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EXECUTIVE SUMMARY

Calcasieu Parish, Louisiana, contains the Calcasieu Estuary, an area with many petrochemical industries that make chlorinated hydrocarbon solvents, vinyl chloride monomer, and other petroleum-based chemicals. Several residents of Calcasieu Parish expressed concerns about the impact that these chemicals may have on their health. In 1998, staff from the U.S. Environmental Protection Agency (EPA) Region VI asked the Agency for Toxic Substances and Disease Registry (ATSDR) to review the blood dioxin results of 11 people and a pooled blood sample from residents of Calcasieu Parish. An ATSDR report concluded that three people and the pooled blood sample had levels of dioxin-like compounds (hereby referred to as dioxins) above a reference range and recommended that the sources of dioxin be identified and measures be implemented to reduce exposure (Agency for Toxic Substances and Disease Registry 1998a). In December 1998, staff from the ATSDR collected blood from an additional 28 self-selected residents of Mossville, an area in Calcasieu Parish, to measure dioxin. The exposure investigation indicated that the mean blood dioxin concentrations of the 28 participants were above the 95th percentile of a reference population (Agency for Toxic Substances and Disease Registry 1999).

This investigation was conducted to better characterize the nature and extent of exposure to dioxin among residents of Calcasieu Parish. Study participants were selected from a residential area surrounding the petrochemical industries located near the Calcasieu Estuary. People living in Lafayette Parish, Louisiana, comprised the comparison group in this investigation.

Overall, the mean serum dioxin level did not differ between residents of Calcasieu Parish and residents of Lafayette Parish. In addition, the mean dioxin levels were similar when Calcasieu residents were placed into three areas based on distance to industrial areas (industrial corridor, industrial buffer, and outer ring). Dioxin levels increased with age in Calcasieu and Lafayette Parishes. Calcasieu Parish residents who reported eating locally caught fish, smoking cigarettes, working in an occupation with potential exposure, or using pesticides, had dioxin levels similar to those of Lafayette Parish residents who reported these activities. Current cigarette smokers in Calcasieu Parish had higher dioxin levels than current cigarette smokers in Lafayette Parish. African Americans in Lafayette Parish had higher dioxin levels than African Americans in Calcasieu Parish and whites in Lafayette Parish.

We also evaluated the blood samples for congener patterns, or the distribution of dioxins in serum. The congener pattern in Calcasieu Parish residents was similar to that of Lafayette Parish residents.

SERUM DIOXIN LEVELS IN RESIDENTS OF CALCASIEU PARISH, LOUISIANA

Following the discovery of petroleum and gas reserves in the 1920s, Calcasieu Parish became a highly industrialized area, containing a large number of petrochemical and agrochemical manufacturing and processing plants. These plants produce chemicals such as chlorinated hydrocarbon solvents, vinyl chloride monomer, petroleum-based chemicals, and commercial feedstock (U.S. Environmental Protection Agency 2003). In 2000, thirty-one Calcasieu Parish industries reported releases of 14,450,855 pounds of environmental contaminants to the Environmental Protection Agency (EPA) Toxic Release Inventory. This included 1.27 pounds of dioxin. Chemical, petroleum, and solvent recovery industries contributed the greatest amount to the total releases (Louisiana Department of Environmental Quality 2000).

Community members were concerned about the effect of chemical releases on their health. Previous review and investigation by the Agency for Toxic Substances and Disease Registry (ATSDR) indicated higher than expected levels of dioxin-like substances in the blood of some community members. As a followup to these previous investigations, ATSDR conducted this study to better characterize the nature and extent of human exposure to dioxin and dioxin-like substances throughout Calcasieu Parish. We selected study participants from a residential area surrounding petrochemical industries located near the Calcasieu Estuary. Residents living in Lafayette Parish, Louisiana, comprised the comparison group in this investigation.

BACKGROUND

Dioxin and dioxin-like compounds

Polychlorinated Dibenzo-p-Dioxins (PCDDs) comprise a family of 75 chemically related compounds each of which is called a congener. PCDDs share properties with two other groups of chemicals, polychlorinated dibenzo furans (PCDFs) and several compounds from a group of chemicals called polychlorinated biphenyls (PCBs). Together with PCDDs, these compounds are referred to as dioxin-like compounds, or dioxins. The term dioxin in this document will be used to describe these three groups of dioxins: PCDDs, PCDFs, and PCBs. Although the mono-ortho PCBs have dioxin activity, this group was not included in the analysis because calculation of the dioxin toxic equivalent (TEQ) for the reference population did not include the mono-ortho PCBs.

Dioxin is found in air, water, and soil. PCDDs and PCDFs are not made on purpose, but result from burning fuel, wood, and waste, and from making certain products. PCBs are commercial mixtures that are no longer produced in the United States, but were used in the past as coolants and lubricants in transformers, capacitors, and other electrical equipment. When humans are exposed to dioxin through contact with contaminated soil, air, and water, dioxins can enter the body and get stored in fat. Individual dioxin congeners are eliminated slowly from the body at different rates. The rate of elimination is calculated in “half-lives”—the time it takes for 50% of dioxin to leave the body.

Regression Analyses. In weighted univariate regression analysis, age of the participants and year first lived in parish had a significant impact upon serum dioxin TEQ level ($\log_{10}$ TEQ) ($P < 0.001$). Age of the participants explained 48% of the variation independently; year first lived in parish explained 23% of the total variation. Parish did not significantly impact $\log_{10}$ TEQ.

Using weighted multiple regression analysis with parish being the main exposure variable in the model, we found no significant difference of $\log_{10}$ TEQ between Calcasieu and Lafayette after controlling for age of the participants, year first lived in parish, fish consumption, gender, smoking, potential occupational exposure, and pesticide usage by the participants. Furthermore, in the final model, we found that age of the participants, race, year first lived in parish were significant covariates. The multivariate model explained about 52% of the total variation.

We also conducted separate multivariate analyses for African Americans and whites. In the weighted multiple regression analysis among African Americans, the difference of $\log_{10}$ TEQ between parishes was significant (i.e., dioxin TEQ higher in Lafayette than Calcasieu in the group) after controlling for age of the participants, year first lived in parish, fish consumption, gender, smoking, potential occupational exposure, and pesticide usage by the participants. Finally, we found that age of participants, year first lived in parish, potential occupational exposure, and the interaction between occupational exposure and parishes were significant covariates in the final African Americans-only model. This model explained about 77% of the total variation in serum dioxin TEQ for African Americans.

In the multivariate analysis for whites only, the difference of $\log_{10}$ TEQ between parishes was not statistically significant after controlling for age of the participants, year first lived in parish, fish consumption, gender, smoking, potential occupational exposure, and pesticide usage by the participants. Moreover, we found that age of the participants, year first lived in parish, fish consumption, and potential occupational exposure were significant covariates in the final whites-only model. This model explained about 51% of the total variation in serum dioxin TEQ for whites.

Comparison With Combined Data Set. Table 3 presents the mean serum dioxin TEQs by age groups for a combined reference data set of unexposed persons from several serum dioxin studies in the United States. There was no overall difference between the mean serum dioxin TEQs for the Parishes and this combined data set (Table 3). However, mean serum TEQs for the youngest age group, age 15–29, were lower in both Calcasieu Parish and Lafayette Parish compared to the combined reference data set. In the oldest age group available for comparison, age 60–68 years, dioxin TEQ concentrations were slightly, but not significantly, higher in the parishes compared to the combined data set.

Comparison of Congener Profiles. In order to describe a congener profile for each parish, the percent of congener contribution to total TEQ is presented in Figure 3. The congener profiles between the two parishes were similar, with PCDDs accounting for more than 70% of total TEQ. Congener concentrations were also compared to NCEH laboratory comparison range of means (Needham et al. 1996) (Figure 4). Congener concentrations in the parishes were within most of the available NCEH comparison ranges. However, overall concentrations for both parishes were slightly below the lower end of the comparison range of means for 123678D, 1234678D, and OCDD.

One limitation of the study was that only 50 mL of whole blood was collected for dioxin analysis. Although this amount of blood was chosen because it was thought to be sufficient for dioxin analysis and would not be a burden on study participants, a larger quantity would have provided more serum for analysis and thus lower detection limits and fewer nondetects. We estimated the results for nondetects by using a recognized method of substituting one half of the detection limit for nondetect results, but fewer nondetect levels would have given a more precise determination of each congener level and of the TEQ for each study participant.

Another limitation of the study was that information regarding weight change and body mass index (BMI) was not included in the questionnaire. In the body, dioxin is found in the blood and in body fat. When weight is stable, a person's dioxin body burden is divided between the blood and the body fat (called partitioning). Total dioxin body burden is represented by the dioxin in blood. However, when weight is gained or lost, the concentration of dioxin in blood and adipose tissue changes. Current and historical information on these parameters may have assisted in the interpretation of the dioxin data.

Finally, we collected self-reported information about consumption of locally caught or raised food. Additional questions regarding consumption of all food sources would have allowed for more detailed analysis. Measurement of dioxin in these foods would also give an indication of the contribution of food on the body burden of dioxin. EPA estimates that more than 90% of the dioxin in humans comes from food sources, especially meat, fish, and dairy products. This study could not identify strong factors in overall food consumption patterns which might have helped to explain the higher dioxin levels observed in some participants.

CONCLUSIONS

1. Overall, people who live in Calcasieu Parish had similar mean serum dioxin TEQ levels as people who live in Lafayette Parish.

2. African Americans who live in Lafayette Parish had significantly higher mean dioxin TEQ levels when compared to those of whites in Lafayette Parish and African Americans in Calcasieu Parish.

3. Dioxin levels in both parishes increased with age and length of residence.

4. Persons in Calcasieu and Lafayette Parishes age 68 years and younger had similar mean serum dioxin TEQ to a combined data set developed to give a best estimate of dioxin level in persons not unusually exposed to dioxin.

5. Serum dioxin TEQ levels were not elevated among the youngest age group evaluated (ages 15 to 29 years) in either Calcasieu Parish or Lafayette Parish when compared with external comparison data. Although not conclusive, these data suggest no unusual current dioxin exposures among the populations in these areas.

6. The dioxin congener profile in Calcasieu Parish is similar to that in Lafayette Parish.

RECOMMENDATIONS

1. Future studies of dioxin exposure should collect information on body mass index, individual weight change, and detailed food consumption patterns.

2. The contribution of race to dioxin level should be further explored in any future population-based studies of serum dioxin.

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T A B L E S

Table 2. Mean Serum Dioxin TEQ Levels (ppt) by Demographic and Other Characteristics

	Industrial Corridor (n=142)	Industrial Buffer (n=122)	Calcasieu Parish Outer Ring (n=31)	Calcasieu Parish: 3 Calcasieu Sections Combined (n=295)	Lafayette (n=120)	p-value*
Sex						
Male	19.7	15.7	19.1	16.7	20.5	0.24
Female	19.3	25.8	15.9	23.0	20.1	0.21
Age (years)						
15-29	9.6	8.0	9.0	8.4	7.5	0.34
30-44	11.2	15.4	13.4	14.3	14.7	0.91
45-59	20.8	19.3	21.9	19.7	19.8	0.96
>60	32.7	41.0	25.8	36.9	42.4	0.42
Race						
White	20.2	20.9	16.1	20.2	18.6	0.58
African-Americans	13.3	17.5	14.5	16.9	38.0	0.001
Ate Locally Caught Fish (ever)						
Yes	19.3	19.6	17.1	19.2	20.4	0.46
No	20.4	25.1	18.6	23.2	20.2	0.41
Ate Locally Caught Fish (past year)						
Yes	18.0	20.3	17.1	19.6	18.0	0.52
No	20.1	16.7	17.3	17.7	30.8	0.20
Year Moved to Parish						
1981+						
1961-1980	11.4	18.6	19.0	17.4	16.0	0.60
1941-1960	19.9	16.4	12.1	16.5	19.1	0.39
1900-1940	19.0	23.5	22.6	23.6	26.2	0.51
	35.5	50.6	33.1	44.9	69.2	0.38
Occupational Exposure to Dioxin						
Yes						
No	22.9	19.6	19.0	20.2	19.5	0.73
	18.5	20.4	16.6	19.6	20.4	0.65
Use Pesticides						
Yes						
No	20.4	19.7	17.3	19.6	20.5	0.48
	12.4	22.3	16.8	20.3	19.0	0.88
Ever Smoked						
Yes						
No	18.0	19.5	15.4	18.8	18.8	0.99
	21.5	22.0	19.7	21.6	22.5	0.79
Currently Smoke						
Yes						
No	16.7	17.3	12.2	16.8	12.9	0.05
	13.9	12.7	12.8	13.0	17.3	0.62
Overall mean serum dioxin TEQ (ppt)	19.5	20.1	17.2	19.7	20.3	0.71

** T test comparing mean serum TEQ levels between Calcasieu Parish and Lafayette Parish.*

F I G U R E S

Appendix A

A Letter of Introduction for Census and A Letter to Community Authorities

Appendix B

Household Census Scripts and Questionnaires

The questionnaire for both parishes is the same, except that in Lafayette Parish, the subject is asked if he/she EVER lived in Calcasieu Parish. For the comparison population "ever living in Calcasieu" is a disqualifier. The questionnaire used in Calcasieu Parish is presented here.

n order for us to scientifically select a respondent who may be able to take part in this study, I will need to list all members of your household, tarting with yourself.

Q6: THE FOLLOWING QUESTIONS WILL BE REPEATED FOR EACH MEMBER OF THE HOUSEHOLD:

	What is your full name?/ What are the names of all the other persons living in this household?			**What is his/her age?**	**What is his/her relationship to you?**	**What is his/her gender?**	**Has he/she lived in Calcasieu for the last 5 years?**
	Last name	First name	Middle name				
Respondent				1 15-29 2 30-44 3 45-59 4 60 +	1 Self	M F	YES NO
Resident #2 Name				1 15-29 2 30-44 3 45-59 4 60 +	2 Wife/Husband 3 Son/Daughter 4 Mother/Father 5 Brother/Sister 6 Grandparent 7 Aunt/Uncle 8 Partner 9 Other: _____	M F	YES NO

Resident #9 Name				1 15-29 2 30-44 3 45-59 4 60 +	2 Wife/Husband 3 Son/Daughter 4 Mother/Father 5 Brother/Sister 6 Grandparent 7 Aunt/Uncle 8 Partner 9 Other: _____	M F	YES NO
Resident #10 Name				1 15-29 2 30-44 3 45-59 4 60 +	2 Wife/Husband 3 Son/Daughter 4 Mother/Father 5 Brother/Sister 6 Grandparent 7 Aunt/Uncle 8 Partner 9 Other: _____	M F	YES NO

NTERVIEWER: VERIFY NAME, AGE, AND GENDER OF EACH HOUSEHOLD MEMBER.

*W*HEN FINISHED, PROBE FOR ADDITIONAL HOUSEHOLD MEMBERS: Have we missed anyone?

Please include any children and babies, and any household members who are currently away traveling, in the hospital, or away on business. **Do not include** any students currently living away at school or anyone staying here temporarily who has a usual residence somewhere else. WHEN FINISHED: Thank you for answering these questions and participating in the household listing. Do you have any questions about the study that I can answer?

YES ∫ ANSWER QUESTIONS

NO ∫ Thank you again for letting me ask you about your household.

COMMENTS: _____

_____

_____

_____

		YES	NO	DK	REFUSED
116.Have you ever eaten locally caught catfish? Q38		1	2 **(GO TO Q39)**	3	4
Q38A	A. Have you eaten locally caught catfish in the past year?	1	2	3	4
117.Have you ever eaten locally caught gar? Q39		1	2 **(GO TO Q40)**	3	4
Q39A	A. Have you eaten locally caught gar in the past year?	1	2	3	4
118.Have you ever eaten locally caught redfish? Q40		1	2 **(GO TO Q41)**	3	4
Q40A	A. Have you eaten locally caught redfish in the past year?	1	2	3	4
119.Have you ever eaten locally caught perch? Q41		1	2 **(GO TO Q42)**	3	4
Q41A	A. Have you eaten locally caught perch in the past year?	1	2	3	4
120.Have you ever eaten locally caught bass? Q42		1	2 **(GO TO Q43)**	3	4
Q42A	A. Have you eaten locally caught bass in the past year?	1	2	3	4
121.Have you ever eaten locally caught flounder? Q43		1	2 **(GO TO Q44)**	3	4
Q43A	A. Have you eaten locally caught flounder in the past year?	1	2	3	4
122.Have you ever eaten locally caught trout? Q44		1	2 **(GO TO Q45)**	3	4
Q44A	A. Have you eaten locally caught trout in the past year?	1	2	3	4
123.Have you ever eaten locally caught drum? Q45		1	2 **(GO TO Q46)**	3	4
Q45A	A. Have you eaten locally caught drum in the past year?	1	2	3	4
124.Have you ever eaten locally caught shrimp? Q46		1	2 **(GO TO Q47)**	3	4
Q46	A. Have you eaten locally caught fish in the past year?	1	2	3	4
125.Have you ever eaten locally caught crawfish? Q47		1	2 **(GO TO Q48)**	3	4
Q47A	A. Have you eaten locally caught crawfish in the past year?	1	2	3	4
126.Have you ever eaten locally caught crab? Q48		1	2 **(GO TO Q49)**	3	4
Q48A	A. Have you eaten locally caught crab in the past year?	1	2	3	4
127.Have you ever eaten locally caught oysters? Q49		1	2 **(GO TO Q50)**	3	4
Q49A	A. Have you eaten locally caught oysters in the past year?	1	2	3	4
128.Have you ever eaten locally caught mussels? Q50		1	2 **(GO TO Q51)**	3	4

	YES	NO	DK	REFUSED
129.Have you ever eaten locally caught clams? Q51	1	2 **(GO TO Q52)**	3	4
Q51A A. Have you eaten locally caught clams in the past year?	1	2	3	4
130.Have you ever eaten locally caught seafood gumbo? Q52	1	2 **(GO TO Q53)**	3	4
Q52A A. Have you eaten locally caught seafood gumbo in the past year?	1	2	3	4
131.Have you ever eaten other locally caught fish? Q53	1	2 **(GO TO Q54)**	3	4
Q53A A. Have you eaten other locally caught fish in the past year? Specify fish Q53OTH_____	1	2	3	4
132.Have you ever eaten vegetables or fruits grown in Lafayette Parish? Q54	1	2 **(GO TO Q55)**	3	4
Q54A A. Have you eaten vegetables or fruits grown in Lafayette Parish in the past year?	1	2	3	4
133.Have you ever eaten beef, poultry, or other meat raised in Lafayette Parish? Q55	1	2 **(GO TO Q65)**	3	4
Q55A A. Have you eaten beef, poultry, or other meat grown in Lafayette Parish in the past year?	1	2	3	4
134.Have you ever eaten locally raised chickens? Q56	1	2 **(GO TO Q57)**	3	4
Q56A A. Have you eaten locally raised chickens in the past year?	1	2	3	4
135.Have you ever eaten locally raised pigs? Q57	1	2 **(GO TO Q58)**	3	4
Q57A A. Have you eaten locally raised pigs in the past year?	1	2	3	4
136.Have you ever eaten locally raised ducks? Q58	1	2 **(GO TO Q59)**	3	4
Q58A A. Have you eaten locally raised ducks in the past year?	1	2	3	4
137.Have you ever eaten locally raised rabbits? Q59	1	2 **(GO TO Q60)**	3	4
Q59A A. Have you eaten locally raised rabbits in the past year?	1	2	3	4
138.Have you ever eaten locally raised cows? Q60	1	2 **(GO TO Q61)**	3	4
Q60A A. Have you eaten locally raised cows in the past year?	1	2	3	4
139.Have you ever eaten locally raised geese? Q61	1	2 **(GO TO Q62)**	3	4
Q61A A. Have you eaten locally raised geese in the past year?	1	2	3	4
140.Have you ever eaten locally raised turkey? Q62	1	2 **(GO TO Q63)**	3	4