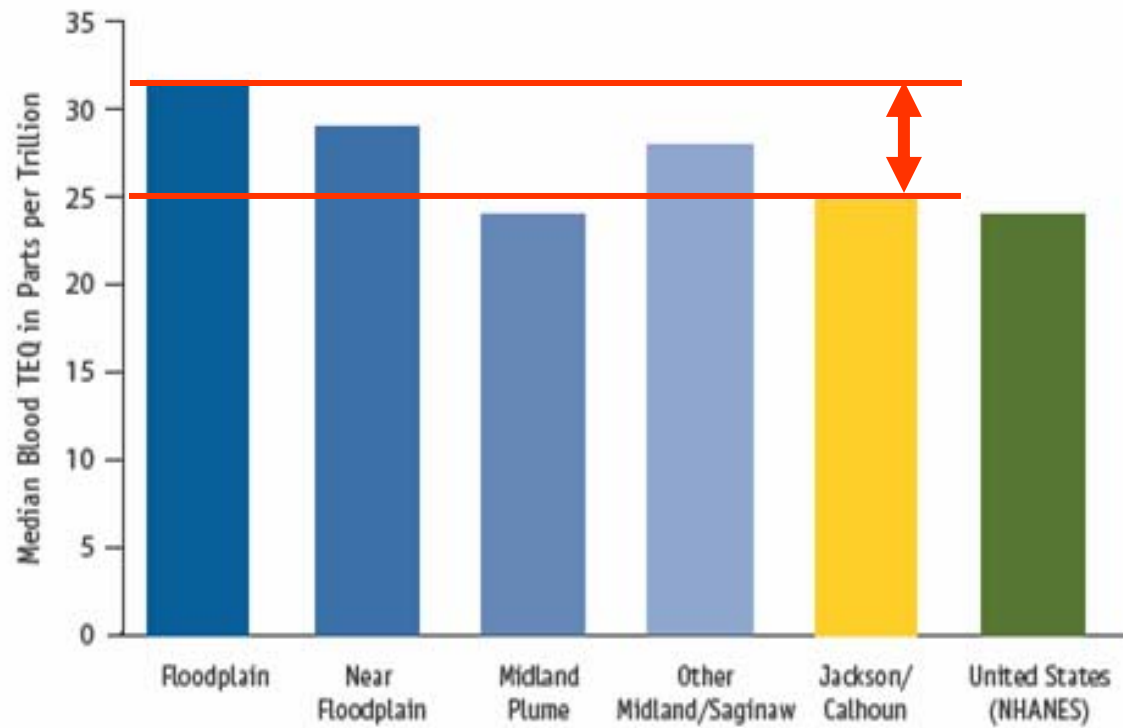


We indicate how we calculated the TEQ using the following subscripts:

- ❖ $TEQ_{DFP29-1998}$ = 1998 TEFs, using 29 congeners (dioxins, furans, and PCBs)
- ❖ $TEQ_{DFP21-1998}$ = 1998 TEFs, using 21 congeners (dioxins, furans, and some PCBs)
- ❖ $TEQ_{DF17-1998}$ = 1998 TEFs, using 17 congeners (dioxins, furans)
- ❖ $TEQ_{DFP29-2005}$ = 2005 TEFs, using 29 congeners (dioxins, furans, and PCBs)
- ❖ $TEQ_{DFP21-2005}$ = 2005 TEFs, using 21 congeners (dioxins, furans, and some PCBs)
- ❖ $TEQ_{DF17-2005}$ = 2005 TEFs, using 17 congeners (dioxins, furans)

Levels of Dioxins in People's Blood

Figure 1. People in the Floodplain, Near Floodplain and Other Midland/Saginaw have higher median TEQ levels than people in Jackson/Calhoun and the national levels.





Linear regression models of serum dioxin concentrations

Linear regression models were performed to identify factors that explain variation in serum TEQ_{DFP29-2005}, 2378-TCDD, 12378-PeCDD, 123678-HxCDD, 23478-PeCDF and PCB-126 concentrations.

- ❖ The 946 participants were sampled from five populations (FP, near FP, other M/S, M/S Plume, J/C) using a two-stage area probability household sample design.
- ❖ Potential predictors were demographic and health variables, residential history, property use, work history, recreational activities in the contaminated areas, food consumption (including meat, fish, game, eggs, milk, other dairy products, vegetables), and household dust and soil dioxin concentrations.



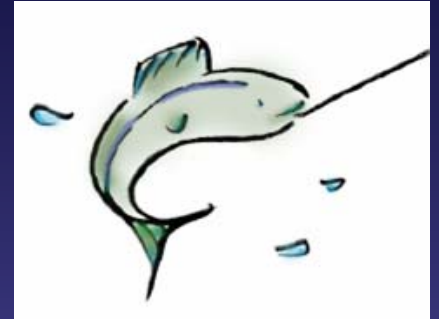
Linear regression models of serum dioxin concentrations

- ❖ All the regression analyses accounted for sampling weights, stratification, and clustering to insure the inferences from the regression models were applicable to the population from which participants were selected.
- ❖ A multi-stage backwards selection was applied to identify significant factors that predict the serum dioxin levels.

Levels of Dioxins in People's Blood

For the results for fish, meat, and game consumption, and fishing and hunting, we will present

- ❖ The **percent change** in blood dioxin level that is associated with the exposure.
- ❖ The **actual change** in blood dioxin level (in parts per trillion) for a person who has the median blood level among the Midland/Saginaw population.



Levels of Dioxins in People's Blood

- ❖ the median blood dioxin concentration among the Midland/Saginaw population.

TEQ_{DFP29-2005}: 20.7 ppt
2378-TCDD: 2.0 ppt
12378-PeCDD: 5.6 ppt
123678-HxCDD: 40.3 ppt
23478-PeCDF: 6.0 ppt
PCB-126: 18 ppt

Region	N	TEQ _{DFP29-2005}	2378-TCDD	12378-PeCDD	123678-HxCDD	23478-PeCDF	PCB-126
Midland/Saginaw Overall	695	20.7	2.0	5.6	40.3	6.0	18.0
FP	243	23.3	2.4	6.3	39.6	6.4	22.6
NearFP	205	21.9	2.1	5.6	35.7	6.8	24.1
OutFP	204	20.7	1.9	5.6	40.4	6.0	17.9
Plume	43	18.7	2.3	5.3	36.6	4.6	18.0

Levels of Dioxins in People's Blood

People who ate fish from the Tittabawassee River, Saginaw River, or Saginaw Bay between 1980 and the present have higher levels of some dioxins in their blood than people who did not eat fish from these areas.

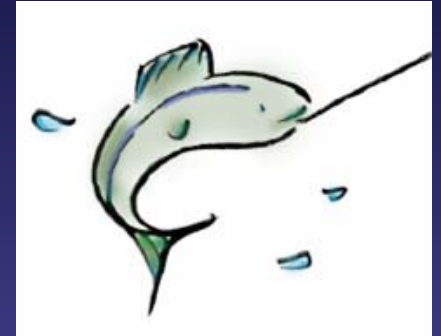


For every one year of consumption the increase is:

- ❖ 0.04 parts per trillion (2%) for 2378-TCDD.
- ❖ No apparent effect for the $TEQ_{DFP29-2005}$ or other specific dioxins studied.

Levels of Dioxins in People's Blood

*People who ate fish **regardless the source of the fish** between 1980 and the present have higher levels of some dioxins in their blood than people who did not eat fish.*

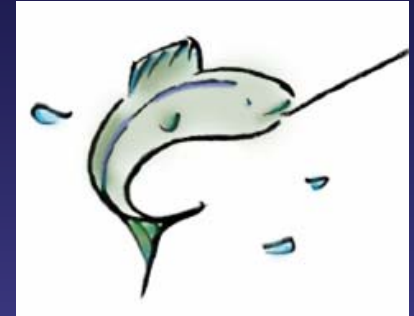


For every one year of consumption the increase is:

- ❖ 0.03 parts per trillion (1.3%) for 2378-TCDD.
- ❖ No apparent effect for the $TEQ_{DFP29-2005}$ or other specific dioxins studied.

Levels of Dioxins in People's Blood

People who *fished in the Saginaw River or Saginaw Bay* between 1980 and the present have higher levels of some dioxins in their blood than people who did not fish in these areas.



The increase for fishing at least once a month (during the entire 1980-2005 period) compared to no fishing activities is:

- ❖ 5.1 parts per trillion (25%) for TEQ_{DFP29-2005}
- ❖ 1 parts per trillion (53%) for 2378-TCDD
- ❖ 1.7 parts per trillion (30%) for 12378-PeCDD
- ❖ 14.9 parts per trillion (83%) for PCB-126

Levels of Dioxins in People's Blood

*People who ate **meat bought in the store or from the restaurant** have higher levels of some dioxins in their blood.*



The increase for eating at least once a month compared to less than once a month is:

- ❖ 1.7 parts per trillion (29%) for 23478-PeCDF
- ❖ 16.2 parts per trillion (40%) for 123678-HxCDD
- ❖ No apparent effect for the $TEQ_{DFP29-2005}$ or other specific dioxins studied

Levels of Dioxins in People's Blood

People who ate skin of the Wild Turkey, Pheasant, Grouse, Quail or Woodcock regardless of where it came from during the past 5 years have higher levels of dioxins in their blood than people who did not eat the skin.



The increase for ever versus never eating the skin of these birds is:

- ❖ 3.1 parts per trillion (15%) for TEQ_{DFP29-2005}
- ❖ No apparent effect for the specific dioxins studied

Levels of Dioxins in People's Blood

People who *ate deer liver regardless of where it came from* during the past 5 years have higher levels of some dioxins in their blood than people who did not eat deer liver.



The increase for ever versus never eating deer liver is:

- ❖ 7.8 parts per trillion (43%) for PCB-126
- ❖ No apparent effect for the TEQ_{DFP29-2005} or other specific dioxins studied

Levels of Dioxins in People's Blood

People who hunted in the Saginaw River or Saginaw Bay from 1960 to 1979 have higher levels of some dioxins in their blood than people who did not hunt from these areas during this period of time.



The increase for ever versus never hunting is:

- ❖ 6.6 parts per trillion (32%) for TEQ_{DFP29-2005}
- ❖ 2.8 parts per trillion (50%) for 12378-PeCDD
- ❖ 13.7 parts per trillion (34%) for 123678-HxCDD
- ❖ No apparent effect for other specific dioxins studied

Levels of Dioxins in People's Blood

Living on property with soil containing

- ❖ 1,000 parts per trillion $TEQ_{DFP29-2005}$ of dioxins was associated with higher levels in blood of 0.5 parts per trillion (2.3%) for the $TEQ_{DFP29-2005}$.
- ❖ 40 parts per trillion of PCB-126 was associated with higher levels in blood of 1.1 parts per trillion (6%) for PCB-126. (40 ppt is the 95th percentile in Jackson/Calhoun)
- ❖ No apparent effect for other specific dioxins studied



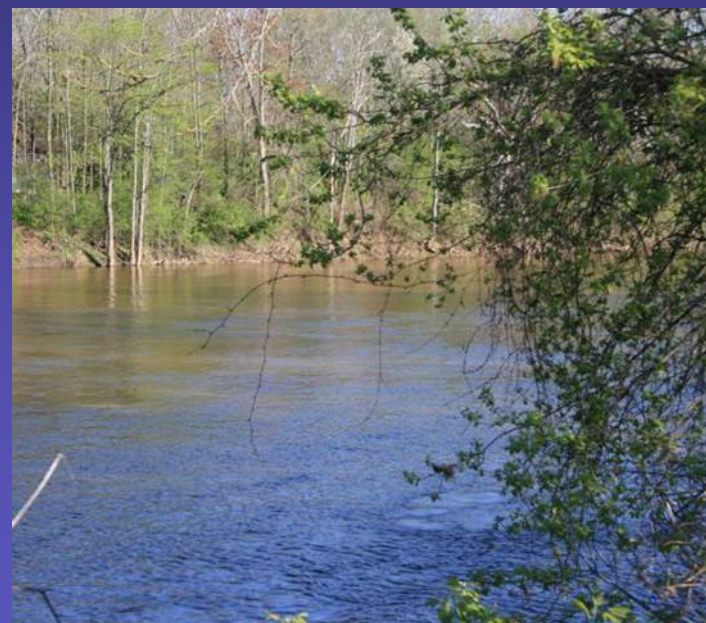
Levels of Dioxins in People's Blood

Living on property with soil containing

- ❖ 1,000 parts per trillion $TEQ_{DFP29-2005}$ of dioxins was associated with higher levels in blood of 0.5 parts per trillion (2.3%) for the $TEQ_{DFP29-2005}$.

Percent of properties that had a soil $TEQ_{DFP29-2005}$ at or above 1,000 parts per trillion (among all soil samples on the property):

- FP 7.0%
- Near FP 1.6%
- Other M/S 0.4%
- Midland Plume 0.0%
- Jackson/Calhoun 0.0%



Levels of Dioxins in People's Blood

Living on property with soil containing

- ❖ 40 parts per trillion of PCB-126 was associated with higher levels in blood of 1.1 parts per trillion (6%) for PCB-126.

Percent of properties that had a soil PCB-126 at or above 40 parts per trillion:

- FP 1.6%
- Near FP 0.5%
- Other M/S 1.9%
- Midland Plume 18.2%
- Jackson/Calhoun 5.6%



Levels of Dioxins in People's Blood

- ❖ **Gardening in soil** containing
 - ❖ 22 parts per trillion of 2378-TCDD was associated with higher levels in blood of 0.8 parts per trillion (43%) for 2378-TCDD. (22 ppt is the median garden soil concentration in the Midland Plume)
 - ❖ 26.8 parts per trillion of PCB-126 was associated with higher levels in blood of 0.6 parts per trillion (3.2%) for PCB-126. (26.8 ppt is the 95th percentile garden soil concentration in Jackson/Calhoun).
 - ❖ Gardening in soil had no apparent effect for the $TEQ_{DFP29-2005}$ or other specific dioxins studied.



Levels of Dioxins in People's Blood

- ❖ **Gardening in soil** containing 22 parts per trillion of 2378-TCDD was associated with higher levels in blood of 0.8 parts per trillion (43%) for 2378-TCDD. Fifty percent of the gardens in the Midland Plume had soil 2378-TCDD levels at or above 22 parts per trillion. Less than 3 percent of the gardens in Midland/Saginaw and Jackson/Calhoun had soil 2378-TCDD levels at or above 22 parts per trillion.
- ❖ **Gardening in soil** containing 26.8 parts per trillion of PCB-126 was associated with higher levels in blood of 0.6 parts per trillion (3.2%) for PCB-126. Five percent of the gardens in Jackson/Calhoun had soil PCB-126 levels at or above 26.8 parts per trillion.
- ❖ Gardening in soil had no apparent effect for the $TEQ_{DFP29-2005}$ or other specific dioxins studied.





Analyses of soil variables defined as high, medium, or low categories

The analyses above show the relationship between blood dioxins and soil dioxins as **continuous variables**.

We repeated the analyses of soil dioxins as **categories (high, medium, low)**.

There was no relationship between blood dioxins and the highest category of soil dioxins for $TEQ_{DFP29-2005}$ or for any of the specific congeners studied (2378-TCDD, 23478-PeCDF, PCB-126).



Analyses of soil variables defined as high, medium, or low categories

Here is how we defined the **high, medium, and low soil dioxin groups**:

	Soil dioxin group		
	Low	Medium	High
TEQ _{DFP29-2005}	Below 50 th percentile	50 th percentile to 90 ppt	Greater than 90 ppt
2378-TCDD	Below 50 th percentile	50 th to 90 th percentile	Greater than 90 th percentile
23478-PeCDF	Below 50 th percentile	50 th to 90 th percentile	Greater than 90 th percentile
PCB-126	Below 50 th percentile	50 th to 90 th percentile	Greater than 90 th percentile



Results of the models where soil variables were defined as categories

Parameter	TEQ _{DFP29-2005}			2378-TCDD			23478-PeCDF			PCB-126		
	Estimate	p-value	ΔR ² (%)	Estimate	p-value	ΔR ² (%)	Estimate	p-value	ΔR ² (%)	Estimate	p-value	ΔR ² (%)
HP1_high	0.0427	0.2264	0.108	0.0579	0.1987	0.138	-0.0338	0.2070	0.156	0.0199	0.6809	0.058
HP1_medium	0.0178	0.3299		0.0527	0.1407		-0.0120	0.4879		0.0200	0.5902	
HP1_low	0			0			0			0		
HP2_high	0.0589	0.2718	0.136	0.0538	0.3143	0.144	-0.0189	0.4358	0.088	0.0821	0.1445	0.148
HP2_medium	0.0199	0.2509		0.0580	0.1283		-0.0081	0.7005		-0.0080	0.8416	
HP2_low	0			0			0			0		
FP1_high	0.0317	0.3688	0.004	0.0032	0.9620	0	0.0789	0.1582	0.004	0.1255	0.1881	0.006
FP1_medium	0.0790	0.0177		0.0142	0.7878		0.0293	0.4394		0.0158	0.8194	
FP1_low	0			0			0			0		
FP2_high	0.0198	0.5884	0.002	0.0513	0.5525	0	0.1064	0.0606	0.004	0.0370	0.7201	0.002
FP2_medium	0.0470	0.1330		-0.0271	0.6216		0.0236	0.5215		0.0089	0.8894	
FP2_low	0											
SC_high	0.1816	0.1940	0.04	-0.006								
SC_medium	0.0096	0.6871		0.030								
SC_low	0											
Max_high	0.0482	0.1579	0.198	0.028								
Max_medium	0.0235	0.1980		0.050								
Max_low	0											

HP1: House perimeter 0-1"
 FP1: Flood plain 0-1"
 SC: Soil contact 0-6"

❖ This was the only result that was statistically significant, and only for the medium category (not the high category).

❖ None of the other soil variables showed any significant relationship to the blood dioxin levels.

Levels of Dioxins in People's Blood

After accounting for all other factors, we examined whether living in Midland/Saginaw was associated with higher blood dioxin levels:

- ❖ People who live in the FP or Near FP have higher levels of PCB-126 (51% and 19%, respectively) compared to people who live in Jackson/Calhoun.
- ❖ Living in any area of Midland/Saginaw counties in 1940-1959 was associated with a 1.4% increase in serum 2378-TCDD per year.
- ❖ Living in any area of Midland/Saginaw counties in 1960-1979 was associated with a
 - 0.7% increase in serum TEQ_{DFP29-2005} per year.
 - 2% increase in serum 2378-TCDD per year.
 - 0.9% increase in serum 12378-PeCDD per year.



Results: Explained variation in serum dioxin concentration

Partial contribution to the adjusted R² (%)

Model	Overall	Health	Property Use	Fish & Fishing	Work	Water Activities	Meat & Hunting	Residence	Soil	Dust	Egg, Dairy, & Vegetable
TEQ _{DFP29-2005}	72.56	40.32	2.21	1.46	0.96	0.92	0.48	0.22	0.09	0.07	
2378_TCDD	67.17	29.55	1.25	2.13	1.39	1.67	0.25	2.85	0.53		0.66
12378_PeCDD	67.55	43.66	0.20	0.88	1.42		0.79	1.23	0.26		
123678_HxCDD	65.59	45.22	0.93	0.45	0.88	1.04	1.88	0.00	0.14		0.01
23478_PeCDF	66.71	40.79	2.33	2.95	1.72	1.62	0.25	0.01	-0.02		
PCB_126	53.34	36.95	4.68	3.96	2.15		0.73	0.46	1.22		

- ❖ This shows that 72.56% of the variation in the blood TEQ_{DFP29-2005} is explained by the analysis.
- ❖ Health factors (age, sex, BMI, smoking, breast feeding) explain most of the variation (40.32%) in blood TEQ_{DFP29-2005}.
- ❖ Eating fish, fishing, eating meat, and hunting explain about 2% of the variation in the blood TEQ_{DFP29-2005}.
- ❖ Living on contaminated soil and having dioxins in house dust explain very little (<0.2%) of the variation in the blood TEQ_{DFP29-2005}.



Comparison of Jackson and Calhoun residents' serum TEQ to other samples of the US general population

Serum TEQ_{DFP21-2005} from the UMDES and two other US reference populations (excluding Mono-Ortho-Chloro-PCBs) (ppt)

	N	Year of Samples	Min	Mean	Median	Max
Jackson & Calhoun Counties, Michigan (UMDES)	251	2005	3.9	20.9	18.2	104.4
Lafayette Parish, Louisiana (ATSDR)	120	2002	2.2	20.3	15.6	146.0
National (NHANES)	1011	2001 - 2002	4.1	22.9	17.5	149.5

Serum congener concentrations from the UMDES and two other US reference populations

	Mean Serum Concentrations (ppt)			
	2378 - TCDD	12378 - PeCDD	23478 - PeCDF	PCB 126
Jackson & Calhoun Counties, Michigan (UMDES)	1.8	5.5	6.0	29.4
Lafayette Parish, Louisiana (ATSDR)	2.8	7.3	6.2	19.5
National (NHANES)	1.3	5.0	7.2	37.6