COMMUNITY BELIEFS ABOUT DIOXIN EXPOSURE PATHWAYS: DO THEY MATCH THE EXPERTS?

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Introduction

High levels of dioxins and dioxin-like compounds (DLCs) have been found in sediments and soils of the Tittabawassee River floodplain, downriver from the Dow Chemical Company, and in Midland, Michigan, USA, headquarters of the Dow Chemical Company. In response to concerns that historic discharges from Dow might have contributed to residents' body burdens of DLCs, researchers at the University of Michigan were asked to conduct an exposure-pathway study of DLCs. The study, named the University of Michigan Dioxin Exposure Study (UMDES), collected field data in 2004-2005, and assessed whether the elevated levels of DLCs in soils in Midland, and in the Tittabawassee River flood plain between Midland and Saginaw, had contributed to levels of DLCs in residents' blood.[1,2] A primary finding was that levels of dioxin in soil were not significant predictors of dioxin levels in blood.[3] UMDES communications to residents during and after data collection focused on providing the results of the exposure assessment to community members and study participants.[4,5]

The present study, Community Perceptions of Dioxins (CPOD), has employed a mental models approach combining both quantitative and qualitative methods to understand Midland/Saginaw community members' mental models of pathways of exposure to dioxins as compared to mental models of experts. The current report documents the prevalence of lay beliefs about possible sources of dioxin exposure (both currently and in the past) that were identified through of a mailed survey of both former UMDES participants and non-participants who live in the same neighborhoods targeted by the UMDES.

Materials and methods

The CPOD study used a mental models approach to better understand lay perceptions of dioxins in communities with and without known significant dioxin contamination. The mental models approach was broken into three phases: In Phase I, we conducted in-depth interviews of 5 experts from academia, government, and community environmental groups who were familiar with dioxins to develop an expert model of dioxin contamination, exposure and health effects. In Phase II, we conducted in-depth interviews of 50 lay community members to document their mental models, which we then compared with the expert model to identify key differences between expert and lay understanding of dioxins. In Phase III, based on a representative sample of the population, we used a mailed survey to determine the prevalence among community residents of those beliefs that differ from experts' beliefs.

In this paper, we focus on analysis of data from the Phase III mailed surveys, which were designed to assess the population prevalence of various beliefs identified in our previous Phase II interviews with community residents of Midland/Saginaw and Jackson/Calhoun counties. In our prior in-depth interviews with both experts and community members, we had identified key elements of participants' mental models of dioxin exposure, including concepts that were mentioned only by community members. Based on these interviews, we created a survey instrument with questions targeting each specific belief for which we wanted to document population prevalence. The survey also collected demographic data, including race/ethnicity, gender, age, education, number and age of any children, length of residence in home, and whether the participant had ever worked for a chemical company.

The sample for Phase III consisted of three distinct groups: residents of Midland and Saginaw counties who were former participants of the UMDES ("M/S UMDES"), residents of Midland and Saginaw counties who were non-

participants of the UMDES ("M/S non-UMDES"), and residents of Jackson and Calhoun counties (>100 miles away) who had participated in the UMDES as controls ("J/C UMDES").

To analyze the Phase III survey data, we conducted descriptive analyses of survey responses by calculating means and frequencies and then examined bivariate relationships between respondent group (M/S UMDES, J/C UMDES, and M/S non-UMDES) using Pearson's chi square test and two group unpaired t-tests. Future reports will focus on multivariate models that predict respondents' beliefs about sources of exposure to dioxins using participant characteristics such as age, gender, education, and residence in the river floodplain as covariates.

Results and discussion
The expert model developed in the current study corresponded closely with published literature concerning known exposure sources and pathways of exposure to dioxins: food is the overwhelming source of exposure to dioxins for most people, particularly dairy, fish, and meat products; dioxins are highly hydrophobic, and so water is generally not a source of exposure to dioxins; air can be an important route of exposure in some circumstances; transcutaneous exposure is probably minimal in the general environment; and merely living on contaminated soil is not a significant source of exposure.[3,6]

A total of 1,036 people completed Phase III surveys. These included 904 residents of Midland and Saginaw counties, 440 of whom had previously participated in the UMDES, and 132 residents of Jackson and Calhoun counties who had previously participated in the UMDES (Table 1). The overall response rate for the entire sample was 55.6%. The response rate for M/S UMDES participants was 60.1%, for M/S non-UMDES participants was 52.4%, and for J/C UMDES participants was 53.4%.

Table 1. Demographic Characteristics of CPOD Study Participants

Total number of participants, n	1036

Participant Group
    Midland/Saginaw non-UMDES, n(%)
    Midland/Saginaw UMDES, n (%)
    Jackson/Calhoun UMDES, n (%)
	
	464 (44.79%)
	440 (42.47%)
	132 (12.74%)

Age, Mean (range, standard deviation)	 58.3 (20-98, 14.4)

Gender
    Male, n (%)
    Female, n (%)
	
	474 (46.79%)
	539 (53.21%)

Education
    Some high school, high school diploma, GED, n (%)
    Some college, associates degree, professional training, n (%)
    Bachelor's degree, n (%)
    Master's degree, Professional school degree, Doctoral degree, n (%)
	
	295 (30.26%)
	348 (35.69%)
	208 (21.33%)
	124 (12.72%)

Table 2 presents the percentage of participants overall as well as by participant group (non-UMDES participants from Midland/Saginaw, UMDES participants from Midland/Saginaw, and UMDES participants from Jackson/Calhoun) who believe each exposure pathway (breathing air, eating food, eating soil, drinking water, touching things, touching water, and living on contaminated soil) is a significant source of current and past dioxin exposure. The percentage of people that selected each of the exposure pathways as a significant source of dioxin exposure was relatively high, ranging from 35% to 89%, with the majority at or above 50%. Perhaps the most critical finding regarding both current and past exposure beliefs is that living on contaminated soil was selected as a significant source by the greatest percent of participants from all three participant groups. In contrast to residents of Midland/Saginaw counties, residents of Jackson/Calhoun counties reported that all of the sources of exposure were more significant at present than in the past.

Table 2. Participants' beliefs about current/past significant sources of dioxin exposure (n = 1036)

| Exposure Pathway | Significant Source of Dioxin Exposure currently/in the past? (% Yes) | | | | |
| | Overall | By participant group: | | | |
		M/S non-UMDES	M/S UMDES	J/C UMDES	p-value
Breathing air	41.5/ 52.2*	41.9/ 54.8	34.6/ 51.1	63.7/ 46.8	< 0.001/ 0.232
Eating food	62.4/ 58.4	59.9/ 57.4	60.9/ 60.3	76.4/ 55.1	0.003/ 0.497
Eating soil (accidentally)	70.1/ 64.8	69.7/ 66.5	71.7/ 67.7	65.9/ 48.4	0.443/ <0.001
Drinking water	54.2/ 58.1	52.8/ 57.9	50.2/ 57.5	73.0/ 61.0	< 0.001/ 0.783
Touching water (i.e., swimming)	52.0/ 49.0	54.4/ 52.2	48.2/ 50.2	56.6/ 33.1	0.107/ 0.001
Touching things (i.e., soil, plants)	47.6/ 43.2	48.6/ 45.6	45.5/ 45.4	50.8/ 27.0	0.484/ <0.001
Living on contaminated soil	85.0/ 81.9	86.7/ 83.6	82.1/ 82.1	88.9/ 75.2	0.070/ 0.097

*(current %)/(past %); p-values refer to differences in percentages between M/S non-UMDES, M/S UMDES and J/C UMDES groups

The percentages of participants from each of the three participant groups and overall that selected each of the seven possible exposure pathways as the single largest current source of dioxin exposure are reported in Table 3. Participants from all three subgroups overwhelmingly selected living on contaminated soil as the single largest source of current exposure. Differences among subgroups exist; only 45% of individuals from Jackson/Calhoun who participated in the UMDES selected living on contaminated soil as the single largest current source of exposure, while, over 60% of individuals living in Midland/Saginaw selected living on contaminated soil as the single largest source of current exposure.

Table 3. Participants' beliefs about the single largest current source of dioxin exposures (n = 1036)

| Exposure Pathway | Largest Current Source? (% Yes) | | | |
| | Overall | By Participant group: | | |
		M/S non-UMDES	M/S UMDES	J/C UMDES
Breathing air	10.7%	11.2%	7.9%	18.0%
Eating food	11.4%	8.7%	10.6%	23.0%
Eating soil (accidentally)	4.4%	5.0%	4.8%	0.8%
Drinking water	8.8%	9.4%	7.3%	11.5%
Touching water (i.e., swimming)	2.6%	2.7%	3.3%	0.0%
Touching things (i.e., soil, plants)	1.9%	2.0%	1.8%	1.6%
Living on contaminated soil	60.3%	61.0%	64.3%	45.1%

In further contrast with the expert model only 11.4% of respondents thought food was the single largest current source of exposure to dioxins. A chi-square test confirmed that responses to this question significantly differed across participant groups (p<0.001; see Table 3).

The results indicate that respondents have an understanding of pathways of dioxin exposures that differs in important ways from the experts we interviewed, all of whom indicated that the greatest source of dioxin exposure is the foods that we eat, specifically those high in fat such as animals and animal products.[6] In contrast, most study participants reported that living on contaminated soil was the single largest current source of exposure to dioxins, a pathway of exposure that the experts did not support. It is also notable that residents of Jackson/Calhoun counties reported that all sources of exposure were more important currently than in the past, which differs from Midland/Saginaw counties, and suggests that location of residence has an important influence on mental models beliefs. In this regard, it is notable that concerns about dioxins have been a major public issue in Midland/Saginaw counties for many years, with extensive coverage in local media, while dioxins have not been a major public issue in Jackson/Calhoun counties. Future communications should focus on developing an innovative way to clarify confusion about misbeliefs and ensure that beliefs about pathways of exposure to dioxins among community residents are more congruent with the understanding of experts.

References:

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