

Serum Dioxin, Furan, and PCB Concentrations and Half-Life Study Among the U.S. General Population

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Goal of the study

- Estimate the age- and gender- specific median, 75th percentile, and 95th percentile of the serum dioxins, furans, and dioxin-like PCBs concentrations among the U.S. (NHANES 2003-2004) and Michigan (UMDES reference population) non-Hispanic white general populations.
 - TEQ: the list of WHO 29 dioxin-like compounds (excluding PCB77, PCB114, and PCB123), using 2005 TEF
 - Specific congeners: having more than a half of observations above the LOD in the J/C or in the NHANES (19 congeners)
 - 2378-TCDD, 23478-PeCDF, and PCB 126
 - Investigate the association between age effects and half-life values

Materials and Methods: Study Population

- The UMDES reference population, the Jackson/Calhoun counties in Michigan, USA, 2005
 - Advantage: lower proportion of data below the limit of detection (LOD) for most of congeners
 - Disadvantage: relatively few participants (n=20) were older than 75 years, especially males (n=3); Estimating the age- and gender- specific percentiles is problematic in the old age group.
- The National Health and Nutrition Examination Survey (NHANES), USA, 2003-2004
 - Advantage: More participants, and more observations older than 75 years.
 - Disadvantage: higher proportion of data below the LOD

Materials and Methods: Study population (Cont.)

- The Jackson/Calhoun (J/C) data
 - Predominantly non-Hispanic white population
 - Pregnancy women were not included in the study
 - Older than 18 years
 - Age was top-coded at 85 years
- The NHANES 2003-2004 data
 - Use the sub-sample of non-Hispanic white population
 - Exclude the pregnancy women
 - Exclude participants younger than 18 years
 - Age was top-coded at 85 years

Materials and Methods: Statistical analyses

- Combine J/C data with the NHANES 2003-2004
- Using multiple imputation technique to impute the data below the LOD.
- Survey-weighted quantile regression models (median, 75th percentile, and 95th percentile) of natural logarithm serum dioxin concentrations were fitted on age, age squared, gender, data source, and interaction terms. Stepwise selection was used to select statistically significant variables into each quantile regression model.

$$\log(TEQ) = \beta_0 + \beta_1(age - 50) + \beta_2(age - 50)^2 + \beta_3source + \beta_4gender + \dots + \varepsilon$$

Results: Comparison between J/C and the NHANES

CONGENERS	UMDES (J/C)			NHANES 2003-2004			
	n	Prop. < LOD	Median LOD Level	n	Prop < LOD	Median LOD Level	
Dioxin	2,3,7,8-tcdd	251	20.7%	0.5	719	48.0%	1.1
	1,2,3,7,8-pncdd	251	1.6%	2.1	719	31.0%	1.1
	1,2,3,4,7,8-hxcdd	251	11.6%	2.6	714	63.3%	4.0
	1,2,3,6,7,8-hxcdd	251	0.8%	3.5	716	10.5%	4.5
	1,2,3,7,8,9-hxcdd	251	9.6%	3.0	714	64.0%	4.0
	1,2,3,4,6,7,8-hpcdd	251	0.4%	2.1	718	3.1%	4.5
	OCDD	251	0.0%		711	8.6%	99.3
Furan	2,3,4,7,8-pncdf	251	1.2%	1.1	717	18.1%	2.5
	1,2,3,4,7,8-hxcdf	251	5.2%	2.4	716	22.9%	3.0
	1,2,3,6,7,8-hxcdf	251	4.8%	1.8	715	33.6%	2.8
	1,2,3,4,6,7,8-hpcdf	251	9.2%	1.8	708	10.6%	3.1
PCB	PCB81	251	56.2%	1.4	711	65.7%	5.2
	PCB105	251	0.4%	<0.0005	723	1.8%	155.6
	PCB118	251	0.4%	<0.0005	723	0.0%	-
	PCB126	251	1.2%	3.8	714	5.6%	6.5
	PCB156	251	0.4%	<0.0005	727	4.3%	113.1
	PCB157	251	0.4%	<0.0005	717	14.6%	113.1
	PCB167	251	0.4%	<0.0005	721	25.5%	113.1
	PCB169	251	0.4%	3.7	717	21.1%	6.0
	PCB189	251	0.4%	<0.0005	699	68.2%	113.1

The median LOD levels are calculated using the LOD levels among the non-detects

Results: TEQ

Table 1: quantile regression results for serum TEQ levels.

Parameter	Median [‡]	75 th Percentile [‡]	95 th Percentile [‡]
Intercept	19.375 ***	23.266 ***	30.356 ***
age [†]	1.031 ***	1.028 ***	1.031 ***
age [†] * age [†]	0.999 **	0.999 ***	
source (NHANES=1, J/C=0)	0.822 ***	0.919 **	
gender (male=1, female=0)	0.990		
age [†] * gender	0.995 **		

[†] Age minus 50; [‡] Results are presented as "estimate + p-value"; *** p-value < 0.01; ** p-value < 0.05; * p-value < 0.1

Example:

$$\begin{aligned}
 \widehat{TEQ}(median) &= e^{\beta_0 + \beta_1(age-50) + \beta_2(age-50)^2 + \beta_3 source + \beta_4 gender + \beta_5 (age-50)*gender} \\
 &= e^{\beta_0} \times (e^{\beta_1})^{age-50} \times (e^{\beta_2})^{(age-50)^2} \times (e^{\beta_3})^{source} \times (e^{\beta_4})^{gender} \times (e^{\beta_5})^{(age-50)*gender} \\
 &= 19.375 \times (1.031)^{age-50} \times (0.999)^{(age-50)*(age-50)} \times (0.822)^{source} \times (0.990)^{gender} \times (0.995)^{(age-50)*gender}
 \end{aligned}$$

$e^{\beta_3} = 0.822$: The median TEQ level in the NHANES is estimated to be 82.2% of the median TEQ level in J/C given age and gender.

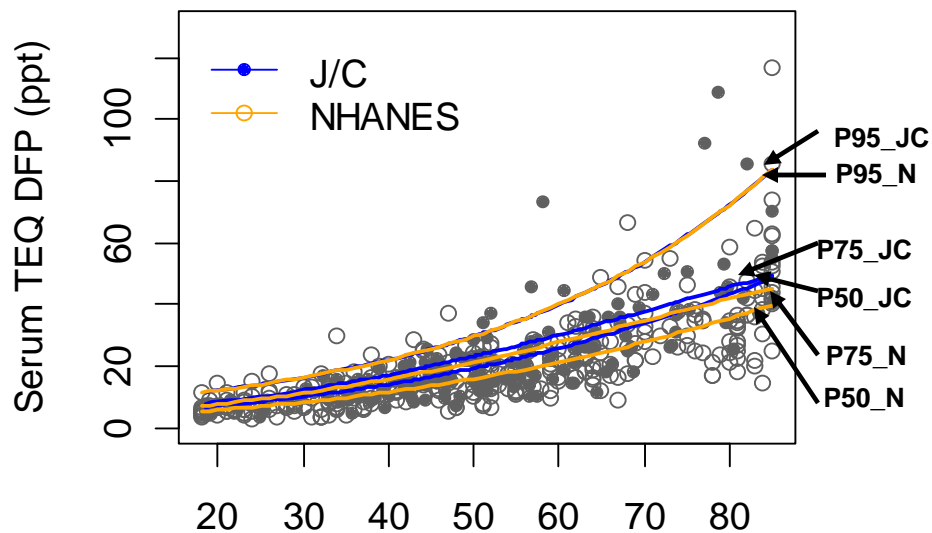
Results: TEQ

Table 1: quantile regression results for serum TEQ levels.

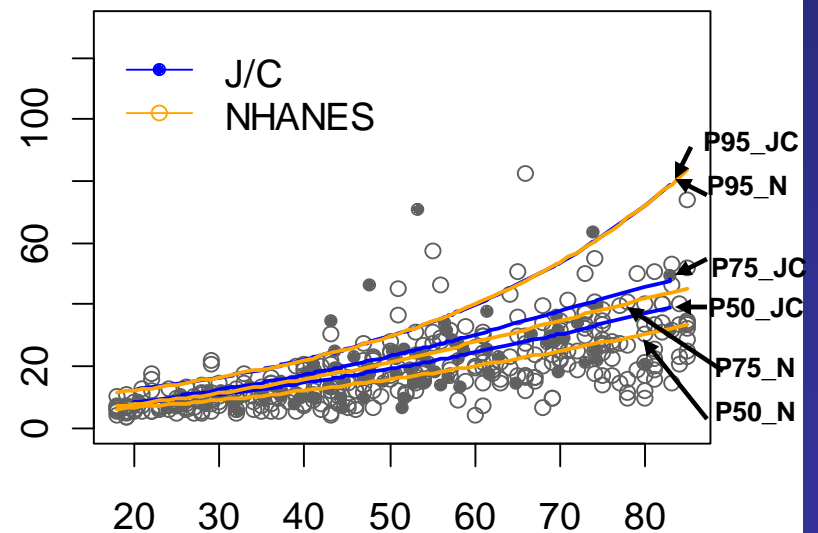
Parameter	Median [‡]	75 th Percentile [‡]	95 th Percentile [‡]
Intercept	19.375 ***	23.266 ***	30.356 ***
age [†]	1.031 ***	1.028 ***	1.031 ***
age [†] * age [†]	0.999 **	0.999 ***	
source (NHANES=1, JC=0)	0.822 ***	0.919 **	
gender (male=1, female=0)	0.990		
age [†] * gender	0.995 **		

[†] Age minus 50; [‡] Results are presented as "estimate + p-value"; *** p-value < 0.01; ** p-value < 0.05; * p-value < 0.1

Females



Males

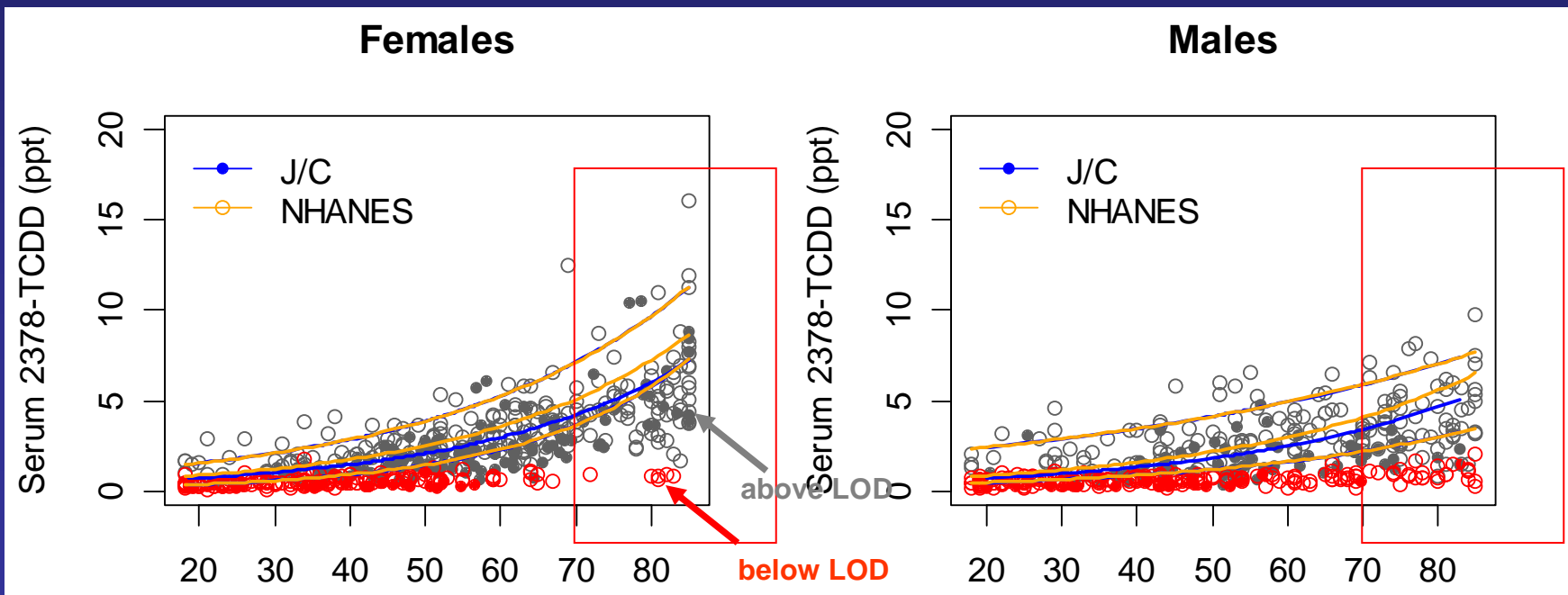


Results: 2378-TCDD

Table 2: quantile regression results for serum 2378-TCDD concentrations.

Parameter	Median [‡]	75 th Percentile [‡]	95 th Percentile [‡]
Intercept	1.456 ***	2.094 ***	3.873 ***
age [†]	1.047 ***	1.036 ***	1.032 ***
source (NHANES=1, JC=0)		1.201 **	
gender (male=1, female=0)	0.824 ***	0.871 *	1.067
age [†] * gender	0.984 ***	0.996	0.987 **

[†] Age minus 50; [‡] Results are presented as estimate + *p*-value; *** *p*-value < 0.01; ** *p*-value < 0.05; * *p*-value < 0.10



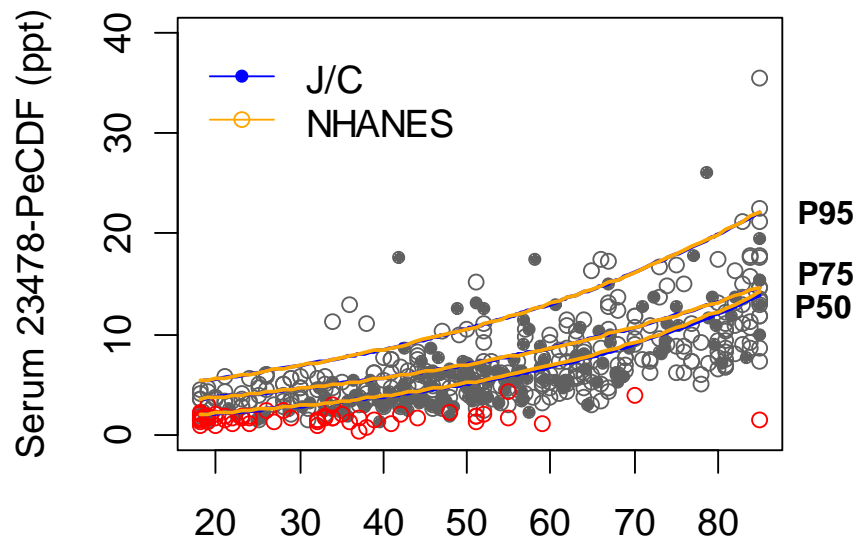
Results: 23478-PeCDF

Table 3: quantile regression results for serum 23478-PeCDF concentrations.

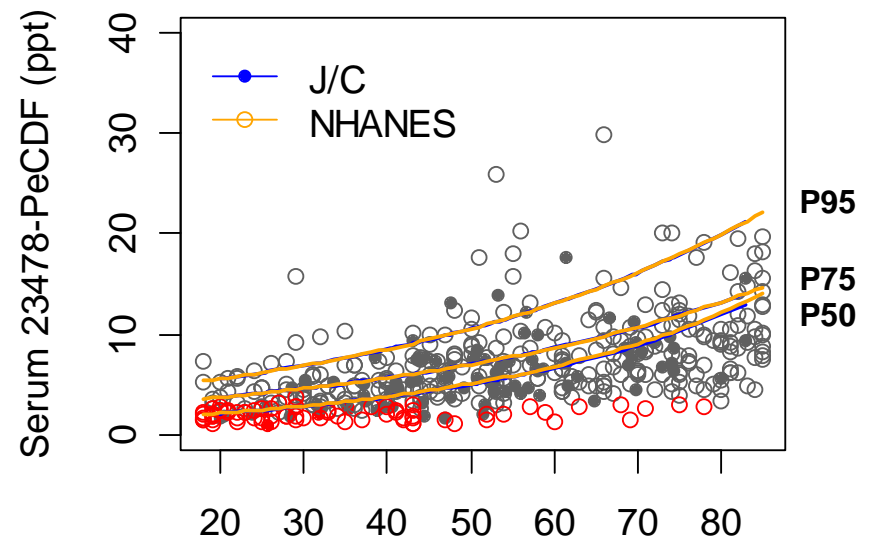
Parameter	Median [‡]	75 th Percentile [‡]	95 th Percentile [‡]
Intercept	5.058 ***	6.994 ***	10.538 ***
age [†]	1.029 ***	1.021 ***	1.021 ***
source (NHANES=1, JC=0)	1.016		
age [†] * source	0.993 **		

[†] Age minus 50; [‡] Results are presented as estimate + *p*-value; *** *p*-value < 0.01; ** *p*-value < 0.05; * *p*-value < 0.10

Females



Males

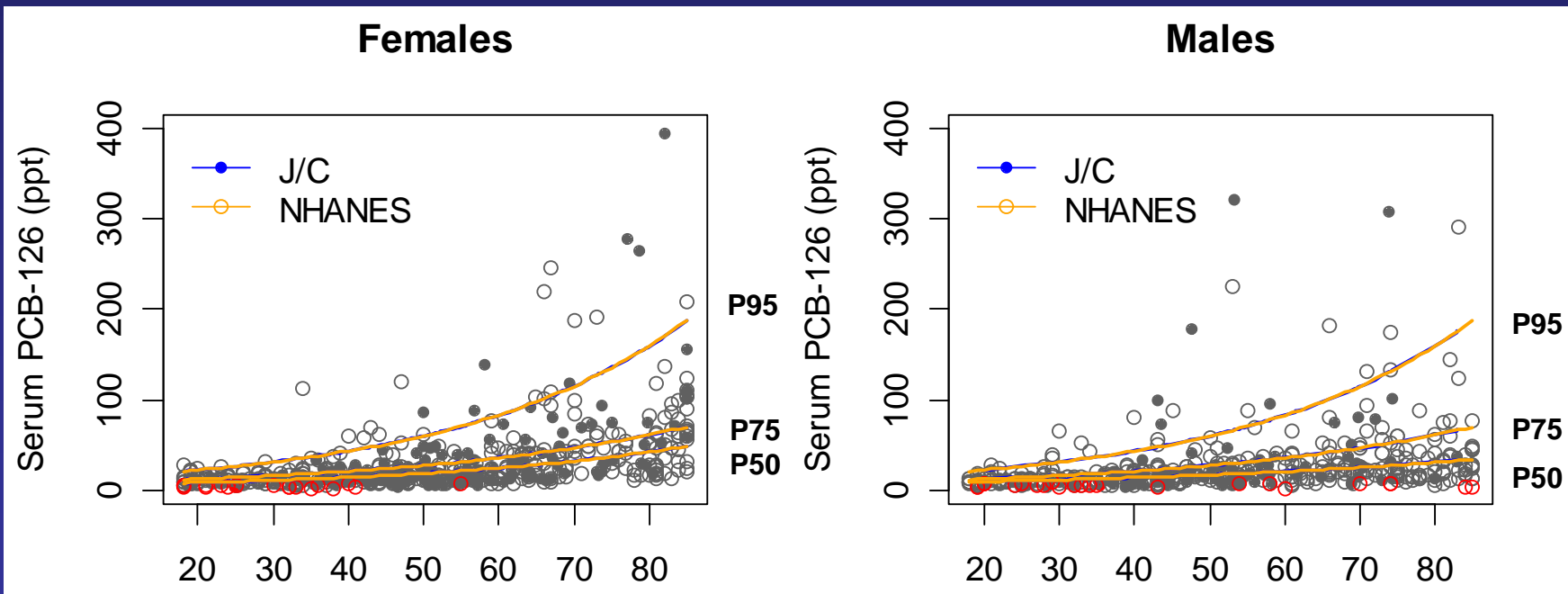


Results: PCB 126

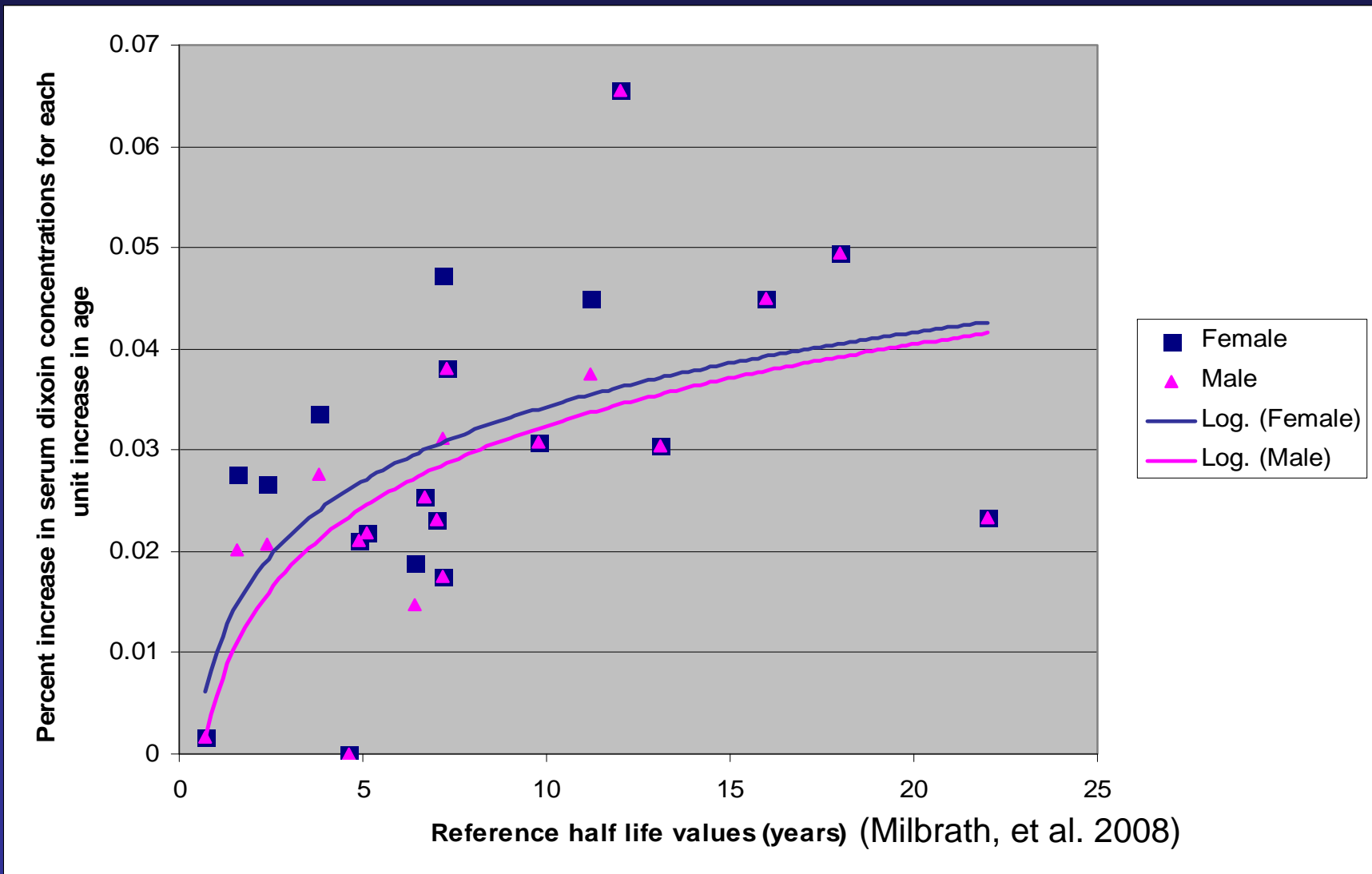
Table 4: quantile regression results for serum PCB-126 concentrations.

Parameter	Median [‡]	75th Percentile [‡]	95th Percentile [‡]
Intercept	18.653 ***	27.385 ***	59.919 ***
age [†]	1.027 ***	1.027 ***	1.034 ***
gender (male=1, female=0)	0.906		
age * gender	0.993 **		

[†] Age minus 50; [‡] Results are presented as estimate + *p*-value; *** *p*-value < 0.01; ** *p*-value < 0.05; * *p*-value < 0.10



Results: Half-lives vs. age effects (at age 50)



Results: Half-lives vs. age effect (Cont.)

- The scatter plot shows
 - There is a strong positive association between the reference half-life values and the percent increases in serum dioxin concentrations for each unit increase in age.
 - For each unit increase in age, the percent increases in serum dioxin concentrations are higher in females than in males for some congeners, which indicates that the half-life values could be different between males and females for these congeners.

Discussion

- The serum dioxin concentrations vary with age and gender
 - It is important to quantify the background serum dioxin concentrations by age and gender
- The present study provides an age- and sex- specific reference level for the non-Hispanic white general adult populations in the U.S. and in Michigan
 - The results can serve as a reference level for the study of other populations

Thanks