SATISFACTION WITH CHEMICAL HAZARD AND EXPOSURE INFORMATION WHEN HEALTH RISK IS UNCERTAIN: ROLE OF RISK JUDGMENTS AND MENTAL MODELS

by

Julia Kay Diebol

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Environmental Health Sciences)
in the University of Michigan
2013

Doctoral Committee:

Professor Alfred Franzblau, Co-Chair
Assistant Professor Brian J. Zikmund-Fisher, Co-Chair
Associate Professor Avery H. Demond
Professor Edith A. Parker, The University of Iowa
Professor Thomas G. Robins

To my parents and teachers

Acknowledgments

I have heard the ‘P’ and the ‘D’ in Ph.D. represent Persistence and Determination. Finding my own persistence and determination has required the patience and support of many people.

First, thank you to my committee members Brian Zikmund-Fisher, Al Franzblau, Edith Parker, Tom Robins, and Avery Demond for listening to my pitches about this research and being willing to help me carry it out. I am especially grateful to my co-chairs Brian Zikmund-Fisher and Al Franzblau for helping me get started and then getting me “unstuck” so many times throughout the process. Thank you to Edith Parker for being willing to bring me into the Community Perceptions of Dioxins (CPOD) study, to Tom Robins for supporting my interest in occupational hazard communication and initially agreeing to serve as my advisor, and to Avery Demond for being willing to join late in the project and providing additional insight from the University of Michigan Dioxin Exposure Study (UMDES).

A huge thank you also goes to CPOD study team members Angela Turkelson, Paula Ross, Isabella Weber, Lindsay Allerton, and Lynna Chung for making such complex data collection go so smoothly, to UMDES researchers for providing limited access to UMDES data, to Fred Conrad of the Institute for Social Research for assisting with the CPOD study design, and to the numerous Midland, Saginaw, Jackson, and Calhoun county residents who took the time to participate in our study.

Funding for the CPOD study was provided by the National Institute of Environmental Health Sciences (NIEHS) Grant #1R01ES016306. My own work was partially funded by a University of Michigan Risk Science Center 2011 Summer Fellowship. I also gratefully acknowledge support from a National Institute for Occupational Safety and Health training appointment in Occupational and Environmental Health in beginning my graduate studies, and many semesters of tuition assistance from my employer, Applied Safety and Ergonomics, Inc. (ASE).

I would not advocate going to graduate school while working full-time, but I am very happy to say that it can, in fact, be done. A large part of my success in this endeavor has been due to the flexibility and understanding of my coworkers. Thank you to all of my colleagues at ASE, especially Tim Rhoades, Paul Frantz, Raina Shah, Karis Faust, and Kristin Darnell, for their much-needed assistance and encouragement.

Additional thanks are due to my instructors in risk assessment, health behavior, and psychology courses (Olivier Jolliet, Vic Strecher, and Frank Yates) for teaching me about such fascinating topics and inspiring me to pursue doctoral studies in this area. Thank you as well to Risk Science Center Director Andrew Maynard for helping keep the social sciences of risk communication and risk perception from slipping through the interdisciplinary cracks at the University. I am also indebted to my colleagues in the Society for Chemical Hazard Communication for sharing their perspectives and the challenges they have faced in developing communications about chemicals.

Finally, thank you to my family, especially Mom, Dad, Greg, Ron, and Chris, and to my friends, especially Kelsea, Kristen, and Katie, for believing in me and always being interested in whether I was finished yet. Most of all, thank you to my husband, Steve, for his many, many months of enduring love and patience during this process. It's done!

Table of Contents

List of Tables

List of Figures

List of Appendices

Abstract

Communications to laypeople about chemical hazards and/or exposure occur frequently. However, satisfaction with such communications has not been widely studied, and there are indications that these communications may be dissatisfying to their receivers due to a lack of health risk information. The goal of the present research was to determine whether receivers who felt they were able to make judgments about health risks were more satisfied with the hazard and exposure information they had received than those receivers who found it difficult to do so. To explore this question, I collaborated with a larger project to collect data from a population that has received hazard and exposure information about dioxins through participation in an exposure study and/or residing in a community with known dioxin contamination. Dioxins are persistent organic pollutants shown to cause cancer and other chronic health effects in animals, but information regarding human health risks is uncertain. Because of this dichotomy, they provide a good case study for examining satisfaction with hazard and exposure communications.

Primary data sources included expert interviews, lay interviews, and a lay questionnaire, all conducted using a technique designed to explore receivers' mental models of dioxins. Lay interviews and the lay questionnaire also assessed judgments of health risk from dioxins and satisfaction with information received.

Results indicate the ability to make risk judgments plays an important role in satisfaction with hazard and exposure information. More specifically, those residents who felt better able to make judgments of their health risk from dioxins were more satisfied with the communications they had received, even though these communications did not contain risk information. The ability to make risk judgments also mediated or partially mediated relationships between residents' satisfaction and (1) confidence in their mental models of dioxins, (2) familiarity with dioxins, and (3) mistrust of government and industry. Judgment of greater magnitude of risk and greater concern about risk also predicted lower satisfaction.

These findings suggest that receivers provided with hazard and exposure information make risk judgments, even when risk information is unavailable to them or uncertain. This implies that communications or other interventions that make it easier for residents to make judgments about health risk could increase their satisfaction with information, even if health risk remains scientifically uncertain. More generally, this research illustrates that the process of transforming hazard and exposure information into risk information among laypeople is an important part of their satisfaction with chemical-related communications.

Chapter 1

Significance and Motivation for Research

Communications to laypeople about chemical hazards and exposure occur frequently. However, satisfaction with such communications has not been widely studied, and there are indications that these communications may be dissatisfactory to their receivers due to a lack of health risk information. The goal of the present research is determine whether receivers who feel they are able to make judgments about health risks are more satisfied with the hazard and exposure information they have received than those receivers who find it difficult to do so.

The present research focuses on a situation in which residents have received a variety of communications containing hazard and exposure information about a contaminant in their community for which health risks remain scientifically uncertain. Few studies have examined receiver satisfaction with these types of communications.

1.1 Introduction

People receive communications about chemicals in many contexts: at work, at home, in their communities, and in the media. These communications often lack information about the magnitude of the health risk posed by the chemical. The omission of risk information is often due to scientific uncertainty, such as in the case of media reports about biomonitoring studies or community exposure assessment studies for which the risk of low-dose exposures is uncertain. In addition to scientific uncertainty, the omission of risk information may also be to due a limited scope of communication. For example, labels and material safety data sheets for chemical products are intended to provide information about the inherent properties of the chemical and the health effects it can cause (hazard information), without considering the magnitude of exposure (exposure information) and the likelihood of experiencing these effects (risk information).

1.2 Research Goal and Hypotheses

The goal of my research is to assess satisfaction with chemical hazard and exposure communication in a community contamination setting. I propose that satisfying receivers in this setting involves enabling residents to make judgments about their health risk from the contaminant. I hypothesize that residents who feel they are able to make judgments about their health risk will be more satisfied with the communications they have received than those who feel unable to make these judgments. Conversely, if receivers of hazard and exposure communications find it difficult, either cognitively or affectively, to judge their health risk, they may feel more dissatisfied with the information they have received.

A potential competing hypothesis could be that, while satisfaction is influenced by judgment of health risk, it is not influenced by the ability to judge the risk, but rather by the outcome of that judgment. That is, those who believe the risk is large may be less satisfied than those who believe it is small. As a secondary goal, I will also test this competing hypothesis.

1.3 Features of Chemical Hazard and Exposure Communications

Chemical hazard and exposure communications may look very different in different settings. They can come from widely varying sources, from manufacturers to family doctors, and be transmitted through a multitude of different channels, from product labels to public meetings. Regardless of the setting, hazard and exposure communications have certain features in common that pose special challenges for receivers to understand and use the information communicated.

First, these communications include information that is scientific or technical in nature, involving chemical and physical properties of substances and the mechanisms by which the substances can cause health effects. Such scientific communications between experts and laypeople have often proven difficult, especially for the experts, as evidenced by recent science communication research studies such as “Do Scientists Understand the Public?” (Mooney 2010), and manuals such as “Am I Making Myself Clear? A Scientist’s Guide to Talking to the Public” (Dean 2009).

Second, these communications consist of information that is known with varying levels of uncertainty, for example regarding the chemical or physical properties, the mechanisms by which they cause health effects, the potential or actual exposure, or the magnitude of the resulting risk of health effects. In a wide variety of situations, uncertainty has been shown to promote pessimistic appraisals of risk and avoidance of decision making, a phenomenon referred to as “ambiguity aversion” (Han et al. 2011, p.831).

Scientific communication about uncertain risks fits within a broader type of communication regarding safety and health risks referred to generically as “risk communication." This term is sometimes a misnomer, as it may not be explicit "risk" information that is being communicated. Those who are tasked with assessing and communicating human health effects of chemicals traditionally divide the information at their disposal into three types: hazard, exposure, and risk. Hazard information is defined as information about the inherent properties of a chemical. Hazard information may include findings from toxicological studies used to assess health hazards such carcinogenicity or reproductive toxicity, or tests of physical properties such as water or lipid solubility. Exposure information is defined as information about human exposure to the chemical. Exposure information includes measurements of concentrations of the chemical in the environment or in human tissues, and assessments of the amount of human intake of contaminated air, water, soil, or food. Risk information is created by combining sufficient hazard and exposure information to assess the magnitude of the health risk to humans resulting from various levels of exposure. For example, an increased cancer or birth defects rate may be observed or estimated for measured or anticipated worker or general population exposures.

Communications about chemical hazards, exposure, and risk often lack complete information, due to the limits on the intended scope of communications and/or the limits of the scientific evidence. Most often it is human health risk information that is omitted, an omission that may leave receivers unable to make even rudimentary judgments of the magnitude of the risk resulting from exposure to a given hazard. Research has shown that although laypeople are aware of the terms 'hazard' and 'risk,' they do not naturally distinguish between the two (Sadhra et al. 2002). One study found that laypeople (chromium platers working for small companies) could not explain the difference and, in fact, regarded the distinction as an unnecessary complication (Sadhra et al. 2002, p.691). There is also evidence that laypeople have different concepts of the word 'exposure,' than do experts. For example, one study regarding carcinogens found that laypeople reserved the term 'exposure' for a level of exposure high enough to cause a health effect (MacGregor et al. 1999, p.653). These differences could make communications that are limited to hazard and exposure information difficult for laypeople to interpret.

When communications lack health risk information, laypeople could be left feeling dissatisfied with the information they have received. It is possible that laypeople will make, or attempt to make, judgments about the magnitude of health risk from a chemical based on the information they have received, regardless of whether it contains risk information from experts or is merely limited to hazard and exposure information, and risk information from non-experts. As a result, their risk judgments could vary widely from those of experts or other laypeople who have received different sets of information or interpreted this information differently. In addition, if it is perceived to be difficult to make risk judgments, laypeople may find the information they have received to be less helpful or useful than they would like and may be dissatisfied with the information provided.

1.4 Satisfaction with Chemical Hazard and Exposure Communications

The issue of satisfaction or dissatisfaction with risk communication has been recognized for nearly as long as risk communication has been recognized. In opening the first-ever National Conference on Risk Communication in 1986, J. Clarence Davies observed that

> "… the risk communication process is very often unsatisfactory for everybody involved. Those who send messages often feel that their messages have not been received, and the recipients often feel that their questions have not been answered. In short, both miscommunication and noncommunication occur in the risk communication process" (Davies et al. 1987, p.2).

The miscommunication and noncommunication Davies describes as unsatisfactory still occur a quarter-century later in the context of hazard and exposure communication. In particular, the "noncommunication" Davis describes may occur when receivers feel their questions about health risk have not been answered by communications limited to hazard and exposure information. Very little research has actually examined receiver satisfaction as an outcome of hazard and exposure communications.

Receiver satisfaction is one of at least two outcomes that could be assessed from chemical hazard and exposure communication; another outcome often assessed is receiver comprehension. Receiver comprehension refers to whether the people receiving the communication correctly understand the information that was transmitted. Assessing comprehension can entail measuring whether the reading level of the information presented in a written communication is appropriate for the audience or administering a comprehension test to receivers to assess whether they understood or retained the knowledge presented in communications (see, e.g., Friedman & Hoffman-Goetz 2006). Receiver comprehension assesses whether the "miscommunication" referred to by Davies is likely to occur, where the sender's message is not received. Receiver satisfaction, in contrast, as conceptualized in this dissertation, refers to whether the people receiving the communications are satisfied with the information they have received. As such, receiver satisfaction focuses on whether the "noncommunication" mentioned by Davies above is likely to occur, in which receivers feel their questions have not been answered. Under either outcome, receivers may seek additional information from other sources to increase comprehension or satisfaction. A detailed examination of information-seeking behaviors among satisfied or dissatisfied receivers is outside the scope of the present research.

Receiver satisfaction has been examined more broadly as "communication satisfaction," mainly focusing on interpersonal communication (Downs & Hazen 1977; Hecht 1978a; Hecht 1978b; Pincus 1986). As discussed by Hecht (1978b), communication satisfaction offers three significant advantages as a variable for study:

> "First, this variable may be utilized as a criterion for research examining process variables. Second, it may be utilized to organize and evaluate classes of variables, thereby contributing to theory building. And, third, the study of communication satisfaction has direct and straightforward applications to the improvement of communication skills."

The present research uses satisfaction with hazard and exposure communications as a criterion to examine two types of process variables. First, this research examines the processes by which laypeople use hazard and exposure communications to build mental models (mental conceptualizations) of the risk process at issue. Second, this research examines the processes by which laypeople use these mental models to make judgments about the resulting risk.

This examination also builds a larger theory of satisfaction with hazard and exposure communications. Theories of satisfaction with these types of communications are absent in the present literature. This research tests a potential model of the ways in which receivers' mental models, risk judgments, and other classes of variables interact to predict their satisfaction with the hazard and exposure communications they have received.

In the context of community contamination, studying communication satisfaction also has direct application to the improvement of hazard and exposure communications. However, in this context, satisfaction must be considered from two perspectives. From the perspective of receivers, satisfaction may be seen as uniformly positive. That is, receivers should prefer communications that they find to be satisfying. However, from an outside perspective, it is possible that receivers could be satisfied by information that is purposely false or misleading. Thus, evaluating whether receivers are satisfied may not be enough to conclude that hazard and exposure communications are or are not adequate. Instead, satisfaction should be considered a desirable outcome in response to communications that are themselves accurate and honest. The direct application of satisfaction in the improvement of hazard and exposure communications is that it allows examination of how communications that are accurate and comprehensible may still fail to satisfy the needs of their receivers.

Satisfaction with hazard and exposure communications has unfortunately not been widely studied. However, research in non-community settings suggest that even detailed and accurate hazard and exposure communications (e.g., detailed Material Safety Data Sheets in workplace settings) may not be satisfying to receivers (U.S. General Accounting Office (GAO) 1991; Kolp et al. 1993; Phillips et al. 1999; Nicol et al. 2008). It is possible that dissatisfaction with hazard and exposure communications in a variety of settings could drive decreased use of these communications, greater outrage or dissatisfaction about the hazard or exposure itself, or greater mistrust of sources of communication.

1.5 Hazard and Exposure Communications in Community Settings

The present research examines satisfaction with hazard and exposure communication in a community setting, as opposed to a workplace or consumer setting. Research on satisfaction with communications in any of these settings is limited, so this study could have important implications for satisfaction with hazard and exposure communications in other settings as well. In particular, if satisfaction with hazard and exposure information is found to be related to residents' ability to make risk judgments in a community setting, then enhancing the ability to make risk judgments among receivers in other settings could increase satisfaction with those communications as well.

In community settings, hazard and exposure communications occur for a variety of reasons, including communications regarding results of toxicological studies, biomonitoring studies, or community exposure studies. Scientific uncertainty often limits the scope of these communications to hazard and exposure information. Satisfaction with these communications may be difficult to measure, since it may be difficult to separate dissatisfaction with communications from outrage regarding potential exposure.

1.5.1 Communications Regarding Toxicological Studies

Toxicological studies of the health effects of chemicals typically generate hazard information, in that they determine whether a chemical is associated with a health effect, usually in animals, without definitively determining the extent to which human health may be at risk. Due to these constraints, communications to laypeople about such studies typically omit unknown exposure or risk information, reporting instead simply that a link has been discovered between a health effect and a chemical. In addition, the animal studies typically reported to laypeople (for example, in the media) are often single studies with novel findings. As such, the scientific community may not consider their results to be conclusive, and interpretation of their results for humans may be highly speculative. Caveats such as these often are not made salient in media reports, and when they are, they may not be attended to.

As a result, information provided to laypeople regarding risk to humans may be limited or unavailable, making it difficult for them to determine "what to worry about" and whether to take action. At the stage of initial reporting, authoritative guidance or recommendations regarding responses to the study's findings are typically unavailable. Rather than providing guidance about whether one should be concerned or whether one should take steps to reduce one's exposure, messages instead provide, for example, symptoms to watch for or ways to reduce exposure "if you are concerned." This type of media content, describing degree of control an individual has to alter their exposure, has been termed 'self-efficacy information,' and has not been found to impact individual worry (Dahlstrom et al. 2012).

Instead, the receiver is often left to his or her own judgment to infer the magnitude of the potential risk and make judgments about any responses that may be appropriate. While some receivers may choose to react strongly to news of health effects (for example, calling on lawmakers to ban the substance in question), and others find it easy to dismiss such reports (for example, adopting a fatalistic attitude such as, "Everything causes cancer"), the remainder of receivers, likely the majority, are left unsure of what to do. This situation may quickly become very dissatisfactory given the volume of toxicological studies reported in the media and the inability of receivers to attend to information about each one. Depending on how widespread the use of the chemical is, exposure may feel involuntary, as in a community contamination setting. Among receivers in both settings, it appears that hazard information, or merely knowing of a hazard without knowing the risk, may be a potential source of great dissatisfaction.

While much literature has examined the connection between media reports and public perception of risk (Kitzinger 1999; Wahlberg & Sjöberg 2000), little research has examined the informational needs of receivers or their satisfaction. Lion et al. (2002) examined priorities in information desire among households in the Netherlands and found that when confronted with a new hazard or risk, receivers first try to determine whether it is relevant to them. Lion et al. (2002) concluded that people desire information to help with the appraisal process in order to create a risk judgment. Without such information, communications may not be satisfying the needs of their receivers. If receivers are motivated to seek out such information and are unable to find it, they may become even more dissatisfied, as evidence has shown that an individual's assessment of the amount of information he or she needs to cope with a risk has been shown to increase with individual worry (Dahlstrom et al. 2012). A similar effect could occur with both toxicological studies and communications in community contamination settings.

1.5.2 Communications Regarding Biomonitoring Studies

Additional challenges closely related to those facing communications in community contamination settings may be found in biomonitoring studies. Biomonitoring refers to the sampling and measurement of chemicals in the blood, urine, milk, or other fluids or tissues of humans to assess intake or internal dose (Paustenbach & Galbraith 2006). Advancements in analytical chemistry have reduced limits of detection for many environmental chemicals in such samples to parts per trillion (ppt) levels, and data from biomonitoring investigations are becoming more widely reported (Paustenbach & Galbraith 2006). However, just because a chemical is present does not mean that it is harmful (Paustenbach & Galbraith 2006) or that chemical sources, human health effects, or exposure-reduction strategies are fully understood (Brody et al. 2007). As a result, it can be difficult to draw conclusions from such data, particularly conclusions about human health risk.

Considerable work has been done recently to provide recommended best practices and lessons learned in communicating results of biomonitoring exposure studies (Quandt et al. 2004; Bates et al. 2005; Paustenbach & Galbraith 2006; Brody et al. 2007; Morello-Frosch et al. 2009; Buck et al. 2010; Woodruff et al. 2011; Woodruff & Morello-Frosch 2011; Haines et al. 2011; Adams et al. 2011). These recommendations for practice indicate that frequently asked questions by participants include the questions, "Is [my concentration] high?," "Is it safe?," "What should I focus on?," and "What should I do?" (Brody et al. 2007)—all risk-based questions for which the absence of clearly established health effects and dose-response relationships makes it difficult to provide answers. In light of these difficulties, researchers and institutional review boards have reportedly argued against reporting individual results when the clinical implications are unclear (Brody et al. 2007).

Although at least one of the studies cited above (Buck et al. 2010) concluded that its receivers were satisfied based on an absence of comments or requests for further information or assistance, no objective assessments of receiver satisfaction appear to have been conducted. It has also been observed more generally that "clinicians, especially general practitioners, are often ill prepared to answer specific questions regarding chemical exposures and health risks, nor are there obvious or readily available resources for them to obtain this information at a level and in a form that they and their patients can understand" (Bates et al. 2005, p.1619). The situation is one in which receiver satisfaction appears unlikely, especially if satisfaction is related to being able to use the information provided to make judgments of health risk.

1.5.3 Communications Regarding Community Exposure Studies

Community contamination settings are becoming more frequent, as communities worldwide find themselves confronted with contamination from past industrial activities. When there has been contamination of a community's soil or groundwater, officials from local, state, or federal government are often charged with overseeing a process to determine what, if any, cleanup activities should be performed. An exposure assessment study may be an important step in evaluating the need for cleanup.

It can be challenging for researchers to communicate the results of exposure assessment studies, including explaining how the study was conducted, what was found, and what the results do (and do not) mean (U.S. Agency for Toxic Substances and Disease Registry Health Investigations Communications Work Group 2004). An added challenge is the fact that at the conclusion of an exposure assessment study, available information may be limited to the inherent properties of the chemical (hazard information) and the findings of the exposure study (exposure information). Information regarding the magnitude of the health risk to community members (risk information) may not be available. As a result, communications may be limited to hazard and exposure communications, rather than risk communications.

Communications in these types of exposure studies are affected by many of the same issues faced by biomonitoring studies. In addition, communications may be greatly affected by fear, outrage regarding the contamination, and politically charged decision-making about cleanup.

Research regarding communicating the results of exposure studies has examined practical “lessons learned” or “best practices” (e.g., Tinker et al. 2000; U.S. Agency for Toxic Substances and Disease Registry Health Investigations Communications Work Group 2004; Quandt et al. 2004), ways to improve comprehension (Olson et al. 2006), and the psychological effects of exposure to hazardous substances (Tucker 1995). Few studies have directly examined the effect of communications on study participants and community members, or their satisfaction with communications received.

One study by McComas (2003) measured satisfaction with public meetings (used for “consensus” risk communication (Lundgren & McMakin 2009)) and found satisfaction to be a sensitive outcome of communication, with many predictors. Regardless of whether they attended the public meetings, residents tended to be more satisfied with public meetings as a risk communication method if they thought meeting organizers were interested in participants’ comments, public meetings were informative, government agencies that conduct public meetings were credible, or the risk was high (McComas 2003). McComas (2003, p.181) also found that citizens were less satisfied with public meetings when they were more concerned about potential risks to their health or safety, concluding that “when citizens are highly fearful or uncertain about potential risks to their health and safety, attending a public meeting may not satisfy their communication needs.”

While exposure assessment studies do provide concrete information to participants and their communities, little is known about receivers' satisfaction with these communications. Nor do we know how the existence of an exposure study might influence community members' satisfaction with other information they have received about the hazard.

1.6 Motivation for Research

In the long term, the larger communication challenge in a community setting is to help residents make sense of what their exposure to the chemical hazard means for their lives. I hypothesize that this involves enabling residents to make judgments about their health risk, and that this ability is what determines residents' satisfaction with the information available to them. This finding could have important implications for communications in other settings as well.

1.7 References

Adams, C. et al., 2011. Disentangling the exposure experience: The roles of community context and report-back of environmental exposure data. *Journal of Health and Social Behavior*, 52(2), pp.180–196.

Bates, M.N. et al., 2005. Workgroup report: Biomonitoring study design, interpretation, and communication—Lessons learned and path forward. *Environmental Health Perspectives*, 113(11), pp.1615–1621.

Brody, J.G. et al., 2007. Is it safe? New ethics for reporting personal exposures to environmental chemicals. *American Journal of Public Health*, 97(9), pp.1547–1554.

Buck, A.J. et al., 2010. Communicating serum chemical concentrations to study participants: Follow up survey. *Environmental Health*, 9(1), p.20.

Dahlstrom, M.F., Dudo, A. & Brossard, D., 2012. Precision of information, sensational information, and self‐efficacy information as message‐level variables affecting risk perceptions. *Risk Analysis*, 32(1), pp.155–166.

Davies, J.C., Covello, V.T. & Allen, F.W. eds., 1987. *Risk Communication: Proceedings of the National Conference on Risk Communication, held in Washington, D.C., January 29-31, 1986*, Washington, D.C.: Conservation Foundation. Available at: http://hdl.handle.net/2027/[u]: mdp.39015014434230 [Accessed August 4, 2012].

Dean, C., 2009. *Am I Making Myself Clear? A Scientist's Guide to Talking to the Public*, Cambridge, MA: Harvard University Press.

Downs, C.W. & Hazen, M.D., 1977. A factor analytic study of communication satisfaction. *Journal of Business Communication*, 14(3), pp.63–73.

Friedman, D.B. & Hoffman-Goetz, L., 2006. A systematic review of readability and comprehension Instruments used for print and web-based cancer information. *Health Education & Behavior*, 33(3), pp.352–373.

Haines, D.A. et al., 2011. Reporting results of human biomonitoring of environmental chemicals to study participants: A comparison of approaches followed in two Canadian studies. *Journal of Epidemiology and Community Health*, 65(3), pp.191 – 198.

Han, P.K.J., Klein, W.M.P. & Arora, N.K., 2011. Varieties of uncertainty in health care: A conceptual taxonomy. *Medical Decision Making*, 31(6), pp.828–838.

Hecht, M.L., 1978a. Measures of communication satisfaction. *Human Communication Research*, 4(4), pp.350–368.

Hecht, M.L., 1978b. Toward a conceptualization of communication satisfaction. *Quarterly Journal of Speech*, 64(1), pp.47–62.

Kitzinger, J., 1999. Researching risk and the media. *Health, Risk & Society*, 1(1), pp.55–69.

Kolp, P. et al., 1993. Comprehensibility of material safety data sheets. *American Journal of Industrial Medicine*, 23(1), pp.135–141.

Lion, R., Meertens, R.M. & Bot, I., 2002. Priorities in information desire about unknown risks. *Risk Analysis*, 22(4), pp.765–776.

Lundgren, R.E. & McMakin, A.H., 2009. *Risk Communication: A Handbook for Communicating Environmental, Safety, and Health Risks* 4th ed., Piscataway, NJ: IEEE Press. Available at: http://dx.doi.org/10.1002/9780470480120 [Accessed November 7, 2011].

MacGregor, D.G., Slovic, P. & Malmfors, T., 1999. "How Exposed Is Exposed Enough?" Lay Inferences About Chemical Exposure. *Risk Analysis*, 19(4), pp.649–659.

McComas, K.A., 2003. Citizen satisfaction with public meetings used for risk communication. *Journal of Applied Communication Research*, 31, pp.164–184.

Mooney, C., 2010. *Do Scientists Understand the Public?*, Cambridge, MA: American Academy of Arts & Sciences. Available at: http://www.amacad.org/projects/sciUnderstand.aspx [Accessed November 5, 2012].

Morello-Frosch, R. et al., 2009. Toxic ignorance and right-to-know in biomonitoring results communication: A survey of scientists and study participants. *Environmental Health*, 8(1), p.6.

Nicol, A. et al., 2008. Accuracy, comprehensibility, and use of material safety data sheets: A review. *American Journal of Industrial Medicine*, 51(11), pp.861–876.

Olson, K. et al., 2006. Communicating complex research results regarding environmental risk to a lay audience: Experiences from the University Of Michigan Dioxin Exposure Study. *Organohalogen Compounds*, 68, pp.1350–1352.

Paustenbach, D. & Galbraith, D., 2006. Biomonitoring: Is body burden relevant to public health? *Regulatory Toxicology and Pharmacology*, 44(3), pp.249–261.

Phillips, C.C. et al., 1999. The efficacy of material safety data sheets and worker acceptability. *Journal of Safety Research*, 30(2), pp.113–122.

Pincus, J.D., 1986. Communication satisfaction, job satisfaction, and job performance. *Human Communication Research*, 12(3), pp.395–419.

Quandt, S.A. et al., 2004. Reporting pesticide assessment results to farmworker families: Development, implementation, and evaluation of a risk communication strategy. *Environmental Health Perspectives*, 112(5), pp.636–642.

Sadhra, S. et al., 2002. Workers' understanding of chemical risks: Electroplating case study. *Occupational and Environmental Medicine*, 59(10), pp.689 –695.

Tinker, T.L. et al., 2000. Assessing risk communication effectiveness: Perspectives of agency practitioners. *Journal of Hazardous Materials*, 73(2), pp.117–127.

Tucker, P., 1995. *Report of the Expert Panel Workshop on the Psychological Responses to Hazardous Substances*, Atlanta, GA: Agency for Toxic Substances and

Disease Registry. Available at: http://www.atsdr.cdc.gov/risk/prhs/ [Accessed November 7, 2011].

U.S. Agency for Toxic Substances and Disease Registry Health Investigations Communications Work Group, 2004. Communicating results to community residents: Lessons from recent ATSDR health investigations. *Journal of Exposure Analysis and Environmental Epidemiology*, 14(7), pp.484–491.

U.S. General Accounting Office (GAO), 1991. *OSHA Action Needed to Improve Compliance with Hazard Communication Standard*, Washington, DC: U.S. General Accounting Office (GAO).

Wahlberg, A.A.F. & Sjöberg, L., 2000. Risk perception and the media. *Journal of Risk Research*, 3(1), pp.31–50.

Woodruff, T.J. & Morello-Frosch, R., 2011. Communicating about Chemical Body Burden, with Tracey Woodruff and Rachel Morello-Frosch. *The Researcher's Perspective*. Available at: http://dx.doi.org/10.1289/ehp.trp050111 [Accessed August 8, 2012].

Woodruff, T.J., Zota, A.R. & Schwartz, J.M., 2011. Environmental chemicals in pregnant women in the United States: NHANES 2003–2004. *Environmental Health Perspectives*, 119(6), pp.878–885.

Chapter 2

Conceptual Model and Literature Review

The goal of this research is to assess a hypothesized model of factors affecting satisfaction with hazard and exposure information. This chapter describes the key constructs in this model (satisfaction, risk judgments, and mental models), reviews key literature about each of these constructs, and presents a conceptual model of the hypothesized relationship between them.

2.1 Conceptual Model

At the core of the hypothesized conceptual model are the questions of how residents make risk judgments about environmental exposures and what role those judgments play in satisfaction. I hypothesize that risk judgments play a key role in the pathway from the information people receive to their satisfaction as receivers. The present research is intended to assess a potential model of receiver satisfaction that includes three key constructs (satisfaction, risk judgments, and mental models) and two types of independent variables (receiver characteristics and information received).

To start, the model proposes that health risk judgments, and the perceived ability to make these judgments, are affected by independent variables related to hazard and exposure Information Received and individual Receiver Characteristics (see Figure 2.1). Aspects of risk judgments considered here include both outcome and process variables related to judging the magnitude of health risk. More specifically, these variables include judgments of the magnitude of health risk resulting from exposure (outcome variables) and the subjective ease or difficulty of making these judgments (process variables).

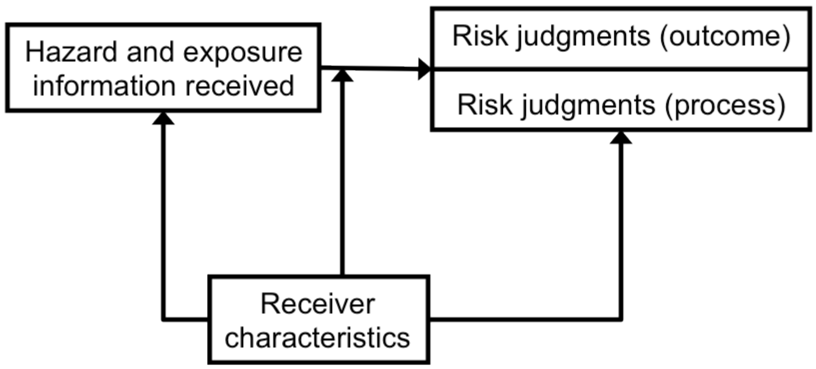


Figure 2.1 Conceptual Model: Risk Judgments

This model then proposes that receivers' "mental models" (mental conceptualizations of the risk process (Morgan et al. 2002)) mediate the effect of inputs and receiver characteristics on health risk judgments and perceived ability to make these judgments (see Figure 2.2). Mental models are discussed in more detail later in this chapter.

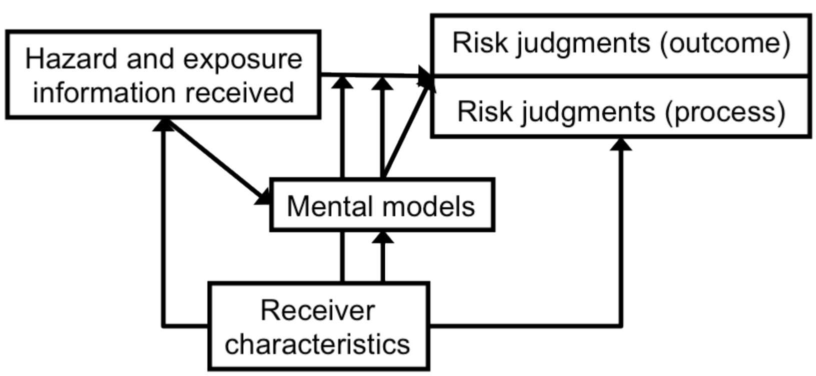


Figure 2.2 Conceptual Model: Mental Models

After accounting for the nature of the above relationships, the model centers on the idea that the perceived ability to judge health risk leads to greater satisfaction. More specifically, this model proposes that the perceived ability to judge health risk mediates the effects of information received, receiver characteristics, and mental models on satisfaction with hazard and exposure information (see Figure 2.3).

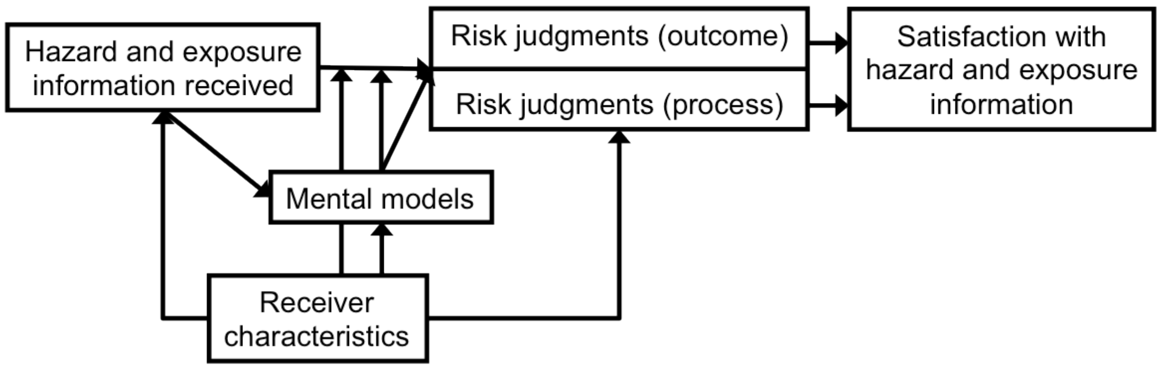


Figure 2.3 Conceptual Model: Satisfaction (Complete Framework)

At the core of this model is the idea that that if receivers of hazard and exposure communications find it difficult, either cognitively or affectively, to judge their health risk (risk judgment process variables), this may leave them feeling dissatisfied with the information they have received. The model also incorporates a competing theory that, while satisfaction is influenced by judgment of health risk, it is not influenced by the ability to judge the risk, but rather by outcome of the judgment (risk judgment outcome variables). That is, those who believe the risk is large may be less satisfied than those who believe it is small.

Other relationships between constructs are also possible. For example, risk judgments may moderate the effects of some mental models, receiver characteristics, and information received variables on satisfaction and not others. Figure 2.4 presents a complete proposed conceptual model of how information received, receiver characteristics, mental models, and risk judgments could interact to affect satisfaction with hazard and exposure communications.

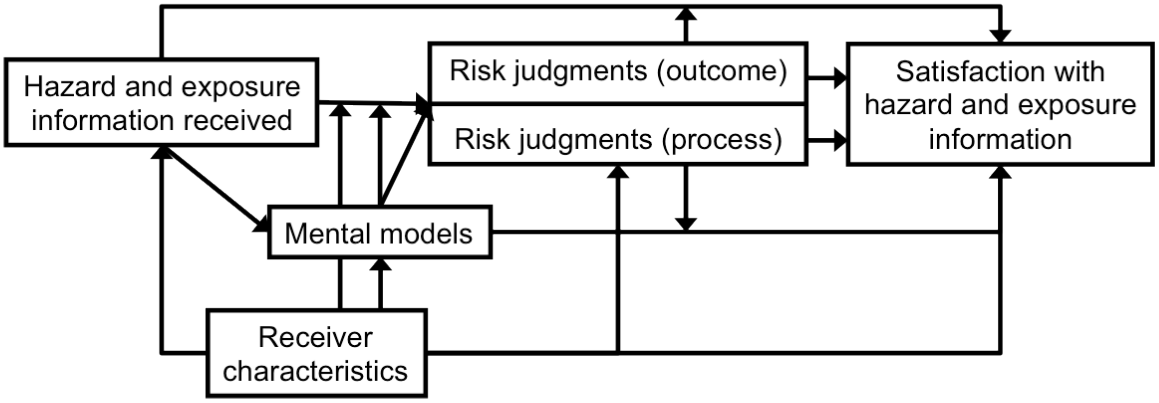


Figure 2.4 Conceptual Model: Complete Framework with Alternative Relationships

Each of the key constructs of satisfaction, risk judgments, and mental models is discussed in further detail below.

2.2 Satisfaction

2.2.1 Definitions of Satisfaction

A general definition of the condition of being satisfied denotes having been provided enough of something to result in cognitive or affective fulfillment (Stevenson & Lindberg 2010). In the case of hazard and exposure communication, if one considers what is being provided to be information, dissatisfaction with communication could result from not being provided enough information to achieve cognitive or affective fulfillment. Many other factors could also influence satisfaction with communication, including the quality of the information conveyed and the manner in which it is provided.

A dictionary definition hints at the dual cognitive/affective nature of satisfaction: "fulfillment of one's wishes, expectations, or needs, or the pleasure derived from this" (Stevenson & Lindberg 2010). Examining definitions of the related adjectives "satisfactory," and "satisfying" also shows these two aspects, with satisfactory denoting the cognitive "fulfilling expectations or needs; acceptable, though not outstanding or perfect" and satisfying denoting the affective "giving fulfillment or the pleasure associated with this" (Stevenson & Lindberg 2010). All three are derived from the Latin "satisfacere" (to satisfy or content), combining the words "satis" (enough) and "facere" (make) (Stevenson & Lindberg 2010).

2.2.2 Communication Satisfaction as a Construct

Communication satisfaction is generally conceptualized as a positive affect arising as an outcome of communication (Hecht 1978b). To study satisfaction as a positive affect arising from hazard and exposure communication may seem odd, as chemical hazards and exposure are rarely associated with a positive affect. However, I argue that it is possible to have a negative affect about hazards or exposure, and still have a positive affect about communication regarding these topics, especially if one finds the communication to be helpful or useful. For example, in a community setting, one could be outraged about the contamination that has occurred, but satisfied with the way government agencies and others have reported what is known about the contamination and what is being done to remediate the contamination. Conversely, one could also believe that there is no risk, and still be dissatisfied with communications received.

2.2.3 Previous Examinations of Communication Satisfaction

Communication satisfaction was first examined by Hecht (1978b) in the context of interpersonal communication. "Due to the dearth of satisfaction research directly related to communication satisfaction," Hecht drew on the conceptualizations of satisfaction from other areas (e.g., organizational satisfaction) (Hecht 1978b, pp.48–49).

In the present research, I draw upon the work of others in interpersonal, group, and organizational communication (Hecht, 1978; Downs and Hazen, 1977) due to the dearth of communication satisfaction research available on the topics of hazard, exposure, or risk communication.

A review of satisfaction research by Hecht (1978b) describes several theories of satisfaction—need gratification, expectation fulfillment, equivocality reduction and constraint-reinforcement—and concludes that the expectation fulfillment approach comes closest to providing a theoretical framework for communication satisfaction. Hecht (1978b) explains that the expectation fulfillment approach posits that satisfaction results when communication meets the internal standards or expectations developed by receivers. Hecht extends expectation fulfillment theory by coupling it with Skinnerian behavioral theory and proposing a discrimination fulfillment approach to communication satisfaction. This approach proposes that the affect of satisfaction arises when behavior in response to a discriminatory stimulus is positively reinforced. Under this approach, either a successful search for pleasure or a successful avoidance of pain produce satisfaction, as both strengthen the association between the stimulus and the behavior. The affect of satisfaction may then act as a secondary reinforcement to continue the behavior in response to the stimulus. As summarized by McComas (2003, p.168), discrimination fulfillment theory "suggests that individuals form standards or expectations from past experiences and satisfaction depends on the extent to which these expectations are positively reinforced." Hecht also discusses the nature of the relationship between satisfaction and dissatisfaction, concluding that the two are not independent, and that 'satisfiers' have a greater impact than 'dissatisfiers' on both satisfaction and dissatisfaction (Hecht 1978b, p.56).

Further work on communication satisfaction by Hecht focused on interpersonal, group, and organizational communication satisfaction (Hecht 1978a). More broadly, satisfaction is commonly used as an outcome variable in medical, organizational, and customer service settings (e.g., job satisfaction, patient satisfaction, customer satisfaction). According to Pincus (1986), in the context of organization communication, satisfaction with communication was determined not only by information acquisition but by relational aspects between those doing the communicating and the manner in which the communication is delivered.

Research regarding communication satisfaction in community exposure contexts has been extremely limited, but McComas (2003) found this to be true in the context of citizen satisfaction with public meetings about landfill siting, and also confirmed aspects of the expectation fulfillment proposed by Hecht (Hecht 1978b). Regardless of whether they attended the public meetings, residents' expectations of these meetings predicted their satisfaction. Residents who thought meeting organizers were interested in participants' comments, residents who thought public meetings were informative, residents who government agencies conducting public meetings to be credible, and residents who thought the risk was high were more likely to be satisfied (McComas 2003). This suggests that satisfaction may be a sensitive outcome with many contributors. If the ability to judge health risk is one of these contributors, or mediates the effect of some of these contributors, satisfaction with hazard and exposure communications could be improved by putting in place mechanisms to help receivers with these judgments.

2.3 Risk Judgments

A 'judgment' is an assessment of what was, is, or will be the state of the world (Yates & Chen 2009). A risk judgment, as defined here, is an assessment of the magnitude or significance of a risk. This is similar to the concept of 'risk perception,' which has been defined as a subjective impression of 'riskiness' (Weber 2009). The term 'risk judgment' is preferred over 'risk perception' by Dunwoody and Neuwirth (1991, p.18), who note that the latter "has been used with such abandon that its meaning has been irreparably fuzzed."

Evidence from focus groups and questionnaires suggests that when confronted with a new hazard or risk, receivers first try to determine whether it is relevant to them, similar to the appraisal stage in health behavior models, in order to decide whether further action is required (Lion et al. 2002). Health behavior models suggest that this decision is based on perceived severity and perceived susceptibility (Lion et al. 2002), which are similar to the concepts of perceived hazard and perceived exposure, respectively. By combining hazard and exposure information in this way, laypeople are assessing risk in a way that is generally similar to that of experts.

As discussed in Chapter 1, experts are careful to distinguish between hazard, exposure, and risk, having separate definitions and uses for each concept and considering information of each type differently. For experts, understanding and managing the risks of health effects from chemicals involves considering and combining information about hazard, exposure, and resulting risk. In contrast, research has shown that although laypeople are aware of the terms 'hazard' and 'risk,' they do not naturally distinguish between the two (Sadhra et al. 2002). One study found that laypeople (chromium platers working for small companies) were not only unable to explain the difference, but also regarded the distinction as an unnecessary complication (Sadhra et al. 2002, p.691). There is also evidence that laypeople have different concepts of the word 'exposure,' than do experts. For example, one study regarding carcinogens found that laypeople reserved the term 'exposure' for a level of exposure significant to cause a health effect (MacGregor et al. 1999, p.653). Participants rated smoking a pack of cigarettes a day, developing a deep suntan, or having a chest x-ray every year as more definitively resulting in someone being 'exposed to a carcinogen' than smoking one cigarette, doing two sessions in a tanning parlor, or having a single chest x-ray (MacGregor et al. 1999, p.653). Taken together, these results suggest that, although laypeople may not differentiate between the terms hazard and risk, and may perceive exposure differently than do experts, they do attempt to make risk judgments based on hazard and exposure information.

Current research has focused on at least three factors affecting risk judgments: heuristic-systematic information processing, psychometric factors, and individual cultural and political values.

2.3.1 Psychometric Factors

Psychometric studies elicit quantitative judgments of mental impressions. In psychometric studies of risk judgments, participants are asked to rate various attributes of a risk and to provide judgments regarding the magnitude of perceived risk and/or benefits from the technology or activity associated with the risk (Fischhoff et al. 1978, p.129).

Originally begun as a way of assessing acceptable societal risk levels (Fischhoff et al. 1978), this work was continued by Slovic et al. to assess how the "personality" of a hazard can affect risk perceptions and acceptance of risks arising from the hazard (Slovic 1992).

This line of research found that two factor-analytic representations predicted large shifts in judgments of the magnitude of the risk. These two factors were (1) whether the risk was unknown and (2) whether the risk was dreaded. The factor "unknown risk" was related to the measurements "not observable," "unknown to those exposed," "effect delayed," "new risk, and "risk unknown to science." The factor "dread risk" was related to the measurements "uncontrollable," "dread," "global catastrophic," "high risk to future generations," "not easily reduced," "risk increasing," and "involuntary." Risks rated as more unknown and more dreaded (e.g., DNA technology, radioactive waste, electric fields) were generally rated as greater risks than those that were more known and less dreaded (e.g., bicycles, swimming pools, chainsaws) (Slovic 1992).

That the quality of being "unknown" should be a large factor is not surprising, and may have important implications for hazard and exposure communications. If risk is perceived to be uncertain, this may create difficulty making judgments about the risk, and greater dissatisfaction with hazard and exposure communications. Uncertainty, defined by Han et al. (2011, p.830) as a state of mind involving "the subjective perception of ignorance," has been historically classified into two types. The first, called "measurable uncertainty," occurs when probabilities are known or can be readily calculated, such as that occurring when a risk has been quantified (Knight 1921). The second, called unmeasurable uncertainty, or "ambiguity," occurs when incomplete or conflicting information does not allow for the calculation of a probability (Ellsberg 1961). The latter type of uncertainty is the factor often preventing hazard and exposure communications from including risk information from being explicitly included. As summarized by Han et al. (2011, p.831), this type of uncertainty has been shown to promote pessimistic appraisals of risk and avoidance of decision making, a phenomenon known as ambiguity aversion. Instructions to participants in the psychometric study by Fischhoff et al. (1978, p.130) acknowledged the difficulty of making risk judgments with limited information, stating: "This is a difficult, if not impossible, task. Nevertheless it is not unlike the task you face when you vote on legislation pertaining to nuclear power, handguns, or highway safety. One never has all the relevant information; ambiguities and uncertainties abound, yet some judgment must be made. The present task should be approached in the same spirit."

While psychometric factors of the risk at issue in the present study of a particular community contamination situation would appear to be held fixed, research suggests that in addition to being able to make comparisons between risks, the psychometric paradigm has been found to be useful in examining single risks under field conditions. Trumbo collected data regarding risk judgments about a "non-hypothetical" risk (community members' concern about cancer rates near a nuclear reactor) (Trumbo 1996) and found that measurements fell along three factors, two of which were related to dread risk, and one of which was related to unknown risk. These factors predicted individual evaluation of personal risk and satisfaction with institutional response (Trumbo 1996).

While psychometric factors are not part of the model being assessed in the present research, it is important to note that chemical hazard and exposure communications in many settings, including community contamination settings, involve risk that may be both dreaded and unknown. Risk judgments made in these settings may take into account psychometric factors, rather than just the content of the hazard and exposure communications, and may not be identical to those of experts in these same settings.

2.3.2 Cultural and Political Values

In addition to attributes of the risks, personal attributes and values have long been considered to influence risk judgments by individuals (Douglas & Wildavsky 1982). Douglas and Wildavsky (1982) posit the conundrum that one cannot know all the risks one faces, but must act as if one does, and argue that individual values determine how one decides which risks to take and which to ignore. In empirical studies, individual cultural and political values have been shown to greatly influence perceptions of risks and judgments about what should be done to manage risk (Kahan et al. 2006; Peters & Slovic 1996; Kahan et al. 2007).

Peters and Slovic studied the effect of worldviews on perceptions of risk from nuclear power (Peters & Slovic 1996), and a similar study was undertaken by Kahan et al. with respect to perceptions of nanotechnology (Kahan et al. 2007). Both found that worldviews (e.g., hierarchical, fatalistic, individualistic, egalitarian, communitarian) impacted judgments of the magnitude of the risk.

Peters and Slovic (1996, p.1437) explained that cultural theory suggests worldviews help people interpret the world in ways that allow them to maintain their system of beliefs and moral codes. They found that those with egalitarian views had lower trust in government decisions and were less likely to support nuclear power and those with fatalist/hierarchical views had greater trust and were more supportive.

Kahan et al. (2007) observed that how people reacted to information about nanotechnology depended largely on their values. Those with hierarchical and individualistic values were predisposed to dismiss claims of environmental risk, and were reassured by balanced information. Those with egalitarian and communitarian values were predisposed to credit claims of environmental risk, and became alarmed by the balanced information provided. Kahan et al. (2007, p.32) concluded that this data was consistent with a ‘cultural evaluator’ theory of risk perception, posing that individuals evaluate their position on a risk in terms of how well it expresses their cultural identities.

These results show that characteristics of receivers are known to affect risk judgments. Receiver characteristics such as those described above will be assessed in the present study to examine their relationship with risk judgments, and also to assess whether risk judgments may mediate any effects of receiver characteristics on satisfaction with hazard and exposure information.

2.3.3 Heuristic-Systematic Information Processing

In addition to characteristics of the risk, and characteristics of the individual, the information processed by individuals, and how they process it, may influence risk judgments.

Two modes of processing have been theorized to occur in processing information used to make risk judgments. A variety of terms for these two modes have been used, including ‘heuristic’ and ‘systematic’ (Chaiken 1980; Trumbo 1999), ‘risk as feelings’ and ‘risk as analysis’ (Slovic & Peters 2006), the potentially less-accurate ‘affective’ and ‘cognitive’ (Finucane et al. 2000), and the less-descriptive ‘System 1’ and ‘System 2’ (Kahneman 2002). This dual processing approach is a departure from the traditional view of receivers as ‘rational actors’ and instead embraces the concept of bounded rationality, building on the work of Tversky and Kahneman regarding heuristics and biases (Tversky & Kahneman 1974) and Simon regarding ‘satisficing’ (Simon 1956).

A complex relationship between heuristic-systematic processing and risk judgments has been found in studies under conditions with artificial stimuli. Finucane et al. (2000) conducted a study in which participants were provided a short vignette providing positive or negative information about the risks or benefits of nuclear power (four conditions total). They found that participants used an affect heuristic to make judgments about risks and benefits. Kahlor et al. (2003) provided participants with a fictional magazine article regarding Great Lakes fish consumption and found that individuals who perceived greater risk were more likely to process the article heuristically. This study also found that a larger ‘information gap’ (between existing understanding and the perceived level of understanding needed to make a decision) was associated with more systematic processing. These results suggest not only that information processing may have an effect on risk judgments, but also that risk judgments may have an effect on subsequent information processing.

Slovic and Peters (2006) offer a possible explanation, in which affect toward a risk or activity affects how risk or benefit information may be interpreted, by suggesting a model in which information about risks is interpreted as providing, inferentially, information about benefits, and vice versa. Those receivers with a negative affect interpret benefits as low and risk as high, and those with a positive affect interpret benefits as high and risks as low. These complex relationships emphasize the value of studies examining risk judgments under real-world information gathering and processing situations. However, available data are limited. A field study conducted by Trumbo (1999) in the context of a suspected cancer cluster near a nuclear reactor found that heuristic processing was associated with a judgment of less risk.

An additional explanation is offered by fuzzy trace theory (Reyna 2004). Fuzzy trace theory posits that receivers encode both “verbatim” and “gist” representations of information into memory, but verbatim representations rapidly become inaccessible. Regarding risk judgments, this theory proposes that it how receivers represent the gist of a communication (which reflects the receiver’s personal characteristics such as affect and worldview) that determines their judgment of the risk, rather than the verbatim information contained in the communication (Reyna 2004).

No research has been identified linking heuristic or systematic processing or fuzzy trace theory to communication satisfaction. However, I hypothesize that if receivers of hazard and exposure communications find it difficult, either cognitively or affectively, to judge their health risk, this inability may leave them feeling dissatisfied with the information they have received.

2.4 Mental Models

2.4.1 Definition of Mental Models

Mental models can generally be defined as mental conceptualizations of how a system or process works (Morgan et al. 2002), based on expectations, experience, and perceptions (Wilson & Rutherford 1989) and “the more or less imperfect knowledge that a person has of his or her functional environment” (Moray 1997). Mental models have historically been employed in diverse settings, for example, as a means of studying novice users' understanding of software functions, physics students' comprehension of laws of motion, and to model motor control feedback loops (Rupietta 1990; Rouse & Morris 1986).

Mental models are often represented as networks of nodes and connections, where each node is connected to one or more other nodes by a connection represented by an arrow (see Morgan et al. 2002 for examples). The direction of the arrow is often used to denote that the node at the arrow's base influences the node at the arrow's tip. The resulting diagrams are referred to as influence diagrams.

2.4.2 Mental Models Method of Risk Communication

It is recognized that experts in a particular topic tend to have different mental models of that topic than laypeople (i.e., non-experts in the topic). Whether these models are simply more detailed, or differ in structure entirely appears to vary by topic (Rouse & Morris 1986).

Lay mental models can be compared with expert mental models to identify gaps (those nodes or connections appearing in the expert model, but not in the lay model) and misconceptions (those nodes or connections appearing in the lay model, but not in the expert model). Identifying these gaps and misconceptions can be useful for developing communications intended to educate laypeople about a particular topic. The central idea is that communications need not include all of the information in the expert model, especially that information that is already well understood by receivers. Rather, communications can be limited to those gaps and misconceptions that are prevalent in the target population. Morgan et al. (2002) describe the use of mental models in this way as a method of discriminating between “what’s worth knowing” (i.e., the expert model) and “what’s worth saying” (i.e., the gaps and misconceptions).

The mental models approach to risk communication, developed by researchers at Carnegie Mellon University (Morgan et al. 2002) is a systematic method for assessing lay and expert understandings of a risk process and comparing the two. The method involves first developing an expert model of the risk through interviews with experts. Then, interviews with laypeople in the population of interest are conducted using a specific technique designed to probe areas of existing mental models without providing new information that might influence the participant’s existing mental model. These interviews are replicated with a large enough number of participants to allow confidence that the set of potential mental model elements has been sufficiently explored and that subsequent interviews are not generally raising new concepts. Interviews are transcribed and coded for these concepts, and the results are used to design a survey questionnaire to be administered to a larger sample to assess the prevalence of particular gaps and misunderstandings.

Since its development in the early 1990s, this method has enjoyed widespread use on variety of topics, including radon (Bostrom et al. 1992; Atman et al. 1994; Bostrom, Atman, et al. 1994), nuclear power sources in space (Maharik & Fischhoff 1992), climate change (Bostrom, Morgan, et al. 1994; D. Read et al. 1994; Reynolds et al. 2010), breast implants (Byram et al. 2001), HIV/AIDS (Morgan et al. 2002), wildfires (Zaksek & Arvai 2004), flash floods and landslides (Wagner 2007), vaccinations (Downs et al. 2008), xenotransplantation (Bruine De Bruin et al. 2009), cancer (Downs et al. 2009), novel foods (Hagemann & Scholderer 2009), mobile communications (Cousin & Siegrist

2010), nuclear waste disposal (Skarlatidou et al. 2012), and flood risk management (Wood et al. 2012). Applications of the mental models method in situations regarding chemical exposures have been limited, but have included applications in both community settings (e.g., radon: Bostrom et al. 1992; Atman et al. 1994; Bostrom, Atman, et al. 1994) and in workplace settings (e.g., dry cleaning solvents and soldering fumes: Cox et al. 2003; Niewöhner et al. 2004).

The mental models method developed by Carnegie Mellon researchers has several advantages and disadvantages as a method of examining understandings and judgments about risk among laypeople. First, it has the advantage of having as a goal to examine the natural state of perceptions among laypeople, without administering any stimuli to influence these perceptions. This allows greater certainty about the understandings and judgments people have drawn from the information they have naturally gathered or received under real-world conditions, something that has proven to be important due to the complex interactions between perceptions and subsequent information processing behaviors. However, this does imply that the method can only be applied in situations where the target population already has some information about the risk under study, making it difficult to use this method to decide in advance how to communicate information about novel risks. Second, this method's coupling of interviews with a large-sample questionnaire provides the advantage of greater robustness and confidence that findings hold true for the larger population under study. While these two steps could appear to be redundant, they allow for a more rigorous examination of findings based on a relatively small number of interviews, typically on the order of 30 (Morgan et al. 2002). Even though the number of interviews may be limited, this method has the disadvantage of still being extremely time- and resource-intensive. Training interviewers and conducting lengthy interviews, coding and carefully analyzing them, and drafting and mailing a detailed, large-sample questionnaire are not easy tasks.

Other methods of studying mental models have been attempted that omit mental models interviews, follow-up questionnaires, or both. Some studies have inferred the structure of mental models through card-sorting tasks and questionnaires (Smith-Jackson & Wogalter 2007) or estimation and justification tasks in qualitative interviews (Pettersson-Strömbäck et al. 2010). While these methods do provide findings regarding portions of receivers' mental models, it is difficult to be confident that they are providing a full picture and that their results are valid for the population as a whole. The omission of the mental models interviewing method in particular would be troubling to mental models method proponents, who argue that this method more accurately and fully captures lay mental models while avoiding providing information that could be leading, and that these interviews provide a basis for developing questionnaire items that will be more reflective of the mental models of the population under study (Morgan et al. 2002).

2.4.3 Relationships between mental models and other variables

Research has neglected to examine how mental models features affect other individual variables, such as perceived risk (Johnson 1993). Because one of the goals of the mental models methods is to allow generalization to the population as a whole, it appears that researchers using this method have typically been less interested in differences among individual judgments. This represents a missed opportunity, as misconceptions and gaps in mental models have the potential to greatly impact subsequent risk judgments made based on these mental models.

It is likely that mental models are influenced by information previously received, and by individual receiver characteristics. Mental models are not static, but rather change over time in response to new information and inferences on the basis of existing information. A person's mental model is a reflection of the sum total of information that the person has gathered or received on a topic, and the inferences they have made from this information. Receiver characteristics (such as age, gender, education, and other demographic variables), may influence both the information received (both in terms of available information and information-seeking behavior) and the inferences made from this information.

However, mental models studies traditionally have not examined the effect of receiver characteristics on mental models, choosing instead to study the mental models of groups that can be considered homogeneous (Morgan et al. 2002), and the typical design of mental models studies does not usually allow for the study of the effect of previous information received. Participants are unlikely to be able to accurately recall from which sources they learned particular facts that are present in their mental models, or be able to accurately report the full set of sources from which they have received information on the topic. If sources of information could be accurately assessed, they would likely be found to be a key factor in the development of mental models. The present research seeks to assess the effects of both information received and receiver characteristics on mental models, and the effects of mental models on risk judgments and satisfaction with hazard and exposure information.

2.5 References

Atman, C.J. et al., 1994. Designing risk communications: Completing and correcting mental models of hazardous processes, Part I. *Risk Analysis*, 14(5), pp.779–788.

Bostrom, A., Atman, C.J., et al., 1994. Evaluating risk communications: Completing and correcting mental models of hazardous processes, Part II. *Risk Analysis*, 14(5), pp.789–798.

Bostrom, A., Morgan, M.G., et al., 1994. What do people know about global climate change? 1. Mental models. *Risk Analysis*, 14(6), pp.959–970.

Bostrom, A., Fischhoff, B. & Morgan, M.G., 1992. Characterizing mental models of hazardous processes: A methodology and an application to radon. *Journal of Social Issues*, 48(4), pp.85–100.

Bruine De Bruin, W. et al., 2009. Communicating about xenotransplantation: Models and scenarios. *Risk Analysis*, 29(8), pp.1105–1115.

Byram, S. et al., 2001. Mental models of women with breast implants: Local complications. *Behavioral Medicine*, 27(1), pp.4–14.

Chaiken, S., 1980. Heuristic versus systematic information processing and the use of source versus message cues in persuasion. *Journal of Personality and Social Psychology*, 39(5), pp.752–766.

Cousin, M.-E. & Siegrist, M., 2010. Risk perception of mobile communication: A mental models approach. *Journal of Risk Research*, 13(5), pp.599–620.

Cox, P. et al., 2003. The use of mental models in chemical risk protection: Developing a generic workplace methodology. *Risk Analysis*, 23(2), pp.311–324.

Douglas, M. & Wildavsky, A.B., 1982. *Risk and Culture: An Essay on the Selection of Technical and Environmental Dangers*, Berkeley, CA: University of California Press.

Downs, J.S. et al., 2009. How people think about cancer: A mental models approach. In R. L. Heath & D. O'Hair, eds. *Handbook of Risk and Crisis Communication*. Routledge Communication Series. New York: Routledge, pp. 507–524.

Dunwoody, S. & Neuwirth, K., 1991. Coming to terms with the impact of communication on scientific and technological risk judgments. In L. Wilkins & P. Patterson, eds. *Risky Business: Communicating Issues of Science, Risk, and Public Policy*. Contributions to the Study of Mass Media and Communications, 0732-4456. New York: Greenwood Press, pp. 11–30. Available at: http://hdl.handle.net/2027/[u]: mdp.39015021495828 [Accessed August 24, 2012].

Ellsberg, D., 1961. Risk, ambiguity, and the Savage axioms. *The Quarterly Journal of Economics*, 75(4), pp.643–669.

Finucane, M.L. et al., 2000. The affect heuristic in judgments of risks and benefits. *Journal of Behavioral Decision Making*, 13(1), pp.1–17.

Fischhoff, B. et al., 1978. How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy Sciences*, 9(2), pp.127–152.

Hagemann, K.S. & Scholderer, J., 2009. Hot potato: Expert-consumer differences in the perception of a second-generation novel food. *Risk Analysis*, 29(7), pp.1041–1055.

Han, P.K.J., Klein, W.M.P. & Arora, N.K., 2011. Varieties of uncertainty in health care: A conceptual taxonomy. *Medical Decision Making*, 31(6), pp.828–838.

Hecht, M.L., 1978a. Measures of communication satisfaction. *Human Communication Research*, 4(4), pp.350–368.

Hecht, M.L., 1978b. Toward a conceptualization of communication satisfaction. *Quarterly Journal of Speech*, 64(1), pp.47–62.

Johnson, B.B., 1993. Advancing understanding of knowledge's role in lay risk perception. *Risk: Issues in Health & Safety*, 4, pp.189–212.

Kahan, D.M. et al., 2007. Affect, values, and nanotechnology risk perceptions: An experimental investigation. *SSRN eLibrary*. Available at: http://papers.ssrn.com.proxy.lib.umich.edu/sol3/papers.cfm?abstract_id=968652 [Accessed June 21, 2012].

Kahan, D.M. et al., 2006. Fear of democracy: A cultural evaluation of Sunstein on risk. *Harvard Law Review*, 119(4), pp.1071–1109.

Kahlor, L. et al., 2003. Studying heuristic‐systematic processing of risk communication. *Risk Analysis*, 23(2), pp.355–368.

Kahneman, D., 2002. Maps of Bounded Rationality: A Perspective on Intuitive Judgment and Choice. Available at: http://www.nobelprize.org/nobel_prizes/economics/laureates/2002/kahneman-lecture.html [Accessed August 26, 2012].

Knight, F.H., 1921. The meaning of risk and uncertainty. In *Risk, Uncertainty and Profit*. Boston, MA: Houghton Mifflin Company, pp. 197–232.

Lion, R., Meertens, R.M. & Bot, I., 2002. Priorities in information desire about unknown risks. *Risk Analysis*, 22(4), pp.765–776.

MacGregor, D.G., Slovic, P. & Malmfors, T., 1999. "How Exposed Is Exposed Enough?" Lay Inferences About Chemical Exposure. *Risk Analysis*, 19(4), pp.649–659.

Maharik, M. & Fischhoff, B., 1992. The risks of using nuclear energy sources in space: Some lay activists' perceptions. *Risk Analysis*, 12(3), pp.383–392.

McComas, K.A., 2003. Citizen satisfaction with public meetings used for risk communication. *Journal of Applied Communication Research*, 31, pp.164–184.

Moray, N., 1997. Models of models of ... mental models. In T. B. Sheridan & Van Lunteren, Ton, eds. *Perspectives on the Human Controller: Essays in Honor of Henk G. Stassen*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc., pp. 271–285.

Morgan, M.G. et al., 2002. *Risk Communication: A Mental Models Approach*, Cambridge, UK: Cambridge University Press.

Niewöhner, J. et al., 2004. Evaluating the efficacy of a mental models approach for improving occupational chemical risk protection. *Risk Analysis*, 24(2), pp.349–361.

Peters, E. & Slovic, P., 1996. The role of affect and worldviews as orienting dispositions in the perception and acceptance of nuclear power. *Journal of Applied Social Psychology*, 26(16), pp.1427–1453.

Pettersson-Strömbäck, A.E. et al., 2010. Workers' mental models of chemical exposure in the workplace. *Risk Analysis*, 30(3), pp.488–500.

Pincus, J.D., 1986. Communication satisfaction, job satisfaction, and job performance. *Human Communication Research*, 12(3), pp.395–419.

Read, D. et al., 1994. What do people know about global climate change? 2. Survey studies of educated laypeople. *Risk Analysis*, 14(6), pp.971–982.

Reyna, V.F., 2004. How people make decisions that involve risk: A dual-processes approach. *Current Directions in Psychological Science*, 13(2), pp.60–66.

Reynolds, T.W. et al., 2010. Now what do people know about global climate change? Survey studies of educated laypeople. *Risk Analysis*, 30(10), pp.1520–1538.

Rouse, W.B. & Morris, N.M., 1986. On looking into the black box: Prospects and limits in the search for mental models. *Psychological Bulletin*, 100(3), pp.349–363.

Rupietta, W., 1990. Mental models and the design of user manuals. In D. Ackermann & M. J. Tauber, eds. *Mental Models and Human-Computer Interaction*. Human Factors in Information Technology. Amsterdam: North-Holland, pp. 321–334.

Sadhra, S. et al., 2002. Workers' understanding of chemical risks: Electroplating case study. *Occupational and Environmental Medicine*, 59(10), pp.689 –695.

Simon, H.A., 1956. Rational choice and the structure of the environment. *Psychological Review*, 63(2), pp.129–138.

Skarlatidou, A., Cheng, T. & Haklay, M., 2012. What do lay people want to know about the disposal of nuclear waste? A mental model approach to the design and development of an online risk communication. *Risk Analysis*. Available at: http://onlinelibrary.wiley.com.proxy.lib.umich.edu/doi/10.1111/j.1539-6924.2011.01773.x/abstract [Accessed July 24, 2012].

Slovic, P., 1992. Perception of risk: Reflections on the psychometric paradigm. In S. Krimsky & D. Golding, eds. *Social Theories of Risk*. Westport, Connecticut: Praeger, pp. 117–152.

Slovic, P. & Peters, E., 2006. Risk perception and affect. *Current Directions in Psychological Science*, 15(6), pp.322 –325.

Smith-Jackson, T. & Wogalter, M., 2007. Application of a mental models approach to MSDS design. *Theoretical Issues in Ergonomics Science*, 8(4), pp.303–319.

Stevenson, A. & Lindberg, C.A. eds., 2010. sat˙is˙fac˙tion, n. *New Oxford American Dictionary*. Available at: http://www.oxfordreference.com.proxy.lib.umich.edu/views/ENTRY.html?subview=Main&entry=t183.e1287351 [Accessed August 23, 2012].

Trumbo, C.W., 1996. Examining psychometrics and polarization in a single-risk case study. *Risk Analysis*, 16(3), pp.429–438.

Trumbo, C.W., 1999. Heuristic-Systematic Information Processing and Risk Judgment. *Risk Analysis*, 19(3), pp.391–400.

Tversky, A. & Kahneman, D., 1974. Judgment under uncertainty: Heuristics and biases. *Science*, 185(4157), pp.1124–1131.

Wagner, K., 2007. Mental models of flash floods and landslides. *Risk Analysis*, 27(3), pp.671–682.

Weber, E.U., 2009. Risk perception. In M. W. Kattan & M. E. Cowen, eds. *Encyclopedia of Medical Decision Making*. Thousand Oaks, CA: Sage Publications, Inc., pp. 1010–1012. Available at: http://sage-ereference.com.proxy.lib.umich.edu/view/medical/n293.xml?result=291&q=&print [Accessed July 6, 2012].

Wilson, J.R. & Rutherford, A., 1989. Mental models: Theory and application in human factors. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 31(6), pp.617–634.

Wood, M. et al., 2012. Flood risk management: US Army Corps of Engineers and layperson perceptions. *Risk Analysis*. Available at: http://onlinelibrary.wiley.com.proxy.lib.umich.edu/doi/10.1111/j.1539-6924.2012.01832.x/abstract [Accessed July 24, 2012].

Yates, J.F. & Chen, L.L., 2009. Judgment. In M. W. Kattan & M. E. Cowen, eds. *Encyclopedia of Medical Decision Making*. Thousand Oaks, CA: Sage Publications, Inc., pp. 645–649.

Zaksek, M. & Arvai, J.L., 2004. Toward improved communication about wildland fire: Mental models research to identify information needs for natural resource management. *Risk Analysis*, 24(6), pp.1503–1514.

Chapter 3

Context for Research

This research seeks to examine the relationship between risk judgments and satisfaction with chemical hazard and exposure information received in a community setting where health risks are uncertain. An appropriate setting for this research needs to meet two requirements: (1) community-level chemical contamination for which health effects are uncertain, and (2) subsequent hazard and exposure communications lacking risk information. A group of chemicals satisfying the first requirement is the group of persistent organic pollutants known as dioxins, for which contamination is relatively common, but for which health effects and dose-response relationships remain uncertain. A location satisfying both requirements is that of Midland and Saginaw counties in Michigan, a community that has experienced environmental contamination from dioxins and has received hazard and exposure communications about the contamination from various sources, including a community exposure study.

This chapter provides background about the chemical, physical, and communications context for the present research, including background about dioxins, dioxin contamination in Michigan's Midland and Saginaw Counties, and the University of Michigan Dioxin Exposure Study (UMDES). The goal of the present research is to determine whether residents who feel they are able to make judgments about health risks from dioxins are more satisfied with the information they have received than those residents who find it difficult to do so.

3.1 Dioxins

Dioxins are a particularly challenging group of contaminants for experts to communicate with community residents about. The challenge arises from the fact that residents may have particular difficulty judging the health risks associated with dioxins, something which could lead them to feel dissatisfied if satisfaction with hazard and exposure communication is based on the ability to judge health risk.

One aspect that makes judging risk from dioxins challenging is the ubiquitous presence of low levels of dioxin contamination. Detectable levels are widespread in soil, sediment, air, animal fats, and human tissues (International Agency for Research on Cancer (IARC) 1997). However, where they are present, oftentimes even in cases of point-source contamination, they are present at extremely low levels. While dioxins have a long history of scientific investigation, their health effects at low levels remain uncertain. As a result, even federal government entities have found it difficult to assess the health risks, resulting in several controversial policy judgments, further discussed below. All of these factors may combine to create an especially difficult situation in which to make risk judgments.

3.1.1 Known Properties

Dioxins pose communication challenges due to their chemical complexity. Instead of a single compound, dioxins are comprised of family of dioxin-like compounds that includes certain types of polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and polychlorinated biphenyls (PCBs). These compounds (herein referred to generically as "dioxins") are grouped together based on chemical reactivity. Their chemical structures are similar, consisting of two benzene rings connected by a single bond (PCBs), an oxygen atom and a single bond (furans), or two oxygen atoms (dioxins). Numerous related congeners are formed by replacing different numbers of hydrogen atoms on the benzene rings with chlorine atoms.

Historically, some dioxins were produced intentionally, but others are produced only as unintended byproducts of man-made processes or by natural processes. PCBs were used through the early 1970s in transformers, capacitors, and other applications, but are now permitted for use in the U.S. only for research and development purposes (U.S. Agency for Toxic Substances and Disease Registry (ATSDR) 2000, p.469). The remaining dioxins are produced as byproducts of natural or manmade processes. Combustion in the presence of chlorine is the most common process by which dioxins are produced. Such combustion can occur in incinerators (e.g., municipal, medical waste, or hazardous waste incinerators), during backyard trash burning, and naturally during wildfires or volcanic eruptions (U.S. Agency for Toxic Substances and Disease Registry (ATSDR) 1998, p.378). Dioxins are also produced by chemical manufacturing processes involving chlorine, and by pulp and paper bleaching (U.S. Agency for Toxic Substances and Disease Registry (ATSDR) 1998, p.378). PCDDs have also been found to occur naturally in certain types of clay (Horii et al. 2008).

The chemical and physical properties of dioxins control where they are found in the environment. Dioxins are hydrophobic and lipophilic, making them insoluble in water, but soluble in fats. In the environment, they also attach to soil and sediment particles. Ingestion of meat, dairy products, and fish accounts for over 90 percent of current human exposure to dioxins in the environment (U.S. Agency for Toxic Substances and Disease Registry (ATSDR) 1998, p.381). Inhalation or ingestion of combustion byproducts is also possible (U.S. Agency for Toxic Substances and Disease Registry (ATSDR) 1998, pp.381–382; International Agency for Research on Cancer (IARC) 1997, p.3). Dioxins are widespread environmentally, with detectable background levels nearly worldwide in both environmental (e.g., soil) and biological (e.g., serum) samples (International Agency for Research on Cancer (IARC) 1997, p.3). Concentrations of dioxins in these samples are typically extremely small and measured in parts-per-trillion (ppt). Dioxins are persistent, with half-lives on the order of years to decades in soils and biological media.

Contamination above background levels has occurred due to discharges to air, soil, or water from point source activities and accidents. Examples of affected communities include Seveso, Italy (Bertazzi et al. 1998); Times Beach, Missouri (Yanders 1986); Anniston, Alabama (Silverstone et al. 2012); and Paritutu, New Zealand (Fowles et al. 2004). Military and civilian exposures also occurred during the Vietnam conflict (Akhtar et al. 2004; Schecter et al. 1986).

The chemical and physical properties of dioxins could lead to difficulty for residents trying to make risk judgments about dioxin contamination in their community. Since dioxins at environmental levels are undetectable to the senses, laypeople must base their understanding of dioxins on information received from other sources, and on the inferences they are able to make from this information. Partial information or incorrect inferences about the chemical or physical properties of dioxins could lead to gaps and misconceptions in lay mental models (Morgan et al. 2002), reducing accuracy and/or causing uncertainty in judgments about contamination in the environment and potential routes of exposure. If these judgments are uncertain or inaccurate, then risk judgments about dioxins are likely to be uncertain or inaccurate, possibly decreasing satisfaction with hazard and exposure information received.

3.1.2 Uncertain Health Effects

In addition to difficulties understanding what is known about the properties of dioxins, residents desiring to make risk judgments are faced with uncertainty and disagreement among experts about the health risks. Although the health effects of dioxins have been the subject of decades of intensive study, much uncertainty remains.

At a basic level, dioxins are believed to have a toxicological activity that is similar to each other, involving binding to the aryl hydrocarbon receptor (AhR). A method for assessing the relative toxicity of different dioxins rates AhR-binding affinity relative to that of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), the dioxin believed to be most toxic. The resulting measures of relative binding affinity, called Toxic Equivalency Factors (TEFs), are set by the World Health Organization (WHO) (World Health Organization (WHO) 2005). They are used to compare exposures to different mixtures of dioxins by calculating a Toxic Equivalent (TEQ) intended to represent an equivalent exposure to 2,3,7,8-TCDD. Relative toxicity varies widely for different dioxins, with a range of five orders of magnitude (0.00003 to 1) in TEFs among the 29 congeners for which they have been assigned (Van den Berg et al. 2006).

While both cancer and non-cancer health endpoints for dioxins have been extensively studied, a comprehensive list of endpoints remains somewhat uncertain, and could vary from congener to congener. One dioxin congener (2,3,7,8-TCDD) is considered to be a human carcinogen by the International Agency for Research on Cancer (IARC) based on evidence that exposure raised the overall rate of cancers, rather than rates of specific types of cancer (International Agency for Research on Cancer (IARC) 1997). Other dioxins are suspected of being human carcinogens because of their similar structures. Additional health endpoints associated with dioxins in animal studies have included endocrine disruption, neurobehavioral effects, birth defects, skin effects, fertility effects, thyroid effects, liver effects, kidney effects, lung effects, and reproductive effects (U.S. Environmental Protection Agency (EPA) 2012). Human epidemiological studies have examined reproductive effects, thyroid effects, birth defects, liver effects, immune system effects, and diabetes (U.S. Environmental Protection Agency (EPA) 2012). A characteristic skin condition, chloracne, is the most clearly confirmed human health effect of dioxin exposure, but this is seen only at very high exposure levels (International Agency for Research on Cancer (IARC) 1997).

Further complicating matters, the dose-response curve for cancer and non-cancer health effects is believed to vary not only by congener but also by animal species, with some species (e.g., hamsters) extremely sensitive and others less so (U.S. Environmental Protection Agency (EPA) 2012). This makes extrapolation from animal health effects to human health effects more uncertain, especially with respect to understanding the shape of the dose-response curve. It is also uncertain whether dioxin carcinogenicity follows a threshold or non-threshold dose-response curve, something which has been debated in the literature (Mackie et al. 2003; Cole et al. 2003). Non-threshold dose-response curves can be especially perplexing to lay audiences (Jardine & Hrudey 1997).

In an attempt to examine dioxin-related health effects comprehensively, the Environmental Protection Agency (EPA) has assessed and reassessed the toxicity of dioxins repeatedly several times over the past 25 years. The U.S. EPA issued health assessments, reassessments, or draft reassessments in 1985, 1994, 2000, and 2003, and recently issued a reassessment (limited to non-cancer health endpoints) in 2012 (U.S. Environmental Protection Agency (EPA) 1985; 1994; 2000; 2003; 2012). These assessments have reviewed hundreds of toxicological studies, exposure studies, and epidemiological studies. Dioxins have also been the subject of widely publicized political, regulatory and legal actions, including decisions regarding veterans' exposure to dioxin as a contaminant in the herbicide Agent Orange used in Vietnam in the 1970s; relocation of residents of the town of Times Beach, Missouri, where dioxin-contaminated oil was sprayed on roads and flooding spread the contamination to residential soils; and a major lawsuit against Monsanto regarding PCB contamination in soils and waterway sediments in the city of Anniston, Alabama.

Expert uncertainty regarding the health effects of dioxins may make it difficult for laypeople to separate information that is known from what is unknown. Instead, it is possible that lay judgments could range from (a) believing that nothing is known about dioxins with certainty, (b) believing that the odds are fifty-fifty on any particular point of disagreement, to (c) believing that the is one correct side of every point is known with certainty. As a result, laypeople may have widely varying degrees of difficulty in making their own judgments about health risk.

3.2 Dioxins in Midland/Saginaw

One community in which soil and sediment have been found to contain elevated levels of dioxins (above background) is in the city of Midland, Michigan, home of Dow Chemical Company. This contamination also extends downstream along the Tittabawassee River between the cities of Midland and Saginaw. The contamination is believed to have come from Dow's historical incinerator emissions and waste discharge to the river during the early- to mid-1900s. Although incinerator emissions were examined and greatly decreased in the 1980s, elevated dioxin levels were not detected in soil and sediments along the Tittabawassee River until the 1990s. Since this time extensive environmental studies and regulatory actions have been conducted and soil remediation has occurred, is currently underway, or is planned, in areas of Midland and along the Tittabawassee River.

Midland/Saginaw is an ideal location to study perceptions of dioxin hazard and exposure communications. First, dioxin contamination is now known to have been present in this location for a long period of time, over 60 years, resulting in a highly stable situation for retroactive study. Second, extensive data about residents' exposure to dioxins have been collected and made available to the community. Frequent communications about these data, and about the dioxin contamination more generally, have been occurring for over a decade from a wide variety of sources, resulting in a presumed saturation of awareness about dioxins within the community. Third, since many of the health effects of dioxins remain uncertain as discussed above, communications have naturally been limited to hazard and exposure information, omitting any reports of conclusive risk information. In effect, a natural experiment regarding the effects of receipt of hazard and exposure communication has occurred, resulting in a real-world example of many of the theoretical concepts previously discussed.

3.2.1 Hazard and Exposure Communications about Dioxins in Midland and Saginaw

Residents of Midland and Saginaw counties have received hazard and exposure communications about dioxins from a wide variety of sources since the 1980s. Some of these communications have been from federal government sources regarding incinerator and river contamination assessment and oversight of cleanup efforts (U.S. Environmental Protection Agency (EPA) 1988; U.S. Environmental Protection Agency (EPA), Region 5 n.d.; U.S. Agency for Toxic Substances and Disease Registry (ATSDR) 2002). The Michigan Department of Community Health (MDCH) and Michigan Department of Environmental Quality (MDEQ) have produced fact sheets and advisories for residents (Michigan Department of Community Health (MDCH) et al. n.d.). Community groups have developed communications advocating for cleanup (Tittabawassee River Watch 2012). The Dow Chemical Company developed a website on the topic and attended various public meetings. Frequent updates regarding ongoing research, decision-making, and activities by various parties have been provided by media sources such as the Midland Daily News (Lascari 2010), Saginaw News (Engle 2009), local television stations (e.g., WNEM Saginaw Channel 5, WJRT Flint Channel 12), and radio stations (Allee 2009).

Since the health effects of dioxins remain uncertain generally, information from all of these sources has naturally been limited to hazard and exposure information.

Although there has been considerable speculation about potential health effects and risk from some sources (e.g., media interviews with residents discussing their judgments of their own risk), and likely discussions among friends and neighbors regarding their own risk judgments, no conclusive information regarding health risks has been provided.

3.3 University of Michigan Dioxin Exposure Study (UMDES)

Another source of hazard and exposure communications to residents has been a extensive community exposure study. In 2004, in response to concerns that elevated levels of dioxins in the city of Midland and in the Tittabawassee River floodplain may be causing elevated body burdens in residents of these areas, Dow asked researchers from the University of Michigan to conduct a study of residents' exposure (Garabrant et al. 2009). The study, called the University of Michigan Dioxin Exposure Study (UMDES) collected samples of participants' blood, residential soil, and house dust. The goal of the UMDES was to determine whether dioxin contamination in soil and house dust was associated with increased body burdens of dioxins among residents of Midland, Saginaw, and southwestern Bay counties (Garabrant et al. 2009), and to assess potential pathways of exposure.

The UMDES resulted in specific communications to participants and more general communications to the community about the magnitude of dioxin exposure. These communications are discussed in more detail below. By examining the perceptions of receivers of these communications, including study participants and non-participants, a great deal can be learned about perceptions of hazard and exposure information.

3.3.1 UMDES Study Design

The UMDES was a very detailed study of exposure pathways, involving a large number of matched samples of blood, soil, and house dust within multiple populations. Five sub-populations were studied by the UMDES: four in the Midland/Saginaw area, and one in a control area over 100 miles away. The first population, called "Floodplain," consisted of those residing in the 100-year Tittabawassee River floodplain, (as defined by the Federal Emergency Management Administration (FEMA)) downstream of the Dow Chemical Company and upstream of the point where the Tittabawassee River joins the Shiawassee River. Participants who stated during the UMDES interview process that their property had previously been flooded by the Tittabawassee River were also included in the "Floodplain" population. The second population, "Near Floodplain," consisted of those residents who lived outside the floodplain, but in census tracts that included the floodplain. The third population, "Plume," consisted of residents of census tracts within the area of aerosol deposition from the Dow Chemical incinerator plume, as modeled by simulation (see Garabrant et al. 2009, p.804). The fourth population, "Other Midland/Saginaw," consisted of those residing in census blocks within Midland and Saginaw counties or Williams Township in Bay County, but outside the Plume, Floodplain, and Near Floodplain regions defined above, and the outside the floodplain of the Shiawassee and Saginaw rivers. The fifth and final population studied by the UMDES was a control group residing in Jackson and Calhoun counties, an area over 100 miles away from Midland/Saginaw, with no known dioxin contamination above background.

Participants underwent interviews to establish lifetime histories of their diet (fish, game, poultry, dairy, and produce consumption and whether it came from contaminated areas), activities in contaminated areas (e.g., hiking, camping, picnicking, water sports), occupation (including work at Dow Chemical Company or in other occupations with likely exposure), and residential history (Garabrant et al. 2009). An 80-mL sample of blood was drawn from participants who were eligible based on Red Cross guidelines. Outdoor soil and indoor dust samples were collected only from the homes of those participants who owned their home, as non-owners did not have legal authority to provide such samples without the consent of the property owner. Table 3.1 summarizes the number of participants, by region and activities completed.

Table 3.1 UMDES Participants Completing Data Collection Activities

UMDES Participant Group	Participants With Interviews	Participants With Blood Samples	Participants With Soil Samples	Participants With Dust Samples	Participants With All Activities
Midland/Saginaw	965	695 (72%)	566 (74%)	572 (59%)	548 (57%)
Floodplain	326	251 (77%)	207 (63%)	203 (62%)	195 (60%)
Near Floodplain	264	197 (75%)	159 (60%)	164 (62%)	156 (59%)
Plume	71	48 (68%)	37 (52%)	37 (52%)	35 (49%)
Other Mid./Sag.	304	199 (65%)	163 (54%)	168 (55%)	162 (53%)
Jackson/Calhoun	359	251 (70%)	198 (55%)	194 (54%)	183 (51%)
Total	1,324	946 (71%)	764 (58%)	766 (58%)	731 (55%)

Blood, dust, and soil samples were all analyzed for the presence of 29 dioxin-like congeners with TEFs established by the World Health Organization (Garabrant et al. 2009).

3.3.2 UMDES Communications

Communication with participants, residents of the affected communities, and other stakeholders was an important part of the design of the UMDES (Garabrant et al. 2009).

Stakeholders actively involved in the Midland/Saginaw dioxin issue were involved in development of the UMDES study protocol through face-to-face and telephone meetings and/or submission of written comments (Garabrant et al. 2009). Such stakeholders included the Michigan Department of Community Health (MDCH), the Michigan Department of Environmental Quality (MDEQ), local county health departments (Midland, Saginaw, and Bay), environmental groups (Lone Tree Council and the Ecology Center), the Dow Chemical Company, and the Agency for Toxic Substances and Disease Registry (ATSDR) (Garabrant et al. 2009). A Scientific Advisory Board (SAB) of four scientists was established to review the conduct of the study.

Two Community Advisory Panels (CAPs) were established to provide the community with information about the study and to provide UMDES researchers with feedback regarding the concerns of the community (Garabrant et al. 2009). The researchers identified key community leaders for interviews, and conducted focus groups to clarify concerns of the community and solicit nominations for potential CAP members (Garabrant et al. 2009). The researchers developed an outreach and education campaign to provide information to the community through a website (University of Michigan Dioxin Exposure Study n.d.), area physicians, elected officials, public health officials, key community leaders, and public meetings (Garabrant et al. 2009). This information included descriptions of the study and its progress, results, and interpretation of findings. The researchers also conducted focus group research to determine how best to communicate quantitative results from the study (Olson et al. 2006).

The UMDES involved economic risks to participants with respect to analyzing the dioxin content of their soil and house dust (Franzblau et al. 2006; Garabrant et al. 2009). If the results of these analyses were disclosed to the participant this could not only impact the value of the participant's property but also had the potential to impact the participants' use of their property under environmental regulations (Franzblau et al. 2006). Under the MDEQ's current standard, a residential property with a dioxin level in soil of 90 ppt or higher TEQ is considered a "facility" (i.e., a hazardous waste facility). Property owners whose property meets this definition are barred from moving the contaminated soil in ways that may spread the contamination (Franzblau et al. 2006). Simply knowing the results of the soil or dust analyses could have resulted in obligations to disclose these levels to future potential purchasers of the property, which could impact the price these purchasers are willing to pay.

Individual UMDES participants could elect whether or not to receive the results of their own blood, dust, and soil sample analyses. After being made aware of the risks of choosing to receive the results of their soil and house dust sampling, most still chose to receive their results. Approximately 95% of participants elected to receive their blood results, and about two-thirds elected to receive their soil and dust results (see Table 3.2). Those electing to receive them were sent letters by mail containing blood, soil, and house dust results (see Appendix A).

Table 3.2 Summary of UMDES Participants' Choices Regarding Receipt of Results

Participant Group	Percent Choosing to Receive Results		
	Blood	Soil	Dust
Midland/Saginaw			
Floodplain	96%	65%	61%
Non-Floodplain	97%	74%	71%
Jackson/Calhoun	93%	67%	63%
Overall	95%	67%	63%

The present research focuses on several key communications to participants and community members, including the 2004-2005 results letters to participants, and detailed results brochures sent to participants described below.

In August 2006, the UMDES researchers produced a 41-page brochure of the overall study results (University of Michigan Dioxin Exposure Study 2006) (see Appendix B). Focus group research was used to determine how to communicate study results in graphs that would be easy to understand (Olson et al. 2006). The brochure was mailed to all UMDES participants, and disseminated to other residents of the affected communities through alternate channels such as public meetings, posting to the UMDES website, and availability of copies at public locations in the community (e.g., public libraries). The 2006 brochure provided a lay summary of results, including a comprehensive discussion of the effects of factors studied on blood dioxin levels. The brochure stated that some dioxin levels in the study population were higher among: people who were older (p. 7); people who ate fish, especially fish from the Tittabawassee River, Saginaw River, and Saginaw Bay (p. 7); people who ate game (p. 7); people who ate more meat, dairy, or eggs (p. 7); people who lived on property with soil contaminated by some dioxins (p. 7); people with household dust contaminated by a certain dioxin (p. 7); people who lived in some areas of Midland/Saginaw (p. 7); people who did recreational activities around the Tittabawassee River more than once a month (p. 19); people who worked at the Dow plant between 1940 and 1959 (p. 20); men with higher Body Mass Index (BMI) (pp. 13-14); people who lost weight in the last year (p. 14); and people who burned trash or yard waste on their properties between 1940 and 1959 (p. 20) (University of Michigan Dioxin Exposure Study 2006). The brochure stated that dioxin levels were lower in the study population among: people who were younger (p. 7); people who smoked (p. 7); women who breastfed (p. 7); and people who ate more fruits and vegetables (p. 7) (University of Michigan Dioxin Exposure Study 2006).

In January 2011, all Midland and Saginaw residents (not only UMDES participants) were mailed a four-page, large-format brochure of updated study results (University of Michigan Dioxin Exposure Study 2011b) (see Appendix C). This mailing occurred during the present research, but during an ideal point between key phases of data collection in Midland and Saginaw. The updated 2011 brochure restated many of the same conclusions as the 2006 brochure, but also stated that additional analyses had found that blood levels of dioxins in the study population were *not* higher among: people who lived in the Midland/Saginaw area after 1980 (and not in the 1960s and 1970s) (pp. 1, 2); people whose houses were on contaminated soil (pp. 1, 3); people who had contaminated dust in their homes (pp. 1, 3); or people who ate fish from the Tittabawassee River, Saginaw River, and Saginaw Bay (pp. 1, 2) (University of Michigan Dioxin Exposure Study 2011b). This brochure was also posted to the UMDES website. A more detailed, 44-page brochure discussing the study's findings (University of Michigan Dioxin Exposure Study 2011a) (see Appendix D) was made available on the study website and in public locations (e.g., libraries) around the community.

3.3.3 Scope of UMDES Communications

The UMDES was strictly an exposure pathway study. As such, it did not focus on the health effects of dioxins, did not examine the health of participants, and did not assess the risk from dioxin exposure. As a result, nothing in the study communications characterized the relative risk from various levels of dioxin exposure, and information was instead limited to exposure information, and some hazard information.

Results letters to study participants characterized the magnitude of exposure by comparing blood levels and soil levels to reference levels. For example, letters to individual participants regarding blood results compared the participant's blood TEQ with 50^{th}, 75^{th}, 90^{th}, and 95^{th} percentile, mean, minimum, and maximum CDC estimates for background TEQ levels in people of age groups 15-29, 30-44, 45-59, and 60+ (see Appendix A). Letters to participants regarding soil results compared the participant's soil TEQ with the MDEQ regulatory standard of 90 ppt and the EPA standard of 1,000 ppt, and with the 25^{th}, 50^{th}, 75^{th}, and 97.5^{th} percentile, mean, minimum, and maximum background TEQ levels for the lower peninsula of Michigan, as measured by the MDEQ (see Appendix A). No comparison values were given for dust results, as none were available from published sources.

Results brochures (2006 and 2011) provided the results of the exposure study, as described above, and also provided some limited hazard information about dioxins. For example, the 2011 brochure mentioned "toxic effects" and "potential to cause harmful health effects," provided the following quote from a Centers for Disease Control and Prevention (CDC) fact sheet: "Human health effects from low environmental exposures are unclear. People who have been unintentionally exposed to large amounts of these chemicals have developed a skin condition called chloracne, liver problems, and elevated blood lipids (fats). Laboratory animal studies have shown various effects, including cancer and reproductive problems" (University of Michigan Dioxin Exposure Study 2011a; U.S. Centers for Disease Control and Prevention (CDC) 2009), and gave the additional statement "One of the specific dioxins, TCDD, is known to cause cancer in people, and related dioxins are suspected to cause cancer in humans." (University of Michigan Dioxin Exposure Study 2011a). Risk information was not provided.

3.4 Conclusion

Dioxin contamination in Michigan's Midland and Saginaw counties, and a multitude of subsequent hazard and exposure communications, has created a natural experiment ideal for studying risk judgments and satisfaction with chemical hazard exposure communications. The chemical, physical, and communications context have created an ideal setting for the present research, and the previous exposure assessment study provides an extremely useful starting point for further research.

3.5 References

Akhtar, F. et al., 2004. Cancer in US Air Force veterans of the Vietnam War. *Journal of Occupational & Environmental Medicine*, 46(2), pp.123–136.

Allee, S., 2009. Dioxin Delays: A Series by The Environment Report. *The Environment Report*. Available at: http://www.environmentreport.org/dioxin_delays.php [Accessed August 28, 2012].

Bertazzi, P.A. et al., 1998. The Seveso studies on early and long-term effects of dioxin exposure: A review. *Environmental Health Perspectives*, 106(Suppl 2), p.625.

Cole, P. et al., 2003. Dioxin and cancer: A critical review. *Regulatory Toxicology and Pharmacology*, 38(3), pp.378–388.

Engle, J., 2009. Dow, environment agencies could sign Saginaw, Tittabawassee river clean-up plan in October. *The Saginaw News*. Available at: http://www.mlive.com/news/saginaw/index.ssf/2009/09/dow_environment_agencies_could.html [Accessed August 28, 2012].

Fowles, J. et al., 2004. *A Study of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) Exposures in Paritutu, New Zealand: Phase II Serum Testing*, Available at: http://www.dioxinnz.com/pdf-NZ-Gov/NZGOV-MOH-STUDY-PHASE-2-INTRIM-RPT-2004.pdf [Accessed October 16, 2012].

Franzblau, A. et al., 2006. Human subject considerations in environmental research: The University of Michigan Dioxin Exposure Study. *Organohalogen Compounds*, 68, pp.1315–1318.

Garabrant, D. et al., 2009. The University of Michigan Dioxin Exposure Study: Methods for an environmental exposure study of polychlorinated dioxins, furans, and biphenyls. *Environmental Health Perspectives*, 117(5), p.803.

Horii, Y. et al., 2008. Novel evidence for natural formation of dioxins in ball clay. *Chemosphere*, 70(7), pp.1280–1289.

International Agency for Research on Cancer (IARC), 1997. Polychlorinated Dibenzo-para-dioxins and Polychlorinated Dibenzofurans. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*, 69. Available at: http://monographs.iarc.fr/ENG/Monographs/vol69/ [Accessed June 18, 2012].

Jardine, C.G. & Hrudey, S.E., 1997. Mixed messages in risk communication. *Risk Analysis*, 17(4), pp.489–498.

Lascari, T., 2010. EPA, DEQ have dioxin agreement with Dow Chemical Co. in place. *Midland Daily News*. Available at: http://www.ourmidland.com/local_news/article_f2d45d95-eb88-5beb-a47d-483d754ec83f.html [Accessed August 28, 2012].

Mackie, D. et al., 2003. No evidence of dioxin cancer threshold. *Environmental Health Perspectives*, 111(9), pp.1145–1147.

Michigan Department of Community Health (MDCH), Michigan Department of Environmental Quality (MDEQ) & Michigan Department of Agriculture (MDA), *Dioxins Fact Sheet*, Lansing, Michigan: Michigan Department of Community Health (MDCH).

Morgan, M.G. et al., 2002. *Risk Communication: A Mental Models Approach*, Cambridge, UK: Cambridge University Press.

Olson, K. et al., 2006. Communicating complex research results regarding environmental risk to a lay audience: Experiences from the University Of Michigan Dioxin Exposure Study. *Organohalogen Compounds*, 68, pp.1350–1352.

Schecter, A.J., Ryan, J.J. & Constable, J.D., 1986. Chlorinated dibenzo-p-dioxin and dibenzofuran levels in human adipose tissue and milk samples from the north and south of Vietnam. *Chemosphere*, 15(9–12), pp.1613–1620.

Silverstone, A.E. et al., 2012. Polychlorinated biphenyl (PCB) exposure and diabetes: Results from the Anniston Community Health Survey. *Environmental Health Perspectives*, 120(5), pp.727–732.

Tittabawassee River Watch, 2012. Tittabawassee River Watch Home page. Available at: http://trwnews.net/ [Accessed August 28, 2012].

U.S. Agency for Toxic Substances and Disease Registry (ATSDR), 2002. *Petitioned Public Health Consultation: Dioxin Contamination in the Tittabawassee River Floodplain South of Midland, Michigan*, Prepared by Michigan Department of Community Health Under a Cooperative Agreement with the Agency for Toxic Substances and Disease Registry. Available at: http://www.atsdr.cdc.gov/HAC/pha/PHA.asp?docid=470&pg=0 [Accessed August 28, 2012].

U.S. Agency for Toxic Substances and Disease Registry (ATSDR), 1998. *Toxicological Profile for Chlorinated Dibenzo-p-Dioxins*, Atlanta, GA: Agency for Toxic Substances and Disease Registry. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp104.pdf [Accessed December 17, 2012].

U.S. Agency for Toxic Substances and Disease Registry (ATSDR), 2000. *Toxicological Profile for Polychlorinated Biphenyls (PCBs)*, Atlanta, GA: Agency for Toxic Substances and Disease Registry. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.pdf [Accessed July 30, 2012].

U.S. Centers for Disease Control and Prevention (CDC), 2009. *Dioxins, Furans and Dioxin-Like Polychlorinated Biphenyls*, Washington, D.C.: U.S. Centers for Disease Control and Prevention (CDC). Available at: http://www.cdc.gov/biomonitoring/DioxinLikeChemicals_FactSheet.html [Accessed October 10, 2012].

U.S. Environmental Protection Agency (EPA), 2000. *Draft Dioxin Reassessment: Draft Exposure and Human Health Reassessment of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and Related Compounds*, Washington, DC. Available at: www.epa.gov/ncea/pdfs/dioxin/ [Accessed June 18, 2012].

U.S. Environmental Protection Agency (EPA), 2012. *EPA's Reanalysis of Key Issues Related to Dioxin Toxicity and Response to NAS Comments, Volume 1*, Available at: http://www.epa.gov/iris/supdocs/1024index.html [Accessed June 18, 2012].

U.S. Environmental Protection Agency (EPA), 2003. *Exposure and Human Health Reassessment of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and Related Compounds*, Washington, DC. Available at: http://www.epa.gov/ncea/pdfs/dioxin/nas-review/ [Accessed June 19, 2012].

U.S. Environmental Protection Agency (EPA), 1994. *Health Assessment Document for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and Related Compounds*, Washington, DC. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=37015 [Accessed June 18, 2012].

U.S. Environmental Protection Agency (EPA), 1985. *Health Assessment Document for Polychlorinated Dibenzo-p-dioxins*, Washington, DC. Available at: http://cfpub.epa.gov/ncea/CFM/recordisplay.cfm?deid=38484 [Accessed June 19, 2012].

U.S. Environmental Protection Agency (EPA), 1988. *Michigan Dioxin Studies: Incinerator Exhaust and Ambient Air Study Fact Sheet, Midland, Michigan*, Chicago, IL: U.S. EPA Office of Public Affairs, Region 5. Available at: http://nepis.epa.gov/Exe/ZyNET.exe/200160CU.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1986+Thru+1990&Docs=&Query=&Time=&EndTime=&SearchMethod

=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C86thru90%5CTxt%5C00000015%5C200160CU.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL# [Accessed August 28, 2012].

U.S. Environmental Protection Agency (EPA), Region 5, Region 5 Cleanup Sites: Tittabawassee River, Saginaw River & Bay Site. Available at: http://www.epa.gov/region5/cleanup/dowchemical/index.htm [Accessed August 28, 2012].

University of Michigan Dioxin Exposure Study, 2006. *Measuring People's Exposure to Dioxin Contamination Along the Tittabawassee River and Surrounding Areas: Findings from the University of Michigan Dioxin Exposure Study*, Ann Arbor, MI: University of Michigan. Available at: http://www.sph.umich.edu/dioxin/PDF/UMDES%20Brochure_FINAL_08042006_lores.pdf [Accessed January 10, 2012].

University of Michigan Dioxin Exposure Study, 2011a. *Measuring People's Exposure to Dioxin Contamination Along the Tittabawassee River and Surrounding Areas: Findings from the University of Michigan Dioxin Exposure Study 2011 Updated*, Ann Arbor, MI: University of Michigan. Available at:

http://www.sph.umich.edu/dioxin/PDF/2011%20results/Booklet_01112011.pdf [Accessed January 10, 2012].

University of Michigan Dioxin Exposure Study, 2011b. *U-M Dioxin Study: What You Need to Know Summary*, Ann Arbor, MI: University of Michigan. Available at: http://www.sph.umich.edu/dioxin/PDF/2011%20results/tabloid_01112011.pdf [Accessed January 10, 2012].

University of Michigan Dioxin Exposure Study, University of Michigan Dioxin Exposure Study. Available at: http://www.sph.umich.edu/dioxin/ [Accessed January 11, 2012].

Van den Berg, M. et al., 2006. The 2005 World Health Organization reevaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. *Toxicological Sciences*, 93(2), pp.223–241.

World Health Organization (WHO), 2005. 2005 Re-Evaluation of Human and Mammalian Toxic Equivalency Factors (TEFs). Available at: http://www.who.int/foodsafety/chem/tef_update/en/index.html [Accessed June 18, 2012].

Yanders, A.F., 1986. The Missouri dioxin episode. *Chemosphere*, 15(9–12), pp.1571–1576.

Chapter 4

Research Approach and Specific Aims

The present research examines risk judgments and satisfaction with hazard and exposure communications in the context of a community that has experienced dioxin contamination, a subsequent exposure assessment study, and a multitude of communications from various sources. This setting is ideal for additional research regarding the effects of hazard and exposure communication. As part of a larger mental models study, the present research examines risk judgments about dioxins and satisfaction with information received in this community setting. This chapter provides background about the existing mental models study, additions to it, and presents specific aims and an analytical model for the present research.

4.1 Community Perceptions of Dioxins (CPOD) Study

In 2009, the National Institute for Environmental Health Sciences (NIEHS) funded a research proposal by researchers at the University of Michigan School of Public Health to examine perceptions of dioxins among residents of Midland and Saginaw counties. The resulting study, titled Community Perceptions of Dioxins (CPOD), was used to simultaneously collect data for the present research. The CPOD study used a modified version of the mental models approach to risk communication (Morgan et al. 2002) to examine the mental models of residents who have been exposed to messages about dioxins from living in an area with known dioxin contamination and/or participating in a dioxin exposure study.

4.1.1 CPOD Study Design

The CPOD study examined mental models of the process of dioxin exposure and health effects. The study was conducted in three phases. Phase 1 involved creating an expert model elicited through expert interviews. Phase 2 involved identifying potential misconceptions and gaps through comparison of the expert model with lay mental models elicited through lay interviews. Phase 3 involved assessing the prevalence of these misconceptions or gaps among the population of interest through a mailed survey to a larger sample of the population.

For its study population, the CPOD study followed up with both UMDES participants and non-participants (residents of Midland/Saginaw), and, as an addition for the present research, UMDES control participants (residents of Jackson/Calhoun). These three groups have each potentially received and processed quite different sets of hazard and exposure communications and as a result represent an interesting population in which to explore satisfaction with communications. UMDES participants residing in Midland/Saginaw received communications directly from the UMDES, and, as residents of Midland/Saginaw, also received information from the experience of living in an area with known dioxin contamination. Non-UMDES participants residing in Midland/Saginaw shared the experience of living in an area with known dioxin contamination and potentially received communications from many of the same sources. These participants also may have received public communications by the UMDES (e.g., brochures, public meetings), but did not receive communications from direct participation in the study (e.g., personal results letters). UMDES participants residing in Jackson/Calhoun received identical communications directly from the UMDES, but did not receive other communications from other sources as Midland/Saginaw residents. In addition to receipt of varying communications, the different lived experiences of each group (e.g., living in an area with known dioxin contamination, participating in an exposure assessment study) could affect how residents within that group interpreted the communications they received. This has resulted in a natural experiment, with different groups receiving hazard and exposure communications about dioxins from a variety of sources under natural conditions and potentially interpreting these communications in different ways.

4.1.2 Additions to the CPOD Study

The present research has expanded the CPOD study to measure additional variables and collect data in the Jackson/Calhoun UMDES participant population (see Table 4.1).

The original CPOD study intended to collect data regarding the mental models of residents of Midland/Saginaw only. For the present research, the CPOD study was extended to include Jackson/Calhoun residents who had participated in the UMDES as a control population. Questions regarding satisfaction with information, more detailed questions regarding judgments of health risk, and questions regarding the ability to make these judgments were also added for the present research. Use of a mental models approach allowed a deeper exploration of these variables, as well as a direct examination of how mental model attributes affect other risk judgments and satisfaction with information.

Table 4.1 Existing CPOD Study and Additions

Phase 2 Component	Original CPOD study	Additions for present research
Interview questions and post-interview questionnaire items regarding health risk judgments	Limited to participant judgment of their own risk from dioxins	• Questions specific to participant judgment of health risk to themselves, their families, and their community • Questions regarding perceived ability to make cognitive/affective health risk judgments
Post-interview questionnaire items regarding satisfaction	None	• Questions regarding participant satisfaction with state of knowledge and messages received
Qualitative mental models interview participants	Limited to Midland/Saginaw residents only	• Extended to include Jackson/Calhoun residents
Phase 3 Component	**Original CPOD study**	**Additions for present research**
Mailed survey items regarding health risk judgments	Limited to participant judgment of their own risk from dioxins	• Questions specific to participant judgment of health risk to themselves, their families, and their community • Questions regarding perceived ability to make health risk judgments
Mailed survey items regarding satisfaction	None	• Questions specific to participant satisfaction with state of knowledge and messages received
Mailed survey recipients	Limited to Midland/Saginaw residents only	• Extended to include Jackson/Calhoun residents

4.2 Specific Aims

The present research seeks to determine whether people who have received hazard and exposure information are more likely to be satisfied with that information if they are able to more easily judge the resulting health risk. Specific aims of the present research are listed below.

1. *Risk Judgments.* To assess judgments about resulting personal/family or community health risks, and perceived difficulty in making these judgments, among residents exposed to messages about dioxins (participants and non-participants in an exposure study).
   1a. To investigate whether health risk judgments, and/or perceived difficulty in making these judgments, vary with the communications residents have received.
   1b. To consider to what degree numeracy and other personal characteristics moderate residents' health risk judgments and/or perceived ability to make these judgments.
2. *Mental Models.* To investigate the extent to which residents' mental models of dioxin exposure/risk mediate their health risk judgments and/or perceived difficulty in making these judgments.
   2a. To determine whether residents' mental models are directly affected by communications received.
   2b. To determine whether residents' mental models are directly affected by numeracy and other personal characteristics.
   2c. To determine whether residents' health risk judgments and/or their difficulty in making to make these judgments are directly affected by their mental models.
   2d. To determine whether residents' mental models mediate the effect of communications received and personal characteristics on their health risk judgments and/or their perceived difficulty in making these judgments.
3. *Satisfaction.* To investigate whether residents' health risk judgments, and/or perceived difficulty in making these judgments, directly influence their satisfaction

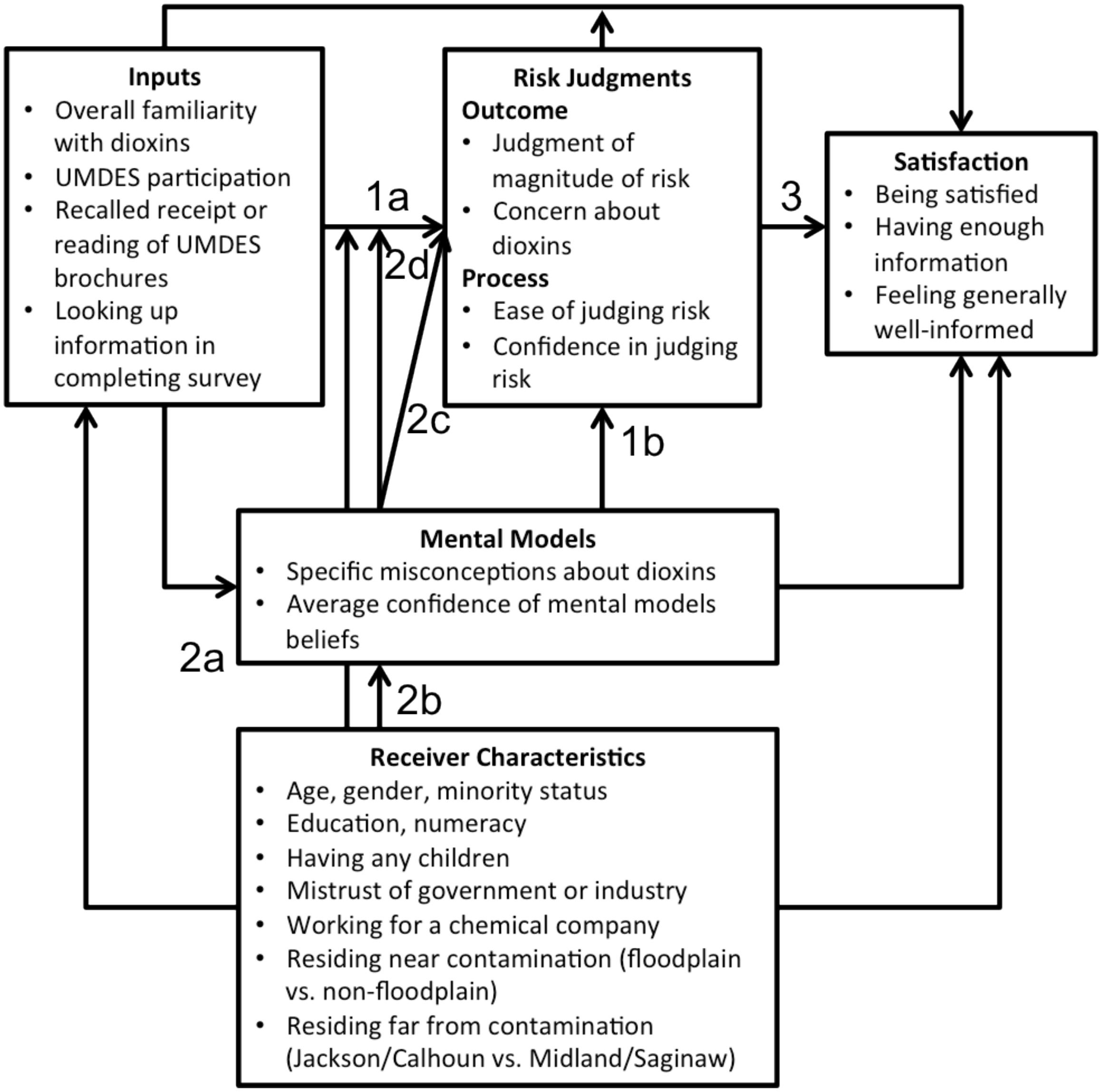
with their level of knowledge about dioxins and/or their satisfaction with the information they have received or gathered about dioxins.

3a. To determine whether residents' health risk judgments, and/or perceived difficulty in making these judgments, mediate residents' satisfaction with their state of knowledge and the information they have received or gathered.

4.3 Analytical Model

Analysis of data from the quantitative survey in Phase 3 is approached in three stages, each corresponding to one set of my specific aims regarding (1) risk judgments, (2) mental models, and (3) satisfaction. An analytical model describing the relationships between variables at each of these three stages is shown in Figure 4.1 and discussed in further detail below.

Figure 4.1 Analytical Model (Numbers Correspond to Specific Aims)



4.3.1 Risk Judgments

The first stage of my analysis involves determining the effect of Receiver Characteristics and Information Received on Risk Judgments (Specific Aims 1, 1a, 1b, as illustrated in Figure 4.1).

Information Received variables relate to differences in information received by participants. These include variables regarding receipt of UMDES communications, such as recalled receipt of UMDES brochures and UMDES participation, as well as variables related to overall familiarity with dioxins, including self-assessed familiarity and exposure to news media (e.g., Jackson/Calhoun vs. Midland/Saginaw), and whether the participant consulted other sources in answering question.

Receiver Characteristics include variables related to individual differences among participants. These include variables known to affect risk judgments, such as gender, race/ethnicity, and mistrust of government or industry. They also include variables related to processing of information, including education, numeracy, and location as a measure of perceived relevance (e.g., Midland/Saginaw versus Jackson/Calhoun, floodplain versus non-floodplain). Working for a chemical company is also included as a measure of past experience with chemicals more generally. Age and location may be related both to processing of information and past experiences with dioxins and chemicals more generally.

Risk Judgments include variables related to judgments of the magnitude of health risk from dioxins, such as judgments of whether health risk from dioxins is low or high, concern about health risk from dioxins; as well as measures of confidence and ease of judging health risk. These variables are intended to capture both cognitive and affective measures of receivers' health risk judgments and subjective ability to make these judgments.

I hypothesize that Receiver Characteristics and Information Received will have direct effects on Risk Judgments. In particular, I hypothesize that the magnitude of health risk judgments, or levels of concern, will be affected by living in the contaminated area (i.e., Midland/Saginaw versus Jackson/Calhoun, floodplain versus non-floodplain) and by exposure to UMDES communications, by mistrust of government and industry, and also potentially by demographic variables (age, gender, race/ethnicity, numeracy, education, children, and working at a chemical company). I hypothesize that the ability to judge health risk, or confidence in judging health risk, will be affected by overall familiarity with dioxins, location as a measure of exposure to media (i.e., Midland/Saginaw versus Jackson/Calhoun), and recalled receipt of UMDES brochures, as well as demographic variables such as numeracy, education, and working at a chemical company.

4.3.2 Mental Models

The second analysis stage involves examining the effects of Mental Models variables on Risk Judgments (Specific Aims 2, 2a, 2b, 2c, 2d, as illustrated in Figure 4.1).

Mental Models variables include variables related misconceptions, completeness, or other characteristics of participants' mental models. These include misconceptions, such as concern about non-significant water or dermal exposure pathways, or beliefs that dioxins are created by additional non-significant sources. Mental models variables also include more general beliefs about whether dioxins in the environment are increasing or decreasing and beliefs about whether there is an exposure threshold below which dioxins do not cause health effects. Finally, mental models variables also include measures of strength of beliefs, assessed by measuring confidence ratings in answers to mental models questions.

I hypothesize that Mental Models variables may mediate the effects of Receiver Characteristics and Information Received on Risk Judgments. In particular, I hypothesize that Mental Models misconceptions and confidence may mediate the effect on ability to judge health risk and confidence in judging health risk of Receiver Characteristics and Information Received such as familiarity with dioxins, location as a measure of exposure to news media (i.e., Midland/Saginaw versus Jackson/Calhoun), and recalled receipt of UMDES brochures, as well as demographic variables such as numeracy, education, and working at a chemical company. Mental Models misconceptions and confidence may also mediate the effect on the magnitude of health risk judgments, or levels of concern, of living in the contaminated area (i.e., Midland/Saginaw versus Jackson/Calhoun, floodplain versus non-floodplain), and exposure to UMDES communications, by mistrust of government and industry, and demographic variables (age, gender, race/ethnicity, numeracy, education, children, and working at a chemical company).

4.3.3 Satisfaction

The third and final stage involves examining the effect of Risk Judgments on Satisfaction variables (Specific Aims 3 and 3a, as illustrated in Figure 4.1).

Satisfaction variables include variables related to receiver satisfaction with total information received or gathered to date. These include assessments of feeling satisfied with the information gathered or received about dioxins, feeling one has enough information about dioxins, and feeling generally well-informed about dioxins.

I hypothesize that Risk Judgment variables will mediate some of the effects of Receiver Characteristics, Information Received, and Mental Models on Satisfaction. In particular, I hypothesize that ease of judging health risk and/or confidence in judging health risk will mediate the effects of other variables on Satisfaction. As a competing hypothesis, judgments of the magnitude of health risk or level of concern could also mediate effects on Satisfaction.

4.4 Reference

Morgan, M.G. et al., 2002. *Risk Communication: A Mental Models Approach*, Cambridge, UK: Cambridge University Press.

Chapter 5

Methods and Participants

The present research was conducted in three phases, concurrent with the phases of the Community Perceptions of Dioxins (CPOD) study. In Phases 1 and 2, CPOD staff conducted mental models interviews with experts (n=5) and laypeople (n=50) to establish expert and lay mental models for further investigation by the CPOD study in Phase 3. Lay interviews also included questions about risk judgments as additions for the present research, and lay participants completed a brief questionnaire that further assessed risk judgments, and satisfaction with information, also as additions for the present research. The purpose of Phases 1 and 2 was to gather preliminary data, including a rich set of qualitative data, and to pilot test potential questions for the mailed survey in Phase 3.

5.1 Phase 1 Expert Interview Methods and Results

The purpose of Phase 1 was to develop an expert mental model of dioxin exposure and health risk for the CPOD study to use in identifying gaps and misperceptions in Phase 2 layperson interviews. I made no additions to CPOD Phase 1 for purposes of the present research.

5.1.1 Phase 1 Participants

Five experts familiar with dioxins participated in interviews in CPOD Phase 1. Four were specifically familiar with the dioxin contamination in Midland and Saginaw counties, and one was familiar with contamination in other locations. Two were from local government agencies, one was from a federal government agency, one was from a community activist group, and one was from academia. Two additional experts from a state government agency declined to participate. One expert was female and four were male.

5.1.2 Phase 1 Interview Methods

Expert interviews ranged from 52 to 82 minutes in length, with an average length of 64 minutes. A single interviewer trained in the mental models technique conducted all five interviews. One or more additional CPOD study team members were also present at each interview. One of the interviews was conducted by telephone, and four were conducted in person.

Interviews used a mental models interviewing format designed to assess interviewee knowledge without providing additional information. The CPOD study team developed the interview guide based on available mental models interview guides for environmental topics (e.g., radon) (Morgan et al. 2002). Except for some refinements added after the first interview, the same guide was used for all five expert interviews. The guide covered general information first and probed more specific areas later to avoid introducing new information. Interviews started with the general prompt, "Tell me about dioxins…." moved to more specific probes such as, "Can you tell me (more) about how dioxins get into people?" The CPOD interviewer generally provided the probes in order but adapted the sequence for each interview to allow follow up on topics as they were mentioned. See Appendix E for a reproduction of the full expert interview guide.

5.1.3 Phase 1 Analysis and Expert Model Construction

Interviews were audio recorded, and a CPOD study team member then transcribed each interview verbatim. Three CPOD study team members then independently analyzed each transcript as it was completed and drafted an influence diagram of the nodes and connections described in the transcript. These CPOD study team members also analyzed each additional transcript was analyzed for new nodes and connections to add to the influence diagrams. Resulting drafts by the individual team members were iterated until agreement was reached with the full CPOD study team as to the scope and level of detail required for use in Phase 2.

The expert model developed is reproduced in Appendix F. The model consists of an influence diagram made up of nodes connected by arrows, in which each arrow denotes that the node at the arrow's base influences the node at the arrow's base.

5.2 Phase 2 Layperson Interview Methods

The purpose of CPOD Phase 2 was to identify, through mental models interviews with laypeople, gaps and misperceptions in lay mental models that could be assessed for frequency in a larger sample in Phase 3. I added questions added to Phase 2 interviews for the present research, and to the Phase 2 a post-interview questionnaire, to gather pilot data in preparation for the larger survey in Phase 3.

5.2.1 Phase 2 Participant Recruitment

The CPOD study recruited participants from three populations: (1) former University of Michigan Dioxin Exposure Study (UMDES) participants from Midland/Saginaw counties, (2) non-UMDES participants from Midland/Saginaw counties (residents of the same neighborhoods as UMDES participants, but who were not approached to participate in the UMDES) and, (3) former UMDES participants from the control group in Jackson/Calhoun counties.

Since the goal in Phase 2 was to obtain a varied point of view (i.e., a wide range of potential mental models gaps and misconceptions) within each population, the CPOD study employed a purposeful sampling approach, specifically targeting individuals based on two types of variables expected to affect the information the participants had received.

The first variable used to stratify Phase 2 participants for purposeful sampling was location. For UMDES participants, the CPOD study stratified location into five groups corresponding with the five UMDES sub-populations: Floodplain, Near Floodplain, Plume, Other Midland/Saginaw, and Jackson/Calhoun. For non-UMDES participants, the CPOD study stratified location into two groups: Floodplain/Near Floodplain and Other Midland/Saginaw. The study focused on location because the study team hypothesized that this would affect mental models beliefs and other perceptions. Individuals living in these regions may have been exposed to different information (e.g., news media, guidance from local public health agencies, etc.), and they may have perceived such information as varying in relevance. In particular, those who lived closer to the floodplain may have perceived greater relevance to information about dioxins, since the contamination of the Tittabawassee River floodplain has been well-publicized in the Midland/Saginaw region.

The second variable was receipt of UMDES results. (For non-UMDES participants, this variable was not used.) The CPOD study used slightly different approaches for Midland/Saginaw and Jackson/Calhoun UMDES participants. The study first divided Midland/Saginaw UDMES participants into two groups: those who had elected to receive all of their individual results and those who had refused one or more of their individual blood, soil, or house dust results. The study then further subdivided Midland/Saginaw participants on the basis of whether or not they had one or more "high" individual results. "High" results were defined as soil testing results over 90 ppt or blood testing results greater than or equal to the 75th percentile for the participant's age. The CPOD study chose a soil threshold of 90 ppt because this was the level at which the participant's property could be declared a "facility" by the Michigan Department of Environmental Quality (MDEQ). The study chose a blood threshold of the 75th percentile because participants were given comparison tables in their individual blood results letters stating the national average 5th, 50th, 75th, and 95th percentiles for blood levels by age (see Appendix A). The study stratified Jackson/Calhoun participants only by whether they had one or more "high" results, and not by whether they elected to receive all results. This was because most "high" results in the Jackson/Calhoun population were blood results (not soil or house dust), and nearly all Jackson/Calhoun participants had elected to receive their individual blood results.

CPOD staff sent targeted mailings to each of the intended sub-groups in waves to achieve a balanced number of participants in each subgroup. Letters directed participants to telephone a study team member to schedule an interview at their convenience. To be eligible for an interview, participants had to reside in the area of interest, be 18 years of age or older, have lived in their current home for one or more years, and speak fluent English, and be available for the interview to be conducted in person. The CPOD study team made decisions collectively regarding the number of interviews to obtain from each group as the interviews progressed. CPOD staff mailed letters to approximately one dozen randomly selected subgroup members and repeated this process approximately every one to two weeks until a sufficient number of interviews had been scheduled. A total of 269 letters were mailed: 96 to Midland/Saginaw UMDES participants, 75 to Midland/Saginaw non-UMDES participants, and 98 to Jackson/Calhoun UMDES participants. Mailings and responses are summarized in Table 5.1.

Table 5.1. Mailings and Enrollment in Phase 2

	Mailed	Un-deliverable	Do Not Contact	Un-available [a]	Completed	Response Rate [b]
Midland/ Saginaw UMDES	96	9	15	2	26	31%
Mailing 1	16	0	4	--	5	--
Mailing 2	16	2	2	--	2	--
Mailing 3	32	4	5	--	10	--
Mailing 4	17	1	4	--	4	--
Mailing 5	15	2	0	--	5	--
Midland/ Saginaw non-UMDES	75	4	6	0	8	11% [d]
Mailing 1 [c]	75	4	6	--	8	--
Jackson/ Calhoun UMDES	98	8	8	0	16	18% [d]
Mailing 1	24	0	4	--	5	--
Mailing 2	24	4	4	--	1	--
Mailing 3 [c]	50	4	0	--	10	--

[a] Out of town (e.g., at a summer or winter residence) and unavailable for in-person interview.
[b] Response Rate = Completed / (Mailed - Undeliverable - Unavailable)
[c] Follow-up activities ceased and two-week reminder cards were not sent to these mailing groups.

[d] Response rate is likely artificially low due to ceasing follow-up activities.

Interviews began with the Midland/Saginaw UMDES group, and continued with this group until the CPOD study team judged that new topics were no longer being raised by participants in each interview (26 interviews total). Interviews continued with the Midland/Saginaw Non-UMDES group, until the CPOD study team judged that topics different from those discussed by Midland/Saginaw UMDES participants were not being raised (8 interviews total). Finally, interviews proceeded with the Jackson/Calhoun UMDES group, and continued until the CPOD study team judged that new topics were not being raised (16 interviews total). At this point, CPOD staff ceased follow-up activities (reminder mailings, telephone calls, etc.) and additional mailings.

A summary of Phase 2 participant stratification is given in Table 5.2.

Table 5.2. Stratification of Phase 2 Participants

UMDES Participation	**Region**				**Participants [n (% of total)]**
Midland/Saginaw UMDES Participants	**Flood Plain**	**Near Flood Plain**	**Plume**	**Other Midland/ Saginaw**	
Participants receiving all UMDES results					
With one or more "high" UMDES results	2	1	2	2	7 (14%)
With all low UMDES results	2	1	2	2	7 (14%)
Participants refusing one or more UMDES results [a]					
With one or more "high" UMDES results	2	1	2	2	7 (14%)
With all low UMDES results	0	1	2	2	5 (10%)
Midland/Saginaw Non-UMDES Participants	**Flood Plain or Near Flood Plain**		**Plume or Other Midland/Saginaw**		
	4		4		8 (16%)
Jackson/Calhoun UMDES Participants	***Not stratified by region***				

	With one or more "high" UMDES results [b]	*Not stratified by region*	7 (14%)
	With all low UMDES results	*Not stratified by region*	9 (18%)
Total			50 (100%)

[a] At UMDES participants' request, blood, dust, and/or soil results may or may not have been returned to participants.
[b] Jackson/Calhoun participants were not stratified on the basis of receipt of results.

5.2.2 Phase 2 Interview Methods

The CPOD interview guide for the Phase 2 layperson interviews was based on the expert interview guide from Phase 1, but with several revisions. First, the CPOD study team added questions to further explore topics found to be important parts of the expert model developed in Phase 1, including more specific probes about how dioxins get into the community and where they go, who is responsible for managing dioxins, and whether the participant knew anyone with health issues believed to be related to dioxins. The study team also added an open-ended question was added to the end of the interview guide asking if there was anything the participant would like to add about dioxins. In addition, I added questions specifically for the present dissertation research about the participant's judgment of his or her individual risk, and the ease or difficulty of making this judgment. See Appendix G for the full lay interview guide.

The CPOD team then pilot tested the lay interview guide by conducting two complete mental models interviews, first with a study team member and then with a University of Michigan student from the Midland/Saginaw area. Once pilot testing was complete, the team received Institutional Review Board approval and obtained a Certificate of Confidentiality to continue original protections on UMDES data.

All 50 interviews were conducted by the same interviewer, a CPOD study team member with previous experience conducting qualitative interviews who was trained in the mental models interviewing technique. An additional CPOD study team member accompanied the interviewer on interviews of three Midland/Saginaw UMDES participants and two Jackson/Calhoun UMDES participants.

Interviews took place in participants' homes, with the exception of one interview that took place at a restaurant near the participant's place of work. One participant declined to answer a number of the interview questions, resulting in an interview that was only 9 minutes long. The remaining interviews lasted from 22 to 105 minutes each, with an average duration of 44 minutes. Following each interview, participants completed a brief questionnaire.

5.2.3 Phase 2 Post-Interview Questionnaire Design

Phase 2 post-interview questionnaires consisted of 54 questions divided into eight sections (see Table 5.3). The full questionnaire, with summary results for each question, is presented in Appendix H.

Table 5.3 Phase 2 Post-Interview Questionnaire Structure

Section	Variable(s) Assessed	Item Numbers in UMDES Version	Item Numbers in Non-UMDES Version
1. Testing of dioxins in soil, dust, and blood	Receiver Characteristics/ Information Received	1-3	1-3
2. Information received about dioxins	Information Received	4-5	4
3. Judgments of dioxin levels in soil, dust, and blood	Receiver Characteristics/ Information Received	6-11	5-10
4. Risk judgments about dioxins [a]	Risk Judgments	12-19	11-18

5. Satisfaction with information about dioxins [a]	Receiver Satisfaction	20-31	19-30
6. Feelings about industry and government	Receiver Characteristics	32-38	31-37
7. Subjective numeracy scale	Receiver Characteristics	39-46	38-45
8. Demographics	Receiver Characteristics	47-54	46-53
	Total (n)	54	53

[a] Addition to the CPOD study for the present research.

The first three sections dealt with UMDES-related receiver characteristics and information received. They asked participants (1) whether they had ever received blood/dust/soil testing results, (2) whether they recalled receiving the 2006 UMDES results brochure and how much they followed news about dioxins in their community, and (3) to provide their own subjective assessments of their blood/dust/soil levels in relation to average concentrations in Michigan and nationwide (below average, about average, above average).

The next two sections dealt with risk judgments and satisfaction. Section 4 asked participants to rate their level of concern about exposure and risk from dioxins to themselves, their families, and their community, and questions about whether they had a clear feeling about these risks. Section 5 asked participants' opinions about the information they had received about dioxins, including whether they were satisfied with the information, whether they felt well-informed, whether they had gotten enough information about dioxins, and how accurate, confusing, or biased they believed the information to be.

The remaining sections dealt with additional receiver characteristics. Section 6 asked about participants' feelings about government and industry, using questions adapted from three existing surveys regarding industrial accidents (Johnson & Chess 2003, n=3) and attitudes toward government (National Public Radio et al. 2007, n=4).

The final two sections (7 and 8) included a validated 8-item Subjective Numeracy Scale (Fagerlin et al. 2007) and questions about participant demographics (age, gender, race/ethnicity, education, tenure in current home, children, previous work at a chemical company).

5.2.4 Phase 2 Interview Coding

Interviews were audio-recorded and later transcribed verbatim by the CPOD interviewer. One interview was not audio-recorded at the participant's request; the study used detailed notes taken by the interviewer in place of a verbatim transcript.

Four members of the CPOD study team then examined each transcript sentence-by-sentence and coded each sentence for nodes and connections from the expert model, as well as for other topics discussed. The team assigned codes using a coding model based on the expert model, adding new nodes and connections where needed to represent lay misconceptions that did not appear in the expert model. For example, the team created new nodes for dioxin concentration in drinking water (a misconception, since experts told us dioxins were not soluble in water), for dermal exposure (also a misconception, since experts told us dermal exposure was possible, but unlikely to be significant for the population in Midland/Saginaw) and for "other sources" of dioxins (sources not identified by the experts we interviewed). The team also added nodes to represent concepts that were needed to represent lay models but had not been needed for expert models, such as the more general concept of exposure from "the environment" (without specifying a source) and the more general concept of "intake" (without specifying a route). The team also added more abstract nodes to represent other concepts mentioned by participants as affecting exposure such as "distance" (e.g., from emissions sources) and "mitigation strategies." Additional codes, referred to as "flags," were used to mark portions of the interview where sources of information, risk judgments, and other non-mental-model-related topics were discussed.

Four CPOD study team members were responsible for coding, with two of these designated as primary coders and two as secondary. To achieve consistency, all four coders met together as a group to code the first three Midland/Saginaw UMDES interviews. Input from other CPOD study team members was sought to resolve disputes, and the coding model was revised accordingly. Each subsequent interview was coded separately by a primary and a secondary coder, who then met to discuss and resolve any discrepancies. The two primary coders also met periodically to discuss the application of codes in order to maintain consistency, and sought input from the CPOD primary investigator to address any questions as they arose.

5.3 Phase 2 Findings Informing Phase 3

I analyzed Phase 2 interview sections regarding risk judgments, as well as post-interview questionnaire questions regarding risk judgments and satisfaction, to assist with the development of survey questions in Phase 3. Findings regarding these topics, as well as a summary of characteristics of Phase 2 participants, are summarized below.

5.3.1 Phase 2 Participants

A total of 50 people (30 male, 20 female) completed Phase 2 interviews and post-interview questionnaires (see Table 5.4).

Table 5.4 Selected Characteristics of Phase 2 Participants

Characteristic	Participants [*n* (%)] [a]
Previous UMDES participation	
Midland/Saginaw UMDES participants	26 (52%)
Midland/Saginaw non-UMDES participants	8 (16%)
Jackson/Calhoun UMDES participants [b]	16 (32%)
Sex	
Male	30 (60%)
Female	20 (40%)
Race	
White	49 (98%)
Other	1 (2%)
Age	
<40	1 (2%)
40-49	8 (16%)
50-59	13 (26%)
60-69	13 (26%)
70-79	10 (20%)
≥80	5 (10%)
Education	
Some high school, high school diploma or equivalent	13 (26%)
Some college, associates degree, or professional training	16 (32%)
Bachelor’s degree	9 (18%)
Master’s degree, professional school degree, or doctoral degree	12 (24%)
Subjective Numeracy Score [c]	
1-1.99	0 (0%)
2-2.99	5 (10%)
3-3.99	16 (32%)
4-4.99	21 (42%)
5	6 (12%)
Children [d]	
Children, one or more ≤ 18 years old	10 (20%)
Children, all > 18 years old	33 (66%)
No children	7 (14%)
Chemical company employment	
Ever worked for a chemical company	9 (18%)
Never worked for a chemical company	41 (82%)

[a] Numbers may not sum to 100% due to rounding and non-responses.
[b] Addition to the CPOD study for the present research.
[c] Eight-item validated scale, range 0-5 (Fagerlin et al. 2007).
[d] Whether participant has any children, regardless of whether the children live at home.

The average age of Phase 2 participants was 62.3 years old (range 37 - 90). Ninety-eight percent were white, consistent with census demographics for Midland

County (94.5% white, U.S. Census Bureau, 2010). This is slightly less representative of individuals from Saginaw, Jackson, and Calhoun counties (74.6%, 87.7%, 82.2% white, respectively, U.S. Census Bureau, 2010), but comparable to the demographics of UMDES subpopulations (89.5-99.7% white, Hedgeman et al. 2009).

5.3.2 Phase 2 Interview Findings Informing Phase 3

I analyzed Phase 2 interview sections regarding risk judgments to assess the magnitude and characteristics of the risk judgments reported by participants, as well as the ease of making these judgments. I did this to determine the best approach to questions about risk judgments in the Phase 3 survey.

In interviews, a large majority of participants judged their personal risk from dioxins to be low. Reasons given included that they had received low results (e.g., "It's negligible; they can't [measure] down to my level. [Laughs and points to results letter.] It's negligible."), that they been individually alerted to a problem (e.g., "I don't think it's anything for me to be concerned about. And I think if it was that somebody would have said you need to see your doctor…."), or that they had an absence of perceived risk factors such as being far from industry or contaminated areas or otherwise healthy. Only six (out of fifty) thought their risk was high. Reasons given for this belief included that they had received high results (e.g., "…all I know is that my blood level is really, really high") or had perceived risk factors such as diet or smoking (e.g., "I think it's probably pretty high, because, personally, you know me being in that water, I'm a smoker, I work in the dirt, although I try to exercise, I don't drink enough water…).

Many participants weren't sure about their risk, but appeared to be trying to base their judgments on exposure results. Reasons given for being uncertain included that they didn't understand their results (e.g., "I have no idea and I'd like to know – in plain English and not some scientific term that [leaves me] going, 'huh?'") or that they hadn't received results (e.g., "I have no clue… [My levels] have never been measured; I don't know how I would compare with someone else my age…").

Participants' responses regarding the difficulty of making risk judgments suggest that they wished to use exposure information in making these judgments, and that difficulty of judgment may be closely related to confidence in the resulting judgment. Most Phase 2 participants said it was easy to judge their risk from dioxins. Some people inferred their risk directly from exposure results (e.g., "I have it right here [in my results letter]"). However, others thought it was easy to judge because of "ignorance" (e.g., "…there's no way to know. …I think it's very easy"), suggesting that it was easy to make a guess, but that they felt they had very little information to assist them. This suggested that measuring the degree of confidence participants had in their resulting judgments could be useful, something which was considered for addition to the questionnaire in Phase 3. Other participants found it more difficult, either analytically (e.g., "I think it's hard. I don't think we know enough") or affectively (e.g., "It's hard in a sense because you don't want to…acknowledge [it], but you know in reality, you know it's there… So you know it's hard but in the same sense it's easy").

5.3.3 Phase 2 Questionnaire Findings Informing Phase 3

The Phase 2 sample size (n=50) and the nature of the post-interview questionnaire as a pilot test for Phase 3 limited quantitative analysis of post-interview questionnaire data. First, I examined histograms of responses to each question for trends that could indicate defects in question design (e.g., lack of variation in responses). Then, I assessed several qualitative relationships between variables of interest to examine whether preliminary results were supportive of the hypothesis to be investigated in Phase 3.

I examined three questionnaire items in particular to explore the relationship between satisfaction and the ability to make risk judgments or the outcome of these judgments: (1) “I am satisfied with the information I have received about dioxins (1=Disagree, 5=Agree) (receiver satisfaction), (2) “I have a clear feeling about the risks that dioxins pose to my personal health and my family’s health” (risk judgment process), and (3) “How concerned are you about the risk to your personal health, and to your family’s health from dioxins?” (risk judgment outcome). The second question was intended to measure the affective difficulty of judging health risk from dioxins. However, the CPOD interviewer received many questions from participants completing the questionnaire as to the intended meaning of “a clear feeling.” As a result, this question was not used again in the larger-sample Phase 3 questionnaire. Despite these difficulties, having “a clear feeling” about the risk to one’s health and one’s family’s health from dioxins was positively related to being satisfied with the information provided (see Figure 5.1). In contrast, being concerned about the risk was not clearly related to being satisfied or dissatisfied with the information received (see Figure 5.2).

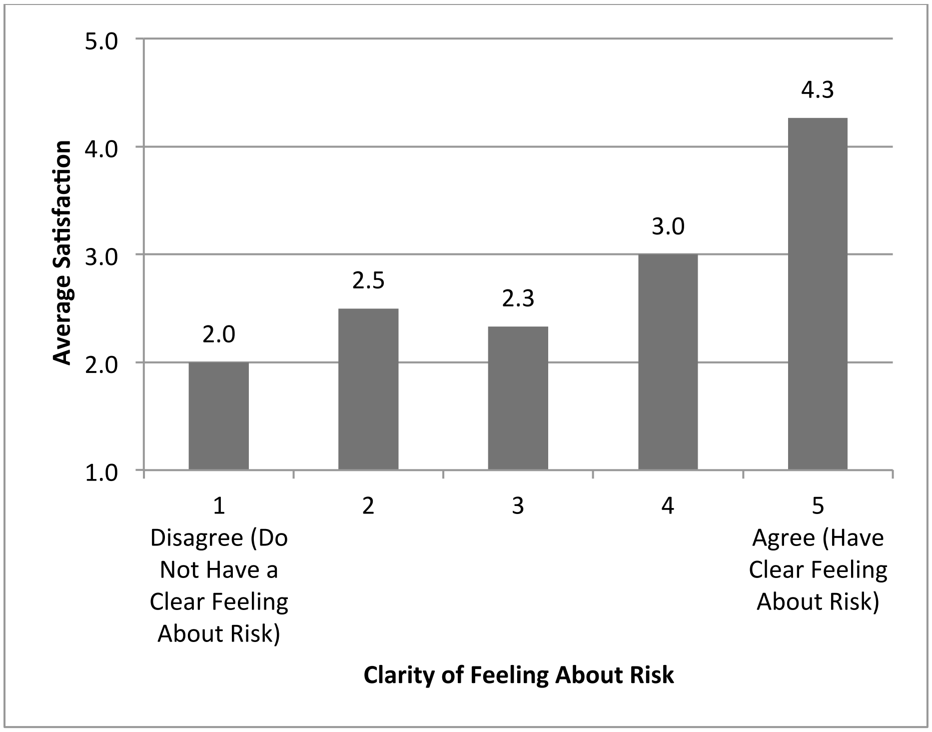


Figure 5.1 Average Satisfaction vs. Clarity of Feeling About Risk in Phase 2 Post-Interview Questionnaires (n=50)

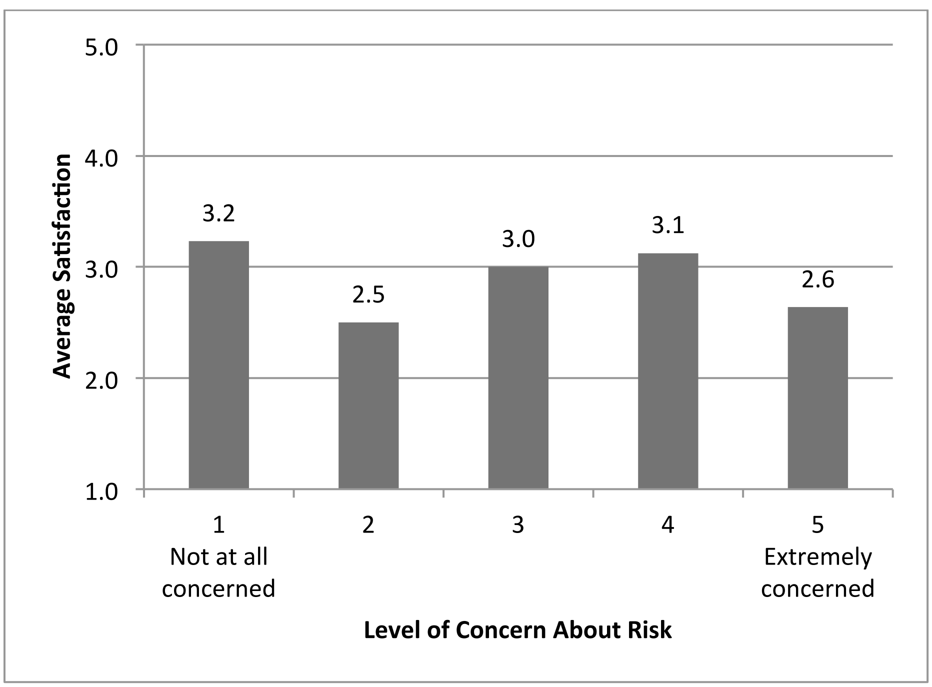


Figure 5.2 Average Satisfaction vs. Level of Concern About Risk in Phase 2 Post-Interview Questionnaires (n=50)

These findings were supportive of the primary hypothesis, that being able to judge health risk contributes to satisfaction, and were not supportive of the alternative hypothesis that satisfaction is determined by the outcome of the risk judgment.

See Appendix H for aggregated responses to the Phase 2 post-interview questionnaire.

5.4 Phase 3 Mailed Survey Methods

CPOD Phase 3, the primary data collection phase for the present research, involved developing a self-administered survey instrument mailed to much larger samples of the populations of interest. The goal of CPOD Phase 3 was to assess the frequency of gaps and misperceptions in lay mental models, and, as an addition for the present research, to gather quantitative data to analyze relationships between satisfaction, risk judgments, and mental models variables.

5.4.1 Phase 3 Questionnaire Design

The Phase 3 questionnaire consisted of approximately 100 questions divided into nine sections (see Table 5.5 and Appendices J and K).

Table 5.5 Phase 3 Questionnaire Structure

Section	Variable(s) Assessed	Item Numbers in Midland/ Saginaw Version	Item Numbers in Jackson/ Calhoun Version
1. Satisfaction with information received or gathered about dioxins [a]	Information Received/ Receiver Satisfaction	1-5	1-5
2. Risk judgments about dioxins [a]	Risk Judgments	6-13	6-13

3. Feelings about industry and government	Receiver Characteristics	14-24	14-24
4. True/false questions about dioxins	Mental Models	25-70	25-60 [b]
5. True/false beliefs about dioxins	Mental Models	71-82	61-72
6. Beliefs about current and past sources of exposure	Mental Models	83-90	73-80
7. Subjective numeracy scale	Receiver Characteristics	91-98	81-88
8. Information received about dioxins	Information Received	99-102	89-92
9. Demographics	Receiver Characteristics	103-110	93-100
	Total (n)	110	100

[a] Addition to the CPOD study for the present research.
[b] Questions regarding local contamination (n=10) were omitted and the phrasing of some questions was changed.

Questions regarding satisfaction with information received about dioxins and risk judgments about dioxins were added to the CPOD Phase 3 survey for the present research. The CPOD study team placed these questions in the first two sections to avoid biasing results based on remaining survey content. The two sections presented questions regarding the primary dependent variable (satisfaction) first, and the primary independent variable (risk judgments) second, to avoid biasing satisfaction questions based on the answers to risk judgment questions. The first question included skip logic to filter out those participants who were very unfamiliar with dioxins, by asking them to skip the first two sections if they had never heard of dioxins before.

I created the questions regarding satisfaction with information (n=4) by identifying and adapting questions from a similar set used in the Phase 2 post-interview questionnaire (n=12) based on responses gathered in Phase 2. I included those questions that seemed to have the highest variation in responses and the simplest phrasing, with modifications to the response scale to provide a larger spectrum of choices and force choices to be binary in nature. To provide greater discrimination, I changed the response scale from a five-point Likert scale with the endpoints “Disagree” and “Agree” used in Phase 2 to the four-point Likert scale “Strongly Disagree,” “Disagree,” “Agree,” and “Strongly Agree” for Phase 3.

I adapted questions regarding risk judgments from both the Phase 2 interview guide (n=2, regarding risk judgments and the ease of making this judgment) and the Phase 2 post-interview questionnaire regarding level of concern about the effects of dioxins (n=5 adapted and simplified from the larger set of n=6 post-interview questionnaire items). I also added a new question about the confidence in risk judgment based on the variation of responses seen in Phase 2 interviews.

The next section included questions about industry and government adapted from those appearing on the Phase 2 post-interview questionnaire regarding industrial accidents (Johnson & Chess 2003, n=1) and attitudes toward government (National Public Radio et al. 2007, n=3). Also included were questions adapted from an existing questionnaire regarding worldviews and environmental concerns (Peters & Slovic 1996, n=6).

The next three sections focused on mental models of dioxin exposure and health risks and made up the majority of the questionnaire. The first two of these sections consisted of statements about dioxins that participants were asked to rate as true or false, and also to rate their confidence in their response. The first of these sections consisted of statements that were objectively true or false, based on the expert model created in Phase 1 and other available information about dioxins, while the second section consisted of items that were less objectively certain. The third section asked about participants’ specific beliefs about the significance of various routes of exposure to dioxins. The beginning of the survey asked participants to avoid referring to other sources of information for help with any questions, and the end of the survey asked them whether they had looked up information from any source in answering the questions. An alternate version of the survey for Jackson/Calhoun participants (see Appendix K) omitted questions about local contamination (n=10) and modified the wording of questions about Dow and the Tittabawassee River to instead ask generically about industrial sources and rivers and streams in contaminated areas (n=6).

The final three sections consisted of information about receiver characteristics and information received. The same subjective numeracy scale (Fagerlin et al. 2007) used in Phase 2 was presented, followed by questions about receipt of the UMDES 2006 and 2011 brochures, UMDES participation, and the question about looking up information from other sources described above. Finally, the questionnaire concluded with slightly modified versions of the same demographic questions used in Phase 2 post-interview questionnaires.

The Phase 3 questionnaire was pilot-tested by a CPOD study team member with two non-residents of Midland/Saginaw who were not study team members but who had heard of dioxins through presentations about the UMDES and/or CPOD studies.

5.4.2 Phase 3 Participant Recruitment

CPOD staff recruited participants were recruited from the same three populations as in Phase 2: (1) former University of Michigan Dioxin Exposure Study (UMDES) participants from Midland/Saginaw counties, (2) non-UMDES participants from Midland/Saginaw counties, and (3), as an addition to the CPOD study for the present research, former UMDES participants from the control group in Jackson/Calhoun counties. Except for those who had participated in Phase 2 interviews (n=50), all UMDES participants from Midland/Saginaw (n=913) and Jackson/Calhoun (n=326) were included in the sample. CPOD staff drew an additional sample of 1,000 non-UMDES participants from an unused sampling line developed for the UMDES. These participants lived in exactly the same neighborhoods as UMDES participants but had not been approached to participate in the UMDES study. The sampling line included addresses but not names or phone numbers, so these were gathered through publicly available database. The CPOD study team chose a sample size of 1,000 for this group to achieve roughly the same number of completed surveys from Midland/Saginaw UMDES and non-UMDES participants, anticipating a slightly lower response rate from non-UMDES participants than from UMDES participants.

CPOD staff mailed a postcard to each member of the sample, stating that they would receive a mailed survey within two to three weeks, and instructing them to call if they had any questions or to check a box and return a portion of the postcard if they did not want to participate. CPOD staff then mailed surveys to all sample members except those who indicated by mail or telephone that they did not wish to participate and those whose postcards had been returned as undeliverable. Each survey included a $5 cash incentive, and solicitation letters explained that participants would receive a $10 VISA® gift card upon return of the completed survey.

Table 5.6 Mailings and Enrollment in Phase 3

	Initial	Added	Un-deliver-able	Do Not Contact	Un-avail-able [a]	Ex-cluded	Com-pleted	Re-sponse Rate [b]
Midland/ Saginaw UMDES	913	0	163	71	17	1 [c]	440	60.11%
Postcard Mailing	913	--	111	53	5	--	--	--
Survey Mailing 1	744	--	37	6	8	--	334	--
Telephone Calls	323	--	8	11	3	--	38 [d]	--
Survey Mailing 2	278	--	7	1	1	--	68	--
Midland/ Saginaw non-UMDES	1000	8 [e]	97	132	22	4 [f]	464	52.43%
Postcard Mailing	1000	--	68	95	9	--	--	--
Survey Mailing 1	828	--	21	7	4	--	301	--
Telephone Calls	464	--	3	26	9	--	90 [d]	--
Survey Mailing 2	343	--	5	4	0	--	73	--
Jackson/ Calhoun UMDES	326	0	69	23	9	1 [g]	132	53.44%
Postcard Mailing	326	--	34	15	1	--	--	--
Survey Mailing 1	276	--	26	5	2	--	92	--
Telephone Calls	147	--	3	2	6	--	18 [d]	--
Survey Mailing 2	118	--	6	1	0	--	20	--
Totals	2239	8	329	226	48	6	1036	55.58%

[a] Deceased or unable to complete due to illness.
[b] Response Rate = Total Completed / (Total Mailed + Total Added – Total Undeliverable – Total Unavailable – Total Excluded)
[c] Reported age under 18.
[d] Completed surveys between the time of the phone calls and the time of the second mailing.
[e] Added after receiving surveys on behalf of former UMDES participants who were deceased (n=3), in long-term care facilities (n=2), or moved with no forwarding address (n=3).
[f] Participants who were duplicative of UMDES participants.
[g] Participant whom it was discovered did not speak English in a follow-up telephone call.

5.4.3 Phase 3 Survey Data Entry and Analysis

CPOD staff outsourced data entry of completed surveys, identified only by study identification number, to a local company. This company entered each survey twice using software that requires the second entry to be identical to the first. CPOD staff then checked the resulting minimum and maximum values for each variable, corrected any errors found, and prepared the data file received for analysis using the statistical software package STATA. All analyses reported in this dissertation were performed in STATA 11.2 (StataCorp 2012).

5.4.4 Phase 3 Participants

Characteristics of the full set of Phase 3 participants are described below. A total of 1,036 people completed and returned usable Phase 3 questionnaires. This total consisted of about 45% each Midland/Saginaw UMDES and Non-UMDES participants, and about 10% Jackson/Calhoun UMDES participants (see Table 5.7). Jackson/Calhoun residents were not further stratified by region, but Midland/Saginaw residents were stratified into two groups: those living in or near the flood plain (as defined in the UMDES study sample lines) and those living elsewhere in Midland/Saginaw. Flood plain residents were slightly more numerous among Midland/Saginaw UMDES participants than Non-UMDES participants (about 65% versus about 55%, respectively).

Table 5.7 Stratification of Phase 3 Participants

UMDES Participation	Region: Flood Plain or Near Flood Plain	Region: Other Midland/Saginaw	Participants [n (% of total)]
Midland/Saginaw UMDES Participants	285 (64.77%)	155 (35.23%)	440 (42.47%)
Midland/Saginaw Non-UMDES Participants	253 (54.53%)	211 (45.47%)	464 (44.79%)
Jackson/Calhoun UMDES Participants [a]	**Not stratified by region**		132 (12.74%)
		Total	1036

[a] Addition to the CPOD study for the present research.

Phase 3 participants were more likely to be female than male (about 53% versus 47%), and were about 93% white, consistent with expected demographics as previously discussed. Participants had an average age of 58.3 years (range 20 to over 90). See Table 5.8 for a summary of characteristics of Phase 3 participants.

Table 5.8 Selected Characteristics of Phase 3 Participants

Characteristic	**Participants [*n* (%)] [a]**
Previous UMDES participation	
Midland/Saginaw UMDES participants	440 (42.47%)
Midland/Saginaw non-UMDES participants	464 (44.79%)
Jackson/Calhoun UMDES participants [b]	132 (12.74%)
Sex	
Male	474 (46.79%)
Female	539 (53.21%)
Ethnicity	
Hispanic	27 (2.81%)
Race	
White	941 (92.98%)
Black or African American	58 (5.73%)
American Indian or Alaska Native	14 (1.38%)
Asian	3 (0.30%)
Age	
20-29	34 (3.37%)
30-39	61 (6.05%)
40-49	170 (16.85%)
50-59	269 (26.66%)
60-69	251 (24.88%)
70-79	146 (14.47%)

≥80	78 (7.53%)
Education	
Some high school, high school diploma, or equivalent	295 (30.26%)
Some college, associates degree, or professional training	348 (35.69%)
Bachelor's degree	208 (21.33%)
Master's degree, professional degree, or doctoral degree	124 (12.72%)
Subjective Numeracy Score [c]	
1-1.99	25 (2.42%)
2-2.99	69 (6.69%)
3-3.99	178 (17.25%)
4-4.99	317 (30.72%)
5-5.99	366 (35.47%)
6	77 (7.46%)
Tenure in Current Home	
Less than five years	118 (11.39%)
6-15 years	296 (29.25%)
16+ years	598 (59.09%)
Children [d]	
One or more children ≤ 18 years old	222 (21.43%)
All children > 18 years old	559 (53.96%)
Chemical company employment	
Ever worked for a chemical company	174 (16.79%)
Type of chemical company employment [e]	
Production	63 (36.2%)
Maintenance/repair/contractor	52 (29.9%)
Office or administrative support	34 (19.5%)
Professional	28 (16.1%)
Transportation	13 (7.5%)
Sales	10 (5.7%)
Management	10 (5.7%)

[a] Numbers may not sum to 100% due to rounding and non-responses.
[b] Addition to the CPOD study for the present research.
[c] Eight-item validated scale, range 0-5 (Fagerlin et al. 2007).
[d] Whether participant has any children, regardless of whether the children live at home.
[e] Numbers will not sum to 100%; participants were instructed to "check all that apply."

5.5 Conclusion

I used data from the in-depth mental models interviews conducted as part of Phases 1 and 2 of the CPOD study to develop targeted questions regarding risk judgments, mental models, and satisfaction with information for the Phase 3 mailed survey, the primary data source for the present research. Specifically, findings regarding risk judgments in Phase 2 interviews suggested that receivers wished to use exposure information in making these judgments, and that the difficulty of making these judgments may be closely related to confidence in the resulting judgment. As a result, I added a question regarding confidence in judgment to the Phase 3 survey. Findings regarding risk judgments and receiver satisfaction in Phase 2 post-interview questionnaires also supported the primary hypothesis that being able to judge health risk contributes to satisfaction, and these interviews did not provide support to the alternative hypothesis that satisfaction is determined by the outcome of the risk judgment.

5.6 References

Fagerlin, A. et al., 2007. Measuring numeracy without a math test: Development of the subjective numeracy scale. *Medical Decision Making*, 27(5), pp.672 –680.

Hedgeman, E. et al., 2009. The University of Michigan Dioxin Exposure Study: Population survey results and serum concentrations for polychlorinated dioxins, furans, and biphenyls. *Environmental Health Perspectives*, 117(5), pp.811–817.

Johnson, B.B. & Chess, C., 2003. Communicating worst-case scenarios: Neighbors' views of industrial accident management. *Risk Analysis*, 23(4), pp.829–840.

Morgan, M.G. et al., 2002. *Risk Communication: A Mental Models Approach*, Cambridge, UK: Cambridge University Press.

National Public Radio, The Henry J. Kaiser Family Foundation & John F. Kennedy School of Government, Harvard University, 2007. Survey on Americans' Attitudes Toward Government. Available at: http://www.kff.org/kaiserpolls/3036-index.cfm [Accessed May 24, 2012].

Peters, E. & Slovic, P., 1996. The role of affect and worldviews as orienting dispositions in the perception and acceptance of nuclear power. *Journal of Applied Social Psychology*, 26(16), pp.1427–1453.

StataCorp, 2012. STATA/IC 11.2 for Mac (64 bit Intel).

Chapter 6

Results Regarding Risk Judgments

This chapter presents results from analyses of Phase 3 mailed survey data regarding risk judgments. More specifically, this chapter examines the impact of information received and receiver characteristics on the risk judgment process and risk judgment outcomes.

6.1 Specific Aims Addressed in this Chapter

This chapter describes analyses regarding specific aims 1, 1a, and 1b, listed in Table 6.1 below.

Table 6.1 Specific Aims Addressed in Chapter 6

Specific Aim	**Description**
1.	To assess judgments about resulting personal/family or community health risks, and perceived difficulty in making these judgments, among residents exposed to messages about dioxins (participants and non-participants in an exposure study).
1a.	To investigate whether health risk judgments, and/or perceived difficulty in making these judgments, vary with the communications residents have received.
1b.	To consider to what degree numeracy and other personal characteristics moderate residents' health risk judgments and/or perceived ability to make these judgments.

6.2 Risk Judgment Variables

Four risk judgment variables were assessed: ease of judging the health risk, confidence in judging the risk, judgment of the magnitude of the risk, and a scale regarding concern about the risk.

Each of these variables was assessed by a single survey item, with the exception of the scale regarding concern about the risk. This scale was constructed from a series five items regarding concern about risks from dioxins. As expected, these five items were highly correlated (see Table 6.2 and Table 6.3). A scale of these five items was created (range 1-5; Cronbach's alpha = 0.9406), with higher numbers on the scale indicating greater concern about risks from dioxins.

Table 6.2 Scale of Five Items Regarding Concern about Risk

Survey Item [a]	Responses	Item-Test Correlation	Item-Rest Correlation	Cronbach's Alpha if Omitted
9. How concerned are you about the threat to your health from dioxins?	956	0.9110	0.8602	0.9232
10. How concerned are you about the threat to your family's health from dioxins?	955	0.9256	0.804	0.9192
11. How concerned are you about any economic effects dioxins may have on you and your family?	955	0.8600	0.7773	0.9384
12. How concerned are you about the effects on your community from dioxins?	957	0.8845	0.8194	0.9305
13. Overall, how concerned are you about your own exposure and your family's exposure to dioxins?	957	0.9162	0.8630	0.9223
		Overall Cronbach's Alpha for Five-Item Concern Scale		0.9406

[a] Answers were given on a five-point Likert scale with anchors "Not at all concerned" (1) and "Extremely concerned" (5)

Table 6.3 Inter-Item Correlations in Five-Item Concern Scale

	Item 9	Item 10	Item 11	Item 12	Item 13
Item 9	1.00				
Item 10	0.89	1.00			
Item 11	0.68	0.70	1.00		
Item 12	0.72	0.74	0.78	1.00	
Item 13	0.82	0.84	0.71	0.76	1.00

Scale: n=958, Mean=3.43, SD=1.07, Min=1, Max=5, Cronbach's alpha=0.94

The remaining three risk judgment variables were assessed by the three survey items listed in Table 6.4 below.

Table 6.4 Survey Items Used to Assess the Risk Judgment Variables Judgment of Risk, Ease of Judgment, and Confidence in Judgment

Variable	Survey Item	Anchors [a]
Judgment of Risk	6. How big of a threat do you believe dioxins are to your health?	"No threat at all" to "Extremely large threat"
Ease of Judgment	7. How easy or difficult is it for you to judge how big of a threat dioxins are to your health?	"Extremely easy" to "Extremely difficult"
Confidence in Judgment	8. How confident do you feel that you know how big of a threat dioxins are to your health?	"Not at all confident" to "Extremely confident"

[a] Answers were given on five-point Likert scales with unlabeled midpoints.

Some of the four risk judgment variables (ease of judgment, confidence in judgment, judgment of risk, and concern about risk) were correlated with each other. As expected, ease of judgment was correlated with confidence in judgment, and judgment of risk was correlated with concern about risk. In addition, ease of judgment was slightly more correlated with judgment of risk and concern about risk than was confidence in judgment.

Table 6.5 Inter-Item Correlations Between Risk Judgment Variables

	Ease of Judgment	Confidence in Judgment	Judgment of Risk	Concern about Risk
Ease of Judgment	1.00			
Confidence in Judgment	0.51	1.00		
Judgment of Risk	-0.22	-0.01	1.00	
Concern About Risk	-0.24	-0.07	0.75	1.00

Descriptive results of the four risk judgment variables are shown in Table 6.6 below.

Table 6.6 Descriptive Statistics Regarding Risk Judgment Variables, by UMDES Participation Group

	Overall Mean (SD)	M/S Non-UMDES Mean (SD)	M/S UMDES Mean (SD)	J/C UMDES Mean (SD)	One-Way ANOVA; Bartlett's Test for Equal Variances
Ease of Judgment	2.58 (1.10)	2.53 (1.12)	2.67 (1.09)	2.41 (1.00)	F-statistic 3.25, p=.04; Chi-squared 2.03, p=.36
Confidence in Judgment	2.68 (1.21)	2.66 (1.26)	2.77 (1.15)	2.39 (1.17)	F-statistic 4.44, p=.01; Chi-squared 3.73, p=.16
Judgment of Risk	3.28 (1.05)	3.38 (1.12)	3.18 (1.01)	3.32 (0.87)	F-statistic 3.96, p=.02; Chi-squared 11.34, p<.01
Concern about Risk	3.43 (1.07)	3.53 (1.08)	3.31 (1.06)	3.47 (1.01)	F-statistic 4.60, p=.01; Chi-squared 0.74, p=.69

M/S = Midland/Saginaw, J/C = Jackson/Calhoun

6.2.1 Ease of Judgment

Respondents provided a mean rating of the ease of judging health risk of 2.58 out of 5 (Standard Deviation 1.10), slightly below the midpoint on the five-point Likert scale with anchors "Extremely easy" and "Extremely difficult." Differences in ratings between UMDES participant groups were statistically significant (2.53 for non-UMDES Midland/Saginaw, 2.67 for UMDES Midland/Saginaw, and 2.41 for UMDES Jackson/Calhoun, F-statistic 3.25, p=.04). Ease of judgment was lowest among UMDES participants in Jackson/Calhoun, who had presumably attended to much less information about dioxins than those in Midland/Saginaw. Ease of judgment was highest among Midland/Saginaw UMDES participants, who had presumably attended to more information regarding dioxins than non-participants.

6.2.2 Confidence in Judgment

Respondents provided a mean rating of their confidence in judging the risk of 2.68 out of 5 (Standard Deviation 1.21), slightly below the midpoint on the five-point Likert scale with anchors "Not at all confident" and "Extremely confident." Differences in ratings between UMDES participant groups were statistically significant (2.66 for non-UMDES Midland/Saginaw, 2.77 for UMDES Midland/Saginaw, and 2.39 for UMDES Jackson/Calhoun, F-statistic 4.44, p=.01). Confidence in judgment was lowest among UMDES participants in Jackson/Calhoun, who had presumably attended to much less information about dioxins than those in Midland/Saginaw. Confidence in judgment was highest among Midland/Saginaw UMDES participants, who had presumably attended to more information regarding dioxins than non-participants.

6.2.3 Judgment of Risk

Respondents provided a mean judgment of the magnitude of the risk of 3.28 out of 5 (Standard Deviation 1.04), slightly above the midpoint on the five-point Likert scale with anchors "No threat at all" and "Extremely large threat." Differences in ratings between UMDES participant groups were statistically significant (3.38 for non-UMDES Midland/Saginaw, 3.18 for UMDES Midland/Saginaw, and 3.32 for UMDES Jackson/Calhoun, F-statistic 3.96, p=.02). Judgment of risk was unexpectedly higher among UMDES participants in Jackson/Calhoun, where no point source contamination had been identified, than in Midland/Saginaw where the Dow Chemical plant had been identified as a source of elevated levels of dioxins.

6.2.4 Concern about Risk

Respondents provided a mean rating of 3.43 (Standard Deviation 1.21), slightly above the midpoint on the five-point Likert scale with anchors "Not at all concerned" and "Extremely concerned." Again, significant differences existed between UMDES groups (3.53 for non-UMDES Midland/Saginaw, 3.32 for UMDES Midland/Saginaw, and 3.47 for UMDES Jackson/Calhoun, F-statistic 4.60, p=.01). Non-UMDES Midland/Saginaw participants were most concerned, followed by UMDES Jackson/Calhoun participants, then UMDES Midland/Saginaw participants.

6.3 Regression Analyses

The effects of Receiver Characteristics and Information Received variables on Risk Judgments were assessed using regression techniques. Ordered logistic regression was used for the three single-item variables (ease of judgment, confidence in judgment, and judgment of risk), which were ordinal, to eliminate the need for assumptions about equal distances between points on the Likert scales. Linear regression was used for the scale of concern about risk, as the overall scale did not have discrete points. Results are shown in Tables 6.7 and 6.8 below.

Table 6.7 Ordered Logistic Regressions of Ease of Judgment and Confidence in Judgment by Receiver Characteristics and Information Received

	Ease of Judgment		Confidence in Judgment	
	Ordered logistic regression N=851 LR chi2(14)=67.60 p-value <0.001		**Ordered logistic regression N=851 LR chi2(14)=95.24 p-value <0.001**	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	-0.060	0.187	-0.051	0.252
Female Gender	-0.119	0.369	-0.088	0.502
Minority Status	-0.261	0.301	0.026	0.917
Numeracy	0.029	0.670	0.019	0.778
Education	0.008	0.913	-0.060	0.395
Having a Child	-0.079	0.607	0.066	0.664
Mistrust	-0.631	<0.001**	-0.394	0.001**
Working for a Chemical Co.	0.335	0.048*	0.287	0.089
Floodplain Resident	-0.108	0.436	-0.060	0.663
Jackson/Calhoun Resident	-0.215	0.346	-0.302	0.184
Information Received				
Familiarity with Dioxins	0.482	0.001**	1.048	<0.001**
UMDES Participation	0.194	0.201	0.070	0.642
UMDES Brochures	0.085	0.560	0.170	0.242
Looking up Information	-0.108	0.733	0.190	0.543
Constant	--	--	--	--

*Significant (p<.05)
**Highly significant (p≤.001)

Table 6.8 Ordered Logistic and Linear Regressions of Judgment of Risk and Concern about Risk by Receiver Characteristics and Information Received

	Judgment of Risk		Concern about Risk	
	Ordered logistic regression N=851 LR chi2(14)=265.25 p-value <0.001		Linear regression [a] N=853 F(14,838)=27.87 p-value <0.001	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	-0.151	0.001**	-0.080	<0.001**
Female Gender	0.127	0.350	0.133	0.040*
Minority Status	0.593	0.023*	0.261	0.023*
Numeracy	0.020	0.778	-0.068	0.039*
Education	-0.007	0.925	-0.009	0.801
Having a Child	-0.086	0.590	0.014	0.857
Mistrust	1.811	<0.001**	0.914	<0.001**
Working for a Chemical Co.	-0.190	0.288	-0.111	0.190
Floodplain Resident	0.048	0.741	0.024	0.729
Jackson/Calhoun Resident	-0.160	0.496	-0.079	0.486
Information Received				
Familiarity with Dioxins	0.184	0.205	0.007	0.915
UMDES Participation	-0.206	0.192	-0.217	0.004*
UMDES Brochures	-0.290	0.055	-0.011	0.878
Looking up Information	0.187	0.556	0.161	0.299
Constant	--	--	1.072	0.001**

*Significant ($p<.05$)

**Highly significant ($p\leq.001$)

[a] Residual df=838, R-squared=0.3177, Adjusted R-squared=0.3063

6.4 Summary and Discussion of Effects on Risk Judgments

Findings are consistent with Aim 1. Regression analyses showed that risk judgments were influenced by both receiver characteristics (Aim 1a) and information received variables (Aim 1b), as described below.

6.4.1 Effects of Receiver Characteristics on Risk Judgments

6.4.1.1 Age

Age was a highly significant predictor of judgment of risk and concern about risk ($p \leq .001$). People who were older judged the risk to be smaller and were less concerned. This is consistent with some of the qualitative interview data from Phase 2, in which some older participants seemed to base their judgments of risk on their own health experiences. Some older interview participants took their present good health, despite decades of presumed exposure to dioxins, to be a sign of low risk posed by dioxins. Other interview participants, presently in poor health, did not attribute their illnesses to dioxin exposure and similarly judged a low risk from dioxins. Age was not a significant predictor of ease of judging the risk or confidence in judgment of the risk.

6.4.1.2 Gender and Minority Status

As expected, female gender and minority status (i.e., non-white race) predicted greater concern about risk from dioxins. This is consistent with research showing a "white male effect" on risk judgments (Finucane et al. 2000), in which females and members of minority groups generally judge risks to be higher than white males. This effect has been explained by differences in cultural worldviews and trust, rather than any differences in biology (Flynn et al. 1994; Finucane et al. 2000; Kahan et al. 2007). In the present research, the effect of minority status was much stronger than the effect of gender, and predicted both judgment of higher risk and greater concern about risk. The fact that female gender predicted greater concern about risk, but did not significantly predict judgment of greater risk, suggests that the effect of female gender in this case could be related to affective processing of information, in which the risk is not judged analytically to be greater, but concern (an affective state) is increased.

Some evidence was found for potential mediation of both gender and minority status by mental models variables. When mental models variables were added to regressions of judgment of risk and concern about risk, gender and minority status became non-significant ($p>.05$). This suggests that, in addition to trust and worldviews, mental models could also play a role in the "white male effect." Further investigation could clarify this relationship. Gender and minority status did not significantly predict ease of judging the risk or confidence in judging the risk.

6.4.1.3 Mistrust of Government and Industry

Mistrust of government and industry was a highly significant predictor of all risk judgment variables, including judgment of risk, concern about risk, ease of judgment, and confidence in judgment ($p\leq.001$). As expected, greater mistrust predicted judgment of higher risk and greater concern about risk. As mentioned above, the effect of trust and worldviews on judgment of risk or concern about risk has been well-documented in the research literature (Slovic 1993; Flynn et al. 1994; Finucane et al. 2000). However, the finding that greater mistrust predicted greater difficulty in judging risk and less confidence in risk judgment is new. This finding suggests that receivers in settings such as this one may find it difficult to obtain trusted sources of information to assist in making risk judgments. For receivers who find it difficult to judge the risk, additional communications from government or industry sources may not be perceived as useful or helpful in these settings.

6.4.1.4 Education and Numeracy

Interestingly, education and numeracy did not significantly predict ease of judgment, confidence in judgment, or judgment of risk. While greater numeracy or greater education might be expected to predict greater ease or confidence in judgment about some risks, in the case of dioxins experts believe the health risks are still uncertain. It is possible that more educated or more numerate participants might be expected to use a more analytical or expert-like process in attempting to judge the risk, and find it difficult to do so since available risk information is limited and uncertain. Alternatively, more educated or more numerate participants might use the same process as other laypeople of translating hazard and exposure information directly into risk information, and find it easier to do so because of a greater facility with the information.

Numeracy, but not education, was a significant predictor of concern about risk, with higher numeracy predicting less concern about the risk. It is unclear why this is so, but it is possible that higher numeracy could predict better understanding of the results of the UMDES, which found largely negative results regarding exposure in the contaminated areas.

6.4.1.5 Working for a Chemical Company

Working for a chemical company was a significant predictor of greater ease of judging the risk from dioxins, but was not a significant predictor of greater confidence in judging the risk. It is unclear whether these effects would be appropriately attributed to a greater expertise or knowledge about chemicals generally; an additional, and likely trusted, source of information in the form of an employer; or merely a greater interest in the topic, which could have led to greater attention to available information or additional information-seeking behaviors. Working for a chemical company was not a significant predictor of judgment of the risk or concern about the risk.

6.4.1.6 Location of Residence

Unexpectedly, residing near areas known to be contaminated with dioxins (i.e., in the Tittabawassee River floodplain), or residing far from areas known to be contaminated (i.e., in Jackson/Calhoun) were not significant predictors of judgment of risk from dioxins, concern about risk from dioxins, ease of judging risk from dioxins, or confidence in judging risk from dioxins. It is possible that effects of location of residence on risk judgments were fully explained by information received variables. Those residing in the floodplain were significantly more likely to report having heard "a lot" about dioxins (43% of floodplain residents vs. 26% of non-floodplain residents, $F=32.39$, $p<.0001$), while those residing in Jackson/Calhoun were significantly less likely (10% of Jackson/Calhoun residents vs. 39% of Midland/Saginaw residents, $F=43.58$, $p<.0001$).

6.4.1.7 Having Children

While it was hypothesized that having children could result in judgment of the risk from a different perspective, having children was not a significant predictor of any risk judgment variables. Note, however, that the average age of the sample was 58.3 years, suggesting that the experience of having young children was probably in the past for many participants.

6.4.2 Effects of Information Received on Risk Judgments

6.4.2.1 Familiarity with Dioxins

Being very familiar with dioxins (i.e., having heard "a lot" about dioxins) was a highly significant predictor of ease of judgment and confidence in judgment ($p \leq .001$). Participants who were very familiar with dioxins found it easier to judge the risk and were more confident in their judgments. While perhaps not surprising, this does suggest that most receivers were converting hazard and exposure information directly into risk information. As previously discussed, available information was limited to hazard and exposure information, since health risk from dioxins remains scientifically uncertain. From an expert point of view, additional hazard and exposure information should not necessarily make it easier for laypeople to judge the risk or make laypeople more confident in their judgments of risk. The fact that this occurred in this case suggests that laypeople are somewhat comfortable relying on hazard and exposure information to make risk judgments. The fact that familiarity with dioxins did not significantly predict judgment of risk or concern about risk suggests that there was no clear message regarding the risk in available information. This lack of risk information further suggests that, instead, receivers were making judgments or extrapolations from available hazard and exposure information.

6.4.2.2 UMDES Participation

UMDES participation significantly predicted lower concern about the risk, but not judgment of lower risk. This result suggests that the effect may be due to affective processing of information, in which the risk may not be analytically judged to be lower, but concern (an affective state) may be decreased. UMDES participants may have affectively processed either their participation in the exposure study or the exposure study findings and found some aspect to be reassuring. As suggested by some Phase 2 interview participants, the experience of having blood drawn for study may have made them feel that they had somehow been examined for health problems, or that they would have been notified if there was a cause for concern. In addition, greater awareness of the scope and magnitude of the study may have made them feel the risk was being adequately examined by others and that there was no cause for personal concern. Non-UMDES participants, without these experiences, expressed greater concern.

Surprisingly, UMDES participation did not predict ease of judging risk or confidence in judging risk. It is unlikely that these effects are fully explained by familiarity with dioxins, as UMDES participants were not significantly more likely to report having heard "a lot" about dioxins (36% among UMDES participants vs. 34% among non-UMDES participants, F=0.45, p=0.502). It is possible that specific aspects of UMDES participation (e.g., receipt of individual blood, dust, and soil results), which were not examined in regressions, made it significantly easier or more difficult to judge the risk, and that these effects are masked by representing UMDES participation as a single variable. However, the additional UMDES communication variable that was examined (recalled receipt or reading of either the 2006 or 2011 UMDES brochures) also did not significantly predict ease of judgment or confidence in judgment.

6.4.2.3 UMDES Brochures

Receipt or reading of the 2006 or 2011 UMDES results brochures and looking up information in completing the survey were not significant predictors of any risk judgment variables. This is again suggestive of the idea that, because the health risk from dioxins is uncertain, there were not clear messages available to participants regarding health risk.

6.4.3 Relationships Between Risk Judgment Variables

As expected, the two risk judgment variables related to the process of judging the health risk (ease of judgment and confidence in judgment) and the two variables related to the outcome of the risk judgment process (judgment of risk and concern about risk) were more highly correlated within each pair (ease-confidence inter-item correlation 0.51, judgment-concern 0.75) than between pairs (maximum inter-item correlation -.24 between ease of judgment and concern about risk).

The positive correlation between ease of judgment and confidence in judgment is interesting in light of some of the comments made in Phase 2 interviews. When asked to make risk judgments about dioxins in interviews, some participants said it was easy to judge the risk because of “ignorance,” suggesting a lack of confidence in their judgments. Results in Phase 3 show that participants who found it easier to judge the risk were generally more confident in their judgments.

As expected, the pairs of risk judgment variables were also predicted in similar ways by variables within regressions. For example, familiarity with dioxins and confidence in mental models significantly predicted both ease of judgment and confidence in judgment, while age significantly predicted both judgment of risk and concern about risk. Similarly, mistrust negatively predicted ease of judgment and confidence in judgment, and positively predicted judgment of risk and concern about risk. These results suggest that these two pairs of variables are representative of the constructs they were intended to represent: one pair regarding the process of judging the risk, and one pair regarding the outcome of risk judgments.

6.5 References

Finucane, M.L. et al., 2000. Gender, race, and perceived risk: The "white male" effect. *Health, Risk & Society*, 2(2), pp.159–172.

Flynn, J., Slovic, P. & Mertz, C.K., 1994. Gender, race, and perception of environmental health risks. *Risk Analysis*, 14(6), pp.1101–1108.

Kahan, D.M. et al., 2007. Culture and identity-protective cognition: Explaining the white-male effect in risk perception. *Journal of Empirical Legal Studies*, 4(3), pp.465–505.

Slovic, P., 1993. Perceived risk, trust, and democracy. *Risk Analysis*, 13(6), pp.675–682.

Chapter 7

Results Regarding Mental Models

This chapter presents results from analyses of Phase 3 mailed survey data regarding mental models. More specifically, this chapter examines the effects of mental models on the risk judgment process and risk judgment outcomes, including whether there is evidence that they mediate the effects of information received and receiver characteristics.

7.1 Specific Aims Covered in This Chapter

This chapter describes analyses regarding specific aims 2, 2a, 2b, 2c, and 2d, described in Table 7.1 below.

Table 7.1 Specific Aims Addressed in Chapter 7

Specific Aim	Description
2	To investigate the extent to which residents' mental models of dioxin exposure/risk mediate their health risk judgments and/or perceived difficulty in making these judgments.
2a	To determine whether residents' mental models are directly affected by communications received.
2b	To determine whether residents' mental models are directly affected by numeracy and other personal characteristics.
2c	To determine whether residents' health risk judgments and/or their difficulty in making to make these judgments are directly affected by their mental models.
2d	To determine whether residents' mental models mediate the effect of communications received and personal characteristics on their health risk judgments and/or their perceived difficulty in making these judgments.

7.2 Mental Models Variables

A large number of mental models variables were assessed using true/false questions and ratings of confidence for each question.

True/false questions each had a "correct" answer according to the expert model, so "wrong" answers were coded as misconceptions (see Table 7.2 and Appendix L). Overall frequency of misconceptions ranged from 4% (for the misconception that dioxins cannot be found in fish raised in contaminated water) to 82% (for the misconception that a person who lives on contaminated soil will usually have elevated levels of dioxins in their body). Frequency of most misconceptions ranged between 30% and 50%.

As shown in Table 7.2, ten questions from the Midland/Saginaw survey were intentionally omitted from the Jackson/Calhoun survey, and six were modified, resulting in a total of 46 mental models questions asked of Midland/Saginaw participants and 36 mental models questions asked of Jackson/Calhoun participants.

Table 7.2 Results of Mental Models True/False Questions, Overall and by UMDES Participation Group

			% With Misconception			
M/S Q. No.	**J/C Q. No.**	**Question Topic**	**Overall**	**M/S Non-UMDES**	**M/S UMDES**	**J/C UMDES**
25	25	Chemical Classification	46%	46%	42%	61%
26	26	Multiple Chemicals	10%	13%	8%	8%
27	27	Chemical Mfg.	12%	15%	11%	7%
28	--	Dow as a Source	--	11%	6%	--
29	--	Dow River Waste	--	13%	8%	--
30	--	Dow Incinerator	--	30%	27%	--
31	--	Dow Burying Waste	--	53%	54%	--
32	28	Levels Increasing	72%	72%	66%	87%
33	--	Past Residence	--	31%	28%	--
34	--	Well Water	--	71%	72%	--
35	--	Tap Water	--	34%	33%	--
36	29(M)	Filtering Water	81%	81%	79%	92%
37	--	River Sediment	--	8%	5%	--

38	--	River Banks	--	11%	8%	--
39	--	Rain Water	--	35%	30%	--
40	30(M)	Swimming	58%	59%	51%	77%
41	31(M)	River Flooding	15%	19%	14%	5%
42	32(M)	Industrial Incin.	44%	44%	36%	71%
43	33	Car Exhaust	44%	45%	41%	53%
44	34	Trash Burning	66%	69%	67%	52%
45	35	Municipal Incin.	62%	62%	67%	42%
46	36	Power Plants	51%	49%	48%	62%
47	37	Products	31%	33%	33%	13%
48	38	Manmade	36%	39%	35%	33%
49	39	Farm Chemicals	56%	56%	53%	67%
50	40	Older Age	40%	45%	32%	49%
51	41	Smoking	72%	70%	71%	83%
52	42	Fish	4%	5%	4%	2%
53	43(M)	River Fish	13%	13%	13%	14%
54	44(M)	Bottom Fish	18%	17%	14%	33%
55	45	Washing Vegetables	50%	49%	50%	53%
56	46	Processed Foods	34%	35%	31%	43%
57	47	Trimming Meat	43%	45%	41%	42%
58	48	Trees	47%	46%	46%	55%
59	49	Property Disclosure	30%	28%	27%	45%
60	50	Property Values	14%	14%	13%	23%
61	51	Touching/Washing	49%	51%	46%	49%
62	52	Breathing Air	29%	31%	28%	20%
63	53	Living on Soil	82%	82%	82%	83%
64	54	Eating Food	6%	6%	5%	7%
65	55	Eating Game	13%	15%	12%	12%
66	56	Moving Soil	17%	18%	16%	15%
67	57	Transport	52%	53%	50%	55%
68	58	Treatments	29%	32%	23%	34%
69	59	Exercise	30%	30%	28%	37%
70	60	Water Drinking	41%	40%	38%	55%

-- = Omitted
(M) = Modified

In addition to providing a true/false answer, participants provided ratings of their confidence in their answer, using a three-point Likert scale with anchors “Not at all” “Somewhat,” and “Very” confident. As a measure of overall mental models confidence, participants’ ratings of confidence in their answers to the true/false questions were averaged. Descriptive statistics of this measure are shown in Table 7.3. Participants reported an average confidence of 2.08, associated with the anchor “Somewhat” confident. Average confidence did not differ significantly by UMDES participation group.

Table 7.3 Descriptive Statistics Regarding Average Mental Models Confidence, by UMDES Participation Group

	Overall Mean (SD)	M/S Non-UMDES Mean (SD)	M/S UMDES Mean (SD)	J/C UMDES Mean (SD)	One-Way ANOVA; Bartlett's Test for Equal Variances [a]
Average Mental Models Confidence	2.08 (0.38)	2.08 (0.38)	2.09 (0.36)	2.05 (0.41)	F-statistic 0.49, p=.61; Chi-squared 2.94, p=.23

7.3 Dimension Reduction Process

Due to the large number true/false questions asked in the CPOD Phase 3 mailed survey regarding mental models misconceptions, I developed an empirical method to screen these variables for inclusion in further analyses to examine the effects of specific misconceptions on risk judgments. First, I conducted regressions of risk judgment variables using the individual misconception variables one at a time, controlling for receiver characteristics and information received. For each risk judgment variable, I chose those mental models variables with p-values less than 0.10 for use in further analyses.

Individual p-values for mental models variables as predictors within these regressions are shown in Table 7.4 and Table 7.5. The screening analyses shown here contain the full sample of participants, omitting questions not asked in Jackson/Calhoun and combining results from modified questions. For an alternate method of screening and analyzing this data, using the full set of questions asked in Midland/Saginaw participants and omitting Jackson/Calhoun participants, see Appendix M. The alternate method produced some changes in the effects of certain variables, but did not change overall conclusions (see discussion in Appendix M).

Table 7.4 Univariate Regressions of Mental Models True/False Questions to Screen for Effects on Risk Judgment Process Variables

				Screening for Effects on Risk Judgment Variables	
				Ease of Judgment	Confidence in Judgment
M/S Q. No.	J/C Q. No.	Question Topic	% With Misconception	p-value [a]	p-value
25	25	Chemical Classification	46%	0.538	0.051*
26	26	Multiple Chemicals	10%	0.132	0.611
27	27	Chemical Mfg.	12%	0.176	0.009*
28	--	Dow as a Source	--	--	--
29	--	Dow River Waste	--	--	--
30	--	Dow Incinerator	--	--	--
31	--	Dow Burying Waste	--	--	--
32	28	Levels Increasing	72%	0.374	0.081*
33	--	Past Residence	--	--	--
34	--	Well Water	--	--	--
35	--	Tap Water	--	--	--
36	29(M)	Filtering Water	81%	0.572	0.986
37	--	River Sediment	--	--	--
38	--	River Banks	--	--	--
39	--	Rain Water	--	--	--
40	30(M)	Swimming	58%	0.619	0.670
41	31(M)	River Flooding	15%	0.276	0.298
42	32(M)	Industrial Incin.	44%	0.219	0.019*
43	33	Car Exhaust	44%	0.901	0.176
44	34	Trash Burning	66%	0.286	0.006*
45	35	Municipal Incin.	62%	0.236	0.017*
46	36	Power Plants	51%	0.343	0.254
47	37	Products	31%	0.750	0.100*
48	38	Manmade	36%	0.658	0.757
49	39	Farm Chemicals	56%	0.310	0.036*
50	40	Older Age	40%	0.268	0.848
51	41	Smoking	72%	0.121	0.104
52	42	Fish	4%	0.125	0.871
53	43(M)	River Fish	13%	0.059*	0.073*
54	44(M)	Bottom Fish	18%	0.156	0.938
55	45	Washing Vegetables	50%	0.403	0.971
56	46	Processed Foods	34%	0.090*	0.160
57	47	Trimming Meat	43%	0.074*	0.457
58	48	Trees	47%	0.391	0.863
59	49	Property Disclosure	30%	0.652	0.836
60	50	Property Values	14%	0.086*	0.008*
61	51	Touching/Washing	49%	0.285	0.078*

62	52	Breathing Air	29%	0.425	0.038*
63	53	Living on Soil	82%	0.421	0.632
64	54	Eating Food	6%	0.094	0.304
65	55	Eating Game	13%	0.013*	0.775
66	56	Moving Soil	17%	0.767	0.484
67	57	Transport	52%	0.437	0.859
68	58	Treatments	29%	0.903	0.796
69	59	Exercise	30%	0.583	0.648
70	60	Water Drinking	41%	0.313	0.054*

*Selected for further analyses (p<.10)
-- = Omitted
(M) = Modified
[a] p-values correspond to regression coefficients in ordered logistic regressions controlling for Receiver Characteristics (age, gender, minority status, numeracy, education, having any children, mistrust of government and industry, working for a chemical company, living in the floodplain, living in Jackson/Calhoun) and Information Received (being very familiar with dioxins, UMDES participation, receipt or reading of UMDES brochures, looking up information in completing survey).

Table 7.5 Univariate Regressions of Mental Models True/False Questions to Screen for Effects on Risk Judgment Outcome Variables

				Screening for Effects on Risk Judgment Variables	
				Judgment of Risk	Concern about Risk
M/S Q. No.	J/C Q. No.	Question Topic	% With Misconception	p-value [a]	p-value
25	25	Chemical Classification	46%	0.393	0.021*
26	26	Multiple Chemicals	10%	0.652	0.807
27	27	Chemical Mfg.	12%	0.921	0.670
28	--	Dow as a Source	--	--	--
29	--	Dow River Waste	--	--	--
30	--	Dow Incinerator	--	--	--
31	--	Dow Burying Waste	--	--	--
32	28	Levels Increasing	72%	0.018*	0.002*
33	--	Past Residence	--	--	--
34	--	Well Water	--	--	--
35	--	Tap Water	--	--	--
36	29(M)	Filtering Water	81%	0.014*	0.036*
37	--	River Sediment	--	--	--
38	--	River Banks	--	--	--
39	--	Rain Water	--	--	--
40	30(M)	Swimming	58%	<0.001*	<0.001*
41	31(M)	River Flooding	15%	<0.001*	<0.001*
42	32(M)	Industrial Incin.	44%	0.014*	0.007*
43	33	Car Exhaust	44%	0.042*	0.027*
44	34	Trash Burning	66%	0.062*	0.066*
45	35	Municipal Incin.	62%	0.036*	0.048*
46	36	Power Plants	51%	0.340	0.147
47	37	Products	31%	0.097*	0.181

48	38	Manmade	36%	0.555	0.078*
49	39	Farm Chemicals	56%	0.865	0.448
50	40	Older Age	40%	0.009*	0.027*
51	41	Smoking	72%	0.009*	0.004*
52	42	Fish	4%	0.032*	0.008*
53	43(M)	River Fish	13%	0.116	0.203
54	44(M)	Bottom Fish	18%	0.282	0.521
55	45	Washing Vegetables	50%	0.115	0.195
56	46	Processed Foods	34%	0.775	0.270
57	47	Trimming Meat	43%	0.712	0.922
58	48	Trees	47%	0.873	0.628
59	49	Property Disclosure	30%	0.082*	0.494
60	50	Property Values	14%	0.510	0.573
61	51	Touching/Washing	49%	0.005*	0.001*
62	52	Breathing Air	29%	0.009*	0.001*
63	53	Living on Soil	82%	0.038*	0.026
64	54	Eating Food	6%	0.934	0.162
65	55	Eating Game	13%	<0.001*	<0.001*
66	56	Moving Soil	17%	0.567	0.224
67	57	Transport	52%	0.037*	0.010*
68	58	Treatments	29%	0.810	0.701
69	59	Exercise	30%	0.966	0.717
70	60	Water Drinking	41%	0.884	0.889

*Selected for further analyses (p<.10)
-- = Omitted
(M) = Modified
[a] p-values correspond to regression coefficients in regressions (ordered logistic regression for judgment of risk, linear regression for concern about risk) controlling for Receiver Characteristics (age, gender, minority status, numeracy, education, having any children, mistrust of government and industry, working for a chemical company, living in the floodplain, living in Jackson/Calhoun) and Information Received (being very familiar with dioxins, UMDES participation, receipt or reading of UMDES brochures, looking up information in completing survey).

7.4 Regression Analyses

Those mental models variables selected using the above screening process were added to previous regressions of risk judgment variables (see Chapter 6) to check for potential mediation effects. Average mental models confidence was also included in each regression. Results of these regressions are shown in Tables 7.6 through 7.9 below.

Table 7.6 Ordered Logistic Regression of Ease of Judgment by Receiver Characteristics and Information Received, With and Without Selected Mental Models Variables

	Ease of Judgment			
	Ordered logistic regression Without mental models N=851 LR chi2(14)=67.60 p-value <0.001		Ordered logistic regression With mental models N=847 LR chi2(20)=94.23 p-value <0.001	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	-0.060	0.187	-0.084	0.070
Female Gender	-0.119	0.369	-0.100	0.454
Minority Status	-0.261	0.301	-0.335	0.192
Numeracy	0.029	0.670	-0.006	0.930
Education	0.008	0.913	0.023	0.748
Having a Child	-0.079	0.607	-0.074	0.633
Mistrust	-0.631	<0.001**	-0.636	<0.001**
Working for a Chemical Co.	0.335	0.048*	0.309	0.070
Floodplain Resident	-0.108	0.436	-0.067	0.635
Jackson/Calhoun Resident	-0.215	0.346	-0.218	0.345
Information Received				
Familiarity with Dioxins	0.482	0.001**	0.358	0.016*
UMDES Participation	0.194	0.201	0.201	0.185
UMDES Brochures	0.085	0.560	0.037	0.802
Looking up Information	-0.108	0.733	-0.204	0.518
Mental Models				
Confidence in Mental Model	--	--	0.603	0.001**
River Fish	--	--	0.264	0.212
Processed Foods	--	--	0.202	0.137
Trimming Meat	--	--	-0.250	0.061
Property Values	--	--	0.211	0.279
Eating Game	--	--	0.464	0.031*

*Significant (p<.05)
**Highly significant (p≤.001)

Table 7.7 Ordered Logistic Regression of Confidence in Judgment by Receiver Characteristics and Information Received, With and Without Selected Mental Models Variables

	Confidence in Judgment			
	Ordered logistic regression Without mental models N=851 LR chi2(14)=95.24 p-value <0.001		Ordered logistic regression With mental models N=847 LR chi2(20)=94.23 p-value <0.001	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	-0.051	0.252	-0.063	0.171
Female Gender	-0.088	0.502	-0.143	0.285
Minority Status	0.026	0.917	-0.063	0.806
Numeracy	0.019	0.778	0.051	0.464
Education	-0.060	0.395	-0.049	0.495
Having a Child	0.066	0.664	0.040	0.797
Mistrust	-0.394	0.001**	-0.518	<0.001**
Working for a Chemical Co.	0.287	0.089	0.248	0.150
Floodplain Resident	-0.060	0.663	-0.021	0.882
Jackson/Calhoun Resident	-0.302	0.184	-0.390	0.102
Information Received				
Familiarity with Dioxins	1.048	<0.001**	0.914	<0.001**
UMDES Participation	0.070	0.642	0.040	0.793
UMDES Brochures	0.170	0.242	0.200	0.179
Looking up Information	0.190	0.543	0.064	0.837
Mental Models				
Confidence in Mental Model	--	--	0.783	<0.001**
Chemical Classification	--	--	0.104	0.460
Chemical Manufacturing	--	--	-0.459	0.029*
Levels Increasing	--	--	-0.228	0.121
Industrial Incinerators	--	--	0.280	0.057
Trash Burning	--	--	-0.252	0.101
Municipal Incinerators	--	--	-0.106	0.496
Products	--	--	-0.073	0.627
Farm Chemicals	--	--	0.148	0.272
River Fish	--	--	0.288	0.163
Property Values	--	--	0.476	0.015*
Touching/Washing	--	--	0.180	0.176
Breathing Air	--	--	-0.145	0.339
Water Drinking	--	--	-0.384	0.004*

*Significant ($p<.05$)
**Highly significant ($p\leq.001$)

Table 7.8 Ordered Logistic Regression of Judgment of Risk by Receiver Characteristics and Information Received, With and Without Selected Mental Models Variables

	Judgment of Risk			
	Ordered logistic regression Without mental models N=851 LR chi2(14)=265.25 p-value <0.001		Ordered logistic regression With mental models N=847 LR chi2(33)=331.8 p-value <0.001	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	-0.151	0.001**	-0.126	0.009*
Female Gender	0.127	0.350	0.008	0.955
Minority Status	0.593	0.023	0.504	0.060
Numeracy	0.020	0.778	0.072	0.329
Education	-0.007	0.925	0.015	0.844
Having a Child	-0.086	0.590	-0.046	0.776
Mistrust	1.811	<0.001**	1.578	<0.001**
Working for a Chemical Co.	-0.190	0.288	-0.118	0.520
Floodplain Resident	0.048	0.741	-0.008	0.958
Jackson/Calhoun Resident	-0.160	0.496	-0.572	0.023
Information Received				
Familiarity with Dioxins	0.184	0.205	0.185	0.226
UMDES Participation	-0.206	0.192	-0.097	0.547
UMDES Brochures	-0.290	0.055	-0.294	0.058
Looking up Information	0.187	0.556	0.294	0.372
Mental Models				
Confidence in Mental Model	--	--	0.013	0.946
Levels Increasing	--	--	0.202	0.190
Filtered Water	--	--	0.036	0.844
Swimming	--	--	0.349	0.028*
River Flooding	--	--	-0.505	0.022*
Industrial Incinerators	--	--	0.105	0.496
Car Exhaust	--	--	0.043	0.783
Burning Trash	--	--	-0.179	0.282
Municipal Incin.	--	--	-0.096	0.553
Products	--	--	-0.120	0.446
Older Age	--	--	0.612	<0.001**
Smoking	--	--	0.158	0.332
Fish	--	--	-0.314	0.423
Property Disclosure	--	--	-0.160	0.287
Touching/Washing	--	--	0.141	0.350
Breathing Air	--	--	-0.080	0.632

Living on Soil	--	--	0.174	0.361
Eating Game	--	--	-0.596	0.009*
Transport	--	--	-0.008	0.959

*Significant (p<.05)
**Highly significant (p≤.001)

Table 7.9 Linear Regression of Concern about Risk by Receiver Characteristics and Information Received, With and Without Selected Mental Models Variables

	Concern about Risk			
	Linear regression [a] Without mental models N=853 F(14,838)=27.87 p-value <0.001		**Linear regression [b] With mental models N=849 F(32,816)=15.52 p-value <0.001**	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	-0.087	<0.001**	-0.072	0.001**
Female Gender	0.133	0.040*	0.071	0.269
Minority Status	0.261	0.023*	0.202	0.073
Numeracy	-0.068	0.039*	-0.052	0.116
Education	-0.009	0.801	-0.004	0.909
Having a Child	0.014	0.857	0.037	0.617
Mistrust	0.914	<0.001**	0.762	<0.001**
Working for a Chemical Co.	-0.111	0.190	-0.086	0.299
Floodplain Resident	0.024	0.729	0.003	0.961
Jackson/Calhoun Resident	-0.079	0.486	-0.236	0.040*
Information Received				
Familiarity with Dioxins	0.007	0.915	0.005	0.937
UMDES Participation	-0.217	0.004*	-0.171	0.019*
UMDES Brochures	-0.011	0.878	0.001	0.984
Looking up Information	0.161	0.299	0.194	0.200
Mental Models				
Confidence in Mental Model	--	--	0.090	0.294
Chemical Classification	--	--	0.002	0.972
Levels Increasing	--	--	0.137	0.054
Filtered Water	--	--	-0.029	0.728
Swimming	--	--	0.181	0.013*
River Flooding	--	--	-0.196	0.046*
Industrial Incinerators	--	--	0.047	0.509
Car Exhaust	--	--	0.061	0.393
Burning Trash	--	--	-0.063	0.407

Municipal Incin.	--	--	-0.027	0.712
Manmade	--	--	0.038	0.551
Older Age	--	--	0.240	<0.001**
Smoking	--	--	0.083	0.259
Fish	--	--	-0.266	0.125
Touching/Washing	--	--	0.086	0.210
Breathing Air	--	--	-0.082	0.270
Eating Game	--	--	-0.283	0.005*
Transport	--	--	-0.011	0.876
Constant	1.072	0.001**	0.975	0.007*

*Significant ($p<.05$)

**Highly significant ($p\leq.001$)

[a] Residual df=838, R-squared=0.3177, Adjusted R-squared=0.3063

[b] Residual df=816, R-squared=0.3784, Adjusted R-squared=0.3540

7.5 Summary and Discussion of Effects of Mental Models on Risk Judgments

7.5.1 Confidence in Mental Models

As expected, average confidence in mental models answers was a highly significant predictor of both ease of judging health risk and confidence in judgment of risk ($p\leq.001$). This indicates that hazard and exposure information that strengthens mental models also makes it easier to judge the resulting risk. As all of the true/false mental models questions dealt with hazard and exposure, and not health risk, this provides further evidence suggesting that laypeople do not naturally differentiate between hazard and risk (Sadhra et al. 2002). In contrast, one could imagine that experts familiar with dioxins, such as those interviewed in CPOD Phase 1, might feel confident in their mental models of dioxin hazards and exposure, but still find it difficult to judge the risk or feel confident in their judgment, due to scientific uncertainty. This is further evidence that laypeople do not experience or react to scientific uncertainty in the same ways as experts. Mental models confidence was not significantly predictive of judgment of risk or concern about risk.

7.5.2 Specific Mental Models Misconceptions

This study is believed to be the first to examine the effect of specific mental models misconceptions on risk judgments, and on difficulty making risk judgments. Several specific misconceptions predicted judgment of risk and/or concern about risk. These include two misconceptions related to river water (regarding the effects of swimming and river flooding), one related to diet (regarding the effect of eating game) and one related to age (regarding the effect of being older). The misconception regarding the effect of being older was a highly significant predictor of both judgment of risk and concern about risk. It is important to note that some of these misconceptions (regarding swimming and being older) predicted judgment of greater risk and/or greater concern about risk, while others (regarding river flooding and the effects of eating game) predicted judgment of lower risk and/or lower concern about risk. This means that while it is clear that providing residents with specific information to correct these misconceptions has the potential to alter risk judgments, it is unclear whether the net effect would be an increase or decrease in judgment of the risk and concern about risk.

A different set of specific mental models misconceptions was found to significantly predict ease of judgment and confidence in judgment. One misconception, regarding the effects of eating game, was a significant predictor of ease of judgment. Several misconceptions, regarding chemical manufacturers as the sole source of dioxins, effects of high levels of dioxin contamination on property values, and the effectiveness of water consumption at ridding the body of dioxins, were significant predictors of confidence in judgment. Again, these effects were in both positive and negative directions, indicating that correcting these misconceptions may not reliably result in either a net increase or a net decrease in ease of judgment or confidence in judgment.

7.5.3 Potential Mediation by Mental Models Variables

Some evidence was found for potential mediation of risk judgment variables by one or more of these specific misconceptions, or by average mental models confidence. More specifically, mental models variables potentially mediated effects of gender, minority status, and numeracy on concern about risk, and the effect of working for a chemical company on ease of judgment. This indicates that the role of mental models in forming risk judgments deserves further study.

7.6 Reference

Sadhra, S. et al., 2002. Workers' understanding of chemical risks: Electroplating case study. *Occupational and Environmental Medicine*, 59(10), pp.689 –695.

Chapter 8

Results Regarding Satisfaction

This chapter presents results from analyses of Phase 3 mailed survey data regarding satisfaction with hazard and exposure information. More specifically, this chapter examines the effects of risk judgments on satisfaction, including whether there is evidence that risk judgments, or the ability to judge health risk, mediate effects of information received, receiver characteristics, and mental models on satisfaction.

8.1 Specific Aims Covered in this Chapter

This chapter describes analyses regarding specific aims 3 and 3a, described in Table 8.1 below.

Table 8.1 Specific Aims Addressed in Chapter 8

Specific Aim	Description
3.	To investigate whether residents' health risk judgments, and/or perceived difficulty in making these judgments, directly influence their satisfaction with their level of knowledge about dioxins and/or their satisfaction with the information they have received or gathered about dioxins.
3a.	To determine whether residents' health risk judgments, and/or perceived difficulty in making these judgments, mediate residents' satisfaction with their state of knowledge and the information they have received or gathered.

8.2 Satisfaction Variables

Four items on the Phase 3 mailed survey were related to satisfaction with information received. A composite scale of these four survey items was created, but it was reduced to three items when it was found that one of the four items (regarding confusing information) was much less strongly related to the other three (see Table 6.2 and Table 8.3).

Table 8.2 Scale of Four Items Regarding Satisfaction with Information

Survey Item [a]	Responses	Item-Test Correlation	Item-Rest Correlation	Cronbach's Alpha if Omitted
2. I have gotten enough information about dioxins.	961	0.8660	0.7397	0.7630
3. I am satisfied with the information I have gotten about dioxins.	962	0.8791	0.7650	0.7506
4. The information I've gotten about dioxins has been confusing to me. [b]	952	0.6698	0.4530	0.8803
5. I feel well-informed about dioxins.	949	0.8616	0.7381	0.7638
		Overall Cronbach's Alpha for Four-Item Satisfaction Scale		0.8377

[a] Answers were given on a four-point Likert scale with anchors "Strongly Disagree," "Disagree," "Agree," and "Strongly Agree"
[b] Removed from scale. Reduced scale: n=966, Mean=2.33, SD=0.61, Min=1, Max=4, Cronbach's alpha=0.88

Table 8.3 Inter-Item Correlations in Four-Item Satisfaction Scale, and Reduction to Three Items

	Item 2	Item 3	Item 4[a]	Item 5
Item 2	1.00			
Item 3	0.78	1.00		
Item 4[a]	0.36	0.40	1.00	
Item 5	0.66	0.69	0.47	1.00

Scale: n=966, Mean=2.35, SD=0.55, Min=1, Max=4, Cronbach's alpha=0.84
[a] Removed from scale. Reduced scale: n=966, Mean=2.33, SD=0.61, Min=1, Max=4, Cronbach's alpha=0.88

Descriptive statistics for individual items and the three-item satisfaction scale are shown in Table 8.4.

Table 8.4 Descriptive Summary of Three-Item Satisfaction Scale, Overall and by UMDES Participation Group

	Mean (Std. Dev.)				
Survey Item [a]	**Overall**	**M/S Non-UMDES**	**M/S UMDES**	**J/C UMDES**	**One-Way ANOVA; Bartlett's Test for Equal Variances**
2. I have gotten enough information about dioxins.	2.36 (0.69)	2.30 (0.70)	2.45 (0.67)	2.28 (0.65)	F-statistic 5.92, p <.01; Chi-squared 1.69, p=.43
3. I am satisfied with the information I have gotten about dioxins.	2.39 (0.67)	2.28 (0.69)	2.51 (0.65)	2.38 (0.66)	F-statistic 12.39, p <.01; Chi-squared 1.56, p=.46
5. I feel well-informed about dioxins.	2.24 (0.67)	2.20 (0.68)	2.30 (0.66)	2.12 (0.63)	F-statistic 4.09, p=.02; Chi-squared 1.00 p=.61
Three-Item Satisfaction Scale	2.33 (0.61)	2.26 (0.63)	2.42 (0.58)	2.26 (0.58)	F-statistic 8.49, p <0.01; Chi-squared 3.18, p=.20

[a] Answers were given on a four-point Likert scale with anchors "Strongly Disagree," "Disagree," "Agree," and "Strongly Agree"

Overall, participants were slightly dissatisfied with the information they had received or gathered about dioxins. Even for Midland/Saginaw participants in the UMDES, the most satisfied group (and the participation group potentially receiving the largest quantity of communications about dioxins), average satisfaction was rated slightly below neutral, slightly below halfway between the anchors associated with "disagree" and "agree" (i.e., dissatisfied and satisfied).

8.3 Regression Analyses

The effects of risk judgments on satisfaction, when controlling for other variables, were assessed using regression techniques. Linear regression was used for the satisfaction scale, as the scale did not have discrete points. Models both with and without risk judgment variables, used to check for potential mediation effects, are shown in Table 8.5 below. These models include all receiver characteristics and information received variables from previous regressions (to control for non-significant effects), as well as mental models variables found to be significant predictors of risk judgment variables in previous regressions.

Table 8.5 Linear Regression of Satisfaction with Information by Receiver Characteristics, Information Received, and Mental Models, With and Without Risk Judgment Variables

	Satisfaction with Information Scale			
	Linear regression [a] Without risk judgments N=859 F(25, 833)=11.91 p-value <0.001		Linear regression [b] With risk judgments N=845 F(29, 815)=18.72 p-value <0.001	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	0.017	0.204	0.017	0.165
Female Gender	-0.044	0.250	-0.021	0.551
Minority Status	-0.047	0.496	-0.028	0.657
Numeracy	0.035	0.083	0.027	0.143
Education	-0.039	0.060	-0.033	0.084
Having a Child	-0.032	0.469	-0.036	0.373
Mistrust	-0.273	<0.001**	-0.099	0.006*
Working for a Chemical Co.	0.150	0.003*	0.117	0.011*
Floodplain Resident	-0.057	0.156	-0.048	0.188
Jackson/Calhoun Resident	0.046	0.515	0.054	0.401
Information Received				
Familiarity with Dioxins	0.303	<0.001**	0.225	<0.001**
UMDES Participation	0.018	0.683	-0.021	0.596
UMDES Brochures	0.183	<0.001**	0.163	<0.001**

Looking up Information	-0.133	0.142	-0.122	0.149
Mental Models				
Confidence in Mental Model	0.128	0.014*	0.065	0.179
Chemical Mfg.	-0.039	0.504	0.011	0.838
Levels Increasing	-0.006	0.891	0.026	0.503
Swimming	-0.076	0.065	-0.041	0.280
River Flooding	0.055	0.340	-0.011	0.829
Industrial Incin.	0.037	0.370	0.011	0.758
Older Age	0.018	0.645	0.053	0.136
Trimming Meat	-0.048	0.218	-0.041	0.244
Property Values	0.031	0.576	-0.011	0.822
Eating Game	0.130	0.030*	0.058	0.293
Water Drinking	-0.048	0.196	-0.019	0.584
Risk Judgments				
Ease of Judgment	--	--	0.074	<0.001**
Confidence in Judgment	--	--	0.113	<0.001**
Judgment of Risk	--	--	-0.051	0.041*
Concern about Risk	--	--	-0.103	<0.001**
Constant	2.741	<0.001**	2.326	<0.001**

*Significant (p<.05)
**Highly significant (p≤.001)
[a] Residual df=833, R-squared=0.2634, Adjusted R-squared=0.2413
[b] Residual df=815, R-squared=0.3998, Adjusted R-squared=0.3784

8.4 Analyses for Mediation of Satisfaction by Risk Judgments

To examine potential mediation of satisfaction by risk judgment variables, additional mediation analyses were conducted for the nine receiver characteristics, information received, and mental models variables showing potential mediation by risk judgments in regressions of satisfaction in Table 8.5. Evidence for potential mediation consisted of a p-value less than 0.10 in regression without mental models variables and increased p-value and/or decreased absolute value of regression coefficient in regression with mental models variables.

Mediation analyses were conducted using methods recommended by Baron and Kenny (1986). This method prescribes conducting three regressions to examine four sets of regression coefficients a, b, c, and c', where a represents the effect of the independent variable on the mediator; b represents the effect of the mediator on the dependent variable, controlling for the independent variable; c represents the effect of the independent variable on the dependent variable; and c' represents the effect of the independent variable on the dependent variable, controlling for the mediator. In this case, satisfaction was the dependent variable; receiver characteristics, information received, and mental models were the independent variables. Thus, regression coefficients and p-values were examined for: (1) the effect of receiver characteristics, information received, and mental models variables on satisfaction, without controlling for risk judgments (labeled c in Figure 8.1 below); (2) the effect of these variables on satisfaction, controlling for risk judgments (labeled c'); (3) the effect of risk judgments on satisfaction, controlling for these variables (labeled b); and (4) the effect of these variables risk judgments (labeled a).

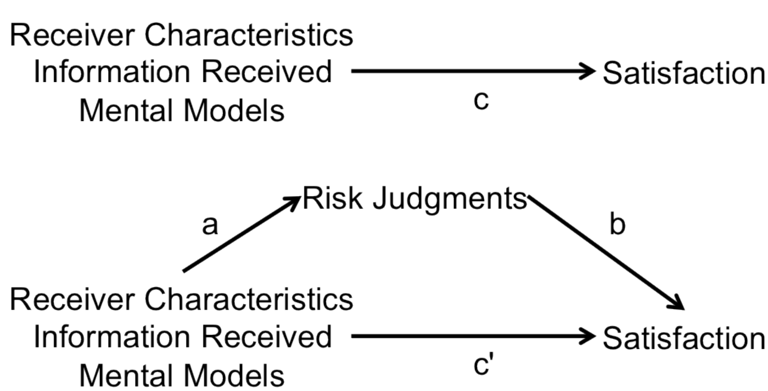


Figure 8.1 Mediation Effects of Risk Judgments on Satisfaction

Regressions to determine b, c, and c' were already conducted in the analyses above. For the additional regressions to determine values of a, see Appendix N. Full results (values of a, b, c, c', and associated p-values) are shown in Table 8.6 below.

Table 8.6 Summary of Mediation Analysis Regression Coefficients for Mediation of Satisfaction by Risk Judgments

	a (p-value)					
	Ease of Judgment	**Confidence in Judgment**	**Judgment of Risk**	**Concern About Risk**	**c (p-value)**	**c' (p-value)**
Receiver Characteristics						
Numeracy	-.008 (.912)	.021 (.767)	.070 (.338)	-.048 (.146)	.035 (.083)	.027 (.143)
Education	.021 (.771)	-.055 (.443)	.018 (.803)	-.003 (.925)	-.039 (.060)	-.033 (.084)
Mistrust	-.635 (<.001**)	-.448 (<.001**)	1.589 (<.001**)	.769 (<.001**)	-.273 (<.001**)	-.099 (.006*)
Working for a Chemical Co.	.334 (.052)	.259 (.129)	-.107 (.556)	-.077 (.353)	.150 (-.003*)	.117 (.011*)
Information Received						
Familiarity with Dioxins	.347 (.020*)	.899 (<.001**)	.182 (.238)	.003 (.961)	.303 (<.001**)	.225 (<.001**)
UMDES Brochures	.060 (.683)	.173 (.240)	-.289 (.061)	-.004 (.951)	.183 (<.001**)	.163 (<.001**)
Mental Models						
Confidence in Mental Model	.597 (.001**)	.834 (<.001**)	.043 (.820)	.118 (.169)	.128 (.014*)	.065 (.179)
Swimming	-.026 (.852)	-.038 (.788)	.477 (.001**)	.238 (<.001**)	-.076 (.065)	-.041 (.280)
Eating Game	.523 (.015*)	-.012 (.952)	-.640 (.004*)	-.315 (.002*)	.130 (.030*)	.058 (.293)
b (p-value)	.074 (<.001**)	.113 (<.001**)	-.051 (.041**)	-.103 (<.001**)		

*Significant (p<.05)
**Highly significant (p<.001)

These additional analyses provided evidence of significant mediation by risk judgments for four key variables, shown in mediation diagrams in the figures below. Numbers in these diagrams correspond to the non-standardized regression coefficients shown in Table 8.6. All effects shown are significant at p<.05, except for the dashed lines in Figure 8.4 and Figure 8.5, which denote effects that became non-significant after adding risk judgment variables.

The first key variable with evidence of mediation by risk judgment variables was the receiver characteristic of mistrust of government and industry (see Figure 8.2). This variable had a negative effect on satisfaction, with a regression coefficient of -.273 without controlling for risk judgments, which was reduced in magnitude to -0.099 when risk judgment variables were added to the regression. The direct effect of mistrust on satisfaction remained significant (p<.05), indicating that complete mediation did not occur. Effects of mistrust on each of the four risk judgment variables were significant and in the expected directions, suggesting partial mediation by each of the four variables.

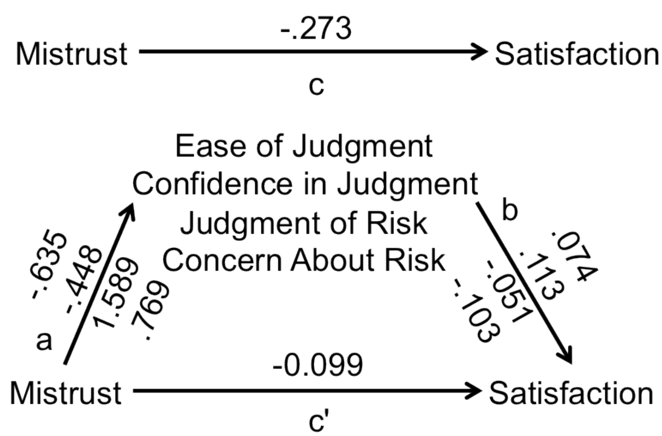


Figure 8.2 Partial Mediation of Negative Effect of Mistrust on Satisfaction by Risk Judgment Variables

The next key variable with evidence of mediation by risk judgment variables was the information received variable of familiarity with dioxins (see Figure 8.3). This variable had a positive effect on satisfaction, with a regression coefficient of 0.303 without controlling for risk judgments, which was reduced to 0.225 when risk judgment variables were added to the regression. The direct effect of familiarity on satisfaction remained significant (p<.05), indicating that complete mediation did not occur. Effects of familiarity on two of the four risk judgment variables were significant and in directions suggestive of partial mediation by these two variables.

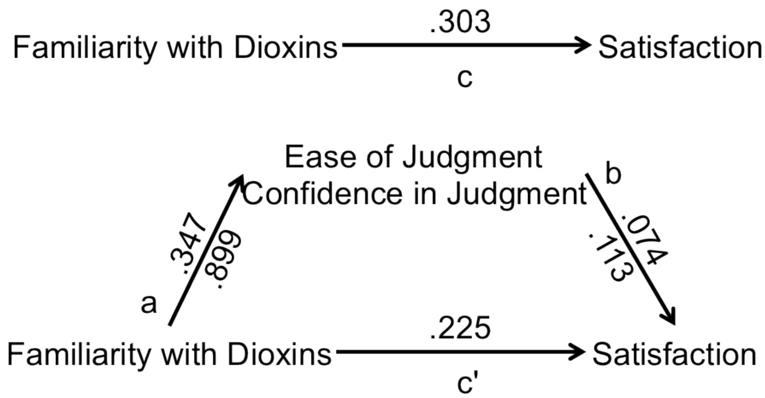


Figure 8.3 Partial Mediation of Positive Effect of Familiarity with Dioxins on Satisfaction by Ease of Judgment and Confidence in Judgment

The next key variable with evidence of mediation by risk judgment variables was the mental models variable regarding mental models confidence (see Figure 8.4). This variable had a positive effect on satisfaction, with a regression coefficient of 0.128 without controlling for risk judgments, which was reduced in magnitude to 0.065 when risk judgment variables were added to the regression. The direct effect of mistrust on satisfaction was no longer significant (p>.05), indicating that mediation was complete or nearly complete. Effects of mistrust on two of the four risk judgment variables were significant and in directions suggestive of mediation by these two variables.

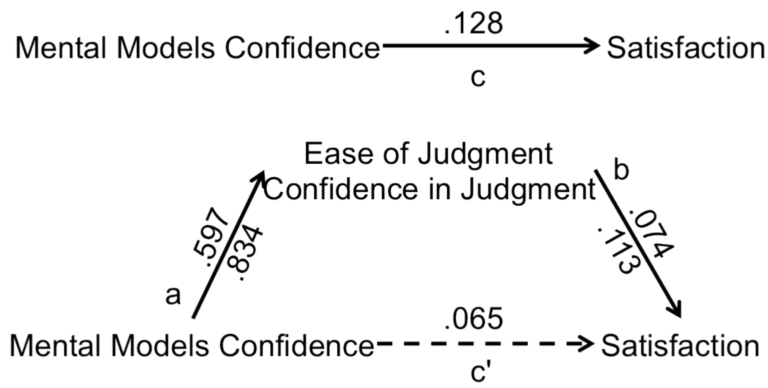


Figure 8.4 Mediation of Positive Effect of Mental Models Confidence on Satisfaction by Ease of Judgment and Confidence in Judgment

The last two variables with evidence of mediation by risk judgment variables were mental models misconceptions regarding swimming and eating game (see Figure 8.4). These variable had mixed effects on satisfaction, with regression coefficients of -0.076 and 0.130, respectively, without controlling for risk judgments, which were reduced in magnitude to -0.041 and 0.058 when risk judgment variables were added to the regression. The direct effect of these misconceptions was no longer significant (p>.05), indicating that mediation was complete or nearly complete. Effects of these misconceptions on two of the four risk judgment variables were significant and in directions suggestive of mediation by these two variables.

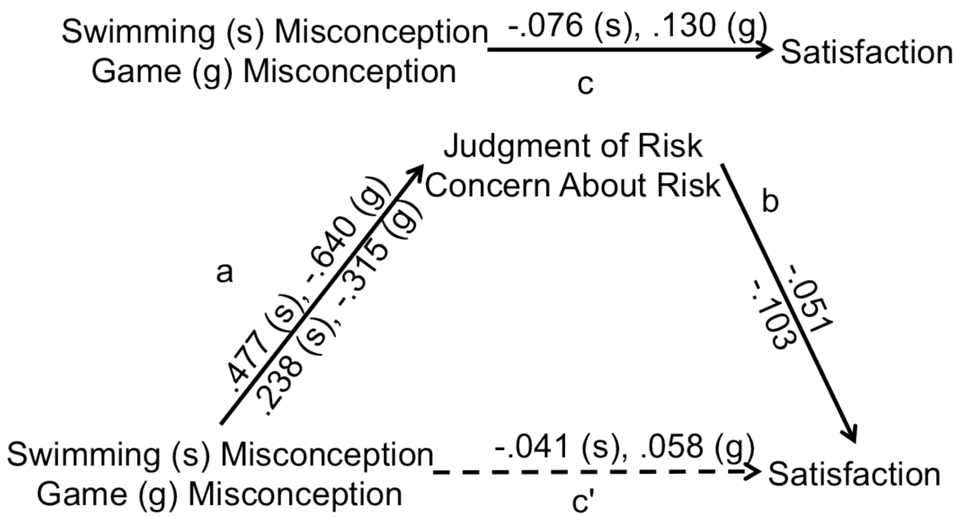


Figure 8.5 Mediation of Effects of Mental Models Misconceptions on Satisfaction by Judgment of Risk and Concern about Risk

8.5 Summary and Discussion of Effects on Satisfaction

Results were consistent with Aim 3. Regression analyses showed that receiver characteristics, information received, and mental models variables significantly predicted satisfaction, and that many of these relationships were mediated by risk judgments.

8.5.1 Effects of Receiver Characteristics on Satisfaction

8.5.1.1 Mistrust of Government and Industry

Mistrust of government and industry was a highly significant predictor of lower satisfaction with information received ($p \leq .001$). This finding provides further indication that it may be difficult for some receivers in settings such as this to find trusted sources of information. Existing sources of communications, including government and industry sources, may be considered untrustworthy, and these receivers may not find any additional communications from government or industry sources to be useful or helpful in these situations. The impact of mistrust on satisfaction was consistent with that found by McComas (2003), finding that positive expectations of public meetings led to greater satisfaction with these meetings. The finding that greater mistrust was also consistently a highly significant predictor of greater difficulty in judging risk, less confidence in risk judgment, judgment of higher risk, and more concern about risk, as well as decreased satisfaction, is evidence of an important linkage between mistrust, risk judgments, and satisfaction. Further exploration of this linkage in mediation analyses demonstrates that risk judgment variables partially mediate the effect of mistrust on satisfaction, reducing the effect size by almost two-thirds. This finding suggests that providing additional information, from trusted sources, to assist in making risk judgments could improve satisfaction with hazard and exposure communications.

8.5.1.2 Working for a Chemical Company

Working for a chemical company was also a significant predictor of greater satisfaction, although it otherwise significantly predicted only greater ease of risk judgment. This result suggests that working for a chemical company had effects on satisfaction that were separate from risk judgment variables. It is unclear whether these effects would be appropriately attributed to a greater expertise or knowledge about chemicals generally; an additional, and likely trusted, source of information in the form of an employer; or a greater interest in the topic, leading to greater attention to available information or additional information-seeking behaviors. This effect was not found to be significantly mediated by risk judgment variables.

8.5.1.3 Other Receiver Characteristics

Age, gender, minority status, having children, and residing near or far from contaminated areas were not significant predictors of satisfaction with information. The fact that some of these variables (age, gender, and minority status) were significant predictors of judgment of risk or concern about risk suggests that satisfaction may be different from judgment of risk and concern about risk with respect to the effects of age, gender, and minority status.

8.5.2 Effects of Information Received on Satisfaction

8.5.2.1 Familiarity with Dioxins

Being very familiar with dioxins (i.e., having heard “a lot” about dioxins) was a significant predictor of satisfaction. This finding suggests that it is partly the quantity of hazard and exposure information available that determines satisfaction. The effects of familiarity were partially mediated by the ease of judging the health risk from dioxins and one’s confidence in this judgment. This finding is significant, as it is further evidence suggesting that laypeople are translating directly from hazard and exposure information into risk information. It also suggests that the sources of information available to receivers in this setting were satisfactory, when controlling for ability to judge risk and mistrust. This would indicate that some receivers are satisfied with making risk judgments based on hazard and exposure information, even when risk is scientifically uncertain.

8.5.2.2 UMDES Brochures

While not a significant predictor in any models of risk judgments, recalled receipt or reading of the 2006 or 2011 UMDES brochures was a highly significant predictor of satisfaction ($p \leq .001$). Those who recalled receiving or reading the brochures were more satisfied with the information they had received, suggesting that the brochures from the UMDES were an important source of information for many participants. This could indicate that information presented in the UMDES brochures, while not significantly assisting with risk judgments, was still presented in a way that was satisfying to receivers, perhaps by presenting information in a thorough, comprehensible manner. Alternatively, this variable may be serving as a more general marker of engagement with the UMDES study. Those who were more engaged with the study may have been more satisfied with the overall set of communications they received pertaining to the study. UMDES participation alone was not a significant predictor of satisfaction.

8.5.2.3 Looking Up Information

Looking up information was not significantly predictive of satisfaction. This further suggests that clear sources of satisfactory information may not be readily available, or at least they were not accessed by these participants during the survey in a way that influenced satisfaction.

8.5.3 Effects of Mental Models on Satisfaction

Relatively few mental models variables significantly predicted satisfaction, including mental models confidence and one mental models misconception.

8.5.3.1 Mental Models Confidence

Mental models confidence was a significant predictor, with participants who were more confident in their mental models reporting greater satisfaction with the information they had received. This suggests that participants were basing their mental models, at least in part, on the information they had received. It also suggests that participants were basing their satisfaction with information, at least in part, on their ability to confidently use this information in their mental models.

The effect of mental models confidence on satisfaction with information appears to be partially mediated by ease of risk judgment and confidence in risk judgment. When the risk judgment variables (ease of judgment, confidence in judgment, judgment of risk, and concern about risk) were added to the regression of satisfaction, the variable representing average mental models confidence became non-significant ($p>.10$). This indicates that the ability to make risk judgments plays an important role in the relationship between having a strong mental model and being satisfied with hazard and exposure communications. More specifically, this provides further evidence that hazard and exposure information that strengthens mental models also makes it easier to judge the resulting risk, and that this, in turn, drives satisfaction.

8.5.3.2 Mental Models Misconceptions

Only one specific mental models misconception significantly predicted satisfaction. This was the misconception regarding the effects of eating game from contaminated areas. Having this misconception (i.e., believing that eating game from contaminated areas could not increase dioxin levels in the body) predicted greater satisfaction with information received. The fact that this misconception predicted greater satisfaction indicates that receivers may be satisfied with information even when their mental models are inaccurate. This is an important finding, as it underscores the need for information that corrects misconceptions, while still satisfying the needs of receivers. While the direction of the relationship with this misconception suggests that providing information to correct this misconception would have a negative effect on satisfaction, it is unclear whether this would actually be the case. Because providing information to correct misconceptions could increase mental models confidence, a net positive effect on satisfaction could still occur.

The effect of the eating game misconception on satisfaction was mediated by risk judgment variables related to judgment of risk and concern about risk. This suggests that it is not the misconception itself driving satisfaction, but rather its effects on judgment of the risk and concern about the risk. This is not surprising. Since participants would not be expected to be aware of the specific misconceptions contained in their mental models, these misconceptions would not be expected to have direct effects on satisfaction with information. Whether correcting these misconceptions would have any net positive or negative effect on risk judgments or satisfaction is unclear from the data. However, if additional information also increased participants' confidence in their mental models, the effect would likely be positive.

8.5.4 Effects of Risk Judgments on Satisfaction

8.5.4.1 Ease of Judgment and Confidence in Judgment

The primary hypothesis that the greater ease of judging health risk and greater confidence in this judgment would significantly predict greater satisfaction was confirmed. Ease of judgment and confidence in judgment were both highly significant predictors of satisfaction with information ($p \leq .001$).

Ease of judging health risk and confidence in this judgment also partially mediated the effects of familiarity with dioxins and mental models confidence on satisfaction. While direct effects of both familiarity and mental models confidence on satisfaction persisted after adding risk judgment variables, the effect sizes were decreased, most significantly in the case of mental models confidence.

These findings indicate that ease of judging health risk and confidence in judgment play an important role in satisfaction with hazard and exposure information received in a community setting. If this is the case, this finding is potentially relevant to the many other settings in which hazard and exposure information is received, including worker-, consumer-, and community-right-to-know settings.

8.5.4.2 Judgment of Risk and Concern about Risk

The alternate hypothesis that judgments of greater risk and greater concern about the risk would significantly predict lower satisfaction was also confirmed. Greater concern about risk, in particular, was a highly significant predictor of lower satisfaction ($p \leq .001$). While modeled in the present research as an effect of judgment and concern on satisfaction, it is possible that the true directionality of this effect could be the reverse. It is possible that lower satisfaction with information about a risk (e.g., due to perhaps a recognition that one is receiving hazard and exposure information without risk information) could actually increase concern about a risk and result in judgment of higher risk.

Judgment of risk and concern about risk also mediated the effect of a significant mental models misconception on satisfaction, suggesting the importance of correcting mental models misconceptions which increase or decrease risk judgments. It is unclear from the data whether providing information to correct misconceptions would have a net positive or net negative effect on satisfaction. However, the positive effects of mental models confidence on ease of judgment and confidence in judgment suggests that the net effect would likely be positive, regardless of the directionality of the effect on satisfaction of the misconception.

8.5.4.3 Overall Effects of Risk Judgments

Together, the four risk judgment variables proved to be powerful predictors of satisfaction. Adding them to the regression model increased the predictive value of the overall model by about a third (R-squared=0.26 without risk judgment variables vs. 0.40 with risk judgment variables). The finding of such a large impact from these four variables, when controlling for a large number of additional variables, underscores the importance judgments of health risk to receivers of hazard and exposure information. This is further supportive of the original hypothesis that the ability of laypeople to use hazard and exposure information to make risk judgments is an important part of satisfaction with hazard and exposure communications.

8.6 Revised Model of Satisfaction

As expected, satisfaction with information received proved to be a very sensitive measure with many predictors. As hypothesized, many of these predictors were mediated or partially mediated by risk judgments. A revised model of satisfaction, showing only those variables with significant direct effects or mediation effects on satisfaction, is shown in Figure 8.6 below. Arrows representing those effects that were highly significant (p≤.001) are shown in bold.

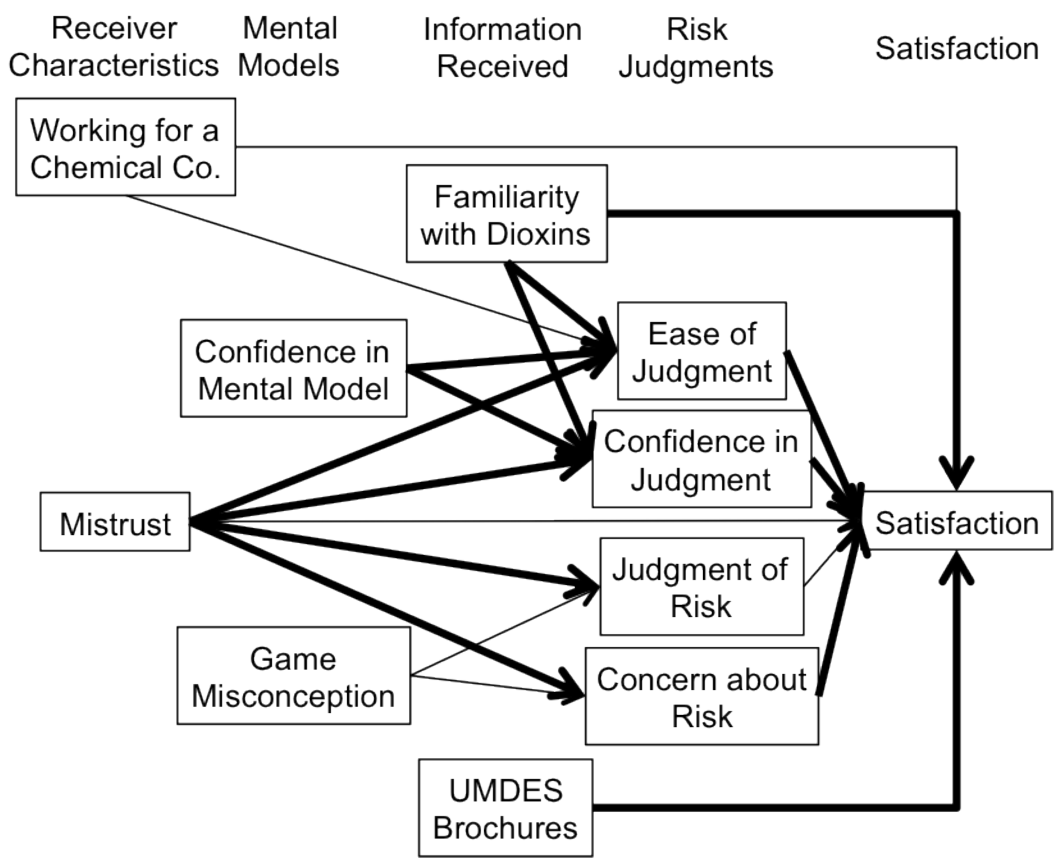


Figure 8.6 Revised Model of Satisfaction

Variables with significant effects on satisfaction that were mediated or partially mediated by risk judgment variables included mistrust of government and industry, familiarity with dioxins, mental models confidence, and one specific mental models misconception regarding eating game. Of these, significant direct effects persisted only for mistrust of government and industry and familiarity with dioxins after adding risk judgment variables. Participants who were more mistrustful of government and industry were less satisfied with the hazard and exposure information they had received. Participants who were more familiar with dioxins were more satisfied. Direct effects, not significantly mediated by risk judgment variables, were also found for working for a chemical company and recalled receipt or reading of the UMDES brochures.

8.7 References

Baron, R.M. & Kenny, D.A., 1986. The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51(6), pp.1173–1182.

McComas, K.A., 2003. Citizen satisfaction with public meetings used for risk communication. *Journal of Applied Communication Research*, 31, pp.164–184.

Chapter 9

Discussion and Conclusions

The purpose of this research was to examine satisfaction with hazard and exposure communications in a community contamination setting where health risk is uncertain. Results showed that risk judgments and the ability to judge health risk play an important role in satisfaction with hazard and exposure communications. This chapter discusses the implications of these findings for hazard and exposure communications, both in community settings and more broadly.

9.1 Findings Regarding the Primary Hypothesis

The primary hypothesis, that residents who felt they were able to make judgments about their health risk would be more satisfied with the hazard and exposure information they had received, was confirmed. Ease of judging risk and confidence in judging risk were both highly significant predictors of satisfaction, even when controlling for many other variables, including receiver characteristics, information received, mental models, judgment of risk, and concern about risk.

This finding indicates that residents provided with hazard and exposure information do not uniformly find it difficult to judge health risk. Even when health risk is scientifically uncertain and experts therefore refrain from communicating judgments of risk, some residents find it easy to make their own risk judgments, and some are even very confident in these judgments. Some of the residents interviewed in Phase 2 of this study indicated that it was easy for them to judge their health risk because of "ignorance," implying that it was easy to make a guess, but that they had very little information to assist them. The findings in Phase 3, however, that ease of judgment and confidence in judgment were positively correlated (inter-item correlation 0.51), that they were predicted by many of the same variables, and that they had similar effects on satisfaction, suggest that many residents did not feel they were guessing when they found it easy to make risk judgments. The fact that those residents who found it easy to make risk judgments were also more likely to be satisfied with the information they had received strongly implies that residents value information that can help them judge their health risk, even when the risk remains scientifically uncertain. This finding is consistent with Lion et al. (2002), which found that people confronted with an unknown risk first try to determine whether it is relevant to them, and desire information to help with an appraisal process to create a risk judgment.

In addition to predicting satisfaction, ease of judging risk and confidence in judging risk also mediated or partially mediated effects on satisfaction related to familiarity with dioxins and confidence in one's mental model of dioxins. These variables are markers of how much information one has been exposed to and retained about dioxins. Mediation of these variables indicates that the receipt and retention of additional information increased satisfaction in large part because it enhanced the ability of residents to make risk judgments. This provides further indication that it is this quality of communications that residents find satisfying, and that hazard and exposure communications that do not enhance receivers' ability to make risk judgments may be dissatisfying. Mediation of these variables also suggests that laypeople may be using a process of judging health risk that differs from that of experts in at least one very important way. An expert in dioxins, likely to be both very familiar with dioxins and very confident in their mental model of fate and transport of dioxins in the environment, would likely still find it difficult to judge the health risk from dioxins and might not be confident in his or her judgment of the health risk, due to scientific uncertainty. In contrast, residents in the present research who were more familiar with dioxins and more confident in their mental models found it easier to judge the health risk. These findings are consistent with research finding that people interpret information in ways that resolve uncertainty (Slovic 1986), and suggest that at least some residents were comfortable making risk judgments from the hazard and exposure information they have received.

Taken together, these findings suggest that communications or other interventions that make it easier for residents to make judgments about health risk could increase their satisfaction with information, even if health risk remains scientifically uncertain. As described in the opening chapter, satisfaction is a desirable outcome in response to communications that are themselves accurate and honest. Although providing accurate information to facilitate judgments about risk in situations where risk is scientifically uncertain is not an easy task, findings from the present research suggest that such information should increase receiver satisfaction.

9.2 Findings Regarding the Alternate Hypothesis

The alternate hypothesis, that residents who judged the risk to be greater would be less satisfied with the communications they had received, was also confirmed. Judgment of greater risk and greater concern about risk were both significant predictors of lower satisfaction, even when controlling for receiver characteristics, information received, mental models, and ease and confidence in judging health risk.

The finding that judgment of greater risk and greater concern about risk predicted lower satisfaction is somewhat inconsistent with McComas (2003), which found that judgment of greater risk predicted greater satisfaction, while greater concern predicted lower satisfaction. However, McComas (2003) was assessing satisfaction specifically with public meetings as a method of communication, rather than satisfaction with overall information received. The finding that both judgment of greater risk and greater concern about risk predict lower satisfaction is consistent with the finding of Griffin et al. (2004) that an individual's assessment of the amount of information needed to cope with a risk increases with individual worry. If greater concern and judgment of greater risk increase information needs, it makes sense that these could also decrease satisfaction with information received.

Judgment of risk and concern about risk were not found to mediate the effects on satisfaction of any variables regarding information received. This is consistent with the fact that conclusive risk information about dioxins was unavailable to residents. Instead, this suggests that residents were basing their risk judgments on their own (i.e., non-expert) process of converting the hazard and exposure information they had received into risk information. It is highly likely that this conversion involved both systematic and affective processing of information. For example, in interviews, residents made risk judgments based on both systematic reasoning about factors they believed would increase or decrease their risk (e.g., "I think it's probably pretty high, because, personally, you know me being in that water, I'm a smoker, I work in the dirt, although I try to exercise, I don't drink enough water…") and affective reasoning about communications they had or had not received (e.g., "I don't think it's anything for me to be concerned about. And I think if it was that somebody would have said you need to see your doctor….").

9.3 Findings Regarding Risk Judgments More Broadly

The present findings suggest that residents do not necessarily seek to make precise quantitative judgments about risk the way scientists do. Instead, qualitative judgments such as those in this study (i.e., 'extremely large threat,' 'no threat at all') appear adequate for satisfaction with communication. As discussed above and in Chapter 2, participants likely made qualitative risk judgments in this study using both systematic and affective processing, with affective processing playing an important role (Slovic & Peters 2006). These findings support the idea that participants are using the type of gist-level encoding described by fuzzy trace theory (Reyna 2004) to process information about their risk and factors contributing to the risk. For example, residents may tend to encode information from communications about dioxins in near-binary ways, judging that the risk is either worth worrying about or not, or judging certain actions to be either safe or not safe, based on various sources of information.

Although it might be very difficult to provide information to help laypeople make precise risk judgments when risk is scientifically uncertain, it may be possible to provide information to assist with qualitative risk judgments.

One way to assist with lay risk judgments could be to provide information about process-level variables pertaining to the risk, including variables related to hazard and exposure. For example, clarifying relevant exposure processes and properties of contaminants such as dioxins can help laypeople understand ways they might or might not be exposed to the contamination (Zikmund-Fisher et al. 2013, in press). This additional information could help strengthen nodes in receivers' mental models. Providing information to further clarify the nature of the relationship between exposure and risk could strengthen connections between these nodes, especially connections to judgments of risk. For example, some workplace chemical hazard communication guidance suggests that labels convey that "the risk of damage or adverse effects depends on the duration and level of exposure" where appropriate for chemicals with chronic hazards (American National Standards Institute (ANSI) 2010, p.24). Strengthening both nodes and connections in receivers' mental models could help receivers better encode information at a gist level in order to use it in making affective risk judgments. Findings from the present research indicate that this could increase mental models confidence, which in turn could increase ease of judging the risk or confidence in judgment and improve satisfaction.

A different type of information that could be provided to help laypeople make qualitative risk judgments could take the form of risk information itself. Very rarely do scientists know nothing about risk, even when many aspects of the risk are scientifically uncertain. Communications that include whatever is known in order to place some bounds on the risk could help with lay risk judgments. Work in the area of crisis risk communication (Sandman 2001; Sandman 2002) has referred to this as being willing to "speculate" or answer "what-if questions." In the absence of any bounding information about risk, lay judgments have the potential to vary widely. Some residents could judge the risk to be extremely high while other could judge it to be extremely low or zero. Research in medical contexts (e.g., regarding breast cancer) has found that laypeople's estimations of risk are often orders of magnitude away from scientifically determined values (Humpel & Jones 2004). Even when risk is scientifically uncertain, the range of lay judgments could still be much wider than the range of expert judgments permitted by the available scientific evidence. Providing accurate information that includes some bounds to risk consistent with the bounds of scientific uncertainty, even if a wide range, could improve satisfaction, especially among those estimating extremely high risk.

The present research points to ways to make it easier for laypeople to make risk judgments when the risk is scientifically uncertain. However, a question could be raised as to the value of doing so. If the scientists aren't sure, isn't it better for laypeople to remain uncertain about the risk and refrain from making risk judgments? After all, unlike risks in medical settings, the health risks from dioxins have not been quantified even by experts. In response, the present research shows that people will and do make qualitative risk judgments, regardless of whether it easy or difficult for them to do so, and regardless of whether risk information has been provided from experts. Providing assistance with these risk judgments may help improve their accuracy (as much as possible), in addition to increasing ease of judgment, confidence in judgment, and satisfaction. As with satisfaction, ease of judgment and confidence in judgment should not necessarily be seen as goals in and of themselves but rather as secondary goals in response to honest and accurate communications. However, even when accurate communications are unavailable to assist people with the process of making risk judgments, the present research demonstrates that people will make such judgments.

9.4 Findings Regarding Mistrust of Government and Industry

Mistrust of government and industry was an extremely important predictor in the model of satisfaction with information that is presented in this research. That mistrust of government and industry would negatively affect satisfaction with information is not surprising, as government and industry were two of the primary sources of information regarding dioxins in this community, two of the primary actors in activities surrounding the assessment and cleanup of dioxins, and industry was also the acknowledged source of the dioxin contamination. As measured in this study, mistrust of government and industry included questions regarding federal, state, and local government; government in general; public officials; industry in the community; and industry in general. Question topics included various aspects of trust and conduct, including corruption; withholding of information; contamination of land, air, and water; pollution and depletion of natural resources; taking care of serious health or environmental problems; and 'doing what is right.' These questions appear to have adequately captured many beliefs relevant to satisfaction with information.

Mistrust of government and industry was largely mediated by risk judgments, with significant mediation effects by all four of the risk judgment variables measured. Residents who were more mistrustful were less satisfied not only because they judged the risk to be higher, but also because they found it more difficult to judge the risk. While literature has consistently linked mistrust with judgment of greater risk and greater concern (e.g., Slovic 1993), the finding that mistrust also makes judgment of the risk more difficult and reduces confidence in this judgment is believed to be new. This finding indicates that residents may be finding it difficult to obtain trusted sources of information to assist in making risk judgments. This suggests that those residents who find it most difficult to judge the risk may not find additional communications from government or industry to be useful or helpful.

These findings underscore the extreme importance of trust in satisfaction with communication and suggest that a lack of trusted sources can lead residents to be dissatisfied with the information available to them. Providing additional information from trusted sources could improve satisfaction with hazard and exposure communications. There is little indication in the present data as to which sources of information would be trusted. While those who recalled reading or receiving the exposure study brochures were more satisfied with the information they had received, it is unclear if this is an indication of trust in university researchers as a source, or an indication that those residents who trusted university researchers were likely to have engaged more deeply with the study (i.e., more likely to have read or recalled the study brochures).

9.5 Findings Regarding Satisfaction More Broadly

As expected based on McComas et al. (2003), satisfaction proved to be a sensitive outcome of communication, with many predictors. All four hypothesized constructs (receiver characteristics, information received, mental models, and risk judgments) had significant or highly significant effects on satisfaction, either directly or mediated by other variables. Assessing satisfaction through multiple survey items combined into a scale proved to be a useful way to examine overall satisfaction with information. Using the subjective measures of having "enough" information and feeling "well informed," in addition to a measure being "satisfied" with information, resulted in a robust scale of satisfaction, with many highly significant predictors. This measure, as intended by Hecht (1978), was useful in examining process variables (risk judgments and mental models) and contributing to theory building.

Although Hecht (1978) maintained that satisfaction also had the advantage of having direct applicability to improving communications, these findings suggest that receiver satisfaction may be valuable as a less direct outcome for assessing and improving hazard and exposure communications in this and other settings, as well as other types of communication. As previously discussed, it may not be useful to consider communication satisfaction as a goal in and of itself for hazard and exposure communications, since receivers could be satisfied by information that is purposely false or misleading. Instead, satisfaction should be considered a desirable outcome in response to communications that are themselves accurate and honest, and may help to explain why communications that are accurate and comprehensible may still fail to satisfy the needs of their receivers.

The fact that the variables assessed in this study together explained approximately 40% of the variance in satisfaction suggests that satisfaction likely has other important contributors beyond those investigated here. These could include, for example, other variables regarding aspects of receivers' worldviews, individually perceived relevance of information or susceptibility to risk, other specific sources of information received, perceptions of quality of information, mental models attributes not captured in the CPOD model, other aspects of risk judgments, or perceptions of fairness in the communication process. Further investigation of other contributors to satisfaction could find other important sources of potential improvements to hazard and exposure communications.

9.6 Relevance to Other Settings in which Hazard and Exposure Communications Occur

In this study, satisfaction with hazard and exposure communications was found to be highly dependent on risk judgments among residents in a community contamination setting. This finding has potential relevance for the many other settings in which hazard and exposure information is received. In addition to direct relevance to communications regarding community exposure studies, biomonitoring studies, and toxicological studies about dioxins and other chemicals, these findings are also relevant to various forms of right-to-know communications about chemicals. Communications in right-to-know contexts may look very different from those in community contamination settings, and risks may also be evaluated differently in these settings. However, receivers in these settings may still make risk judgments based on hazard and exposure information, and the ability to make these judgments may be an important predictor of their satisfaction with right-to-know communications. Three such right-to-know settings, and the potential relevance of the present research, are discussed in more detail below.

9.6.1 Worker Right-to-Know

In the U.S., worker right-to-know information about chemicals is communicated through a system of manufacturer on-product labels and material safety data sheets (MSDSs), as well as employer training (U.S. Occupational Safety and Health Administration (OSHA) 2011). These regulations mandate the provision of information in labels and MSDSs that is hazard-based, in order to insure, conservatively, that known hazards are disclosed even when the manufacturer does not believe the risk will be significant (U.S. Occupational Safety and Health Administration (OSHA) 2011). Although employer training is permitted to include exposure and risk information, the level of sophistication and quality of this training varies widely among employers. As a result, many employees may find it difficult to translate hazard information into more meaningful risk information, and may find these hazard-based communications dissatisfying. Reports in the literature have been critical of a lack of awareness, use, or comprehensibility of hazard-based right-to-know information among employees (U.S. General Accounting Office (GAO) 1991a; Phillips et al. 1999; Nicol et al. 2008), but it is possible, based on the present research, that these findings instead suggest a lack of satisfaction with the information provided, due to a lack of available risk information. Recent changes to U.S. worker right to know have adopted a system used globally that considers hazard severity in more detail (U.S. Occupational Safety and Health Administration (OSHA) 2012). It remains to be seen whether this system will enhance the ability of workers to judge health risks and result in increased satisfaction with communications.

9.6.2 Consumer Right-to-Know

U.S. consumer product labeling about chemicals occurs under both consumer right-to-know and manufacturer duty-to-warn obligations, including those pertaining to food, drugs, cosmetics, pesticides, and other products for household use (Viscusi & Zeckhauser 1996, p.107; U.S. Food and Drug Administration (FDA) 2011c; U.S. Food and Drug Administration (FDA) 2011b; U.S. Food and Drug Administration (FDA) 2011a; U.S. Environmental Protection Agency (EPA) 2011c; U.S. Consumer Product Safety Commission (CPSC) 2011). While thresholds for label statements may be risk-based in some cases, the information presented in labels is generally limited to hazards and precautions. Statements of hazard on consumer product labels are typically similar to workplace labeling, with somewhat more detailed precautions and directions for use. Risk information is typically not provided (Hadden 1986, p.207).

There is evidence that consumers have difficulty judging health risk from hazard-based labels that do not provide explicit risk information. For example, warnings required under California's Safe Drinking Water and Toxic Enforcement Act of 1986 (also known as Proposition 65), have proven difficult for consumers to evaluate. Although such warnings are intended to denote cancer risks greater than 1 in 100,000 over a 70-year lifetime, one survey found that consumers believed cancer risk from using a product with such a Prop 65 warning was comparable to that from smoking over half a pack of cigarettes a day, something associated with a risk more on the order of 1 in 10 (Viscusi & Zeckhauser 1996). As described by Viscusi and Zeckhauser (1996, p.109), mismatches such as these do not achieve the objective of consumer product labeling to "enable consumers to form accurate judgments of the risk level and take appropriate action." Findings from the present research suggest that making it easier for consumers to judge the risks posed by products they use could improve satisfaction with consumer right-to-know communications.

9.6.3 Community Right-to-Know

Unlike communications in community contamination settings, community right-to-know communications occur during normal operations in nearly every community. In the U.S., community right-to-know communications about chemicals stored and used in communities are governed by the Emergency Planning and Community Right-to-Know

Act (EPCRA), and include chemical inventories, material safety data sheets (MSDSs), and emissions data (U.S. Environmental Protection Agency (EPA) 2011a; U.S. Environmental Protection Agency (EPA) 2011b; U.S. Environmental Protection Agency (EPA) 2011e). Other examples of community right-to-know information include water supplier reports about contaminants in drinking water provided to water customers under the Safe Drinking Water Act (SDWA) (U.S. Environmental Protection Agency (EPA) 2011d). Each of these communications is typically hazard- or exposure-based and does not provide risk information.

Without interpretation and conversion to risk information, community right-to-know data may not be helpful to laypeople. Hadden (1989, p.114) characterized the emissions data available under EPCRA Section 313 as "almost meaningless" since little can be inferred about exposure or health risk from simple emissions data. According to a 1991 report by the U.S. General Accounting Office (U.S. General Accounting Office (GAO) 1991b, pp.33–34), a survey of residents in three counties with high levels of reported emissions found although many expressed interest in learning about emissions in their communities, over half were unaware that emissions data was available to the public. Although reasons for non-use can be many and varied, a lack of perceived usefulness could be one reason, as receivers may filter out (i.e., not attend to and forget about) sources that do not seem potentially useful or satisfying.

Presenting right to know information in ways that meet receivers' needs is challenging, however. The GAO report observed that "program officials have disagreed about whether EPA should be engaged in interpreting the significance of the data for the public" (1991b, p.4) and that some officials "expressed uncertainty about the meaning of the data; consequently, they felt uncomfortable responding to public inquiries" (1991b, p.36). Although difficult, it has been argued that this is still a necessary and important task. Hadden (1989, p.188) recommended that community right to know should "[force] us to think through the kinds of information people need for particular decisions and to devise ways of presenting it that are responsive to those needs." As observed by Hadden (1989, p.133), "It is an irony of right to know that we only want and need that right because the risks we hope to control are so difficult to understand." The present research suggests that it is the understanding of these risks that would help to improve satisfaction with information.

9.7 Limitations and Directions for Future Research

The present research assessed satisfaction with hazard and exposure communications received as part of a natural experiment in a community contamination setting following an exposure assessment study. Several important limitations are noted.

First, data collection for the present study occurred approximately six to seven years after data collection for the University of Michigan Dioxin Exposure Study (UMDES). While communications were still ongoing in the community regarding dioxins (e.g., Allee 2009; Lascari 2010) and the UMDES (University of Michigan Dioxin Exposure Study 2011), it is likely that some UMDES participants no longer recalled the details of their participation. Thus, any effects found relating to UMDES participation may be weaker or may otherwise differ from the effects that would have been measured had data collection occurred immediately following the UMDES. This study measured satisfaction with overall information received or gathered to date, which likely includes information obtained from a variety of unknown sources and channels in addition to the

UMDES. As a result, this study takes into account information-seeking behaviors subsequent to participation in the UMDES. However, the effects of specific information-seeking behaviors, and any effects of satisfaction on information-seeking behaviors (or vice versa), were not investigated in the present research. As a result, although satisfaction was likely influenced by many sources outside the UMDES, it cannot be reliably attributed to any specific non-UMDES sources of communication in the present study.

Second, interaction effects between variables under study were neither hypothesized nor examined. Potential interaction effects could mask variables that do not otherwise have direct effects, or change the direction of significant direct effects among sub-populations. Further investigation of interaction effects could find more complex relationships between the variables assessed in the present research.

Regarding generalizability of results, data collection for the present study was conducted through a mailed survey. While response rates were high (approximately 50-60%), it is possible that there were differences between residents who completed the survey and those who did not. If these differences were related to residents' knowledge or attitudes regarding dioxins, the survey sample may not be reflective of the population under study as a whole. Results also may not be directly generalizable to other communities. In settings involving different contaminants and sources of contaminants, different histories of hazard and exposure communications, or significantly different demographics, receivers' risk judgments and satisfaction may depend on different factors than those found in this study. For similar reasons, results also may not be directly generalizable to other hazard and exposure communication settings, such as consumer or occupational contexts.

Research in additional community settings, among participants in additional exposure assessment studies, or in some of the many additional contexts in which hazard and exposure information is received (e.g., community, consumer, or worker right-to-know settings) could help determine whether processes are similar to those found in this study. This additional research could help generalize findings to hazard and exposure communications more broadly. Research in laboratory settings, in which hazard and exposure information are provided as stimuli under the experimenter's control, could be used to confirm whether risk judgments may impact satisfaction with information more generally. Research in laboratory settings could also be used to test potential interventions, by measuring whether communications that improve the ability of receivers to judge health risk result in increased satisfaction.

9.8 Conclusions

The present research examined satisfaction with hazard and exposure communications in a community contamination setting. The primary hypothesis, that residents who felt they were able to make judgments about their health risk would be more satisfied with the hazard and exposure information they had received, was confirmed. The alternate hypothesis, that residents who judged the risk to be greater would be less satisfied with the communications they had received, was also confirmed. Satisfaction was found to be a sensitive outcome with many predictors and potential applicability to improvement of communications.

Findings from the present research suggest that satisfaction with information could be improved by communications or other interventions that make it easier for residents to make judgments about health risk, even if health risk remains scientifically uncertain. These findings suggest that providing accurate information that includes some bounds to risk consistent with the bounds of scientific uncertainty could reduce variability in lay risk judgments, and improve satisfaction. Findings also suggest that clarifying relationships between variables affecting risk (e.g., explaining how hazard or exposure relates to risk), could improve satisfaction by strengthening lay mental models. Mistrust of government and industry was also found to be an important predictor of satisfaction, indicating that providing additional information from trusted sources could improve satisfaction, but that those residents who find it most difficult to judge the risk may not find additional communications from government or industry to be useful or helpful.

Findings may also be relevant to other settings in which hazard and exposure information is communicated, including worker, consumer, and community right-to-know settings. Improving the ability of laypeople to judge health risk in these settings could also improve satisfaction with hazard and exposure communications.

9.9 References

Allee, S., 2009. Dioxin Delays: A series by The Environment Report. *The Environment Report*. Available at: http://www.environmentreport.org/dioxin_delays.php [Accessed August 28, 2012].

American National Standards Institute (ANSI), 2010. American National Standard for Hazardous Workplace Chemicals—Hazard Evaluation and Safety Data Sheet and Precautionary Labeling Preparation: ANSI Z400.1/Z129.1-2010.

Griffin, R.J. et al., 2004. Information sufficiency and risk communication. *Media Psychology*, 6(1), pp.23–61.

Hadden, S.G., 1989. *A Citizen's Right to Know: Risk Communication and Public Policy*, Boulder, CO: Westview Press. Available at: http://hdl.handle.net/2027/[u]: mdp.39015019043051 [Accessed October 30, 2011].

Hadden, S.G., 1986. *Read the Label: Reducing Risk by Providing Information*, Boulder: Westview Press. Available at: http://hdl.handle.net/2027/[u]: mdp.39015012934769 [Accessed October 30, 2011].

Hecht, M.L., 1978. Toward a conceptualization of communication satisfaction. *Quarterly Journal of Speech*, 64(1), pp.47–62.

Humpel, N. & Jones, S.C., 2004. "I don't really know, so it's a guess": Women's reasons for breast cancer risk estimation. *Asian Pacific Journal of Cancer Prevention*, 5(4), pp.428–432.

Lascari, T., 2010. EPA, DEQ have dioxin agreement with Dow Chemical Co. in place. *Midland Daily News*. Available at: http://www.ourmidland.com/local_news/article_f2d45d95-eb88-5beb-a47d-483d754ec83f.html [Accessed August 28, 2012].

Lion, R., Meertens, R.M. & Bot, I., 2002. Priorities in information desire about unknown risks. *Risk Analysis*, 22(4), pp.765–776.

McComas, K.A., 2003. Citizen satisfaction with public meetings used for risk communication. *Journal of Applied Communication Research*, 31, pp.164–184.

Nicol, A. et al., 2008. Accuracy, comprehensibility, and use of material safety data sheets: A review. *American Journal of Industrial Medicine*, 51(11), pp.861–876.

Phillips, C.C. et al., 1999. The Efficacy of Material Safety Data Sheets and Worker Acceptability. *Journal of Safety Research*, 30(2), pp.113–122.

Reyna, V.F., 2004. How People Make Decisions That Involve Risk A Dual-Processes Approach. *Current Directions in Psychological Science*, 13(2), pp.60–66.

Sandman, P.M., 2001. Be willing to answer what-if questions. In *Anthrax, Bioterrorism, and Risk Communication: Guidelines for Action*. Available at: http://www.psandman.com/col/part3.htm#17 [Accessed January 21, 2013].

Sandman, P.M., 2002. Speculation versus refusal to speculate ... or versus treating speculation as fact. In *Dilemmas in Emergency Communication Policy, Emergency Risk Communication CDCynergy (CD-ROM, February 2003)*. pp. 5–7.

Slovic, P., 1986. Informing and educating the public about risk. *Risk Analysis*, 6(4), pp.403–415.

Slovic, P., 1993. Perceived risk, trust, and democracy. *Risk Analysis*, 13(6), pp.675–682.

Slovic, P. & Peters, E., 2006. Risk perception and affect. *Current Directions in Psychological Science*, 15(6), pp.322 –325.

U.S. Consumer Product Safety Commission (CPSC), 2011. Hazardous Substances and Articles; Administration and Enforcement Regulations, 16 CFR 1500. *Code of Federal Regulations*, 16(2), pp.452–562.

U.S. Environmental Protection Agency (EPA), 2011a. Emergency Planning and Notification, 40 CFR 355. *Code of Federal Regulations*, 40(28), pp.429–447.

U.S. Environmental Protection Agency (EPA), 2011b. Hazardous Chemical Reporting: Community Right-to-Know, 40 CFR 370. *Code of Federal Regulations*, 40(28), pp.448–458.

U.S. Environmental Protection Agency (EPA), 2011c. Labeling Requirements for Pesticides and Devices, 40 CFR 156. *Code of Federal Regulations*, 40(24), pp.61–83.

U.S. Environmental Protection Agency (EPA), 2011d. National Primary Drinking Water Regulations, 40 CFR 141-142. *Code of Federal Regulations*, 40(23), pp.367–695.

U.S. Environmental Protection Agency (EPA), 2011e. Toxic Chemical Release Reporting: Community Right-to-Know, 40 CFR 372. *Code of Federal Regulations*, 40(28), pp.458–498.

U.S. Food and Drug Administration (FDA), 2011a. Cosmetic Labeling, 21 CFR 701. *Code of Federal Regulations*, 21(7), pp.144–156.

U.S. Food and Drug Administration (FDA), 2011b. Drug Labeling, 21 CFR 201. *Code of Federal Regulations*, 21(4), pp.8–96.

U.S. Food and Drug Administration (FDA), 2011c. Food Labeling, 21 CFR 101. *Code of Federal Regulations*, 21(2), pp.10–171.

U.S. General Accounting Office (GAO), 1991a. *OSHA Action Needed to Improve Compliance with Hazard Communication Standard*, Washington, DC: U.S. General Accounting Office (GAO).

U.S. General Accounting Office (GAO), 1991b. *Toxic Chemicals: EPA's Toxic Release Inventory Is Useful but Can Be Improved*, Washington, D.C.: U.S. General

Accounting Office (GAO). Available at: http://www.gao.gov.proxy.lib.umich.edu/products/RCED-91-121 [Accessed August 20, 2012].

U.S. Occupational Safety and Health Administration (OSHA), 2011. Hazard Communication, 29 CFR 1910.1200. *Code of Federal Regulations*, 29(6), pp.462–484.

U.S. Occupational Safety and Health Administration (OSHA), 2012. Hazard Communication, 29 CFR 1910.1200. *Code of Federal Regulations*, 29(6), pp.464–599.

University of Michigan Dioxin Exposure Study, 2011. *Measuring People's Exposure to Dioxin Contamination Along the Tittabawassee River and Surrounding Areas: Findings from the University of Michigan Dioxin Exposure Study 2011 Updated*, Ann Arbor, MI: University of Michigan. Available at: http://www.sph.umich.edu/dioxin/PDF/2011%20results/Booklet_01112011.pdf [Accessed January 10, 2012].

Viscusi, W.K. & Zeckhauser, R.J., 1996. Hazard communication: Warnings and risk. *Annals of the American Academy of Political and Social Science*, 545, pp.106–115.

Zikmund-Fisher, B.J. et al., 2013. The effect of misunderstanding the chemical properties of environmental contaminants on exposure beliefs: A case involving dioxins (in press). *Science of the Total Environment*.

Appendix A

University of Michigan Dioxin Exposure Study (UMDES)

Results Letters

This appendix presents letters mailed by the University of Michigan Dioxin Exposure Study (UMDES) to those participants who elected to receive their blood, dust, or soil results.

The University of Michigan Dioxin Exposure Study
University of Michigan School of Public Health
1420 Washington Heights, Ann Arbor 48109-2029
Toll Free Line: 1.888.689.0006
Website: http://www.umdioxin.org

Date

Name & Address

Dear Mr/Ms XXX:

Thank you for participating in the University of Michigan Dioxin Exposure Study. This letter summarizes the results of chemical analyses of the blood sample you provided for the study.

You also may have had soil and/or house dust sampled from your home or property. Chemical analyses of soil and house dust have not been completed. If soil and/or dust were collected for the study, and if you indicated that you wanted to receive the results of analyses of those samples, you will receive separate letters containing those results.

The University of Michigan Dioxin Exposure Study seeks to understand how people are exposed to dioxin-like chemicals. The study will examine the impact of where people have lived, what they eat, their jobs, their hobbies, and their environment, including their soil and household dust, on levels of dioxins in their blood. The study will not look at the effects of dioxins on people's health. We anticipate that the full results of the study will be available in late 2006.

There are hundreds of different types of dioxin-like chemicals. They fall in three broad classes that share similar chemical structures: dioxins, furans and polychlorinated biphenyls (PCBs). Within each class, the individual members are called 'congeners'. Analyses of your blood involved measuring 29 different congeners of dioxins, furans and PCBs. These 29 congeners were chosen because they have been identified by the World Health Organization (WHO), the United States Environmental Protection Agency (USEPA), and the Michigan Department of Environmental Quality (MDEQ) as having dioxin-like toxicity, and are believed to be the most important in terms of potential health effects. Table 1 provides the concentration of each of the 29 congeners found in your blood. If the level of a congener in your blood was below the level at which the laboratory can reliably provide a measurement, one half of the reliably measurable level is shown in Table 1.

Scientists have assigned relative potency values, or Toxic Equivalency Factors (TEFs), to each of the 29 dioxin-like compounds; the TEFs are also listed in Table 1. The TEF for each congener relates its toxicity to that of 2,3,7,8-tetrachlordibenzo-p-dioxin (2,3,7,8-TCDD), the best characterized of these chemicals. The total dioxin toxic equivalent (TEQ) concentration is calculated by multiplying the concentration of each congener by its TEF and adding up the products. The TEQ is the most important indicator of the combined effect of these 29 compounds, and is expressed in picograms per gram (pg/g) of blood lipid. (The number of picograms per gram is the same as parts per trillion.)

The level of total dioxin TEQ in the blood sample you provided, based on these 29 congeners, is ____ pg/g of blood lipid.

Almost everyone has measurable dioxins in their blood. The human health effects of dioxins at blood levels similar to yours are not known. Scientists at the Centers for Disease Control and Prevention (CDC) are working on finding current estimates for the level of dioxin-like compounds in the blood of a person with no known exposure to dioxins other than background exposure. Background exposure means that a person was never exposed to dioxin in a job setting or by an industrial chemical release. Most persons living in the United States have been exposed to small amounts of dioxins in food. While the new estimates are not yet finalized, the CDC has preliminary data from 4 different U.S. studies that you can use as a comparison for the levels of dioxin-like compounds found in your blood sample[1].

Table 2 shows the preliminary CDC estimates for background dioxin TEQ levels in pg/g of blood lipid. The table lists the estimates of dioxin TEQ by age group because dioxin levels in blood tend to increase with age. Please note that the dioxin estimates in Table 2 are based on only 21 of the 29 dioxin congeners that we measured for the University of Michigan Dioxin Exposure Study. The 21 congeners used to calculate the CDC estimated background TEQ levels are identified in Table 1.

Table 2. Preliminary estimates for background dioxin TEQ levels (pg/g of blood lipid) based on 21 measured congeners, by age-group.

Age Group In years	Mean	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Minimum	Maximum
15-29	6.4	5.4	7.8	11.7	14.0	0.0	53.9
30-44	11.8	9.8	16.6	21.1	23.2	0.2	50.4
45-59	16.9	14.9	22.3	29.5	32.8	0.8	55.4
60+	36.1	32.3	45.6	69.2	85.4	3.4	146.4

The level of total dioxin TEQ in the blood sample you provided, based on these 21 congeners is ____ pg/g of blood lipid.

The level of dioxin-like compounds in your blood sample falls between the ____ and the _____ percentile of dioxin-like compound levels in the blood of people in your age group. [Alternative versions for the preceding sentence, depending on the individual result: 1) The level of dioxin-like compounds in your blood sample was above the 95th percentile of dioxin-like compound levels in the blood of people in your age group. 2) The level of dioxin-like compounds in your blood sample was below the 50th percentile

[1] Patterson D.G., Patterson D., Canady R., Wong L., Lee R., Turner W., Caudill S., Grassman J., Needham L., Henderson A. Age Specific Dioxin TEQ Reference Range. Organohalogen Compounds. 2004;66:2878-2883.

of dioxin-like compound levels in the blood of people in your age group.] (For example, the 90th percentile TEQ for persons 45-59 years old is 29.5 pg/g, meaning that 90 percent of persons in this age group would be expected to have blood TEQ less than or equal to this number.)

In order to have scientifically valid results about the relationship between levels of dioxins in soil, household dust and blood, the entire study must be completed and analyzed. Individual or partial results do not permit scientists to make valid conclusions. This means that it is not possible at this time to make any judgments about the association between levels of dioxins in soil and household dust and levels of dioxins in your blood.

We greatly appreciate your participation in the University of Michigan Dioxin Exposure Study. If you have any questions or would like more information, you can visit our web site, or contact us using the information shown below. Additionally, the Community Advisory Panel for the University of Michigan Dioxin Exposure Study will be holding a public meeting on Thursday, March 10, 2005, starting at 6:00pm at the Freeland Elementary School (710 Powley Drive, Freeland). I, along with members of the study team, will be there to answer questions.

Sincerely,

Dr. David Garabrant
Professor
University of Michigan School of Public Health
109 South Observatory
Ann Arbor, Michigan 48109-2029
(888) 689-0006 (toll free)
umdioxin@umich.edu – email address
www.umdioxin.org – web address

Table 1: Results of Blood Concentrations of Dioxin-like Compounds

Congener	TEF	Serum Concentration*	Contribution to TEQ (based on 29 congeners)	Contribution to TEQ (based on 21 congeners)
Dioxins:				
2,3,7,8-TCDD	1			
1,2,3,7,8-PentaCDD	1			
1,2,3,4,7,8-HexaCDD	0.1			
1,2,3,6,7,8-HexaCDD	0.1			
1,2,3,7,8,9-HexaCDD	0.1			
1,2,3,4,6,7,8-HeptaCDD	0.01			
OctaCDD	0.0001			
Furans:				
2,3,7,8-TetraCDF	0.1			
1,2,3,7,8-PentaCDF	0.05			
2,3,4,7,8-PentaCDF	0.5			
1,2,3,4,7,8-HexaCDF	0.1			
1,2,3,6,7,8-HexaCDF	0.1			
1,2,3,7,8,9-HexaCDF	0.1			
2,3,4,6,7,8-HexaCDF	0.1			
1,2,3,4,6,7,8-HeptaCDF	0.01			
1,2,3,4,7,8,9-HeptaCDF	0.01			
OctaCDF	0.0001			
Polychlorinated biphenyls (PCBs):				
3,4,4′,5-TetraCB (81)	0.0001			
3,3′,4,4′-TetraCB (77)	0.0001			
3,3′,4,4′,5-PentaCB (126)	0.1			
3,3′,4,4′,5,5′-HexaCB (169)	0.01			
2,3,3′,4,4′-PentaCB (105)	0.0001			
2,3,4,4′,5-PentaCB (114)	0.0005			
2,3′,4,4′,5-PentaCB (118)	0.0001			
2′,3,4,4′,5-PentaCB (123)	0.0001			
2,3,3′,4,4′,5-HexaCB (156)	0.0005			
2,3,3′,4,4′,5′-HexaCB (157)	0.0005			
2,3′,4,4′,5,5′-HexaCB (167)	0.00001			
2,3,3′,4,4′,5,5′-HeptaCB (189)	0.0001			
		Your Overall TEQ:		

* All results shown are expressed as picograms per gram (pg/g) of blood lipid, which is the same as parts per trillion (PPT)

** The level of this congener in your blood was below the level at which the laboratory can reliably provide a measurement so one half of the reliably measurable level is shown.

Abbreviations:
CDD - chlorinated dibenzodioxins
CDF - chlorinated dibenzofurans
CB - chlorinated biphenyls
TEF – toxic equivalency factor
TEQ – toxic equivalency

The University of Michigan Dioxin Exposure Study
University of Michigan School of Public Health
109 South Observatory, Ann Arbor 48109-2029
Toll Free Line: 1.888.689.0006
Website: http://umdioxin.org

Date

Name & Address

Dear Mr/Ms XXX:

Thank you for participating in the University of Michigan Dioxin Exposure Study. You have indicated that you wish to receive results of chemical analyses of house dust collected from your home. This letter summarizes the results of analyses of dioxins and dioxin-like chemical compounds that were measured in dust collected from your home.

You also may have given a blood sample or had soil sampled from around your home. If you indicated that you wanted to receive the results of analyses from those samples, you will receive separate letters containing those results.

There are hundreds of different dioxin-like chemicals. We selected 29 of these chemicals because they are believed to have the most potential for affecting health. The total dioxin toxic equivalent (TEQ) concentration is the most important index of the combined effect of these 29 compounds, and is expressed in parts per trillion (ppt) of house dust. (See Technical Details, below.)

In the house dust sample collected from your home, the TEQ is ____ ppt. That means that for every gram of dust there are ___ trillionths of a gram of these dioxin-like chemicals.

We also calculated how heavily dioxins are concentrated over the area of flooring that we vacuumed. For every square meter vacuumed there were ___ picograms of dioxin-like chemicals. (A picogram is the same as one trillionth of a gram. A gram is 0.04 ounces.)

The University of Michigan Dioxin Exposure Study seeks to understand how people are exposed to dioxin-like chemicals. It will examine the impact of where people have lived, what they eat, their jobs, their hobbies, and their environment, including their soil and household dust, on levels of dioxins in their blood. In order to have scientifically valid results about the relationship between levels of dioxins in soil, household dust and blood, the entire study must be completed and analyzed. Individual or partial results do not permit scientists to make valid conclusions about the population. This means that it is not possible at this time to make any judgments about the association between levels of dioxins in soil and household dust and levels of dioxins in your blood. We anticipate that the full results of the study will be available in late 2006. The University of Michigan Dioxin Exposure Study will not look at the effects of dioxins on people's health.

So, what do your numbers mean? Although it is possible that finding dioxins in your house dust may cause harm, at this point, we do not yet know. There are no published data from Michigan or elsewhere in the United States to provide a comparison for your results for house dust. There are no government regulations concerning dioxins in house dust. It is likely that most homes in the U.S. have some measurable levels of dioxin-like compounds. One negative consequence that may result from finding a measurable level in your home is that it could affect the value of your home. For example, at the time of sale of the home you may be obligated to divulge your knowledge of these results to potential buyers. We encourage you to share your house dust results with other people who may have exposure to the house dust in your home.

We greatly appreciate your participation in the University of Michigan Dioxin Exposure Study. If you have any questions or would like more information, you can visit our web site, or contact us using the information shown below.

Sincerely,

Dr. David Garabrant
Professor
University of Michigan School of Public Health
109 South Observatory
Ann Arbor, Michigan 48109-2029
(888) 689-0006 (toll free)
umdioxin@umich.edu – email address
www.umdioxin.org – web address

TECHNICAL DETAILS

There are hundreds of different dioxin-like chemicals. They fall in three broad classes that share similar chemical structures: dioxins, furans and polychlorinated biphenyls (PCBs). Within each class the individual members are called 'congeners'. Your house dust sample was analyzed for 29 different PCBs, furans, and dioxins. These 29 congeners were chosen because they have been identified by the World Health Organization (WHO), the United States Environmental Protection Agency (USEPA), and the Michigan Department of Environmental Quality (MDEQ) as having dioxin-like toxicity, and are believed to be the most important in terms of potential health effects. Table 1 provides the concentration of each of the 29 congeners found in your house dust. If the level of a congener in your house dust was below the level at which the laboratory can reliably provide a measurement, one half of the reliably measurable level is shown in Table 1.

Scientists have assigned relative potency values, or Toxic Equivalency Factors (TEFs), to each of the 29 dioxin-like compounds; the TEFs are also listed in Table 1. The TEF for each congener relates its toxicity to that of 2,3,7,8-tetrachlordibenzo-p-dioxin (2,3,7,8-TCDD), the best characterized of these chemicals. The total dioxin toxic equivalent (TEQ) concentration is calculated by multiplying the concentration of each congener by its TEF and adding up the products. The TEQ is the most important index of the combined effect of these 29 compounds, and is expressed in parts per trillion (ppt) of house dust. (The number of parts per trillion is the same as picograms per gram. One picogram is one trillionth of a gram.)

The concentration of total dioxin TEQ in the house dust sample collected from your home, based on these 29 congeners, is ____ ppt of house dust.

The total dioxin TEQ in your house dust sample can also be expressed as an area concentration. The area concentration is the concentration of dioxins per unit area and is expressed in picograms of dioxins per square meter of floor surface that was vacuumed (pg/m^2). The area concentration is often called the 'loading'.

The area concentration of total dioxin TEQ in the house dust sample collected from your home, based on the 29 congeners, is ____ pg/m^2.

Table 1: Concentrations of Dioxin-like Compounds in House Dust

Congener	TEF	House Dust Concentration*	Contribution to TEQ
Dioxins:			
2,3,7,8-TCDD	1		
1,2,3,7,8-PentaCDD	1		
1,2,3,4,7,8-HexaCDD	0.1		
1,2,3,6,7,8-HexaCDD	0.1		
1,2,3,7,8,9-HexaCDD	0.1		
1,2,3,4,6,7,8-HeptaCDD	0.01		
OctaCDD	0.0001		
Furans:			
2,3,7,8-TetraCDF	0.1		
1,2,3,7,8-PentaCDF	0.05		
2,3,4,7,8-PentaCDF	0.5		
1,2,3,4,7,8-HexaCDF	0.1		
1,2,3,6,7,8-HexaCDF	0.1		
1,2,3,7,8,9-HexaCDF	0.1		
2,3,4,6,7,8-HexaCDF	0.1		
1,2,3,4,6,7,8-HeptaCDF	0.01		
1,2,3,4,7,8,9-HeptaCDF	0.01		
OctaCDF	0.0001		
Polychlorinated biphenyls (PCBs):			
3,4,4′,5-TetraCB (81)	0.0001		
3,3′,4,4′-TetraCB (77)	0.0001		
3,3′,4,4′,5-PentaCB (126)	0.1		
3,3′,4,4′,5,5′-HexaCB (169)	0.01		
2,3,3′,4,4′-PentaCB (105)	0.0001		
2,3,4,4′,5-PentaCB (114)	0.0005		
2,3′,4,4′,5-PentaCB (118)	0.0001		
2′,3,4,4′,5-PentaCB (123)	0.0001		
2,3,3′,4,4′,5-HexaCB (156)	0.0005		
2,3,3′,4,4′,5′-HexaCB (157)	0.0005		
2,3′,4,4′,5,5′-HexaCB (167)	0.00001		
2,3,3′,4,4′,5,5′-HeptaCB (189)	0.0001		
		Your Overall TEQ:	

* All results shown are expressed as parts per trillion (ppt) of house dust, which is the same as picograms per gram (pg/g) of house dust.

** The level of this congener in your house dust was below the level at which the laboratory can reliably provide a measurement so one half of the reliably measurable level is shown.

Abbreviations:
CDD - chlorinated dibenzodioxins
CDF - chlorinated dibenzofurans
CB - chlorinated biphenyls
TEF – toxic equivalency factor
TEQ – toxic equivalency

The University of Michigan Dioxin Exposure Study
University of Michigan School of Public Health
109 South Observatory, Ann Arbor 48109-2029
Toll Free Line: 1.888.689.0006
Website: http://umdioxin.org

Date

Name & Address

Dear Mr/Ms XXX:

Thank you for participating in the University of Michigan Dioxin Exposure Study. You indicated that you wished to receive the results of chemical analyses of the dioxins and dioxin-like compounds in soil and vegetation collected from your property. This letter summarizes these analyses.

There are hundreds of different dioxin-like chemicals. We selected 29 of these chemicals because they are believed to have the most potential for affecting health. The total dioxin toxicity equivalence (TEQ) concentration is the most important index of the combined effect of these 29 compounds, and is expressed in parts per trillion (ppt). Calculation of the TEQ is explained in the attached Technical Details.

There were XX/was one soil sample(s) collected from your property that were/was chemically analyzed. The number of soil samples obtained from properties, their locations, and the manner in which they were combined and selected for analysis is described in the Technical Details (see below). Full details of the analysis/analyses from soil analyzed on your property are shown in the table(s) at the end of this letter. The TEQ(s) (the index/ices of the combined effect of the 29 dioxin-like compounds) is/are shown in the following table:

Table A: Soil and Vegetation Sample Result(s) for your property

Sample	**Total TEQ (parts per trillion)**	**Complete Results**
House perimeter 0-1 inch composite		Table 1
House perimeter 1-6 inch composite		Table 2
House perimeter surface vegetation		Table 3
Soil contact zone 0-6 inch composite		Table 4
Soil contact zone surface vegetation		Table 5
Floodplain 0-1 inch composite		Table 6
Floodplain 1-6 inch composite		Table 7
Floodplain surface vegetation		Table 8

[note: this table, and the table numbers, will vary depending on the number of samples analyzed for each property, as will the corresponding tables displayed at the end – there will be no blank rows here and no blank tables at the end]

What do these numbers mean? We can tell you that finding dioxins in your soil does not necessarily mean that you or your family will become ill. Almost all soil in Michigan is believed to have measurable levels of dioxins, even in areas that are not known to have industrial contamination. The background levels of dioxins in soil vary across the state. The Michigan Department of Environmental Quality (MDEQ) has performed limited testing for dioxins in soil in the lower peninsula of Michigan (See Technical Details below for a summary of the MDEQ results).

For regulatory purposes the MDEQ currently has a combined standard for dioxins, furans and PCBs in soil of 90 ppt. The United States Environmental Protection Agency (USEPA) has a combined standard of 1,000 ppt.

Overall, results of analyses of your soil samples are [insert proper ending]

-in the background range for soils in Michigan.

-above the background range for soils in Michigan, but below the MDEQ regulatory standard of 90 ppt.

-above the MDEQ regulatory standard of 90 ppt but below the USEPA standard of 1,000 ppt.

-above the USEPA standard of 1,000 ppt.

As stated in the consent document, knowledge of levels of dioxins, furans and PCBs in soil on your property could affect the value of the property. For example, at the time of the sale of your home you may be obligated to share these results with potential buyers. In addition, the MDEQ currently has a combined standard for dioxins, furans and PCBs in soil of 90 ppt. MDEQ considers any property with values at or above this threshold to be a "facility" for the purposes of state regulations. If you know that your property is a "facility," and you caused the contamination, there are a number of regulatory requirements you must comply with to address the contamination. If you did not cause the contamination, but it migrated onto your property, you have no obligation to notify the MDEQ or clean it up. However, in either case, you may not move the contaminated soil in such a manner that it would spread the contamination. Additional information about state regulations can be found on the MDEQ website: http://www.michigan.gov/deq.

The University of Michigan Dioxin Exposure Study seeks to understand how people are exposed to dioxin-like chemicals. It will examine the impact of where people have lived, what they eat, their jobs, their hobbies, and their environment, including their soil and household dust, on levels of dioxins in their blood. In order to have scientifically valid results about the relationship between levels of dioxins in soil, household dust and blood, the entire study must be completed and analyzed. Individual or partial results do not permit scientists to make valid conclusions about the population. This means that it is not possible at this time to make any judgments about the association between levels of dioxins in soil and household dust and levels of dioxins in your blood. We anticipate that the full results of the study will be available in late 2006. The University of Michigan Dioxin Exposure Study will not look at the effects of dioxins on people's health. For more details about the study please see our website, www.umdioxin.org.

You also may have given a blood sample or had dust sampled from your home. If you indicated that you wanted to receive the results of analyses from those samples, you will receive (or may have received) separate letters containing those results.

We greatly appreciate your participation in the University of Michigan Dioxin Exposure Study. If you have any questions or would like more information, you can visit our web site, or contact us using the information shown below.

Sincerely,

Dr. David Garabrant
Professor
University of Michigan School of Public Health
109 South Observatory
Ann Arbor, Michigan 48109-2029
(888) 689-0006 (toll free)
umdioxin@umich.edu – email address
www.umdioxin.org – web address

TECHNICAL DETAILS

Chemical Analyses:
There are hundreds of different dioxin-like chemicals. They fall into three broad classes that share similar chemical structures: dioxins, furans and polychlorinated biphenyls (PCBs). Within each class the individual members are called 'congeners.' Your soil was analyzed for 29 different PCBs, furans, and dioxins. These 29 congeners were chosen because they have been identified by the World Health Organization (WHO), the United States Environmental Protection Agency (USEPA), and the Michigan Department of Environmental Quality (MDEQ) as having dioxin-like toxicity, and are believed to be the most important in terms of potential health effects. The attached table/s provide/s the concentration of each of the 29 congeners found in your soil. If the level of a congener in a soil sample was below the level at which the laboratory can reliably provide a measurement, one half of the reliably measurable level is shown in the table.

Scientists have assigned relative potency values, or Toxicity Equivalence Factors (TEFs), to each of the 29 dioxin-like compounds; the TEFs are also listed in the table/s. The TEF for each congener relates its toxicity to that of 2,3,7,8-tetrachlordibenzo-p-dioxin (2,3,7,8-TCDD), the congener about which scientists have the most information. The total dioxin toxicity equivalence (TEQ) concentration is calculated by multiplying the concentration of each congener by its TEF and adding up the products. The TEQ is the most important index of the combined effect of these 29 compounds, and is expressed in parts per trillion (ppt). Parts per trillion is the same as picograms per gram. One picogram is one trillionth of a gram.

Soil Sampling:
Properties were sampled in multiple locations using a push core sampler that collected a core of soil from the surface to about six inches below the surface. Surface vegetation, such as grass or weeds, at the site of the core was also collected except in situations where garden plants might be damaged. The protocol identified three possible locations on each property for sampling: around the house (known as the house perimeter set), vegetable or flower gardens on the property where skin contact is likely (known as the soil contact zone), and areas in or near the floodplain of the Tittabawassee River (known as the flood plain set). Since some properties do not have gardens or are not in the floodplain, the number of samples varied across properties. The locations of sampling stations are illustrated in Figure 1.

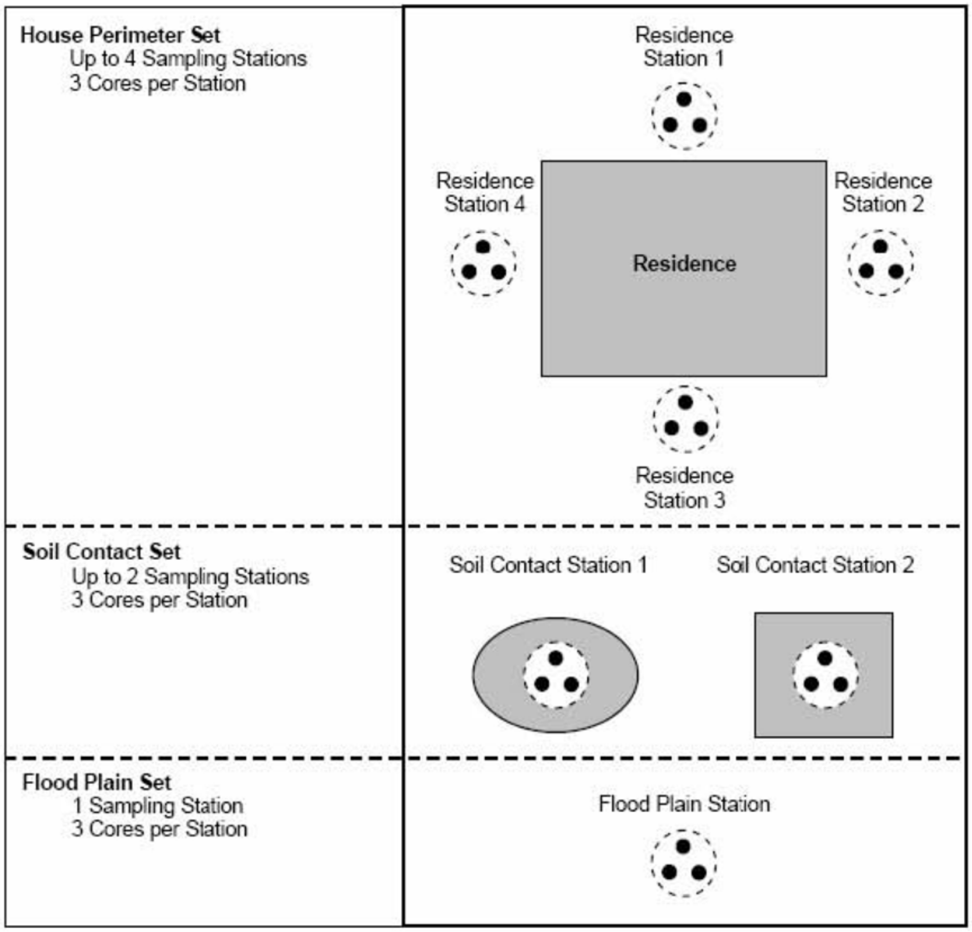


Figure 1. Soil sample locations

Previous analyses done by MDEQ and other researchers have shown that levels of dioxins may vary by how deep the soil is from the surface. To account for this variation, the cores from the house perimeter and the floodplain stations were separated into two groups, known as strata: the 0-1 inch (i.e., the top one inch) stratum and 1-6 inch stratum (i.e., the bottom five inches) for each core. Since people mix soil when they garden, the cores from the soil contact stations were not separated into strata. If the core had vegetation (such as grass or weeds), this part was separated from the 0-1 inch stratum. To have one representative soil sample for each property, all of the soil from each stratum within sets for that property was combined or mixed together, a process known as compositing. For example, all of the soil collected from the top one inch of soil around the house, known as the house perimeter set, was systematically combined for analysis. The soil from the bottom five inches of the house perimeter set was also, separately, combined for analysis. The collected vegetation was composited separately from the soil. Ultimately, each residence yielded the following composite samples for analysis:

• House perimeter set 0-1 inch composite;
• House perimeter set 1-6 inch composite; and
• House perimeter set surface vegetation composite (if available).

If there was a soil contact station or stations, the residence yielded the following additional samples:

• Soil contact set 0-6 inch composite; and
• Soil contact set surface vegetation composite (if available).

In addition, residences that were determined to be in the Tittabawassee River floodplain yielded the following samples:

• Floodplain set 0-1 inch composite;
• Floodplain set 1-6 inch composite; and
• Floodplain set surface vegetation composite (if available).

The number of soil samples available for chemical analyses from each property varied, depending on the property location, and whether there was gardening with potential skin contact. However, not all soil samples were necessarily analyzed. All properties had analyses conducted on the 0-1 inch house perimeter composite sample. If any part of the property was determined to be in the Tittabawassee River floodplain, then all remaining composites (1-6 inch and vegetation house perimeter; 0-1 inch, 1-6 inch and vegetation floodplain; and 0-6 inch and vegetation soil contact) were also submitted for chemical analysis. If the property was not part of the floodplain, but the study participant had a vegetable garden, or worked in a flower garden, then all of the composites from the soil contact zone (the 0-6 inch and vegetation soil contact composites) also were analyzed.

Analyses of the house perimeter 1-6 inch composite and of the house perimeter vegetation stratum were triggered by the TEQ of the 0-1 inch house perimeter composite. If the TEQ of the 0-1 inch house perimeter composite for any property outside the floodplain was greater than 8 ppt, then the 1-6 inch and vegetation house perimeter composites were also analyzed. The trigger value of 8 ppt TEQ represents the 75th percentile (Table B) of the background distribution for the lower peninsula of Michigan. This means that for any area in the lower peninsula of Michigan, it would be expected that 25% of soil samples would be above 8 ppt. For quality control purposes, a random subset of properties outside of the floodplain had the 1-6 inch house perimeter composite analyzed even if the 0-1 inch house perimeter composite was below 8 ppt.

Almost all soil in Michigan is believed to have measurable levels of dioxins, even in areas that are not known to have industrial contamination. The background levels of dioxins in soil vary across the state. The Michigan Department of Environmental Quality has performed limited testing for dioxins in soil in the lower peninsula of Michigan. A summary of the MDEQ results is shown in the following table.

Table B: Summary of Background Levels of Dioxins in Soil in the Lower Peninsula of Michigan

(in ppt TEQ)

Number of soil samples (n)	52
Minimum value	0.4
25th percentile	2.18
Median or 50th percentile	4.60
Mean value	6.73
75th percentile	7.88
97.5th percentile	34.4
Maximum value	34.7

Full details of the University of Michigan Dioxin Exposure Study protocol, including soil sampling and compositing procedures, can be found at the study website: www.umdioxin.org

Table 1: Concentrations of Dioxin-like Compounds in House Perimeter 0-1 inch Composite

Congener	TEF	Soil Concentration*	Contribution to TEQ
Dioxins:			
2,3,7,8-TCDD	1		
1,2,3,7,8-PentaCDD	1		
1,2,3,4,7,8-HexaCDD	0.1		
1,2,3,6,7,8-HexaCDD	0.1		
1,2,3,7,8,9-HexaCDD	0.1		
1,2,3,4,6,7,8-HeptaCDD	0.01		
OctaCDD	0.0001		
Furans:			
2,3,7,8-TetraCDF	0.1		
1,2,3,7,8-PentaCDF	0.05		
2,3,4,7,8-PentaCDF	0.5		
1,2,3,4,7,8-HexaCDF	0.1		
1,2,3,6,7,8-HexaCDF	0.1		
1,2,3,7,8,9-HexaCDF	0.1		
2,3,4,6,7,8-HexaCDF	0.1		
1,2,3,4,6,7,8-HeptaCDF	0.01		
1,2,3,4,7,8,9-HeptaCDF	0.01		
OctaCDF	0.0001		
Polychlorinated biphenyls (PCBs):			
3,4,4′,5-TetraCB (81)	0.0001		
3,3′,4,4′-TetraCB (77)	0.0001		
3,3′,4,4′,5-PentaCB (126)	0.1		
3,3′,4,4′,5,5′-HexaCB (169)	0.01		
2,3,3′,4,4′-PentaCB (105)	0.0001		
2,3,4,4′,5-PentaCB (114)	0.0005		
2,3′,4,4′,5-PentaCB (118)	0.0001		
2′,3,4,4′,5-PentaCB (123)	0.0001		
2,3,3′,4,4′,5-HexaCB (156)	0.0005		
2,3,3′,4,4′,5′-HexaCB (157)	0.0005		
2,3′,4,4′,5,5′-HexaCB (167)	0.00001		
2,3,3′,4,4′,5,5′-HeptaCB (189)	0.0001		
		Your Overall TEQ:	

* All results shown are expressed as parts per trillion (ppt) of dry mass of soil, which is the same as picograms per gram (pg/g) of dry mass of soil.

** The level of this congener in your soil was below the level at which the laboratory can reliably provide a measurement so one half of the reliably measurable level is shown.

Abbreviations:
CDD - chlorinated dibenzodioxins
CDF - chlorinated dibenzofurans
CB - chlorinated biphenyls
TEF – toxicity equivalence factor
TEQ – toxicity equivalence

Table 2: Concentrations of Dioxin-like Compounds in House Perimeter 1-6 inch Composite

Congener	TEF	Soil Concentration*	Contribution to TEQ
Dioxins:			
2,3,7,8-TCDD	1		
1,2,3,7,8-PentaCDD	1		
1,2,3,4,7,8-HexaCDD	0.1		
1,2,3,6,7,8-HexaCDD	0.1		
1,2,3,7,8,9-HexaCDD	0.1		
1,2,3,4,6,7,8-HeptaCDD	0.01		
OctaCDD	0.0001		
Furans:			
2,3,7,8-TetraCDF	0.1		
1,2,3,7,8-PentaCDF	0.05		
2,3,4,7,8-PentaCDF	0.5		
1,2,3,4,7,8-HexaCDF	0.1		
1,2,3,6,7,8-HexaCDF	0.1		
1,2,3,7,8,9-HexaCDF	0.1		
2,3,4,6,7,8-HexaCDF	0.1		
1,2,3,4,6,7,8-HeptaCDF	0.01		
1,2,3,4,7,8,9-HeptaCDF	0.01		
OctaCDF	0.0001		
Polychlorinated biphenyls (PCBs):			
3,4,4′,5-TetraCB (81)	0.0001		
3,3′,4,4′-TetraCB (77)	0.0001		
3,3′,4,4′,5-PentaCB (126)	0.1		
3,3′,4,4′,5,5′-HexaCB (169)	0.01		
2,3,3′,4,4′-PentaCB (105)	0.0001		
2,3,4,4′,5-PentaCB (114)	0.0005		
2,3′,4,4′,5-PentaCB (118)	0.0001		
2′,3,4,4′,5-PentaCB (123)	0.0001		
2,3,3′,4,4′,5-HexaCB (156)	0.0005		
2,3,3′,4,4′,5′-HexaCB (157)	0.0005		
2,3′,4,4′,5,5′-HexaCB (167)	0.00001		
2,3,3′,4,4′,5,5′-HeptaCB (189)	0.0001		
		Your Overall TEQ:	

* All results shown are expressed as parts per trillion (ppt) of dry mass of soil, which is the same as picograms per gram (pg/g) of dry mass of soil.

** The level of this congener in your soil was below the level at which the laboratory can reliably provide a measurement so one half of the reliably measurable level is shown.

Abbreviations:
CDD - chlorinated dibenzodioxins
CDF - chlorinated dibenzofurans
CB - chlorinated biphenyls
TEF – toxicity equivalence factor
TEQ – toxicity equivalence

Table 3: Concentrations of Dioxin-like Compounds in House Perimeter Surface Vegetation

Congener	TEF	Vegetation Concentration*	Contribution to TEQ
Dioxins:			
2,3,7,8-TCDD	1		
1,2,3,7,8-PentaCDD	1		
1,2,3,4,7,8-HexaCDD	0.1		
1,2,3,6,7,8-HexaCDD	0.1		
1,2,3,7,8,9-HexaCDD	0.1		
1,2,3,4,6,7,8-HeptaCDD	0.01		
OctaCDD	0.0001		
Furans:			
2,3,7,8-TetraCDF	0.1		
1,2,3,7,8-PentaCDF	0.05		
2,3,4,7,8-PentaCDF	0.5		
1,2,3,4,7,8-HexaCDF	0.1		
1,2,3,6,7,8-HexaCDF	0.1		
1,2,3,7,8,9-HexaCDF	0.1		
2,3,4,6,7,8-HexaCDF	0.1		
1,2,3,4,6,7,8-HeptaCDF	0.01		
1,2,3,4,7,8,9-HeptaCDF	0.01		
OctaCDF	0.0001		
Polychlorinated biphenyls (PCBs):			
3,4,4′,5-TetraCB (81)	0.0001		
3,3′,4,4′-TetraCB (77)	0.0001		
3,3′,4,4′,5-PentaCB (126)	0.1		
3,3′,4,4′,5,5′-HexaCB (169)	0.01		
2,3,3′,4,4′-PentaCB (105)	0.0001		
2,3,4,4′,5-PentaCB (114)	0.0005		
2,3′,4,4′,5-PentaCB (118)	0.0001		
2′,3,4,4′,5-PentaCB (123)	0.0001		
2,3,3′,4,4′,5-HexaCB (156)	0.0005		
2,3,3′,4,4′,5′-HexaCB (157)	0.0005		
2,3′,4,4′,5,5′-HexaCB (167)	0.00001		
2,3,3′,4,4′,5,5′-HeptaCB (189)	0.0001		
		Your Overall TEQ:	

* All results shown are expressed as parts per trillion (ppt) of dry mass of vegetation, which is the same as picograms per gram (pg/g) of dry mass of vegetation.

** The level of this congener in your vegetation was below the level at which the laboratory can reliably provide a measurement so one half of the reliably measurable level is shown.

Abbreviations:
CDD - chlorinated dibenzodioxins
CDF - chlorinated dibenzofurans
CB - chlorinated biphenyls
TEF – toxicity equivalence factor
TEQ – toxicity equivalence

Table 4: Concentrations of Dioxin-like Compounds in Soil Contact Zone 0-6 inch Composite

Congener	TEF	Soil Concentration*	Contribution to TEQ
Dioxins:			
2,3,7,8-TCDD	1		
1,2,3,7,8-PentaCDD	1		
1,2,3,4,7,8-HexaCDD	0.1		
1,2,3,6,7,8-HexaCDD	0.1		
1,2,3,7,8,9-HexaCDD	0.1		
1,2,3,4,6,7,8-HeptaCDD	0.01		
OctaCDD	0.0001		
Furans:			
2,3,7,8-TetraCDF	0.1		
1,2,3,7,8-PentaCDF	0.05		
2,3,4,7,8-PentaCDF	0.5		
1,2,3,4,7,8-HexaCDF	0.1		
1,2,3,6,7,8-HexaCDF	0.1		
1,2,3,7,8,9-HexaCDF	0.1		
2,3,4,6,7,8-HexaCDF	0.1		
1,2,3,4,6,7,8-HeptaCDF	0.01		
1,2,3,4,7,8,9-HeptaCDF	0.01		
OctaCDF	0.0001		
Polychlorinated biphenyls (PCBs):			
3,4,4′,5-TetraCB (81)	0.0001		
3,3′,4,4′-TetraCB (77)	0.0001		
3,3′,4,4′,5-PentaCB (126)	0.1		
3,3′,4,4′,5,5′-HexaCB (169)	0.01		
2,3,3′,4,4′-PentaCB (105)	0.0001		
2,3,4,4′,5-PentaCB (114)	0.0005		
2,3′,4,4′,5-PentaCB (118)	0.0001		
2′,3,4,4′,5-PentaCB (123)	0.0001		
2,3,3′,4,4′,5-HexaCB (156)	0.0005		
2,3,3′,4,4′,5′-HexaCB (157)	0.0005		
2,3′,4,4′,5,5′-HexaCB (167)	0.00001		
2,3,3′,4,4′,5,5′-HeptaCB (189)	0.0001		
		Your Overall TEQ:	

* All results shown are expressed as parts per trillion (ppt) of dry mass of soil, which is the same as picograms per gram (pg/g) of dry mass of soil.

** The level of this congener in your soil was below the level at which the laboratory can reliably provide a measurement so one half of the reliably measurable level is shown.

Abbreviations:
CDD - chlorinated dibenzodioxins
CDF - chlorinated dibenzofurans
CB - chlorinated biphenyls
TEF – toxicity equivalence factor
TEQ – toxicity equivalence

Table 5: Concentrations of Dioxin-like Compounds in Soil Contact Zone Surface Vegetation

Congener	TEF	Vegetation Concentration*	Contribution to TEQ
Dioxins:			
2,3,7,8-TCDD	1		
1,2,3,7,8-PentaCDD	1		
1,2,3,4,7,8-HexaCDD	0.1		
1,2,3,6,7,8-HexaCDD	0.1		
1,2,3,7,8,9-HexaCDD	0.1		
1,2,3,4,6,7,8-HeptaCDD	0.01		
OctaCDD	0.0001		
Furans:			
2,3,7,8-TetraCDF	0.1		
1,2,3,7,8-PentaCDF	0.05		
2,3,4,7,8-PentaCDF	0.5		
1,2,3,4,7,8-HexaCDF	0.1		
1,2,3,6,7,8-HexaCDF	0.1		
1,2,3,7,8,9-HexaCDF	0.1		
2,3,4,6,7,8-HexaCDF	0.1		
1,2,3,4,6,7,8-HeptaCDF	0.01		
1,2,3,4,7,8,9-HeptaCDF	0.01		
OctaCDF	0.0001		
Polychlorinated biphenyls (PCBs):			
3,4,4′,5-TetraCB (81)	0.0001		
3,3′,4,4′-TetraCB (77)	0.0001		
3,3′,4,4′,5-PentaCB (126)	0.1		
3,3′,4,4′,5,5′-HexaCB (169)	0.01		
2,3,3′,4,4′-PentaCB (105)	0.0001		
2,3,4,4′,5-PentaCB (114)	0.0005		
2,3′,4,4′,5-PentaCB (118)	0.0001		
2′,3,4,4′,5-PentaCB (123)	0.0001		
2,3,3′,4,4′,5-HexaCB (156)	0.0005		
2,3,3′,4,4′,5′-HexaCB (157)	0.0005		
2,3′,4,4′,5,5′-HexaCB (167)	0.00001		
2,3,3′,4,4′,5,5′-HeptaCB (189)	0.0001		
		Your Overall TEQ:	

* All results shown are expressed as parts per trillion (ppt) of dry mass of vegetation, which is the same as picograms per gram (pg/g) of dry mass of vegetation.

** The level of this congener in your vegetation was below the level at which the laboratory can reliably provide a measurement so one half of the reliably measurable level is shown.

Abbreviations:
CDD - chlorinated dibenzodioxins
CDF - chlorinated dibenzofurans
CB - chlorinated biphenyls
TEF – toxicity equivalencefactor
TEQ – toxicity equivalence

Table 6: Concentrations of Dioxin-like Compounds in Floodplain 0-1 inch Composite

Congener	TEF	Soil Concentration*	Contribution to TEQ
Dioxins:			
2,3,7,8-TCDD	1		
1,2,3,7,8-PentaCDD	1		
1,2,3,4,7,8-HexaCDD	0.1		
1,2,3,6,7,8-HexaCDD	0.1		
1,2,3,7,8,9-HexaCDD	0.1		
1,2,3,4,6,7,8-HeptaCDD	0.01		
OctaCDD	0.0001		
Furans:			
2,3,7,8-TetraCDF	0.1		
1,2,3,7,8-PentaCDF	0.05		
2,3,4,7,8-PentaCDF	0.5		
1,2,3,4,7,8-HexaCDF	0.1		
1,2,3,6,7,8-HexaCDF	0.1		
1,2,3,7,8,9-HexaCDF	0.1		
2,3,4,6,7,8-HexaCDF	0.1		
1,2,3,4,6,7,8-HeptaCDF	0.01		
1,2,3,4,7,8,9-HeptaCDF	0.01		
OctaCDF	0.0001		
Polychlorinated biphenyls (PCBs):			
3,4,4′,5-TetraCB (81)	0.0001		
3,3′,4,4′-TetraCB (77)	0.0001		
3,3′,4,4′,5-PentaCB (126)	0.1		
3,3′,4,4′,5,5′-HexaCB (169)	0.01		
2,3,3′,4,4′-PentaCB (105)	0.0001		
2,3,4,4′,5-PentaCB (114)	0.0005		
2,3′,4,4′,5-PentaCB (118)	0.0001		
2′,3,4,4′,5-PentaCB (123)	0.0001		
2,3,3′,4,4′,5-HexaCB (156)	0.0005		
2,3,3′,4,4′,5′-HexaCB (157)	0.0005		
2,3′,4,4′,5,5′-HexaCB (167)	0.00001		
2,3,3′,4,4′,5,5′-HeptaCB (189)	0.0001		
		Your Overall TEQ:	

* All results shown are expressed as parts per trillion (ppt) of dry mass of soil, which is the same as picograms per gram (pg/g) of dry mass of soil.

** The level of this congener in your soil was below the level at which the laboratory can reliably provide a measurement so one half of the reliably measurable level is shown.

Abbreviations:
CDD - chlorinated dibenzodioxins
CDF - chlorinated dibenzofurans
CB - chlorinated biphenyls
TEF – toxicity equivalence factor
TEQ – toxicity equivalence

Table 7: Concentrations of Dioxin-like Compounds in Floodplain 1-6 inches Composite

Congener	TEF	Soil Concentration*	Contribution to TEQ
Dioxins:			
2,3,7,8-TCDD	1		
1,2,3,7,8-PentaCDD	1		
1,2,3,4,7,8-HexaCDD	0.1		
1,2,3,6,7,8-HexaCDD	0.1		
1,2,3,7,8,9-HexaCDD	0.1		
1,2,3,4,6,7,8-HeptaCDD	0.01		
OctaCDD	0.0001		
Furans:			
2,3,7,8-TetraCDF	0.1		
1,2,3,7,8-PentaCDF	0.05		
2,3,4,7,8-PentaCDF	0.5		
1,2,3,4,7,8-HexaCDF	0.1		
1,2,3,6,7,8-HexaCDF	0.1		
1,2,3,7,8,9-HexaCDF	0.1		
2,3,4,6,7,8-HexaCDF	0.1		
1,2,3,4,6,7,8-HeptaCDF	0.01		
1,2,3,4,7,8,9-HeptaCDF	0.01		
OctaCDF	0.0001		
Polychlorinated biphenyls (PCBs):			
3,4,4′,5-TetraCB (81)	0.0001		
3,3′,4,4′-TetraCB (77)	0.0001		
3,3′,4,4′,5-PentaCB (126)	0.1		
3,3′,4,4′,5,5′-HexaCB (169)	0.01		
2,3,3′,4,4′-PentaCB (105)	0.0001		
2,3,4,4′,5-PentaCB (114)	0.0005		
2,3′,4,4′,5-PentaCB (118)	0.0001		
2′,3,4,4′,5-PentaCB (123)	0.0001		
2,3,3′,4,4′,5-HexaCB (156)	0.0005		
2,3,3′,4,4′,5′-HexaCB (157)	0.0005		
2,3′,4,4′,5,5′-HexaCB (167)	0.00001		
2,3,3′,4,4′,5,5′-HeptaCB (189)	0.0001		
		Your Overall TEQ:	

* All results shown are expressed as parts per trillion (ppt) of dry mass of soil, which is the same as picograms per gram (pg/g) of dry mass of soil.

** The level of this congener in your soil was below the level at which the laboratory can reliably provide a measurement so one half of the reliably measurable level is shown.

Abbreviations:
CDD - chlorinated dibenzodioxins
CDF - chlorinated dibenzofurans
CB - chlorinated biphenyls
TEF – toxicity equivalence factor
TEQ – toxicity equivalence

Table 8: Concentrations of Dioxin-like Compounds in Floodplain Surface Vegetation

Congener	TEF	Vegetation Concentration*	Contribution to TEQ
Dioxins:			
2,3,7,8-TCDD	1		
1,2,3,7,8-PentaCDD	1		
1,2,3,4,7,8-HexaCDD	0.1		
1,2,3,6,7,8-HexaCDD	0.1		
1,2,3,7,8,9-HexaCDD	0.1		
1,2,3,4,6,7,8-HeptaCDD	0.01		
OctaCDD	0.0001		
Furans:			
2,3,7,8-TetraCDF	0.1		
1,2,3,7,8-PentaCDF	0.05		
2,3,4,7,8-PentaCDF	0.5		
1,2,3,4,7,8-HexaCDF	0.1		
1,2,3,6,7,8-HexaCDF	0.1		
1,2,3,7,8,9-HexaCDF	0.1		
2,3,4,6,7,8-HexaCDF	0.1		
1,2,3,4,6,7,8-HeptaCDF	0.01		
1,2,3,4,7,8,9-HeptaCDF	0.01		
OctaCDF	0.0001		
Polychlorinated biphenyls (PCBs):			
3,4,4′,5-TetraCB (81)	0.0001		
3,3′,4,4′-TetraCB (77)	0.0001		
3,3′,4,4′,5-PentaCB (126)	0.1		
3,3′,4,4′,5,5′-HexaCB (169)	0.01		
2,3,3′,4,4′-PentaCB (105)	0.0001		
2,3,4,4′,5-PentaCB (114)	0.0005		
2,3′,4,4′,5-PentaCB (118)	0.0001		
2′,3,4,4′,5-PentaCB (123)	0.0001		
2,3,3′,4,4′,5-HexaCB (156)	0.0005		
2,3,3′,4,4′,5′-HexaCB (157)	0.0005		
2,3′,4,4′,5,5′-HexaCB (167)	0.00001		
2,3,3′,4,4′,5,5′-HeptaCB (189)	0.0001		
		Your Overall TEQ:	

* All results shown are expressed as parts per trillion (ppt) of dry mass of vegetation, which is the same as picograms per gram (pg/g) of dry mass of vegetation.

** The level of this congener in your vegetation was below the level at which the laboratory can reliably provide a measurement so one half of the reliably measurable level is shown.

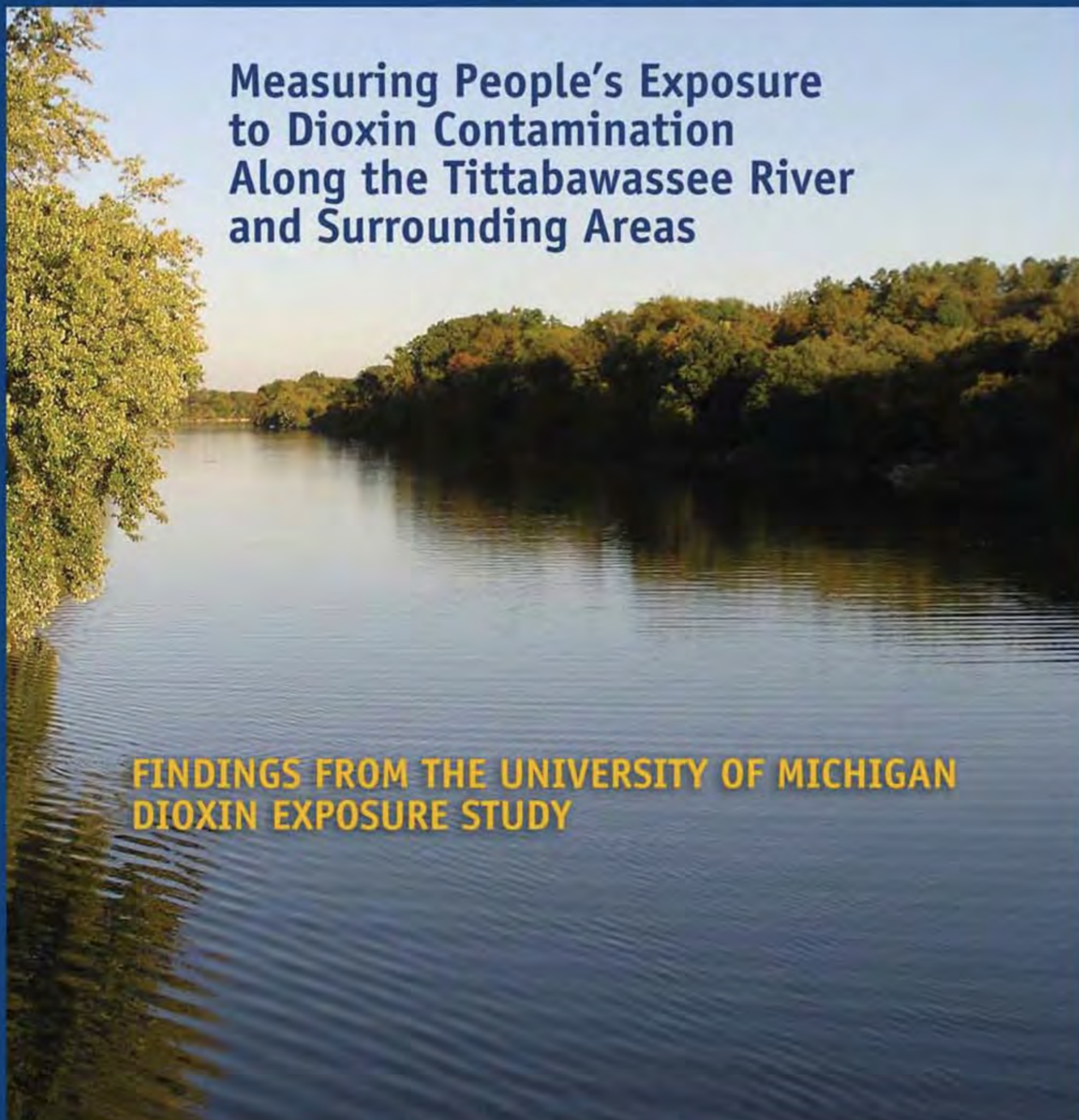
Abbreviations:
CDD - chlorinated dibenzodioxins
CDF - chlorinated dibenzofurans
CB - chlorinated biphenyls
TEF – toxicity equivalence factor
TEQ – toxicity equivalence

Appendix B

UMDES Results Brochure, August 2006

This appendix presents the brochure mailed by the University of Michigan Dioxin Exposure Study (UMDES) to all UMDES participants in August 2006. Copies of this brochure were also made available at public meetings, on the UMDES website, and at public locations in the community (e.g., public libraries).

UNIVERSITY OF MICHIGAN



Measuring People's Exposure to Dioxin Contamination Along the Tittabawassee River and Surrounding Areas

FINDINGS FROM THE UNIVERSITY OF MICHIGAN DIOXIN EXPOSURE STUDY

AUGUST 2006

UNIVERSITY OF MICHIGAN

Financial support for the study comes from The Dow Chemical Company through an unrestricted grant to the University of Michigan. The University of Michigan has complete independence to design, carry out, and report the results of the study. The University of Michigan controls all aspects of the study. Results will be publicly released, whether they are favorable or unfavorable to the funder. They will be posted to the study's website (www.umdioxin.org), presented in community forums, published in academic journals, and reported in the news media.

Summary

Older age is by far the most important factor related to higher levels of dioxins in people's blood. Eating fish from the Tittabawassee River, Saginaw River, and Saginaw Bay also leads to higher levels of dioxins in blood. Living on contaminated soil contributes a small amount to the levels of dioxins in people's blood.

This is the initial report of the University of Michigan Dioxin Exposure Study (UMDES). Dioxins are a family of chemicals that includes three different groups: polychlorinated dioxins, polychlorinated furans, and certain PCBs. They can be produced by combustion and industrial processes – often as unwanted byproducts. They are of concern because they have toxic effects in common.

All Americans have some dioxins in their blood. This study sought to identify pathways of exposure to dioxins in the area near the Dow Chemical Company plant in Midland, Michigan. We studied people who live in five different geographic areas:

- **The Floodplain** — the Tittabawassee River Floodplain extending southeast from Dow to the confluence of the Tittabawassee and Shiawassee Rivers in Midland and Saginaw Counties.
- **The Near Floodplain** — areas next to the Tittabawassee River Floodplain in Midland and Saginaw Counties.
- **The Midland Plume** — an area downwind of the Dow plant in the city of Midland.
- **Other Midland/Saginaw** — other areas in Midland and Saginaw Counties and Williams Township in Bay County.
- **For comparison, Jackson/Calhoun** — Jackson and Calhoun Counties, an area in Michigan over 100 miles away from the Dow plant.

When we refer to "Midland/Saginaw," we are referring to the Floodplain, Near Floodplain, Midland Plume and Other Midland/Saginaw as one combined geographic area. See map on page 8.

In this study we measured levels of dioxins in people's blood, in their soil and in their household dust. We focused on 29 key chemicals within the family of dioxins. We report the results for a summary measure of all 29 chemicals and also for seven specific chemicals within that group of 29 dioxins.

The summary measure — The combined toxicity of all 29 dioxins is called the "TEQ" (for Toxic EQuivalency). It is a summary measure of the toxicity of the 29 dioxins, giving them different weights depending on how toxic they are. Another way of saying it is that the TEQ is a measure of total dioxin-like activity of the 29 chemicals.

The specific chemicals — Within that group of 29 chemicals, we looked at seven specific chemicals. These seven are the major contributors to the TEQ in people's blood in our study and in the United States. (See Glossary and Technical Notes on pages 36-37 for information about these chemicals.)

Key Study Findings About Blood

The most important factor related to levels of dioxins in people's blood is age. We found that older people have higher levels of dioxins in their blood. This effect was found in both Midland/Saginaw and Jackson/Calhoun and has been found in other studies for people across the United States.

The region in which people live, living on contaminated soil and having contaminated household dust contribute small amounts to the levels of dioxins in people's blood. Although small, they contribute in several ways to people having certain dioxins in their blood:

- People who live in some regions of Midland/Saginaw have higher levels of some dioxins in their blood than do people in Jackson/Calhoun.
- People who have higher levels of dioxins in their soil have a higher TEQ (total dioxin-like activity) and higher levels of some specific dioxins in their blood.
- People who have higher levels of dioxins in their household dust have higher levels of one of the specific dioxins (PCB-118) in their blood.

Why do some people in Midland/Saginaw have higher levels of dioxins than people in Jackson/Calhoun?

- In some cases there is a direct relationship between higher levels of dioxins in soil and higher levels of dioxins in people's blood. This relationship is small and applies to some, but not all of the specific dioxins.
- Other factors, some of which are related to contamination in Midland/Saginaw, are more important than living on properties with contaminated soil or with contaminated household dust. These include eating fish, recreational activities, and occupation.
- Eating fish, no matter whether it is sport-caught, store-bought, or from a restaurant, is related to higher levels of dioxins in people's blood. This applies to fish both from the contaminated area in Midland/Saginaw and from outside the contaminated area.
- People who eat fish from the Tittabawassee River, Saginaw River, and Saginaw Bay have higher levels of dioxins in their blood than people who do not eat fish from these areas. Most of these people live in Midland/Saginaw. For example, 65 percent of people who live in the Floodplain have eaten fish from the Tittabawassee River, Saginaw River, or Saginaw Bay at some point during their lives, compared to only 8 percent in Jackson/Calhoun.
- People who do recreational activities in the Tittabawassee River, Saginaw River, and Saginaw Bay have higher levels of dioxins in their blood than people who do not do recreational activities in these areas.
- People who worked at the Dow plant from 1940 to 1959 have higher levels of dioxins in their blood than people who did not work at Dow during that period.
- People in Midland/Saginaw are slightly older than people in Jackson/Calhoun.

Key Study Findings about Soil

- Soil from properties in the Floodplain, Near Floodplain, Midland Plume, and Other Midland/Saginaw is more contaminated with dioxins than soil in Jackson/Calhoun.
- More properties in Midland/Saginaw than in Jackson/Calhoun have soil TEQ levels at or above 90 parts per trillion, an important level set by the State of Michigan.
  - Forty-three percent of properties in the Floodplain, 11 percent of properties in the Near Floodplain, 30 percent of properties in the Midland Plume, and 5 percent of properties in Other Midland/Saginaw have levels higher than 90 parts per trillion.
  - Only one percent of the properties in Jackson/Calhoun have levels above 90 parts per trillion.
- Levels of dioxins in soil in Jackson/Calhoun are similar to levels in soil across Michigan based on a small number of soil samples collected by the Michigan Department of Environmental Quality.
- Soils in the Floodplain and Near Floodplain show patterns of dioxins suggestive of Dow's historical discharges. These patterns are not seen in Jackson/Calhoun.

Key Study Findings about Household Dust

- Household dust from properties in the Midland Plume is more contaminated than household dust from properties in any other region.
- Levels of dioxins in household dust are higher than levels of dioxins in soil in most of the study regions, suggesting that there are sources other than soil for dioxins in household dust.
- Higher levels of dioxins in soil are associated with higher levels of dioxins in household dust. However, not all properties with high levels of dioxins in household dust have high levels of dioxins in soil.

Further Information

Additional reports will be issued as further analyses are completed. Definitions of some terms are provided in the Glossary on page 36. Full descriptions of the study and results are posted on the study web site: www.umdioxin.org.

Study Design

Dioxins are a family of hundreds of similar chemicals that can be produced by combustion and by some industrial processes. People who have been exposed to extremely high levels of dioxins (much higher than were observed in this study) have developed chloracne, a skin disease like severe acne. One of the specific dioxins, called 2,3,7,8-TCDD, is known to cause cancer in people, and others are suspected to be human carcinogens. Animal studies suggest that dioxins may cause reproductive, immune or developmental effects. Other health effects are also suspected.

The University of Michigan Dioxin Exposure Study (UMDES) was undertaken in response to concerns among the population of Midland and Saginaw Counties that dioxin-like compounds from the Dow Chemical Company facilities in Midland have contaminated areas of the City of Midland and sediments in the Tittabawassee River Floodplain. The study was designed to determine if there is a relationship between levels of dioxins in soil and household dust and levels of dioxins in people's blood. It also examined other factors – where people live, what they eat, their jobs and hobbies and recreational activities – that may be associated with levels of dioxins in people's blood. It is important to remember that this is not a health effects study. It is strictly an assessment of factors that can lead to higher levels of dioxins in people.

The UMDES selected a random sample of Michigan residents in Midland, Saginaw, Jackson and Calhoun Counties and Williams Township in Bay County. Jackson and Calhoun Counties were selected to represent other areas of Michigan that have no known industrial source of dioxins, such as the Dow Chemical Company plant.

To be eligible to be in the survey, residents had to be at least 18 years old and had to have lived at their current address continuously for the past five years. Participants were asked to complete a one-hour personal interview that gathered information about demographic and health factors, residence history, land use, occupation and military history, recreational activities, and detailed food consumption. If eligible, participants were asked to provide an 80 milliliter blood sample, to consent to sampling of household dust, and to consent to sampling of soil around their home.

Full details on the study design, field and laboratory methods, and study findings are posted on the study website www.umdioxin.org.

Number of Participants

	Floodplain	Near Floodplain	Midland Plume	Other Midland/ Saginaw	Jackson/ Calhoun	Total Across All Areas
Interviews	314	276	66	309	359	1324
Blood Samples	243	205	43	204	251	946
Household Dust Samples	205	161	32	168	198	764
Soil Samples	203	164	32	173	194	766
Interviews, blood, dust and soil	195	156	30	167	183	731

What are the most important factors related to levels of dioxins in people's blood?

The most important factor related to levels of dioxins in people's blood is their age. Older people have more dioxins in their blood, and this is true in Midland/Saginaw, Jackson/Calhoun, and across the United States. Other important factors related to dioxins in blood are gender and body fat. These three factors account for half of the variability in TEQ levels in blood across Midland/Saginaw and Jackson/Calhoun. Other studies in the United States have found similar results.

The region in which people live, soil contamination, and household dust contamination combined account for about one percent of the variability in levels of 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, PCB-118, and PCB-126 in people's blood. For the other types of dioxins and the TEQ, region, soil and household dust contamination combined account for less than 0.2 percent of the variability in levels of dioxins in people's blood.

People's exposure to Dow's contamination of the Midland/Saginaw region (and environmental contamination from other sources) extends beyond direct soil and household dust exposure. Exposure pathways include eating fish and game from the contaminated area, doing water-related activities in the contaminated area, and certain occupations (e.g., working at Dow). Taken all together, these sources account for:

- 1 to 2 percent of the variability in TEQ levels;
- 2 to 3 percent of the variability in 2,3,7,8-TCDD, 2,3,4,7,8-PeCDF, and 1,2,3,6,7,8-HxCDD levels;
- 5 to 6 percent of the variability in 1,2,3,7,8-PeCDD and PCB-126 levels;
- and less than one percent of the variability in PCB-118 and PCB-156 levels in people's blood.

Other important factors, unrelated to Dow (or to other environmental contamination in the Midland/Saginaw region), include breastfeeding, smoking, eating game from other areas, eating fish from other areas, and eating store-bought meat, dairy, and home-raised eggs from outside the Tittabawassee River Floodplain, the Saginaw River Floodplain, and the Saginaw Bay Floodplain.

Summary table of factors that explain higher and lower levels of dioxins in blood (in order of decreasing importance)

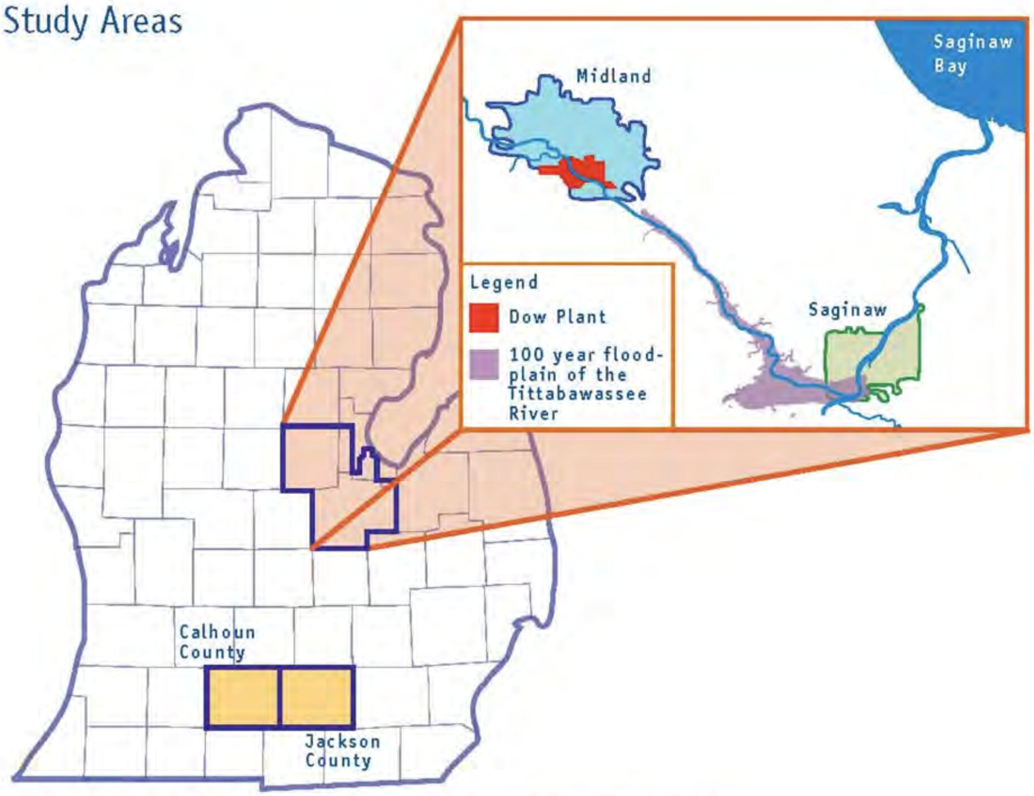
Factors associated with higher levels of dioxins in people's blood

- Being older
- Eating fish, especially fish from the Tittabawassee River, Saginaw River, and Saginaw Bay
- Eating game, regardless of where it came from
- Eating meat, dairy, or eggs
- Living on property with soil contaminated by some dioxins
- Having household dust contaminated by PCB-118
- Living in the Floodplain, Near Floodplain, Midland Plume, and Other Midland/Saginaw, areas that are contaminated by some dioxins

Factors associated with lower levels of dioxins in people's blood

- Being younger
- Smoking
- Breastfeeding
- Eating fruit and vegetables

Study Areas



REGION AND LEVELS OF DIOXINS IN BLOOD

How do blood results in Midland/Saginaw compare with blood results in Jackson/Calhoun?

People who live in the Floodplain, Near Floodplain, and Other Midland/Saginaw have higher levels of dioxins in their blood than do people in Jackson/Calhoun. People who live in the Midland Plume have similar levels of dioxins in their blood compared to people in Jackson/Calhoun. The median level (the level at which half the levels are above and half the levels are below) of dioxins for people living in Jackson/Calhoun was about 25 parts per trillion, compared to 32 parts per trillion in the Floodplain, 29 parts per trillion in the Near Floodplain, 24 parts per trillion in the Midland Plume, and 28 parts per trillion in Other Midland/Saginaw.

In Jackson/Calhoun, about 25 percent of people had TEQ levels of at least 36 parts per trillion in their blood. A similar percentage is found in the Near Floodplain and the Midland Plume. However, a higher percentage of people – just over 35 percent – had this TEQ level or higher in their blood in the Floodplain and Other Midland/Saginaw.

Small differences across the regions remain even after looking at people who are comparable with respect to age, occupation, consumption of certain meat, fish and game, recreational activities, soil, and household dust. The region in which people live accounts for about one percent of the variability in levels of TEQ and the seven specific dioxins in people's blood.

- People who live in the Floodplain have slightly higher levels of 2,3,7,8-TCDD, 2,3,4,7,8-PeCDF, and 1,2,3,7,8-PeCDD than do people who live in Jackson/Calhoun.
- People who live in the Near Floodplain have slightly higher TEQ levels, and higher levels of 2,3,7,8-TCDD, 2,3,4,7,8-PeCDF, 1,2,3,7,8-PeCDD, and PCB-126 than do people who live in Jackson/Calhoun.
- People who live in the Midland Plume have slightly higher levels of 2,3,7,8-TCDD than do people who live in Jackson/Calhoun.
- People who live in Other Midland/Saginaw have slightly higher levels of 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD than do people who live in Jackson/Calhoun.

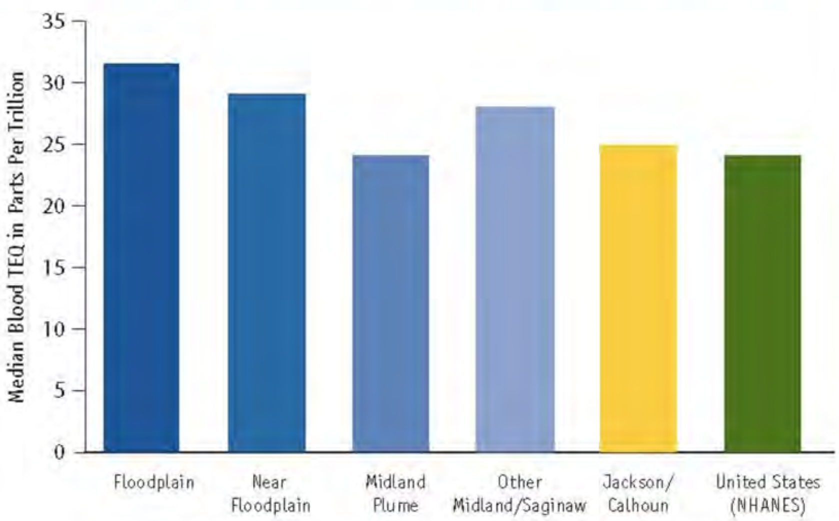
For example, the average difference in 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF levels in blood between people who live in any of the Midland/Saginaw regions and Jackson/Calhoun is less than 1 part per trillion.

How do the blood levels in people from this study compare with levels across the nation?

As shown in Figure 1, people who live in Midland/Saginaw have higher levels of dioxins in their blood than the national median level (the level at which half the levels are above and half the levels are below). Levels of dioxins in people in Jackson/Calhoun are about the same as the national median.

We used one of the best publicly-available resources for the national levels of dioxins in blood — the Centers for Disease Control and Prevention's National Health and Nutrition Examination Survey (NHANES, www.cdc.gov/nchs/nhanes.htm). In 2000-2001, NHANES tested about 1000 people aged 20 years and older in the United States for 26 dioxins in the blood. The median blood TEQ level for the United States was 24 parts per trillion.

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.



Note: Results unadjusted for age or other factors. NHANES refers to the Centers for Disease Control and Prevention's National Health and Nutrition Examination Survey (www.cdc.gov/nchs/nhanes.htm).

Is living in Midland/Saginaw during different historic periods related to higher levels of dioxins in people's blood?

People who lived in Midland/Saginaw between 1940 and 1959 have higher levels of 2,3,7,8-TCDD in their blood. We believe this is suggestive of Dow's operations during that time period. Other types of dioxins and TEQ do not have this kind of relationship. Other time periods do not have this relationship.

SOIL AND HOUSEHOLD DUST AND LEVELS OF DIOXINS IN BLOOD

Are levels of dioxins in soil related to levels of dioxins in people's blood?

Four of the seven specific types of dioxins examined showed no relationship between levels of dioxins in soil and levels of dioxins in blood. People who have higher levels of 2,3,4,7,8-PeCDF, 1,2,3,7,8-PeCDD, 1,2,3,6,7,8-HxCDD, and PCB-156 in their soil do not have higher levels of these dioxins in their blood.

Three of the seven specific types of dioxins plus the TEQ showed some relationship between levels of dioxins in soil and levels of dioxins in blood. People who have higher TEQ levels and higher levels of 2,3,7,8-TCDD, PCB-118, and PCB-126 in some of their soil samples have higher levels of these dioxins in their blood.

We looked at the highest level of dioxins in soil out of all the soil samples taken on each property. This value, the highest soil value measured on the property, is related to the TEQ level in people's blood. For a person living on a property with a soil TEQ of 1,000 parts per trillion, the blood TEQ is about 0.7 parts per trillion higher than that for a person living on a property with a soil TEQ of four parts per trillion (which is the median soil TEQ in Jackson/Calhoun).

We also looked at levels of dioxins in soil from vegetable and flower gardens. People whose gardens have higher levels of 2,3,7,8-TCDD or higher levels of PCB-118 have higher levels of these dioxins in their blood. For a person living on a property with a garden soil 2,3,7,8-TCDD level of 22 parts per trillion (which is the median level of soil from homes in the Midland Plume), the blood 2,3,7,8-TCDD level is 0.7 parts per trillion higher than that for a person living on a property with garden soil at the median level of Jackson/Calhoun (0.1 parts per trillion).

People who have higher levels of PCB-126 and PCB-118 in soil from around the house have slightly higher levels of these two specific dioxins in their blood. For example, a person whose soil around the house has a PCB-118 level of 1000 parts per trillion has a less than 1 percent increase (about 18 parts per trillion) of this chemical in their blood compared to someone whose soil has a lower level of this chemical.

Are levels of dioxins in household dust related to levels of dioxins in people's blood?

People who have higher levels of six of the seven specific dioxins in their household dust and the TEQ (total dioxin-like activity) do not have higher levels of these dioxins in their blood. The six chemicals are 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,6,7,8-HxCDD, 2,3,4,7,8-PeCDF, PCB-126, and PCB-156.

The seventh chemical is PCB-118. People whose houses have higher levels of PCB-118 in household dust have slightly higher levels of PCB-118 in their blood. When we compare a person whose household dust PCB-118 level is at the median for the Midland Plume (9,300 parts per trillion) to a person whose household dust is at the median level in Jackson/Calhoun (4,740 parts per trillion), the blood PCB-118 increases by about one percent (81 parts per trillion).

Does where people live and the levels of dioxins in their soil and household dust matter when explaining the levels of dioxins in their blood?

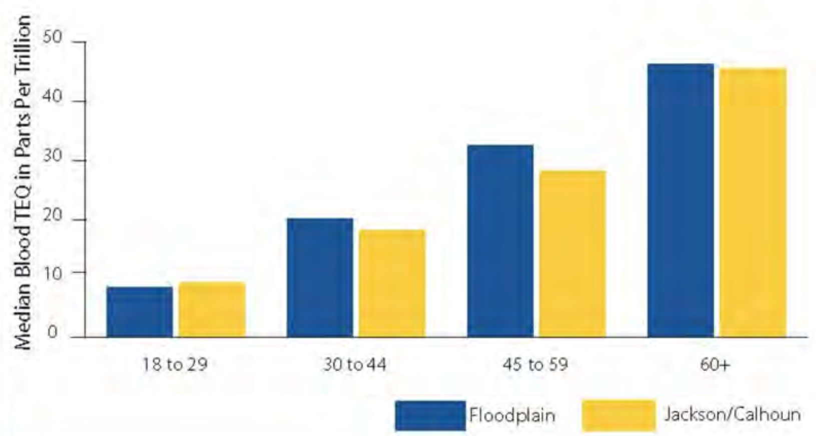
Yes, to a small extent. The region in which people live, soil contamination, and household dust contamination combined account for about one percent of the variability in levels of 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, PCB-118, and PCB-126 in people's blood. For the other types of dioxins and the TEQ, region, soil and household dust contamination combined account for less than 0.2 percent of the variability in levels of dioxins in people's blood.

HEALTH FACTORS AND LEVELS OF DIOXINS IN BLOOD

Does age matter?

Yes. Older people have higher levels of dioxins in their blood than younger people.

Figure 2. Levels of dioxins in blood increase with age no matter where people live.



Do men and women have different levels of dioxins in their blood?

Yes, and it varies by age. In general, at ages less than 40, women have lower TEQ levels than do men of the same age. At older ages, levels of dioxins are higher for women than for men of the same age.

Do people who are overweight, normal weight or underweight have different levels of dioxins in their blood?

One measure of weight that adjusts for differences in height is called Body Mass Index, commonly referred to as BMI. People with a higher BMI tend to be overweight and people with a lower BMI tend to be underweight.

Men with a higher BMI have higher levels of four of the seven specific dioxins (2,3,4,7,8-PeCDF, 1,2,3,7,8-PeCDD, 1,2,3,6,7,8-HxCDD, PCB-126) in their blood than men with a lower BMI. The relationship between BMI and levels of dioxins in blood was not seen in women.

People who lost weight during the last year have higher TEQ levels and higher levels of 2,3,4,7,8-PeCDF and PCB-126 in their blood than do people who did not lose weight.

Do smokers have higher levels of dioxins in their blood?

People who have smoked more cigarettes during their life have lower levels of dioxins in their blood. This result is consistent with other studies of dioxins. Nevertheless, the risks from smoking outweigh any possible benefit from a reduction in levels of dioxins in blood.

Do women who breastfed their children have different levels of dioxins in their blood?

Women who breastfed have lower levels of dioxins in their blood than do women who did not breastfeed. The longer a child was breastfed, the lower the level of dioxins in a woman's blood. Other studies have shown that dioxins are contained in breast milk and are transferred from the mother to the nursing baby. Nevertheless, the benefits of breastfeeding outweigh the potential risks from dioxins in breast milk.

FOODS AND LEVELS OF DIOXINS IN BLOOD

Do people who eat fish from the Tittabawassee River, Saginaw River, and Saginaw Bay have higher levels of dioxins in their blood?

Yes. People who ate fish from the Tittabawassee River, Saginaw River, and Saginaw Bay between 1980 and the present have higher TEQ levels and higher levels of 1,2,3,7,8-PeCDD and 1,2,3,6,7,8-HxCDD in their blood. The levels of the TEQ and these specific dioxins increased by about 1 percent per year for each year that the fish were eaten, compared to people who did not eat fish from this area. Similarly, levels of 2,3,7,8-TCDD in blood increased by about 2.5 percent per year for each year that the fish were eaten.

We found that people who fished in the Saginaw River or Saginaw Bay had higher levels of some specific dioxins in their blood compared to people who did not fish there. However, because fishing and fish eating are associated with each other, further analyses are needed to fully understand what these relationships mean.

Do people who eat fish, regardless of where it came from, have higher levels of dioxins in blood?

People who ate fish from any source (whether sport-caught, from stores, or from restaurants) after 1980 have levels of TEQ, 1,2,3,7,8-PeCDD, and PCB-126 in their blood that are 0.5 to 1.4 percent higher per year of eating fish than people who did not eat fish during this time period.

People who ate store-bought or sport-caught catfish, bullhead, carp, suckers, pike, pickerel, muskellunge, walleye and perch from areas other than the Tittabawassee River, Saginaw River, or Saginaw Bay have higher levels of some dioxins in their blood than people who did not eat these fish. The specific types of dioxins vary by fish.

Do people who eat game have higher levels of dioxins in their blood?

We found few associations between eating game and levels of dioxins in people's blood. We asked about five different groups of game (whitetail deer or venison; duck or goose; wild turkey, pheasant, grouse, quail or woodcock; squirrel or wild rabbit; and other wild game) in three different areas (Tittabawassee River Floodplain; Saginaw River and Saginaw Bay Floodplains; and elsewhere in Michigan). We also asked about eating game in different time periods.

Only a few of these comparisons showed any difference in levels of dioxins in people's blood. For example, we found that:

- People who ate game from any area between 1980 and the present have levels of 2,3,4,7,8-PeCDF in their blood that increase by about 1 percent per year for each year that the game was eaten compared to people who did not eat game during that period.
- People who ate deer liver from any area have PCB-126 levels in their blood that are 11 parts per trillion higher than people who do not eat deer liver.
- People who ate squirrel or wild rabbit from any area during the last five years have higher levels of three of the specific dioxins (2,3,7,8-TCDD, 2,3,4,7,8-PeCDF, and 1,2,3,6,7,8-HxCDD) than do people who did not eat these game.

- There is no difference in levels of dioxins in blood for people who ate whitetail deer (venison), duck or goose, or wild game such as raccoon, opossum, woodchuck, muskrat, wild turtle, or frog from the Tittabawassee River, Saginaw River, or Saginaw Bay Floodplains, or taken from anywhere else, compared to people who did not eat these game.

All of the game from any area taken together account for less than two percent of the variability in levels of all of the specific dioxins and TEQ in people's blood.

We also found that hunting in different areas often is associated with higher levels of dioxins in blood. People who hunted around the Tittabawassee River, Saginaw River, and Saginaw Bay in the 1960s and 1970s have higher levels of certain specific dioxins in their blood, but this was not true for people who hunted in these areas after 1980. However, because hunting and eating game are associated with each other, further analyses are needed to fully understand these relationships.

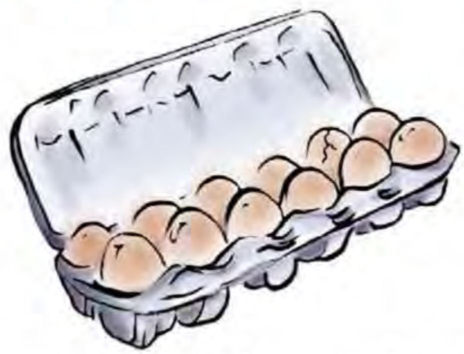
Do people who eat fruit and vegetables have higher levels of dioxins in their blood?

In general, people who ate more fruit and vegetables have similar or lower levels of dioxins in their blood as compared to people who eat fewer fruit and vegetables. This is largely true whether or not the fruit and vegetables come from the contaminated areas or are bought from a store. People who ate root vegetables from the Tittabawassee River, Saginaw River, and Saginaw Bay Floodplains do not have higher levels of dioxins in their blood.

Do people who drink milk have higher levels of dioxins in their blood?

Largely no. People who drank milk do not have a higher TEQ level or higher levels of six of the seven specific dioxins in their blood. People who drank more milk bought at the store have higher levels of PCB-126 in their blood.

Do people who eat eggs have higher levels of dioxins in their blood?



In some cases, people who ate home-raised eggs have higher levels of dioxins in their blood, but people who ate eggs bought from a store or restaurant did not have higher levels of dioxins in their blood.

People who ate home-raised eggs from areas other than the Tittabawassee River, Saginaw River, or Saginaw Bay Floodplains have higher TEQ levels and higher levels in their blood of most of the dioxins we studied.

Very few people reported eating home-raised eggs from the Tittabawassee River, Saginaw River, or Saginaw Bay Floodplains. As a result, there is little information from this study on whether eating eggs from these areas contributes to levels of dioxins in blood.

RECREATIONAL ACTIVITIES AND LEVELS OF DIOXINS IN BLOOD

Do people who swim, boat, hike or picnic on or near the Tittabawassee River, Saginaw River, and Saginaw Bay have higher levels of dioxins in their blood?

Yes. People who did these recreational activities around the Tittabawassee River more than once a month at any time between 1940 and the present have higher levels of some specific dioxins in their blood. The relationship between levels of specific dioxins in blood and recreational activities varies across different historic periods. For example, people who did these recreational activities around the Tittabawassee River from the 1980s to the present have higher levels of 2,3,7,8-TCDD in their blood.

There was no consistent relationship between water activities on the Saginaw River or Saginaw Bay and levels of dioxins in blood. Participating in recreational activities around the Tittabawassee River, Saginaw River, and Saginaw Bay account for 1.5 percent or less of the variability in levels in people's blood.

OCCUPATION AND LEVELS OF DIOXINS IN BLOOD

Do people who have worked at the Dow plant have higher levels of dioxins in their blood?

People who worked at Dow between 1940 and 1959 have higher levels of TEQ and 2,3,7,8-TCDD in their blood. People who worked at Dow during any other time period either have no difference in the levels of dioxins in their blood or have lower levels of dioxins in their blood than people who did not work at Dow.

RESIDENTIAL ACTIVITIES AND LEVELS OF DIOXINS IN BLOOD

Do people who have animals or family who track dirt into the house every day have higher levels of dioxins in their blood?

No. People who had pets that ran in and out of the house do not have higher levels of dioxins in their blood. Taking shoes off before coming into a home also is not related to levels of dioxins in blood.

Do people who burn trash on their properties have higher levels of dioxins in their blood?

Sometimes. People who burned trash or yard waste on their properties between 1940 and 1959 have higher levels of 2,3,7,8-TCDD in their blood. Burning trash or yard waste from 1980 to the present is not related to levels of dioxins in people's blood.

Do people who live in a house that was damaged by fire have higher levels of dioxins in their blood?

Living in a house that was recently damaged by fire is not related to levels of dioxins in blood. The story from past decades is mixed. Further analyses are needed to understand this relationship.

OTHER INFORMATION ABOUT LEVELS OF DIOXINS IN BLOOD

How many people were tested for dioxins in their blood?

We took blood samples from 946 people — 243 people in the Floodplain, 205 people in the Near Floodplain, 43 people in the Midland Plume, 204 people in Other Midland/Saginaw, and 251 people in Jackson/Calhoun.

What are the highest and lowest levels of dioxins for all of the blood samples?

The lowest TEQ level measured in blood was about five parts per trillion — this was found in all of the study areas. The highest was about 240 parts per trillion which was found in the Floodplain.

What patterns of dioxins were found in blood?

Unlike soil and household dust samples, we did not see evidence of a predominant pattern in blood suggestive of a particular source such as combustion or Dow's historical emissions. We found only one major pattern of dioxins in the blood, which is present in 93 to 98 percent of the people we measured. This pattern is similar to that seen in the rest of the United States population.

Where can I find out more about the blood results?

The UMDES website, www.umdioxin.org, contains detailed tables on all of the blood results.

How many people's properties were tested for dioxins in soil?

766 properties were tested — 203 properties in the Floodplain, 164 properties in the Near Floodplain, 32 properties in the Midland Plume, 173 properties in Other Midland/Saginaw, and 194 properties in Jackson/Calhoun. Multiple samples were taken from each property.

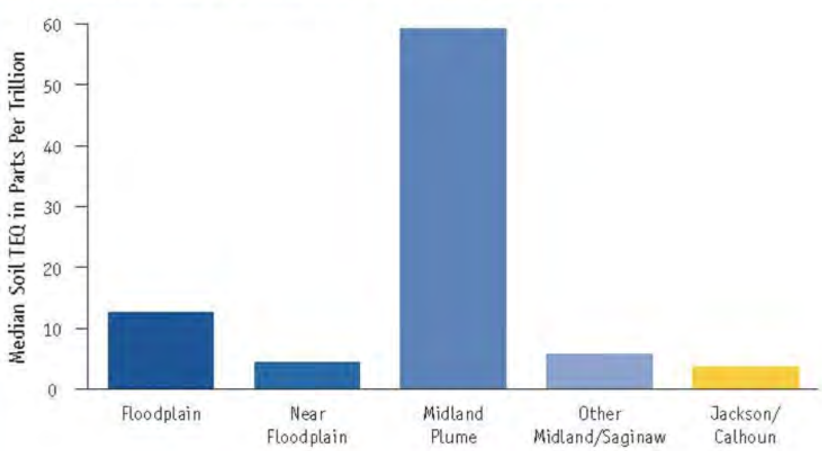
Where were soil samples taken on each participant's property?

We took soil samples around the participant's house, from the flower or vegetable garden (if the participant had a garden), and near the river (if the property was in the Tittabawassee River Floodplain).

How do soil results in Midland/Saginaw compare to soil results in Jackson/Calhoun?

Levels of dioxins in soil around houses in Midland/Saginaw are higher than levels of dioxins in soil around houses in Jackson/Calhoun, measured by the median (half of the soil samples have levels above the median and half are below). The Floodplain and the Midland Plume have the highest median levels. In Jackson/Calhoun, the median is only four

Figure 3. Soil taken from around houses in the Floodplain and the Midland Plume has higher median levels of dioxins than soil in Jackson/Calhoun.



parts of dioxins per trillion parts of soil. In the Midland Plume, the median is 59 parts per trillion. In the Floodplain, the median is 13 parts per trillion. The median for the Near Floodplain is four parts per trillion and the median for Other Midland/Saginaw is six parts per trillion.

In Jackson/Calhoun, only 25 percent of properties had a soil level of 9 parts per trillion TEQ or higher. However, virtually all of the soil samples from around houses in the Midland Plume area were above this level. Almost 70 percent of the samples from around houses in the Floodplain were above this level. The Near Floodplain and Other Midland/Saginaw areas had 33 percent and 41 percent of properties above this level, respectively.

What are the highest and lowest levels for all the soil samples?

Low levels of dioxins in soil were measured in all of the study areas. The lowest level measured was 0.3 parts dioxins per trillion parts of soil. The highest level measured was 15,300 parts per trillion. This sample was taken from a property in Other Midland/Saginaw. This unusually high level seems to be from moving contaminated Tittabawassee River Floodplain soil to an area outside the Floodplain.

The lowest level measured near the Tittabawassee River was about one part per trillion, and the highest was about 9,350 parts per trillion. In general, samples that were taken near the Tittabawassee River were higher than samples taken around houses or from gardens in the Floodplain region.

What are the important regulatory levels and exposure criteria for levels of dioxins in soil?

Two important levels of dioxins in soil are 90 parts per trillion TEQ and 1,000 parts per trillion TEQ. The Federal government uses 1,000 parts per trillion as a level at which action should be taken to consider various public health measures. States can use lower levels for their criteria. The State of Michigan sets 90 parts per trillion as the soil direct contact criterion.

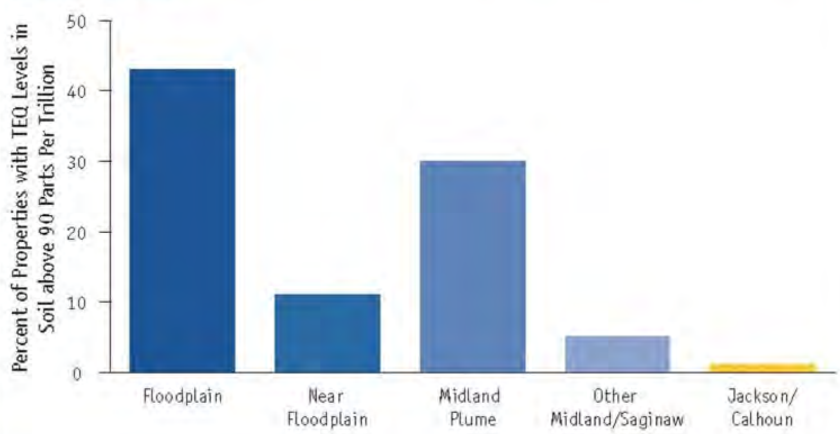
How many properties had levels of dioxins above 90 parts per trillion parts of soil?

Only one percent of the properties in Jackson/Calhoun have at least one soil sample above 90 parts per trillion, compared to 43 percent of properties in the Floodplain, 11 percent of properties in the Near Floodplain, 30 percent of properties in the Midland Plume and 5 percent of properties in Other Midland/Saginaw.

How many properties had levels of dioxins above 1,000 parts per trillion parts of soil?

None of the properties tested in Jackson/Calhoun had a soil sample above 1,000 parts per trillion. However, in the Floodplain, 14 percent of the properties tested had a soil sample over 1,000 parts per trillion, compared to 3 percent in the Midland Plume and less than 1 percent in the Near Floodplain and Other Midland/Saginaw.

Figure 4. Properties in the Midland/Saginaw regions are more likely to have at least one soil sample above the TEQ level of 90 parts per trillion than properties in Jackson/Calhoun.



What patterns of dioxins were found in soil?

We found three important patterns of dioxins in soil. These patterns accounted for 95 percent of all soil samples.

The most common pattern, believed to be due to combustion, was found in soils throughout Jackson/Calhoun and Midland/Saginaw.

The next most common pattern was found mainly in the Floodplain and Near Floodplain. This pattern is similar to the pattern found by the Michigan Department of Environmental Quality in Tittabawassee River sediment. We believe this pattern is the result of Dow's historic discharges into the river.

Another distinguishable pattern, which was found in the Midland Plume region, downwind of the Dow plant in Midland, was similar to the combustion pattern but had elevated 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD. We believe this pattern is a result of Dow's historic airborne discharges.

How do the levels of dioxins in soil from Jackson/Calhoun compare with levels across the nation?

We don't know the levels of dioxins in soil across the nation because there have been no such similar studies. However, a small number of soil samples taken by the Michigan Department of Environmental Quality from the lower peninsula of Michigan found the median level of dioxins to be about five parts per trillion. This is close to the median level of dioxins that we found in Jackson/Calhoun – four parts per trillion.

Where can I find out more about the soil results?

The UMDES website, www.umdioxin.org, contains detailed tables of the soil results.

How many people's households were tested for dioxins in their household dust?

Overall, 764 people's households were tested for dioxins in their household dust — 205 households in the Floodplain, 161 households in the Near Floodplain, 32 households in the Midland Plume, 168 households in Other Midland/Saginaw, and 198 households in Jackson/Calhoun.

Where were household dust samples taken in each participant's house?

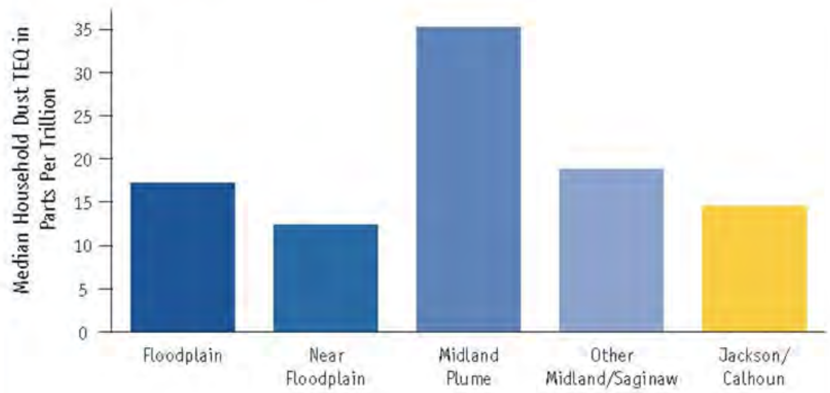
Household dust samples were taken from easily accessible floors in frequently used living or family areas and nearby hallways in each participant's home.

How do household dust results in the Midland/Saginaw regions compare to household dust results in Jackson/Calhoun?

The Midland Plume has the highest median level — 35 parts of dioxins per trillion parts of household dust, compared to 14 parts per trillion for Jackson/Calhoun. Levels of dioxins in household dust in the Floodplain (17 parts per trillion) and Other Midland/Saginaw (19 parts per trillion) are similar to those in Jackson/Calhoun. The Near Floodplain (12 parts per trillion) is slightly lower than Jackson/Calhoun.

In Jackson/Calhoun, 26 percent of homes had levels of dioxins in household dust of 35 parts per trillion or higher, compared to 50 percent of the samples taken in the Midland Plume. Similar to Jackson/Calhoun, 27 percent in the Floodplain, 11 percent in the Near Floodplain, and 21 percent in Other Midland/Saginaw of the household dust samples had levels of dioxins above 35 parts per trillion.

Figure 5. Household dust in the Midland Plume has higher median levels of dioxins than household dust in Jackson/Calhoun.



What were the highest and lowest levels of dioxins in household dust?

Low levels of dioxins were measured in household dust in all of the study areas. The lowest level measured was two parts per trillion. The highest level measured was about 1,745 parts per trillion. This sample was taken from a property in the Near Floodplain.

What are the important regulatory levels and exposure criteria for levels of dioxins in household dust?

Unlike soil, there is no government standard for dioxin levels in household dust. We can use the soil criteria of 90 parts per trillion and 1,000 parts per trillion as benchmarks.

How many residences had levels of dioxins in household dust above 90 parts per trillion?

Five percent or fewer of properties in any of the study regions had household dust levels above 90 parts per trillion. In Jackson/Calhoun, 5 percent of the household dust levels were above 90 parts per trillion, with 3 percent in Other Midland/Saginaw and less than 1 percent in the Floodplain, Near Floodplain, and Midland Plume.

How many residences had levels of dioxins in household dust above 1,000 parts per trillion?

In all of the study regions, very few properties – less than 1 percent – had household dust levels above 1,000 parts per trillion, with no household dust samples above 1,000 parts per trillion in the Floodplain or Midland Plume.

What patterns of dioxins were found in household dust?

Like soil, we found three important patterns of dioxins in household dust. These patterns accounted for 96 percent of all household dust samples.

The most common pattern was found in most household dust samples throughout Jackson/Calhoun and Midland/Saginaw. We do not know the source.

The next most common pattern in household dust was found mainly in the Floodplain and Near Floodplain. Like soil, this pattern is similar to the pattern found in Tittabawassee River sediment. We believe this pattern is the result of Dow's historic discharges into the river.

Another distinguishable pattern was consistent with a combustion source. This pattern was found scattered throughout Midland/Saginaw and Jackson/Calhoun.

In the Midland Plume there were elevated levels of 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD in household dust.

How do levels of dioxins in household dust from Jackson/Calhoun compare with levels across the nation?

There are no other national or statewide studies of levels of dioxins in household dust. This study is the first study of its kind to look at dioxins in household dust for an area this large.

Is the level of dioxins in household dust related to levels of dioxins in soil?

Yes. Higher levels of dioxins in soil are associated with higher levels of dioxins in household dust. However, not all properties with high levels of dioxins in soil had high levels of dioxins in household dust, and not all properties with high levels of dioxins in household dust had high levels of dioxins in soil.

Are levels of dioxins in household dust as high as they are in soil?

Median levels of dioxins in household dust are higher than median levels of dioxins in soil in the Floodplain, Near Floodplain, Other Midland/Saginaw, and Jackson/Calhoun. This suggests that there are sources of contamination for household dust other than soil. Previous scientific studies indicate that there are many commercial products that can release dioxins indoors, such as wood preservatives and old electrical appliances.

Levels of dioxins in the Midland Plume are higher in both household dust and soil, but the levels of dioxins in household dust tend to be lower than the levels of dioxins in soil for this region. Further analyses are needed to understand these relationships.

Where can I find out more about the household dust results?

The UMDES website, www.umdioxin.org, contains detailed tables of the household dust results.

Information about people who live in the study areas

How many people answered the questionnaire?

Overall, 1324 people answered questions in the questionnaire — 314 in the Floodplain, 276 in the Near Floodplain, 309 in Other Midland/Saginaw, 66 people in the Midland Plume, and 359 people in Jackson/Calhoun. About 56 percent of the people were women and about 44 percent were men.

How old are the people in the study?

The median age for the entire study population is about 50 years old. The Floodplain has the oldest residents, with a median age of 53 years. The median ages of people who lived in Other Midland/Saginaw and in Jackson/Calhoun are about 49 years.

How long have people in Midland/Saginaw lived in that area? What about for Jackson/Calhoun?

On average, people living in Midland/Saginaw have lived in those counties for almost 40 years. People in the Floodplain have lived in Midland/Saginaw for the longest amount of time (45 years), Near Floodplain residents have lived in Midland/Saginaw for 38 years, and Midland Plume residents have lived in Midland/Saginaw for the shortest amount of time (36 years).

People in Jackson/Calhoun have lived in those counties for an average of 38 years.

Do people in the study areas have gardens? What kind of gardens?

Between 20 and 30 percent of people across all study regions have a vegetable garden. Between 60 and 75 percent of people across all study regions have a flower garden.

Were people's properties or homes ever flooded by the Tittabawassee River?

About 85 percent of people in the Floodplain report that their property had been flooded by the Tittabawassee River, and 39 percent reported that their home had been flooded.

Do people who live in the study areas fish? Where do they fish?

About 80 percent of people in the study regions have fished in Michigan at some point during their lives. Not surprisingly, people who live in the Floodplain are the most likely to have fished in the Tittabawassee River during their lifetime – 35 percent of Floodplain residents, compared to 22 percent in the Near Floodplain and Other Midland/Saginaw, less than 8 percent in the Midland Plume, and only 1 percent in Jackson/Calhoun.

Between 40 and 50 percent of Floodplain, Near Floodplain, and Other Midland/Saginaw residents have ever fished in Saginaw Bay, compared to about 5 percent of people who live in Jackson/Calhoun. Between 20 and 30 percent of Floodplain, Near Floodplain, and Other Midland/Saginaw residents have ever fished in the Saginaw River, compared to 2 percent of people who live in Jackson/Calhoun.

Few people in the study areas have fished in the Kalamazoo River between Morrow Pond Dam and Lake Michigan. Only about 6 percent of people in Jackson/Calhoun have ever fished there, with less than 1 percent in the Midland/Saginaw regions.

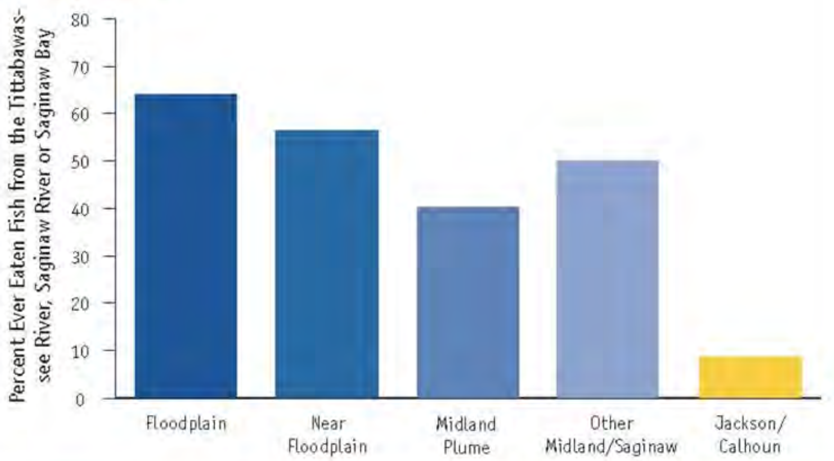
Do people in the study areas hunt? Where do they hunt?

Between 30 and 40 percent of people across all of the study areas have hunted in Michigan at some point during their lifetime. People who live in the Floodplain or Near Floodplain are most likely to have hunted in and around the Tittabawassee River. Less than 10 percent of people have hunted around the Saginaw River and Saginaw Bay for all the study regions. Less than two percent of participants have hunted around the Kalamazoo River. Between 15 and 30 percent of individuals reported hunting in and around other Michigan rivers and lakes.

Do people in the study areas eat fish from the Tittabawassee River, Saginaw River, or Saginaw Bay?

Roughly 65 percent of Floodplain residents ate fish from the Tittabawassee River, Saginaw River, or Saginaw Bay during their lifetime, and about 25 percent ate these fish during the last five years. Between 40 and 60 percent of people in the Near Floodplain, Midland Plume, and Other Midland/Saginaw have eaten fish from the Tittabawassee River, Saginaw River, or Saginaw Bay during their lifetime, and between 15 and 30 percent ate these fish during the last five years. Less than 10 percent of Jackson/Calhoun residents have eaten fish from these rivers during their lifetime, and less than 5 percent ate these fish during the last five years.

Figure 6. People in all of the Midland/Saginaw regions are more likely to have eaten fish from the Tittabawassee River, Saginaw River or Saginaw Bay than people in Jackson/Calhoun.



Do people in the study areas eat game?

Around 85 percent of people in all of the study areas have eaten game meat during their lifetime, and slightly more than half ate game during the last five years.

Around 15 percent of people in the Floodplain ate deer or venison from the Tittabawassee River Floodplain during the last five years, compared to around 10 percent for the other areas of Midland/Saginaw, and less than one percent in Jackson/Calhoun. Fewer people – seven percent or less in all study regions – ate venison from the Saginaw River or Saginaw Bay Floodplain during the last five years, again with less than one percent in Jackson/Calhoun. Most venison eaten during the last five years came from other areas — about half of the people in Midland/Saginaw and Jackson/Calhoun had eaten venison from an area other than the Floodplains of the Tittabawassee or Saginaw Rivers or Saginaw Bay.

The percentage of people who ate other types of game (such as wild turkey, duck, goose, squirrel, and rabbit) is much smaller.

What percent of the people in Midland/Saginaw and Jackson/Calhoun participated in recreational activities around the Tittabawassee River, Saginaw River, or Saginaw Bay?

In the Floodplain, 46 percent of people have swum, picnicked, hiked, boated, and participated in other recreational activities in and around the Tittabawassee River, compared to 31 percent in the Near Floodplain, 23 percent in the Midland Plume, 21 percent in Other Midland/Saginaw, and only 2 percent in Jackson/Calhoun.

Almost 44 percent of people in the Floodplain, 47 percent of people in the Near Floodplain, 13 percent of people in the Midland Plume, and 34 percent in Other Midland/Saginaw participated in these activities around the Saginaw River, compared to 2 percent in Jackson/Calhoun. Higher percentages have participated in these activities around Saginaw Bay – 60 percent of people in the Floodplain and Near Floodplain and 45 percent of people in the Midland Plume and Other Midland/Saginaw, compared to 5 percent in Jackson/Calhoun.

What percent of the people in Midland/Saginaw and Jackson/Calhoun worked at Dow?

Almost 10 percent of Floodplain residents, 9 percent of Near Floodplain residents, 12 percent of people in Other Midland/Saginaw, 16 percent from the Midland Plume, and less than 1 percent of Jackson/Calhoun residents ever worked at Dow.

How can I find out more about people who participated in the study?

The UMDES website, www.umdioxin.org, contains detailed tables on the questions asked of study participants.

Frequently Asked Questions

How can I tell if I have dioxins in my blood?

Everyone has some dioxins in their blood. The only way you can know the levels of dioxins in your blood is to have them measured.

How can I tell if I have dioxins in my household dust?

We found measurable levels of dioxins in all 764 of the household dust samples that were tested. The only way you can know the levels of dioxins in your household dust is to have them measured.

How can I tell if I have dioxins in my soil?

There are many potential sources of dioxins in soil. We found measurable levels of dioxins in all 766 of the properties that had soil samples tested. The only way you can know the levels of dioxins in your soil is to have them measured.

Where can I get my blood tested for dioxins?

Testing for dioxins should be done only by experienced, approved laboratories. Individual tests for dioxins cost between $1,200 and $1,500. See the Michigan Department of Community Health website for more information on testing for dioxins in blood: www.michigan.gov/documents/Blood_Testing_for_Dioxins_119419_7.pdf.

How do I reduce my exposure to dioxins?

The best way to limit exposure to dioxins is to follow the State of Michigan consumption guidelines for fish and game. This guide will tell you which fish you should avoid to reduce your exposure to dioxins.

Are there things that can happen when you're exposed to dioxins?

People who have been exposed to extremely high levels of dioxins (much higher than were observed in this study) sometimes develop chloracne, which looks like a severe form of acne. Some dioxins have been shown to cause cancer in animals and are suspected to cause cancer in people. There are also concerns that dioxins may cause diabetes, reproductive and developmental problems, and may have effects on the nervous and immune systems.

Where can I get more information?

The University of Michigan Dioxin Exposure Study team will be holding public meetings in the study areas during Fall 2006. If you have questions or would like more information, please contact our toll-free number (1-888-689-0006) or visit the UMDES website at www.umdioxin.org.

General information about dioxins is available from the Michigan Department of Environmental Quality and Michigan Department of Community Health websites.

Michigan Department of Environmental Quality:
www.michigan.gov/deq/

Michigan Department of Community Health:
www.michigan.gov/mdch

If you wish to talk with a health professional, contact your personal physician or health officials at your local county health department:

Bay County Health Dept.	*989-895-4001*
Calhoun County Health Dept.	*269-966-1210*
Jackson County Health Dept.	*517-788-4420*
Midland County Health Dept.	*989-832-6380*
Saginaw County Health Dept.	*989-758-3800*

Glossary

BMI: Body Mass Index is a measure of weight that adjusts for differences in height. People with a higher BMI tend to be overweight. People with a lower BMI tend to be underweight.

Congener: One type of chemical in a group of other similar chemicals. One type of dioxin.

Higher levels/Lower levels: Any mention in this booklet of "higher levels" or "lower levels" indicates a statistically significant difference at the $p<0.05$ level. Mention of "not any higher" or "similar" indicates that the difference is not statistically significant at the $p<0.05$ level.

Mean: The arithmetic average, which is the sum of the values on a list divided by the number of values on the list.

Median: The middle value of a list. The number for which half the numbers on a list are below and half of the numbers on the list are above. This is also known as the 50th percentile.

Midland/Saginaw: "Midland/Saginaw" refers to the combined geographic areas of the Floodplain, Near Floodplain, Midland Plume, and Other Midland/Saginaw.

Patterns of dioxins: The relative levels of the 29 dioxins in a given blood, household dust, or soil sample. This pattern is also called the congener profile. Sometimes a single pattern is found in many samples. These patterns can be informative about the source of the pollution.

People who live in Midland/Saginaw (Jackson/Calhoun): "People who live in Midland/Saginaw (Jackson/Calhoun)" refers to people who lived in their current residence for at least five years and were 18 years of age or older.

Parts per trillion: Parts per trillion (ppt) is a unit of how much of one substance is mixed in another substance, or its concentration. One part per trillion is about the same as mixing one drop of ink into an Olympic-sized swimming pool. A part per trillion in soil means that there is one ounce of dioxins in one trillion ounces (31,250,000 tons) of soil.

TEF: Dioxins vary in their effects on people. Some have more toxic effects than others. The Toxic Equivalency Factor, or TEF, is a measure of the toxicity of each of the specific dioxins compared to the most toxic dioxin, 2,3,7,8-TCDD.

TEQ: The combined toxicity of all 29 dioxins is called the "TEQ" (for Toxic EQuivalency). The TEQ is a summary measure of the toxicity of the 29 dioxins in a sample, giving them different weights (the TEFs) depending on how toxic they are. Another way of saying it is that the TEQ is a measure of total 2,3,7,8-TCDD-like activity in a sample. The TEQ is the sum over all 29 dioxins of the TEF multiplied by the congener concentration in that sample.

All samples collected were analyzed for the World Health Organization 29 dioxins: polychlorinated dioxins, polychlorinated furans and co-planar PCBs, for which there are consensus toxic equivalency factors, also known as TEFs. All blood results were adjusted for serum lipids.

The TEQs in this report reflect TEFs from 1998. New TEFs were released in July while this report was being written.

At the time of this report, our analyses focused on the TEQ and the following seven specific dioxins. These seven dioxins, of the 29 dioxins measured, have the highest contribution to the TEQ in the study blood samples and in the U.S. population.

2,3,7,8-TCDD – 2,3,7,8-Tetrachlorodibenzo-p-dioxin. This is the most toxic chemical of all 29 types of dioxins; TEF=1.0.

1,2,3,7,8-PeCDD — 1,2,3,7,8-Pentachlorodibenzo-p-dioxin; TEF=1.0.

1,2,3,6,7,8-HxCDD — 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin; TEF=0.1.

2,3,4,7,8-PeCDF — 2,3,4,7,8-Pentachlorodibenzofuran; TEF=0.5.

PCB-118 — 2,3',4,4',5-Pentachlorobiphenyl; TEF=0.0001.

PCB-126 — 3,3',4,4',5-Pentachlorobiphenyl; TEF=0.1.

PCB-156 — 2,3,3',4,4',5-Hexachlorobiphenyl; TEF=0.0005.

Study Oversight

University of Michigan Investigators

David Garabrant, MD, MPH

Alfred Franzblau, MD

Brenda Gillespie, PhD

Peter Adriaens, PhD, PE

James Lepkowski, PhD

Avery Demond, PhD, PE

Scientific Advisory Board

Linda Birnbaum, PhD, DABT,
U.S. Environmental Protection Agency

Paolo Boffetta, MD, MPH,
International Agency for Research on Cancer

Ronald Hites, PhD,
Indiana University

David Kleinbaum, PhD,
Emory University

Community Advisory Panels

Midland/Saginaw CAP

Chairperson
Veronica Horn, Executive Vice President, Saginaw County Chamber of Commerce

Liaison to the Scientific Advisory Board
Neill Varner, DO, MPH, Medical Director, Saginaw County Department of Community Health

Members
Peter Boyse, PhD, President, Delta College
Craig Douglas, PhD, Superintendent, Carrollton Public Schools
Rick Hayes, Committee Chair, Tittabawassee Parks
Gary Hughes, EDD, Superintendent, Midland Public Schools
Brian Kischnick, Township Manager, Tittabawassee Township
Michael Krecek, RS, MA, Director/Health Officer, Midland County Health Department
Reverend Wallace Mayton, Memorial Presbyterian Church
Allen Veenkant, Superintendent, Freeland Community School District

Jackson/Calhoun CAP

Chairperson and Liaison to the Scientific Advisory Board
Ron Grimes, Director/Health Officer, Jackson County Health Department

Members
Karl Dehn, Director of Marketing and Environment, Battle Creek Unlimited
Travis Fojtasek, President, Recycle Jackson
Ted Havens, RS, MPA, Environmental Health Director, Calhoun County Health Department
Roxanna Hopkins, DPA, Assistant Superintendent, Jackson Public Schools
Susan Milhoan, President, Greater Jackson Chamber of Commerce

The University of Michigan Dioxin Exposure Study is protected by a Certificate of Confidentiality issued by the National Institutes of Health.

The Certificate of Confidentiality ensures that study participants, the UMDES team and the University of Michigan cannot be forced to reveal "sensitive," personally identifiable information. No court, agency or other body can compel release of information that could affect a subject's financial standing, employability, reputation or insurability, or have any other adverse effects.

Members of the study team cannot be forced to reveal any information about the levels of dioxins in your body or on your property...nor your answers to any of the survey questions.

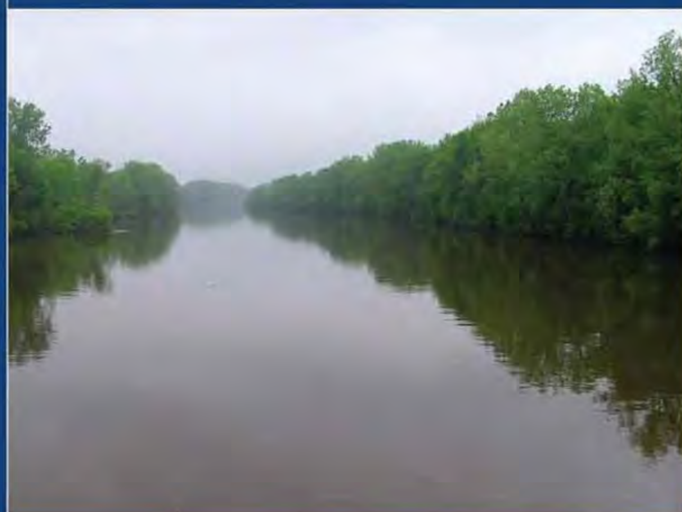
The Certificate of Confidentiality issued to the UMDES can be viewed at the study website: www.umdioxin.org.

The Regents of the University of Michigan

The University of Michigan, as an equal opportunity/affirmative action employer, complies with all applicable federal and state laws regarding nondiscrimination and affirmative action, including Title IX of the Education Amendments of 1972 and Section 504 of the Rehabilitation Act of 1973. The University of Michigan is committed to a policy of nondiscrimination and equal opportunity for all persons regardless of race, sex*, color, religion, creed, national origin or ancestry, age, marital status, sexual orientation, disability, or Vietnam-era veteran status in employment, educational programs and activities, and admissions. Inquiries or complaints may be addressed to the Senior Director for Institutional Equity and Title IX/Section 504 Coordinator, Office for Institutional Equity, 2072 Administrative Services Building, Ann Arbor, Michigan 48109-1432, 734-763-0235, TTY 734-647-1388. For other University of Michigan information call 734-764-1817.

*Includes discrimination based on gender identity and gender expression.

UNIVERSITY OF MICHIGAN



THE UNIVERSITY OF MICHIGAN:
School of Public Health
College of Engineering
Center for Statistical Consultation & Research
Institute for Social Research

Toll Free 1-888-689-0006
UMDES website www.umdioxin.org

Appendix C

UMDES Results Mailing, January 2011

This appendix presents a large-format brochure mailed by the University of Michigan Dioxin Exposure Study (UMDES) to all Midland and Saginaw residents in January 2011. Copies of this brochure were also available on the UMDES website.

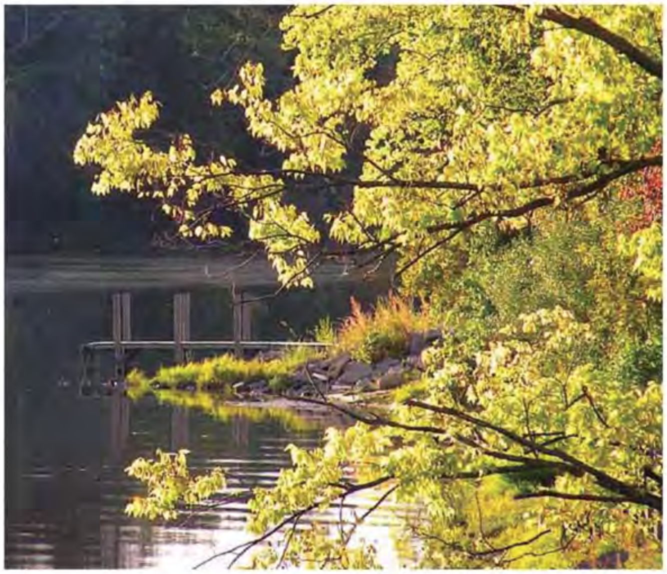
U-M Dioxin Study

What You Need to Know

University of Michigan
School of Public Health
1415 Washington Heights Room 6529
Ann Arbor, MI 48109-2025

Residential Customer
ECRWSS

NONPROFIT
US Postage PAID
Ann Arbor, MI
Permit #144



In 2006, the University of Michigan-Ann Arbor conducted the "Dioxin Exposure Study" in the Midland/Saginaw area. An updated version of this study has just been released, which contains a number of revised findings that will be of interest to you.

The original U-M study measured human exposure to "dioxins." Dioxins are a family of toxic chemicals that are produced by combustion and by some industrial processes. One of the chemicals, TCDD, has been known to cause cancer in humans.

This study will give you some basic information about the updated study. You can read the whole study online at **www.umdioxin.org.**

If you have any questions about this study, please email us at **um-dioxin@umich.edu.**

Summary of key findings in the updated version:

NUMBER OF PARTICIPANTS

	Floodplain	Near Floodplain	Midland Plume	Other Midland/ Saginaw	Jackson/ Calhoun	Total Across All Areas
Interviews	326	264	71	304	359	1324
Blood Samples	251	197	48	199	251	946
Household Dust Samples	207	159	37	163	198	764
Soil Samples	203	164	37	168	194	766
Interview, Blood, Dust, and Soil Samples	195	156	35	162	183	731
Estimated Number of Eligible Persons	2070	1955	6550	90270	101330	202175

You can read full details on the study design, field and laboratory methods, and study findings on the study's website at **www.umdioxin.org.**

AGE

Older people have higher levels of dioxins in their blood.

GENDER

Women tend to have higher levels than men.

TIME PERIOD AND LOCATION

People who lived in the Midland/Saginaw area in the 1960s and 1970s have higher levels of the dioxin chemical TCDD in their blood than people who lived in the same area after 1980. The TCDD is likely from airborne emissions from the Dow Chemical plant in Midland during that era.

SOIL AND HOUSE DUST

People whose houses are on contaminated soil or who have contaminated dust in their homes do ***not*** have higher levels of dioxins in their blood.

FISH

People eating fish from the Tittabawassee River, Saginaw River, and Saginaw Bay do not have higher levels of dioxins in their blood. But you should still follow government advisories about eating fish from contaminated areas.

Dioxin Study Details

Age is by far the most important factor for dioxin levels in blood. All people everywhere have some dioxin in their blood, and as they age they usually are exposed to more. People in Midland/Saginaw tend to be older, on average, than a control group living about 100 miles away in Jackson and Calhoun counties, where there is no Dow plant.

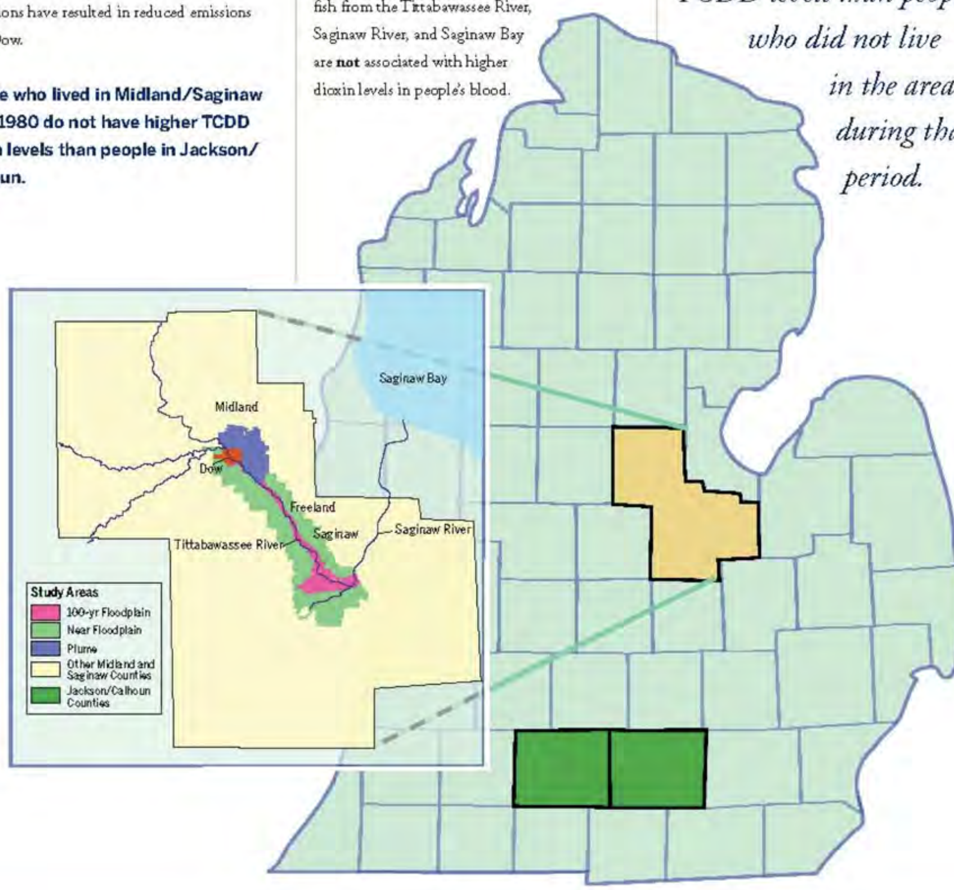
People who lived in Midland/Saginaw for the entire 20 years from 1960 through 1979 on average have 86 percent higher blood TCDD levels than people who did not live in the area during that period. The U-M researchers believe that these higher levels are consistent with past airborne emissions from Dow facilities. Dow's pre-1980 emissions of TCDD and other dioxins likely contributed to contamination of parts of the Midland/Saginaw area. In later years, enforcement of environmental legislation and regulations have resulted in reduced emissions from Dow.

People who lived in Midland/Saginaw after 1980 do not have higher TCDD dioxin levels than people in Jackson/Calhoun.

The Midland/Saginaw residents who were surveyed as part of this study—and who eat fish from the Tittabawassee River, Saginaw River, and Saginaw Bay—do not have higher levels of dioxins in their blood. This is a revision of the finding in the earlier U-M report, which said "people who eat fish from the Tittabawassee River, Saginaw River, and Saginaw Bay have higher levels of dioxins in their blood. . ." Why this difference? The later report included new data about the actual levels of dioxins in fish that were simply not available at the time of the earlier report. Taking account of the actual levels of dioxins in fish allows us to get a more accurate result.

Because the earlier report did not adjust for the actual levels of dioxins in fish, it concluded eating fish from the contaminated waters was associated with higher blood dioxin levels in people. After adjusting for the actual levels of dioxins in fish, though, it is clear that typical patterns of eating fish from the Tittabawassee River, Saginaw River, and Saginaw Bay are **not** associated with higher dioxin levels in people's blood.

People who lived in Midland/Saginaw for the entire 20 years from 1960 through 1979 on average have 86% higher blood TCDD levels than people who did not live in the area during that period.

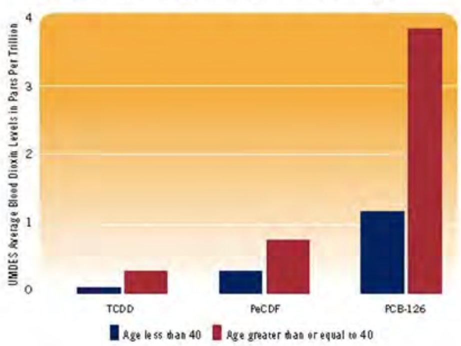


But, to be on the safe side, you should follow government advisories about eating fish from contaminated areas.

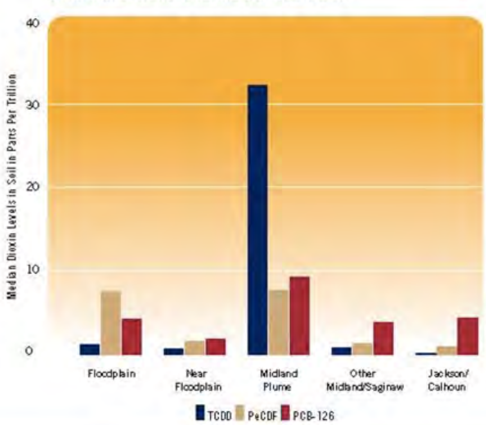
The Midland/Saginaw residents who were surveyed by this study and whose houses are on contaminated soil—or whose homes contain contaminated dust—do **not** have higher levels of dioxins in their blood. This is a revision of the finding in the earlier, 2006 U-M report, which said: "People who have higher levels of dioxins in their soil have a higher TEQ (total dioxin-like activity) and higher levels of some specific dioxins in their blood."

In this new report we found that the 2006 association was due to a single soil sample that was high in TCDD. This association was not seen for any other dioxin compound including those that had much higher levels in soil. The absence of an association for every other compound is a strong argument that the single influential observation for TCDD was an anomaly.

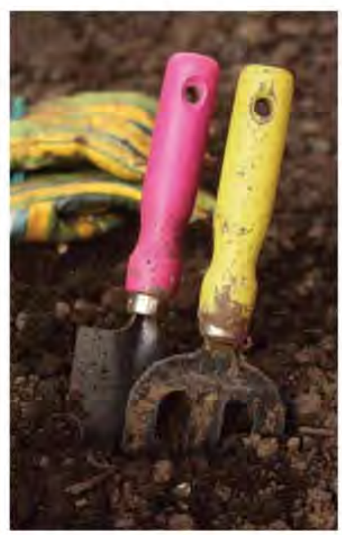
Levels of dioxins in blood increase with age.



Soil samples from around houses in the Floodplain and the Midland Plume have higher median levels of dioxins than in Jackson/Calhoun.



The Midland/Saginaw residents who were surveyed in this study and whose houses are on contaminated soil—or whose homes contain contaminated dust—do **not** *have higher levels of dioxins in their blood.*



Study Background

The U-M Dioxin Exposure Study was financed by a grant from The Dow Chemical Company and was developed and conducted entirely by U-M researchers. Research decisions were reviewed by an independent scientific advisory board.

U-M researchers spent six years studying residents in five geographic areas:

- The Tittabawassee River floodplain, extending from the Dow plant in the city of Midland through Midland and Saginaw counties, an area known to be contaminated by emissions from Dow.

- Areas near the floodplain.
- An area downwind of the Dow plant in the city of Midland.
- Other areas of Midland and Saginaw counties, and nearby Williams Township in Bay County.
- Jackson and Calhoun counties, areas with similar demographics (and dioxin levels in residents similar to national averages) but no nearby Dow plant. This area was surveyed as a comparison to the other four locations nearer to the Dow plants.

Phone: 989-372-0796
Email: um-dioxin@umich.edu

U-M scientists studied levels of dioxins in people's property soil, household dust, and blood samples, and interviewed residents about their age, body mass, dietary habits, land use, occupation, and other personal details. A total of 695 Midland/Saginaw residents and 251 Jackson/Calhoun residents gave blood samples. Participants in the study were at least 18 years old.

The U-M study looked only at the *extent* of human exposure to dioxins, not the *health effects* of that exposure.

The study was conducted by U-M researchers from the School of Public Health, College of Engineering, Center for Statistical Consultation & Research, and Institute for Social Research.

Print copies of the report may be found in Midland/Saginaw at local libraries, Chamber of Commerce offices, churches, and local government offices.

You can read the online version of the full report on the U-M study's website, **www.umdioxin.org**. This site includes links to other websites, including the Centers for Disease Control and Prevention, which has general information about dioxins and health.

The study was conducted by U-M researchers from the School of Public Health, College of Engineering, Center for Statistical Consultation & Research, and Institute for Social Research.

Appendix D

UMDES Results Brochure, January 2011

This appendix presents a brochure created by the University of Michigan Dioxin Exposure Study (UMDES) in January 2011. Copies of this brochure were available at public meetings, on the UMDES website, and at public locations in the community (e.g., public libraries).

UNIVERSITY OF MICHIGAN

Measuring People's Exposure to Dioxins

Along the Tittabawassee River and Surrounding Areas

Findings from the University of Michigan

Dioxin Exposure Study

2011 UPDATED

Financial support for the study comes from The Dow Chemical Company through an unrestricted grant to the University of Michigan. The University of Michigan has complete independence to design, carry out, and report the results of the study. The University of Michigan controls all aspects of the study. Results will be publicly released, whether they are favorable or unfavorable to the funder. They will be posted to the study's website (www.umdioxin.org), presented in community forums, published in academic journals, and reported in the news media.

Contents

Summary

29th International Symposium on Halogenated Persistent Organic Pollutants
August 23-28, 2009 Beijing, China

Summary

This is the second report of the University of Michigan Dioxin Exposure Study (UMDES). We issued the first report in August 2006. Dioxins are a family of chemicals that includes three different groups: polychlorinated dibenzo-*p*-dioxins, polychlorinated dibenzofurans, and certain polychlorinated biphenyls (PCBs). They can be produced by combustion and industrial processes—often as unwanted byproducts. They are of concern because they have toxic effects.

The goal of this study was to understand whether dioxins in the environment from the Dow Chemical Company, based in Midland, get into people's blood, and if so, how. We measured levels of dioxins in people's blood, in the soil surrounding their house, and in their household dust. We asked them about their diet and activities that might bring them into contact with dioxins in the environment. We focused on 29 key chemicals within the family of dioxins. We compared people in the Midland/Saginaw area, near the Dow plant, with a control group of people in the Jackson/Calhoun area, which has no Dow plant.

Government agencies often regulate dioxins based on a summary number that represents their potential to cause harmful health effects. That summary number is called the TEQ, which stands for Toxic EQuivalency. It is a measure of the toxicity of the 29 dioxins, giving them different emphasis depending on how toxic they are. This report focuses on three key chemicals rather than the summary TEQ because they give a clearer picture of how dioxins in the environment enter people's bodies. Full results for all 29 dioxin compounds and the TEQ are on the UMDES website. This report focuses primarily on the three most important dioxins among the 29 that were studied. These three chemicals are known technically as:

- 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD);
- 2,3,4,7,8-pentachlorodibenzofuran (PeCDF); and
- 3,3',4,4',5-pentachlorobiphenyl (PCB-126).

These are important contributors to dioxins in people's blood in our study and in the United States. In 2006 we reported on TEQ and seven specific dioxin compounds. We are not focusing on PCB-118 and PCB-156 because the World Health Organization in 2006 lowered its estimate of the toxicity of these two chemicals, and they are much less important contributors to blood levels of dioxins. We are not focusing on 1,2,3,6,7,8-HxCDD and 1,2,3,7,8-PeCDD because they give very similar results to TCDD, which is a good representative for this family of dioxins. (See Glossary and Technical Notes on page 44 for information about these chemicals.)

Key Findings:

- The level of dioxins in people's blood increases with age. Older age is by far the most important factor related to higher levels of dioxins in people's blood.
- Women tend to have slightly higher levels than men.
- People who lived in the Midland/Saginaw area in the 1960s and 1970s have higher blood levels of TCDD—likely due to airborne emissions from Dow.
- People living on contaminated soil and having contaminated household dust do not have higher levels of dioxins in their blood.
- People who eat fish from the Tittabawassee River, Saginaw River, or Saginaw Bay do not have higher levels of dioxins in their blood. (For details on eating fish, see page 21.) Nonetheless, eating a lot of contaminated fish could be an important source of dioxins in your blood, and people should follow the government fish advisories about eating fish from the contaminated area.
- People who worked at Dow have higher levels of TCDD in their blood, but not higher levels of PeCDF or PCB-126.

Key Study Findings about Blood

- The most important factor related to levels of dioxins in people's blood is age. We found that older people have higher levels of dioxins in their blood. This effect was found in both Midland/Saginaw and Jackson/Calhoun, and has been found in other studies of people across the United States.
- People who lived in the Midland/Saginaw area in the 1960s and 1970s have higher blood levels of one of the chemicals —TCDD—but not the other two—PeCDF or PCB-126. People who have lived in Midland/Saginaw since 1980 do not have higher blood levels of any of the dioxins. In other words there is no evidence of ongoing exposure from living in this region at the present time, or in the past 25 years. But there is evidence of exposure to TCDD from living in this region in the 1960s and 1970s.

- People who live on contaminated soil and have contaminated household dust do not have higher levels of dioxins in their blood. Our study included 21 people who lived on soil contaminated at 1,000 to 11,200 ppt TEQ of dioxins, and we believe our results apply to populations whose soil is contaminated in this range.
- People who eat fish from all sources (including store bought, from restaurants, and sport caught fish from everywhere) have higher levels of two of the chemicals—TCDD and PCB-126—in their blood.
- However, people who eat fish specifically from the Tittabawassee River, Saginaw River, or Saginaw Bay do not have higher levels of dioxins in their blood. In 2006 we reported that people who ate fish from these areas had higher levels of dioxins in their blood than people who did not eat fish from these areas. In our earlier analysis we did not have information about levels of dioxins in fish, so we assumed that all fish contained the same levels of dioxins. After further analysis, and adjusting for the actual levels of dioxins in the specific fish that people reported eating the most, we find a different result. When we take into account the amount of dioxins in the fish, eating fish from these areas does not contribute to levels of dioxins in blood. In general, people who eat fish from the contaminated areas also eat a lot of fish from elsewhere, and so the contribution of fish from the contaminated areas to the overall dioxin intake from fish is relatively small and not measurable.
- Our study found that people who engaged in some outdoor activities in parts of the Midland/Saginaw area before 1980 have higher levels of TCDD and PeCDF in their blood. People who did water activities in the Tittabawassee River in the 1960s and 1970s more than once per month have higher levels of TCDD and PeCDF in their blood. Water activities include boating, swimming, hiking, and picnicking. People who hunted in the Saginaw River or Saginaw Bay area in the 1960s and 1970s have higher levels of PeCDF in their blood.

• In more recent years, there is only one recreational activity that is associated with higher blood dioxin levels. People who fished more than once per month in the Saginaw River or Saginaw Bay after 1980 have higher levels of PeCDF and PCB-126 in their blood.

Key Study Findings about Soil

• Soil from properties in the Floodplain, Near Floodplain, Midland Plume, and Other Midland/Saginaw (see page 30 and map on pages 16–17) is more contaminated with dioxins than soil in Jackson/ Calhoun.

• Levels of dioxins in soil in Jackson/ Calhoun are similar to levels in soil across Michigan based on comparison with a small number of soil samples collected by the Michigan Department of Environmental Quality.

• Soils in the Floodplain, Near Floodplain, and Midland Plume show patterns of dioxins suggestive of Dow's past discharges. These patterns are not seen in Jackson/Calhoun.

Key Study Findings about Household Dust

• Levels of dioxins in dust are usually greater than the levels in soil around the perimeter of people's homes.

• Properties in the Midland Plume have household dust that is more contaminated with dioxins than properties from any other region in our study.

• Properties with higher levels of dioxins in soil tend to have higher levels of dioxins in household dust.

• Not all properties with high levels of dioxins in household dust have high levels of dioxins in soil. Dioxins in household dust may come from many sources, such as wood preservatives, old electrical appliances and burning trash in the yard, not just the soil.

Why are some of these results different from those reported in 2006?

There are four important differences between the two reports. These differences have to do with eating fish from the contaminated areas, living on contaminated soil, and having lived in the Midland/Saginaw region in different past time periods.

Fish – In 2006 we said "People who eat fish from the Tittabawassee River, Saginaw River and Saginaw Bay have higher levels of dioxins in their blood. . . ." In this new report, in which we actually had information on the amount of dioxins in the fish that people reported eating, we found no effect of eating fish from the contaminated areas.

Soil – In 2006 we said "People who have higher levels of dioxins in their soil have a higher TEQ (total dioxin-like activity) and higher levels of some specific dioxins in their blood." In this new report we found that the 2006 association was due to a single soil sample that was high in TCDD.

This association was not seen for any other dioxin compound including those that had much higher levels in soil. The absence of an association for every other compound is a strong argument that the single influential observation for TCDD was an anomaly.

Historic Time Period – In 2006, we reported that blood levels of TCDD were higher among people who lived in Midland/Saginaw between 1940–1959. Since then we have done further analyses that show both living in Midland/Saginaw between 1940–1959 and between 1960–1979 are associated with higher blood TCDD levels and that the computer model that fits the data best includes the 1960–1979 time period. The model that includes the 1940–1959 time period fits the data slightly less well. We believe that both models indicate that living in the Midland/Saginaw area prior to 1980 is an important source of TCDD in people's blood and that living in the Midland/Saginaw area after 1980 is not.

Region – In 2006, we reported that blood levels of some dioxins were higher among people who lived in the Floodplain, Near Floodplain, and Other Midland/Saginaw than in Jackson/Calhoun. Since then, we have done further analyses to understand why this is true. We found that this difference was entirely explained by whether people had lived in Midland/Saginaw prior to 1980. People who lived in Midland/Saginaw prior to 1980 had higher levels of dioxins in their blood, whereas people who lived in Midland/Saginaw only since 1980 did not. So, while some people who currently live in the Floodplain, Near Floodplain, and Other Midland/Saginaw have higher blood TCDD levels than people who live in Jackson/Calhoun, this is entirely due to having lived in the Midland/Saginaw region prior to 1980.

Further Information

Many of the findings from the UMDES have been published. A full listing of these publications and links to their sources can be found on the UMDES website at www.umdioxin.org. Definitions of some terms are provided in the Glossary on page 44. Full descriptions of the study and results are posted on the study website at www.umdioxin.org.

Background

Background

Dioxins are a family of chemicals that includes three different groups: polychlorinated dioxins, polychlorinated furans, and certain polychlorinated biphenyls (PCBs). They can be produced by combustion and industrial processes—often as unwanted byproducts. They are of concern because they have toxic effects in common.

History

The Dow Chemical Company has operated in Midland since 1897. One of the company's earliest processes was making chlorine gas from salt water. Over the past century a number of Dow processes created unwanted waste chemicals, including:

- polychlorinated dibenzo-*p*-dioxins (PCDDs)
- polychlorinated dibenzofurans (PCDFs).

Air emissions from burning tar-like waste and from other chemical processes that produced PCDDs are believed to explain the soil contamination downwind of Dow in Midland. The production of chlorine from salt water produced high levels of PCDFs which are believed to explain the contaminated sediments in the Tittabawassee River. Thus there are two different patterns of environmental contamination: one pattern running to the southeast in the Tittabawassee River sediments which contain high levels of PCDFs and proportionately less PCDDs, and the other pattern to the north and east downwind of Dow in the soils which contains high levels of PCDDs.

Contamination of the Saginaw River is more complex. Contaminated sediments from the Tittabawassee River have been carried downstream into the Saginaw River and explain the elevated levels of PCDDs and PCDFs in the Saginaw River. Polychlorinated biphenyls (PCBs) are also found in high concentrations in the Saginaw River, but there is no evidence that these came from Dow. General Motors and other companies are believed to be the source of the PCBs. Levels of PCBs in the Tittabawassee River floodplain are not elevated—they are similar to background levels found elsewhere in Michigan.

It is not known when these PCDDs, PCDFs, and PCBs were released. Prior to the 1960s dioxins could not be measured or identified in the environment. Nonetheless, it is likely that they were first released into the Tittabawassee River in the early part of the 20th century and that the ongoing flooding and movement of sediments ever since then have resulted in contamination of the 55 miles of the Tittabawassee and Saginaw River floodplains downstream from the Dow plant.

Although it is not known when air emissions of dioxins from Dow began, it is likely that sooty materials coming from Dow in the 1960s and 1970s were a major source of soil contamination downwind of Dow. It is believed that the release of contaminants into the air and river was dramatically reduced in the 1980s as the EPA enforced environmental regulations such as the Clean Air Act (1970 with major amendments in 1977 and 1990) and the Clean Water Act (1972).

What are Dioxins?

The word "dioxin" is commonly used to refer to any mixture of PCDDs, PCDFs, and PCBs. There are hundreds of specific chemicals that fall under the dioxin heading. According to the Centers for Disease Control (2010):

"Human health effects from low environmental exposures are unclear. People who have been unintentionally exposed to large amounts of these chemicals have developed a skin condition called chloracne, liver problems, and elevated blood lipids (fats). Laboratory animal studies have shown various effects, including cancer and reproductive problems."[1]

[1]How Dioxins, Furans, and Dioxin-Like PCBs Affect People's Health (from CDC Factsheet about dioxins in the *National Report on Human Exposure to Environmental Chemicals*). Page last updated: Tuesday April 13, 2010.

One of the specific dioxins, TCDD, is known to cause cancer in people, and related dioxins are suspected to cause cancer in humans.

In this report we focus on the three compounds that are the most important contributors to dioxins in human blood:

- **TCDD** (2,3,7,8-tetrachloro-*p*-dibenzodioxin),
- **PeCDF** (2,3,4,7,8-pentachlorodibenzofuran), and
- **PCB-126** (3,3',4,4',5-pentachlorobiphenyl).

These are the important contributors to dioxins in people's blood in our study and in the United States. (See Glossary and Technical Notes on page 44 for information about these chemicals.)

These three compounds are associated with different sources of contamination:

- TCDD is an unwanted byproduct of some past chemical processes at Dow and is a dominant contaminant in soils downwind of Dow.
- PeCDF is an unwanted byproduct of some other past chemical processes at Dow and is an indicator for contamination in the Tittabawassee River sediments.
- PCB-126 is an indicator of widespread past use of polychlorinated biphenyls in hydraulic oils, electrical transformers, caulks, paints, plastics, and other industrial and household products.

TCDD and PeCDF are signatures of Dow's activities in the area. There is no evidence that Dow released PCB-126, but it is included here because it is a large contributor to blood levels of dioxin in the Michigan and U.S. populations.

How do dioxins move in the environment?

Dioxins attach to organic material such as humus (a degraded organic material) in soil and river sediments. Thus, they travel with sediment as it moves during flooding. Dioxins are very insoluble in water and are not detectable in the drinking water in Midland and Saginaw. This was verified by the Environmental Protection Agency (EPA). Dioxins can also be carried in air from burning and incineration.

How do dioxins get into animals?

In the Tittabawassee and Saginaw Rivers where the sediments are contaminated with dioxins, the lower life forms in the sediments (such as small worms that eat and are covered in the sediment) are eaten by

small fish which are eaten in turn by larger fish. Because of this, dioxins accumulate in larger fish, especially bottom feeders, such as carp and catfish. Animals (such as deer, turkey, chickens, and cattle) that feed in contaminated areas and eat contaminated soil can also accumulate dioxins in their bodies from the soil.

Is it safe to eat plants and animals that have been exposed to dioxins?

Because dioxins stay in the fat of animals and fish, eating the fatty parts of contaminated animals and fish can lead to human exposure. Although most fruits and vegetables do not absorb dioxins when grown on contaminated soil, they may have dirt on their surfaces, which is why they should be washed before being eaten.

How do scientists find out if chemicals are causing harm to people?

In order to understand whether chemicals in the environment may affect people's health, scientists perform studies called risk assessments. A first step in assessing risk to human health from environmental chemicals is to find out how the chemicals get into people's bodies. The UMDES is this type of study. Chemicals cannot have health effects if they do not get into the body, so determining if and how chemicals get into the body is an important first step. Other studies assess whether chemicals cause harmful health effects in humans and in animals. The UMDES is not this type of study, but future studies of this type could build on the UMDES results.

Study Design

Study Design

The University of Michigan Dioxin Exposure Study (UMDES) was carried out in response to concerns that dioxin-like compounds from the Dow Chemical Company facilities in Midland, Michigan, have contaminated areas in the City of Midland and sediments in the Tittabawassee River Floodplain. This study was designed to find out if there is a relationship between levels of dioxins in soil and household dust and levels of dioxins in people's blood. It also looked at other factors—where people live, what they eat, their jobs and hobbies and recreational activities—that may be related to levels of dioxins in people's blood.

It is important to remember that this is not a health effects study. It is strictly a study of exposure pathways that can lead to higher levels of dioxins in people's blood.

The UMDES selected a random sample of Michigan residents in Midland, Saginaw, Williams Township in Bay County, and Jackson and Calhoun counties. Jackson and Calhoun counties were selected to represent areas of Michigan that have no known industrial source of dioxins, such as the Dow Chemical Company plant. We studied people who live in five different geographic areas:

The Floodplain—the Tittabawassee River Floodplain extending southeast from the Dow plant to the confluence of the Tittabawassee and Shiawassee Rivers in Midland and Saginaw counties.

The Near Floodplain—areas next to the Tittabawassee River Floodplain in Midland and Saginaw counties.

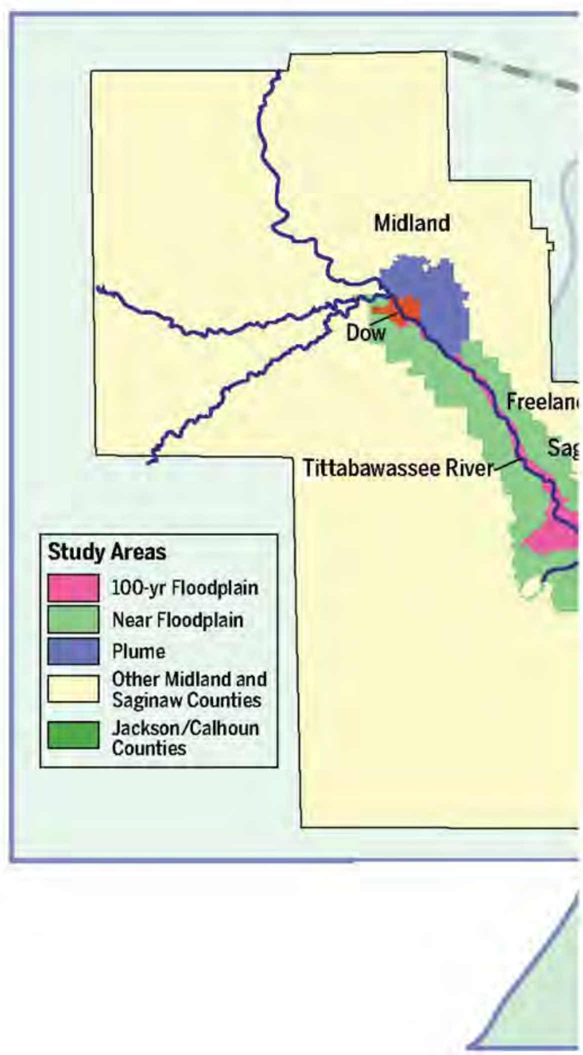
The Midland Plume—an area downwind of the Dow plant in the city of Midland.

Other Midland/Saginaw—other areas in Midland and Saginaw counties and Williams Township in Bay county.

For comparison, Jackson/Calhoun—Jackson and Calhoun counties, an area in Michigan over 100 miles away from the Dow plant.

When we refer to "Midland/Saginaw," we are referring to the Floodplain, Near Floodplain, Midland Plume, and Other Midland/Saginaw as one combined geographic area.

To be in this study, residents had to be at least 18 years old and had to have lived at



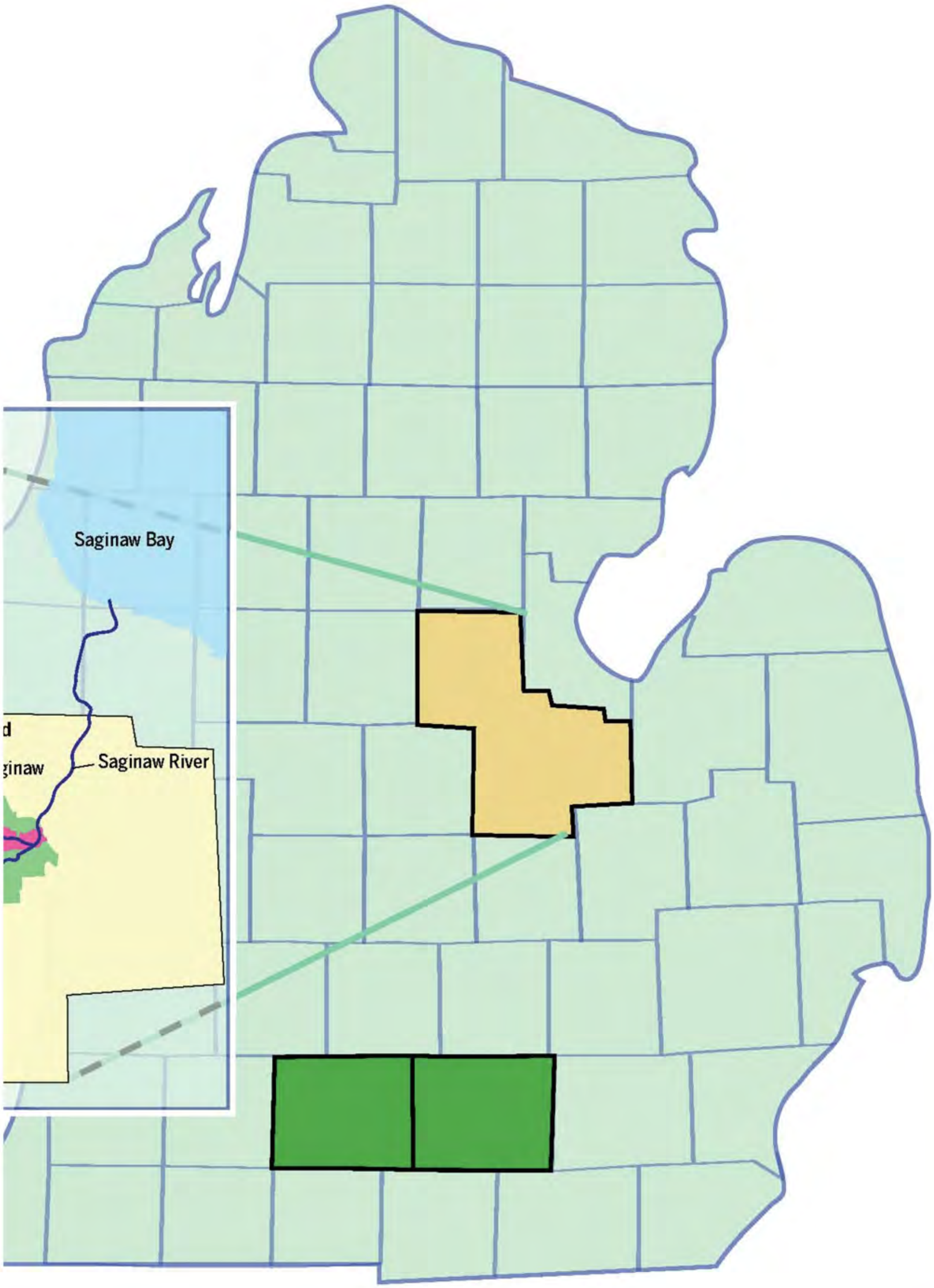

Saginaw Bay
d
ginaw
Saginaw River

Table 1. Number of Participants

	Floodplain	Near Floodplain	Midland Plume	Other Midland/ Saginaw	Jackson/ Calhoun	Total Across All Areas
Interviews	326	264	71	304	359	1324
Blood Samples	251	197	48	199	251	946
Household Dust Samples	207	159	37	163	198	764
Soil Samples	203	164	37	168	194	766
Interview, Blood, Dust, and Soil Samples	195	156	35	162	183	731
Estimated Number of Eligible Persons	2070	1955	6550	90270	101330	202175

Full details on the study design, field and laboratory methods, and study findings are posted on the study's website www.umdioxin.org.

their current address continuously for the preceding five years (approximately 2000–2005). We targeted residents who lived in the most frequently flooded areas on the Tittabawassee River because they were thought to be the most likely to be exposed to highly contaminated soil and household dust. This study did not include children. The levels of dioxin in children's blood are too low to be detected without taking unacceptably large amounts of blood from the children, given the technology available at the time the study was done in 2005.

Participants were asked to complete a one-hour personal interview. The interview gathered information about demographic and health factors, residence history, land use, occupation and military history, recreational activities, and detailed food consumption patterns. The amounts eaten of fish, game, and other foods from contaminated areas was a primary focus of the interview. Eligible participants were asked to provide an 80 milliliter blood sample, to consent to sampling of household dust, and to consent to sampling of soil around their home. Twenty-nine dioxin compounds were measured in the blood, household dust, and soil samples. These compounds are recognized by the World Health Organization as the most important representatives of the entire class of dioxin compounds. A summary of the 29 compounds, the TEQ (Toxic EQuivalency), is used by the EPA, as well as many national and international agencies, to assess overall levels of dioxin contamination in the environment.

Results

Levels of Dioxins in People's Blood

What are the most important factors related to levels of dioxins in people's blood?
The most important factor related to levels of dioxins in people's blood is their age. Almost everyone's dioxin level increases with age, so older people have higher levels in every population. The effect of age is likely the result of cumulative intake in the past and long persistence of dioxins in humans. In addition, women have higher levels than men and people with more body fat have higher levels than people with less body fat.

Breastfeeding reduces the amount of dioxins in a woman's blood because dioxins are excreted in the breast milk. The more months a woman has breastfed her babies the lower her blood dioxin levels. This also means that the dioxins in breast milk are taken in by the nursing baby. Nevertheless, the benefits to the baby of breastfeeding outweigh the potential risks from dioxins in breast milk.

Smoking is associated with lower levels of dioxins in people's blood. (It is not understood why this is true.) Nevertheless, the risks from smoking outweigh any possible benefit from a reduction of dioxins in blood.

What other factors are related to levels of dioxins in people's blood?
After accounting for the most important factors (age, sex, body fat, breastfeeding, and smoking) the next most important factor is having lived in the Midland/Saginaw area between 1960 and 1979. People who lived in Midland/Saginaw for the entire 20 years between 1960–1979 have 86% higher blood TCDD levels than people who did not live in this area. However, this was not true for PeCDF or PCB-126, for which living in Midland/Saginaw in 1960–1979 had no relationship to blood levels.

Are people who are currently living in Midland/Saginaw still being exposed to dioxins?
In contrast to having lived in Midland/Saginaw in 1960–1979, living in this region in the past 25 years has no relationship to blood dioxin levels. People who lived in Midland/Saginaw for the entire period 1980–2005 (and who did not live in the area during 1960–1979) have the same levels of TCDD, PeCDF, and PCB–126 in their blood as people who live in Jackson/Calhoun. We believe that this pattern of findings is consistent with past emissions of TCDD from the Dow facilities prior to 1980, and is also consistent with there being no measurable current exposure from local industrial sources.

People who live on properties with contaminated soil and in households with contaminated dust do not have higher levels of dioxins in their blood. This is true even among the people who lived on the most contaminated soils downwind of the Dow plant or along the Tittabawassee River. We had 132 people who lived on soil with dioxin levels exceeding 72 parts per trillion (the 2010 EPA proposed soil remediation guideline), 118 people who lived on soil with dioxin levels exceeding 90 parts per trillion (the MDEQ residential soil direct contact criterion), and 21 people who lived on soil with dioxin levels above 1,000 parts per trillion (the current EPA level at which action should be taken for residential soil), so we had plenty of data to address this issue and to find a relationship if it existed.

Foods and Levels of Dioxins in Blood

We also looked carefully at people who ate fish and game from the contaminated areas of the Tittabawassee River and Saginaw River, and calculated their dioxin intake from these fish and game. There was no relationship between eating these fish and game and blood dioxin levels, most likely because there were few people who ate the more contaminated fish (carp and catfish) and few people who ate the most contaminated parts of the game (deer liver and turkey skin). Also, people who ate fish and/or game from the Tittabawassee River, Saginaw River, or Saginaw Bay usually ate a lot of fish from other sources (from other rivers and lakes in Michigan, bought from stores, or eaten in restaurants). It is possible that eating large amounts of fish or game from the Tittabawassee River, Saginaw River, and Saginaw Bay could have a measurable effect on blood dioxin levels, but this was not the case in our study. *TO BE ON THE SAFE SIDE, WE RECOMMEND THAT PEOPLE FOLLOW THE MICHIGAN DEPARTMENT OF COMMUNITY HEALTH (MDCH) GUIDELINES FOR EATING FISH AND GAME.*

We found that people who eat fish from other sources (store-bought, restaurants, sport-caught from any other area) have higher levels of TCDD and PCB-126, but not PeCDF. Eating fish from all sources has been shown in many studies to be a major source of dioxins in the human diet.

Eating game meat from any source was associated with higher blood PeCDF levels, but not TCDD or PCB-126. There did not appear to be any different effect on blood dioxins between game meat from the contaminated area and game meat from any other source.

Recreational Activities and Levels of Dioxins in Blood

Fishing in the Saginaw River or Saginaw Bay after 1980, but not in other time periods, was associated with higher blood levels of PCB-126 and PeCDF. We have no evidence that PCB-126 in the Saginaw River and Saginaw Bay came from Dow.

Fishing and other water activities in the Tittabawassee River during the 1960s and 1970s (but not in other time periods) were associated with higher blood levels of TCDD.

Hunting in the Saginaw River or Saginaw Bay area between 1960 and 1979 was associated with higher blood PeCDF levels. However, we are cautious about what this means because we did not find that eating game meat from this area was associated with higher blood PeCDF levels. We did not see any association between hunting in the Tittabawassee River area and blood dioxin levels (TCDD, PeCDF, or PCB-126), nor did we see any association between hunting in the contaminated areas after 1980 and any of the blood dioxin levels (TCDD, PeCDF, or PCB-126). Other recreational activities after 1980, such as swimming, boating, hiking, and picnicking, around the Tittabawassee River, Saginaw River, or Saginaw Bay had no association with blood dioxin levels. People who engaged in recreational activities around the Tittabawassee River between 1960–1979 have higher blood TCDD and PeCDF levels, but not PCB-126.

We found a small number of people who ate meat from cattle raised in the Tittabawassee River Floodplain and who had high blood PeCDF levels. This suggests strongly that eating meat from livestock raised on contaminated soil can be an important source of blood dioxins and should be avoided. We also looked at eating fruits and vegetables grown on contaminated soil and found no relationship to blood dioxin levels. We suggest that fruits and vegetables from contaminated areas be washed carefully to remove soil. We also looked at eating eggs and milk from animals raised in the Floodplain. We found no relationship to blood dioxin levels because there were very few people who reported eating eggs and milk from animals raised in the Floodplain. Nevertheless, we recommend that people not eat eggs, milk, or other animal products from the Floodplain.

Working at Dow

Working at Dow is associated with higher blood levels of TCDD. Previously we reported that working at Dow between 1940–1959 was associated with higher blood levels of TCDD. We have done further analyses that show working at Dow any time after 1940 is associated with higher blood levels of TCDD.

Region and Levels of Dioxins in Blood

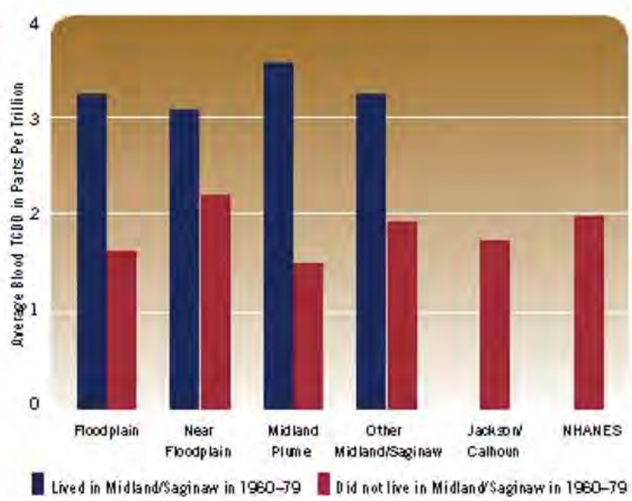
How do blood results in Midland/Saginaw compare with blood results in Jackson/Calhoun and with the general U.S. population?

In 2006, we reported that blood levels of dioxins were higher among people who lived in the Floodplain, Near Floodplain, and Other Midland/Saginaw than in Jackson/Calhoun. Since then we have done further analyses to understand why this is true. We found that this difference was entirely explained by whether people had lived in Midland/Saginaw prior to 1980. People who lived in Midland/Saginaw prior to 1980 had higher levels of dioxins in their blood, whereas people who lived in Midland/Saginaw only since 1980 did not.

We believe this result is due to Dow's past discharges of dioxins prior to 1980. We believe that these discharges decreased in the early 1980s because of environmental regulations.

Levels of dioxins in people who only lived in Midland/Saginaw after 1980 and who live in Jackson/Calhoun are about the same as in the general U.S. population. In order to compare our results to the general U.S. population, we used one of the best publically available resources for the national dioxin levels in blood—the Centers for Disease Control and Prevention's

Figure 1. People who lived in the Midland/Saginaw area from 1960–1979 have higher average TCDD levels than people who did not.



National Health and Nutrition Examination Survey (NHANES, www.cdc.gov/nchs/nhanes.htm). In 2003–2004, NHANES tested about 1,000 people age 12 and older in the United States for 26 dioxins in the blood. The average blood TCDD level for the comparable (age 18 and older non-Hispanic white) general U.S. population was 2 parts per trillion.

Figure 1 shows the age-adjusted blood TCDD levels according to where people currently live. In every region of Midland/Saginaw, only the people who lived there from 1960–1979 have higher TCDD levels compared to both Jackson/Calhoun and the current U.S. population. People who have lived in Midland/Saginaw only after 1980 (and not before that) have blood TCDD levels that are not meaningfully different from Jackson/Calhoun and the current U.S. population.

Is having lived in Midland/Saginaw during different historic periods related to higher levels of dioxins in people's blood?
Yes. In 2006, we reported that blood levels of TCDD were higher among people who lived in Midland/Saginaw between 1940–1959. Since then we have done further analyses that show living in Midland/Saginaw both between 1940–1959 and between 1960–1979 are associated with higher blood TCDD levels. We believe that living in the Midland/Saginaw area any time prior to 1980 is an important source of TCDD in people's blood and that living in the Midland/Saginaw area after 1980 is not.

Soil and Household Dust and Levels of Dioxins in Blood

Are levels of dioxins in soil related to levels of dioxins in people's blood?
No. We measured the dioxin levels in soil samples from around the perimeter of each person's house in the study, from their gardens, and from a location near the Tittabawassee River (if they lived in the floodplain of the river). After looking at all these different samples, we found no statistically significant relationship between dioxin levels in these soil samples and dioxin levels in the blood of subjects.

In 2006 we said "People who have higher levels of dioxins in their soil have a higher TEQ (total dioxin-like activity) and higher levels of some specific dioxins in their blood." We also said "People who have higher TEQ levels and higher levels of 2,3,7,8-TCDD, PCB-118, and PCB-126 in some of their soil samples have higher levels of these dioxins in their blood." In this new report we found no association between soil and blood dioxins after taking into account past air emissions and other factors that we had not analyzed in 2006.

Gardening and/or eating vegetables from a garden does not contribute to dioxin levels in blood. In other words, dioxin contamination that may be in the soil around one's home does not contribute to exposure or to blood levels. An exception is if people raise livestock on their property and the soil on the property is contaminated.

Table 2. Summary table of important factors that explain higher levels of dioxins in blood

Section	Factors associated with HIGHER levels of dioxins in the body	TCDD	PeCDF	PCB-126
Demographics	Being older than 40 at the time of the survey in 2005 (more so for females)	Pg. 25	Pg. 25	Pg. 25
	Having more body fat			Pg. 26
Residence	Number of years lived in Midland/ Saginaw between 1960–1979*	Pg. 22, 23		
Property Use	Number of years lived on property where trash or yard waste was burned between 1940–1959	Pg. 29		
	Number of years lived on a property where a wood burning fireplace or wood burning stove was used regularly between 1940–1959		Pg. 29	
	Number of years lived on a farm between 1940–1959			Pg. 29
Work	Worked at the Dow chemical company in Midland, Michigan*	Pg. 29		
	Number of years served as an emergency responder such as a fire fighter, police officer, or emergency medical technician between 1940–1959	Pg. 29		
	Number of years stationed in Vietnam	Pg. 29		
	Number of years worked in waste disposal (including incinerator, waste-water, solid waste, scrapped equipment), metal scrap yards other than for auto-mobiles, or water treatment facility between 1960–1979		Pg. 29	
Fish or fishing	Number of years ate fish from all sources, after 1980	Pg. 21, 26		Pg. 21, 26
	Fishing on average at least once a month in the Tittabawassee River below the Tridge between 1960–1979*	Pg. 21, 27		
	Fishing on average at least once a month in the Saginaw River or Bay after 1980*		Pg. 21, 27	Pg. 21, 27
Meat, game meat, or hunting	Number of years ate game meat from all sources, after 1980		Pg. 21, 27	
	Number of meals of any kind of meat that was home-raised from somewhere other than the Tittabawassee River, Saginaw River, and Saginaw Bay within 5 years at the time of survey in 2005		Pg. 28	
	Did hunting activities in the surrounding areas of the Saginaw river or Bay 1960–1979 (ever versus never)*		Pg. 21, 28	
Water activities	Did water activities on average at least once a month in or around the Tittabawassee River below the tridge between 1960–1979 *	Pg. 22, 28, 29	Pg. 22, 28, 29	

*Associated with potential dioxin pollution from the Dow Chemical Company in the Midland/Saginaw area.

Table 3. Summary table of important factors that explain lower levels of dioxins in blood

Section	Factors Associated with LOWER levels of Dioxins in the body	TCDD	PeCDF	PCB-126
	Being younger than 40 at the time of the survey in 2005	Pg. 25	Pg. 25	Pg. 25
	Breastfeeding	Pg. 26	Pg. 26	
	Smoking	Pg. 26	Pg. 26	Pg. 26

Entries with page numbers in Tables 2 and 3 indicate statistically significant associations and their locations in this report. Blank boxes indicate no statistically significant association.

Animals ingest soil when they graze, and so they can ingest dioxins in the soil. People who then regularly eat the meat from such animals can have increased blood levels of dioxins. In other words, raising livestock on contaminated soil can result in a completed pathway of human exposure to the dioxins in the soil. Therefore, livestock (and also poultry, pigs, sheep, goats, and/or dairy cows) should not be raised or allowed to graze on soil that is suspected of contamination with dioxins.

Are levels of dioxins in household dust related to levels of dioxins in people's blood?

No. Dioxins in household dust are not associated with blood dioxin levels.

Personal Factors and Levels of Dioxins in Blood

Does age matter?

Yes. Older people have higher levels of dioxins in their blood than younger people. Figure 2 on the next page compares the blood TCDD, PeCDF, and PCB-126 levels among people under age 40 with people age 40 and older among UMDES study participants in Midland/Saginaw and Jackson/Calhoun counties. It shows, in general, that blood levels are substantially higher in the older age group than in the younger age group for all three dioxins. This also applies to the U.S. population of adults as shown by the NHANES data.

The study participants in Midland and Saginaw on average were slightly older than those from Jackson/Calhoun. This explains part of the difference in blood levels of dioxins in these two groups. However older people in Midland/Saginaw were more likely to have lived there during the period of higher emissions from Dow (in the1960s and 1970s). This fact also explains an important part of the difference in blood levels of dioxins (see page 22).

Do men and women have different levels of dioxins in their blood?

Yes, and it varies by age. In general, at ages less than 40, women have lower dioxin levels than do men of the same age. At older ages, levels of dioxins are higher for women than for men of the same age.

Do people who are overweight, normal weight, or underweight have different levels of dioxins in their blood?

Yes. One measure of weight that adjusts for differences in height is called Body Mass Index, commonly referred to as BMI. People with a higher BMI tend to be overweight and people with a lower BMI tend to be underweight.

People who have a higher BMI have higher levels of PCB-126 (but not TCDD or PeCDF) in their blood than people with a lower BMI.

Do smokers have higher levels of dioxins in their blood?

No. People who have smoked cigarettes have lower levels of TCDD, PeCDF, and PBC-126 in their blood. This result is consistent with other studies of dioxins. Nevertheless, the risks from smoking outweigh any possible benefit from a reduction in levels of dioxins in blood.

Do women who breastfed their children have different levels of dioxins in their blood?

Women who breastfed have lower levels of TCDD and PeCDF in their blood than do women who did not breastfeed. The longer a child was breastfed, the lower the level of these two dioxins in a woman's blood. Other studies have shown that dioxins are contained in breast milk and are transferred from the mother to the nursing baby. However, the emotional, immunological, and nutritional benefits of breastfeeding outweigh the potential risks from dioxins in breast milk. For supporting information see the FDA Questions and Answers about Dioxins release from: www.fda.gov/Food/FoodSafety/FoodContaminantsAdulteration/ChemicalContaminants/DioxinsPCBs/ucm077524.htm

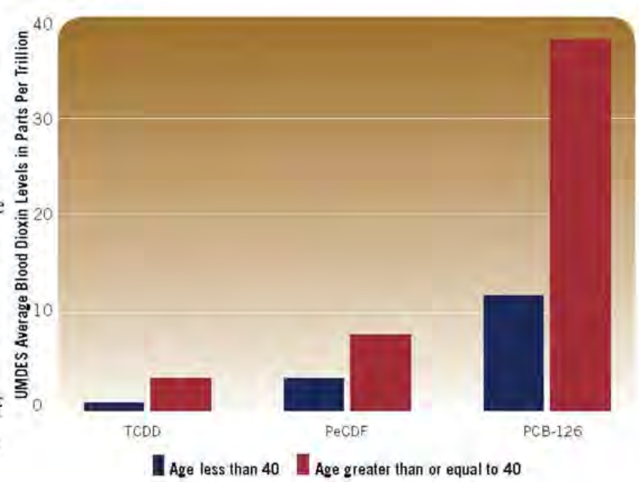
Foods and Levels of Dioxins in Blood

Do people who eat fish and game, regardless of where it came from, have higher levels of dioxins in blood? Do people who eat fish and game from the Tittabawassee River, Saginaw River, or Saginaw Bay have higher levels of dioxins in their blood?

Eating fish, regardless of where it comes from, contributes to blood TCDD and PCB-126 levels. Eating game, regardless of where it comes from, contributes to blood PeCDF levels.

We looked at people who ate fish and game from the contaminated areas of the Tittabawassee River and Saginaw River, and calculated their dioxin intake from these fish and game. There was no relationship between eating these fish and game and blood dioxin levels, most likely because there were few people who ate the more contaminated fish (carp and catfish) and few people who ate the most contaminated parts of the game

Figure 2. Levels of dioxins in blood increase with age.



(deer liver and turkey skin). Also, people who ate fish and/or game from the Tittabawassee River, Saginaw River, or Saginaw Bay usually ate a lot of fish and game from other sources (i.e., from other rivers and lakes in Michigan, bought from stores, or eaten in restaurants). It is possible that eating large amounts of fish or game from the Tittabawassee River, Saginaw River, or Saginaw Bay could have a measurable effect on blood dioxin levels, but this was not observed in our study. We recommend that people follow the Michigan Department of Community Health (MDCH) guidelines for eating fish and game.

In 2006, we reported that eating fish from the Tittabawassee River, Saginaw River, and Saginaw Bay between 1980 and 2005 was associated with higher levels of TEQ and TCDD. Now that we have calculated the dioxin intake from these fish, there is no relationship to blood dioxin levels. We believe that the analyses based on the actual dioxin intake are more reliable than the analyses based only on the number of fish meals that people reported eating. This means that once we accounted for whether people ate fish from any source, eating fish from the contaminated area did not contribute to blood dioxin levels. In other words, we could not see any contribution to blood dioxin levels from eating fish from the contaminated areas over and above the contribution to blood dioxin levels from eating fish from everywhere else. Because most fish that were eaten from the Tittabawassee River, Saginaw River, or Saginaw Bay were not much more contaminated than fish from other sources, their contribution to blood levels of dioxins was too small to see.

In addition to asking about whether people ate fish, we asked them about fishing in the contaminated areas. Fishing more than once per month in the Saginaw River or Saginaw Bay after 1980 was associated with higher blood levels of PeCDF and PCB-126, but not TCDD. However, fishing in the Saginaw River or Saginaw Bay during other time periods (before 1980) was not associated with blood levels of TCDD, PeCDF, or PCB-126.

Fishing in the Tittabawassee River more than once per month between 1960–1979 was associated with higher blood levels of TCDD. Fishing in the Tittabawassee River in other time periods was not associated with blood levels of TCDD, PeCDF, or PCB-126. We have no evidence that PCB-126 in the Saginaw River or Saginaw Bay came from Dow. This is consistent with the fact that PCB-126 levels are elevated in the sediments in the Saginaw River and Saginaw Bay but are not elevated in the Tittabawassee River sediments.

We believe that the analyses that look at eating fish are more meaningful than the analyses of fishing habits. The analyses of eating fish accounted for the amount of each type of fish the person ate, where the fish came from, and the amount of dioxins measured in the fish meat. We believe this is a more reliable indicator of exposure than is fishing because many people who fish don't eat what they catch, and many people who eat sport-caught fish don't actually do the fishing.

We asked people about eating game meat over their entire lifetimes. We found that people who ate game meat (from any location) for many years had higher levels of PeCDF than people who did not eat game meat over many years. People who ate game meat for many years did not have higher TCDD or PCB-126 levels. In another set of questions, we asked people about what they ate during the last five years (from the time of the interview in 2004–2005) and, if they ate game meat, where it came from. Only a few people reported eating game meat from the contaminated areas during that time period.

Those people did not have higher blood dioxin levels. Nevertheless, people should follow the Michigan Department of Community Health guidelines for the consumption of game meat from this region.

In addition to asking people about eating game meat, we asked them about hunting in the contaminated areas. We found that hunting in the Saginaw River and Saginaw Bay area between 1960 and 1979 was associated with higher blood PeCDF levels, but not TCDD or PCB-126 levels. We found no relationship between blood dioxin levels and hunting in the Tittabawassee River area between 1960 and 1979. We also found no relationship between hunting in any of the contaminated areas after 1980 and any of the blood dioxin levels.

Do people who eat fruit and vegetables have higher levels of dioxins in their blood?

No. We found no relationship between blood dioxin levels and reported consumption of fruits and vegetables including fruits and vegetables from the contaminated region. We recommend that people wash fruits and vegetables thoroughly to remove soil.

Do people who drink milk and eat dairy products have higher levels of dioxins in their blood?

We found no relationship between blood dioxin levels and eating milk or dairy products in general. More than 90 percent of the people in the study reported eating eggs and dairy products. However, very few people reported eating milk or dairy products from the Tittabawassee River, Saginaw River, or Saginaw Bay Floodplains. Nevertheless, we recommend that people not eat milk and dairy products raised in the contaminated areas.

Do people who eat eggs have higher levels of dioxins in their blood?

We found no relationship between blood dioxin levels and eating home-raised eggs from the contaminated areas. However, very few people reported eating home-raised eggs from the Tittabawassee River, Saginaw River, or Saginaw Bay Floodplains. As a result, there is little information from this study on whether eating eggs from these areas contributes to levels of dioxins in blood. We recommend that people not eat eggs from the contaminated areas.

Do people who eat home-raised meat have higher levels of dioxins in their blood?

One study participant raised beef cattle in the flood plain of the Tittabawassee River, ate the meat frequently, and had an elevated blood level of PeCDF. Other than this individual, there were few study participants who ate meat raised in the contaminated areas. We believe this observation is a strong warning not to eat meat from animals raised in the contaminated areas.

We also found that people who ate home-raised meat from areas other than the Tittabawassee River, Saginaw River, or Saginaw Bay Floodplains had higher levels of PeCDF in their blood.

Recreational Activities and Levels of Dioxins in Blood

Do people who swim, boat, hike, or picnic on or near the Tittabawassee River, Saginaw River, or Saginaw Bay have higher levels of dioxins in their blood?

Recreational activities have a very small effect on dioxin levels in blood. In 2006 we said that the very small effect applied to people who did these recreational activities around the Tittabawassee River after 1980. Since then we have done further analyses that show recreational activities around the Tittabawassee River before 1980 and after 1980 are both associated with higher blood TCDD levels and that the computer model that fits the data best includes the 1960–1979 time period. The model that includes the 1980–2005 time period fits the data slightly less well. We found that recreational activities around the Tittabawassee River in 1960–1979 were associated with higher blood PeCDF levels. By "very small effect" we mean that this factor explained less than 1 percent of the differences in blood levels among the participants.

Occupation and Levels of Dioxins in Blood

Do people who have worked at the Dow plant have higher levels of dioxins in their blood?

Yes. People who worked at Dow have higher levels of TCDD in their blood, but not higher levels of PeCDF or PCB-126.

Residential Activities and Levels of Dioxins in Blood

Do people who have pets or family who track dirt into the house every day have higher levels of dioxins in their blood?

No. People who had pets that ran in and out of the house do not have higher levels of dioxins in their blood. Taking shoes off before coming into a home also is not related to levels of dioxins in blood.

Were there other ways that people used their property that were associated with higher levels of dioxins in people's blood?

Yes. People who burned trash or yard waste on their properties between 1940 and 1959 have higher levels of TCDD in their blood.

People who lived on a property where a wood-burning fireplace or wood-burning stove was used regularly between 1940–1959 had higher levels of PeCDF in their blood. This relationship was not seen for TCDD or PCB-126 and was not seen for wood-burning fireplaces and stoves after 1960.

People who lived on farms between 1940–1959 had higher levels of PCB-126 in their blood. We did not see this relationship for TCDD or PeCDF.

Other Information About Levels of Dioxins in Blood

What other factors were associated with blood dioxin levels?

There were a number of other factors associated with one or more of the dioxins in blood. However, these factors had very small influence on the levels of dioxin in blood. These include the number of years served as an emergency responder, the number of years served in Vietnam, and the number of years worked in waste disposal.

How many people were tested for dioxins in their blood?

We took blood samples from 946 people—251 people in the Floodplain, 197 people in the Near Floodplain, 48 people in the Midland Plume, 199 people in Other Midland/Saginaw, and 251 people in Jackson/Calhoun. (See Table 1, pg 18.)

What are the highest and lowest levels of dioxins for all of the blood samples?

The lowest TCDD level measured in blood was less than 0.5 parts per trillion (levels below this were not measurable). The highest TCDD was 65 parts per trillion.

The lowest PeCDF level measured in blood was less than 1.5 parts per trillion (levels below this were not measurable). The highest PeCDF was 50 parts per trillion.

The lowest PCB-126 level measured in blood was less than 4.7 parts per trillion (levels below this were not measurable). The highest PCB-126 was 394 parts per trillion.

Where can I find out more about the blood results?

The UMDES website, www.umdioxin.org, contains detailed tables on all of the blood results.

Levels of Dioxins in Soil

As mentioned earlier, dioxins attach to soils. The contamination of soil and the potential for contaminated soils to get into people's bodies has been a major concern in Midland and Saginaw. Therefore, it is important to answer questions about how badly the soils are contaminated in the study communities. The following is a series of questions raised by people in the community about these issues and the answers we have found in the study data.

What are the important regulatory and exposure criteria for levels of dioxins in soil?

In order to put the findings from our study in perspective, it is important to consider the State of Michigan and U.S. Environmental Protection Agency (EPA) regulations about dioxin contamination of residential soil. These agencies regulate soil dioxin contamination in terms of the TEQ rather than in terms of specific dioxin compounds such as TCDD, PeCDF, or PCB-126.

Three important levels of dioxins in soil are:

• 72 parts per trillion TEQ (72 parts per trillion means there are 72 units of dioxin in every trillion units of soil). This level was proposed by the EPA in 2009 as the starting point for residential soil cleanup levels at Superfund sites.

• 90 parts per trillion TEQ. The State of Michigan defines residences that have soil TEQ levels at or above 90 part per trillion as "facilities." Under Michigan law, if a residential property is a "facility," the owner is required to inform a potential purchaser of this, and must not move the contaminated soil into uncontaminated areas.

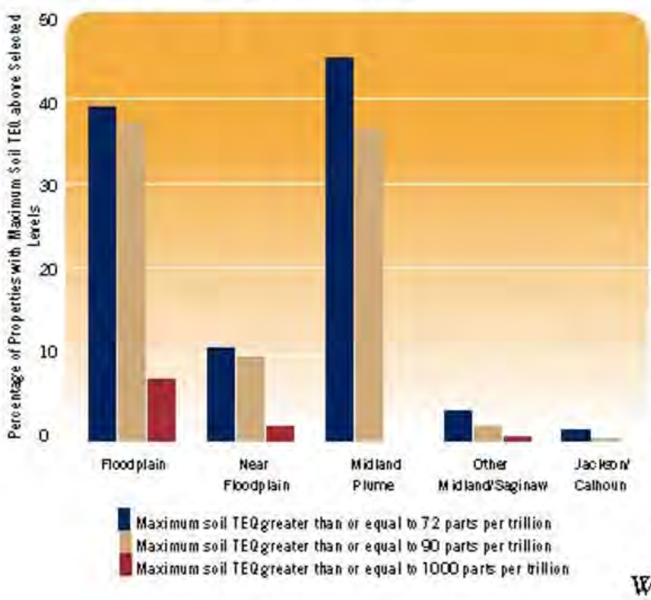
• 1,000 parts per trillion TEQ. The EPA currently uses 1,000 parts per trillion as a level at which action should be taken to consider various public health measures concerning residential soil. This value may be replaced by the proposed EPA value of 72 parts per trillion. States can use lower levels for their criteria.

How frequently were properties found to exceed 72 parts per trillion TEQ?

• Thirty-eight percent (n=88) of properties in the Floodplain, 11 percent (n=19) of properties in the Near Floodplain, 44 percent (n=17) of properties in the Midland Plume, and 3 percent (n=6) of properties in Other Midland/Saginaw have levels higher than 72 parts per trillion.

• Only 1 percent (n=2) of the properties in Jackson/Calhoun have levels above 72 parts per trillion.

Figure 3. Percentage of properties with maximum soil TEQ above selected levels.



How frequently were properties found to exceed 90 parts per trillion TEQ?

• Thirty-seven percent (n=83) of properties in the Floodplain, 10 percent (n=18) of properties in the Near Floodplain, 36 percent (n=12) of properties in the Midland Plume, and 2 percent (n=4) of properties in Other Midland/Saginaw have levels higher than 90 parts per trillion.

• Less than one half of 1 percent (n=1) of the properties in Jackson/Calhoun have levels above 90 parts per trillion.

How frequently were properties found to exceed 1000 parts per trillion TEQ?

• Seven percent (n=19) of properties in the Floodplain, 2 percent (n=1) of properties in the Near Floodplain, none of the properties in the Midland Plume, and less than one-half of 1 percent (n=1) of properties in Other Midland/Saginaw have levels higher than 1000 parts per trillion.

• None of the properties in Jackson/Calhoun has levels above 1000 parts per trillion.

The findings concerning these three levels are summarized by region in Figure 3. This figure shows the percentage of properties that exceeded these levels, after choosing the soil sample that had the highest contamination level from each property.

How many people's properties were tested for dioxins in soil?

Seven hundred and sixty-six properties were tested—203 properties in the Floodplain, 164 properties in the Near Floodplain, 37 properties in the Midland Plume, 168 properties in Other Midland/Saginaw, and 194 properties in Jackson/Calhoun. Multiple samples were taken from each property.

Where were soil samples taken on each participant's property?

We took soil samples around the participant's house, from the flower or vegetable garden (if the participant had a garden), and near the river (if the property was in the Tittabawassee River Floodplain).

How do the UMDES soil findings compare to other soil findings in the study areas?

The UMDES targeted the neighborhoods along the Tittabawassee River that were known to be most frequently flooded and believed to have the highest levels of soil contamination. The UMDES also targeted neighborhoods immediately downwind of Dow that were believed to be most highly contaminated by air emissions from the Dow facility. It must be remembered that when this study was begun in 2004, there were few soil measurements available in those neighborhoods or on private properties. UMDES has compared its results for the Floodplain of the Middle Tittabawassee River with the results obtained by others and has shown comparable soil contamination levels.

How do soil results for TCDD, PeCDF, and PCB-126 in the soil around the houses in Midland/Saginaw compare to soil results in Jackson/Calhoun?

Median levels of TCDD in soil in the Midland Plume are higher (32.1 parts per trillion) than in the other areas of Midland/Saginaw and Jackson/Calhoun (0.2–1.3 parts per trillion—see Figure 4). (The median is the concentration where half of the soil samples are above and half are below.) Median levels of PeCDF in soil are slightly higher in the Floodplain (7.6 parts per trillion) and Midland Plume (7.6 parts per trillion) than in the other areas of Midland/Saginaw and Jackson/Calhoun (1.0–1.6 parts per trillion). Median levels of PCB-126 in soil are higher in the Midland Plume (9.3 parts per trillion) than in the other areas of Midland/Saginaw (1.8–4.2 parts per trillion) and Jackson/Calhoun (4.4 parts per trillion).

How do the TEQ levels in soil in Midland/Saginaw compare to soil results in Jackson/Calhoun?

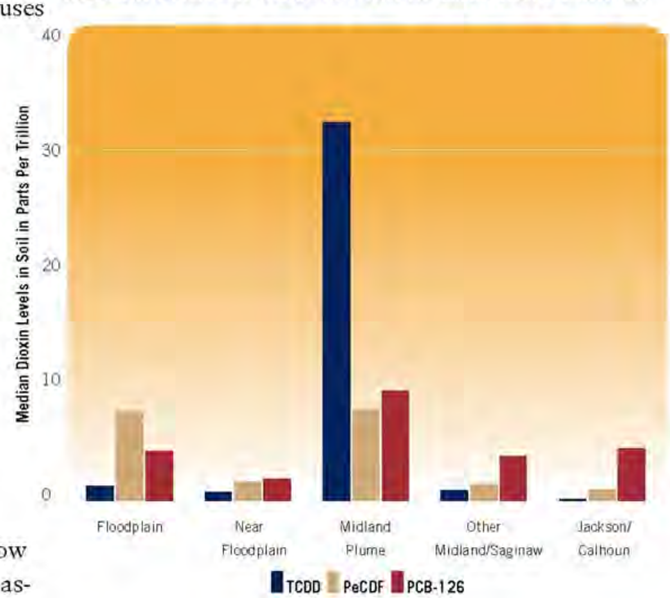
Levels of dioxins (TEQ) in soil around houses in Midland/Saginaw are higher than levels of dioxins in soil around houses in Jackson/Calhoun, measured by the median (half of the soil samples have levels above the median and half are below). In Jackson/Calhoun, the median is 4 parts of dioxins per trillion parts of soil. However, in Midland/Saginaw, the median soil level is 58 parts per trillion in the Midland Plume area downwind from the Dow plant. In the Floodplain, the median is 11 parts per trillion. The median for the Near Floodplain is 4 parts per trillion and the median for Other Midland/Saginaw is 5 parts per trillion. So, this means that the soils are most contaminated downwind from Dow and in the areas closest to the Tittabawassee River. Dioxin levels in other areas in Midland and Saginaw are no different, on average, from Jackson/Calhoun.

What are the highest and lowest levels (TEQ) for all the soil samples?

Low levels of dioxins in soil were measured in all of the study areas. The lowest level measured was 0.4 parts dioxins per trillion parts of soil. The highest level measured was 11,200 parts per trillion. This sample was taken from a property in Other Midland/Saginaw. This unusually high level seems to have resulted from moving contaminated Tittabawassee River Floodplain soil to an area outside the Floodplain.

The lowest level measured near the Tittabawassee River was about 1 part per trillion, and the highest was about 7,260 parts per trillion. In general, samples that were taken near the Tittabawassee River were higher than samples taken around houses or from gardens in the Floodplain region.

Figure 4. Soil samples from around houses in the Floodplain and the Midland Plume have higher median levels of dioxins than in Jackson/Calhoun.



Did you find evidence of the contamination from Dow Chemical?

In order to understand the evidence about whether the contamination came from a source such as Dow, we need to examine the patterns of the dioxins in the different soil samples. When we say "patterns" of dioxins, we mean certain combinations of the 29 chemicals that suggest the source of the contamination. These patterns are sometimes called "fingerprints."

We found three important patterns of dioxins in soil. These patterns were seen in 95 percent of all soil samples.

- The most common pattern is a background pattern found in soils throughout all areas of Jackson/Calhoun and Midland/Saginaw. This pattern is seen throughout the world and is due to burning a variety of materials such as fossil fuels and trash, both by old municipal incinerators and in the back yard. This is not related to Dow.
- The second-most common pattern, found mainly in the Floodplain and Near Floodplain, had high levels of PeCDF. This pattern is similar to the pattern found by the Michigan Department of Environmental Quality in Tittabawassee River sediment. We believe this pattern is the result of Dow's past discharges into the river.
- The third pattern, found in the Midland Plume, downwind of the Dow plant in Midland, had high levels of TCDD. We believe this pattern is the result of Dow's past airborne discharges.

How do the levels of dioxins in soil from Jackson/Calhoun compare with levels across the nation?

We do not know the levels of dioxins in soil across the nation because there have been no similar studies. However, a small number of soil samples taken by the Michigan Department of Environmental Quality from the lower peninsula of Michigan found the median level of dioxins to be about 5 parts per trillion. This is close to the median level of dioxins that we found in Jackson/Calhoun—4 parts per trillion.

Where can I find out more about the soil results?

The UMDES website, www.umdioxin.org, contains detailed tables of the soil results.

Levels of Dioxins in Household Dust

How many people's households were tested for dioxins in their household dust?
Overall, 764 households were tested for dioxins in their household dust—207 households in the Floodplain, 159 households in the Near Floodplain, 37 households in the Midland Plume, 163 households in Other Midland/Saginaw, and 198 households in Jackson/Calhoun.

Did you take dust from all parts of the household or just in certain places?
Household dust samples were taken from easily accessible floors in frequently used living or family areas and nearby hallways in each participant's home.

How do levels of dioxins (TEQ) in household dust in Midland/Saginaw compare to household dust in Jackson/Calhoun?
The Midland Plume had the highest median level—31 parts of dioxins per trillion parts of household dust, compared to 14 parts per trillion for Jackson/Calhoun. Levels of dioxins in household dust in the Floodplain (16 parts per trillion) and Other Midland/Saginaw (18 parts per trillion) are similar to those in Jackson/Calhoun. The median dioxin level in dust samples from the Near Floodplain (11 parts per trillion) is slightly lower than Jackson/Calhoun.

Are there any regulatory levels and exposure criteria for levels of dioxins in household dust?
There are no government regulations pertaining to dioxin contamination in household dust. Therefore, for purposes of comparison we describe our results using the same benchmarks that we use for soil, even though those benchmarks are not linked to government regulations.

How frequently were homes found to exceed 72 parts per trillion TEQ?
• Eleven percent (n=23) of homes in the Floodplain, 1 percent (n=3) of homes in the Near Floodplain, 9 percent (n=4) of homes

Figure 5. Percentage of properties with household dust TEQ above selected levels.

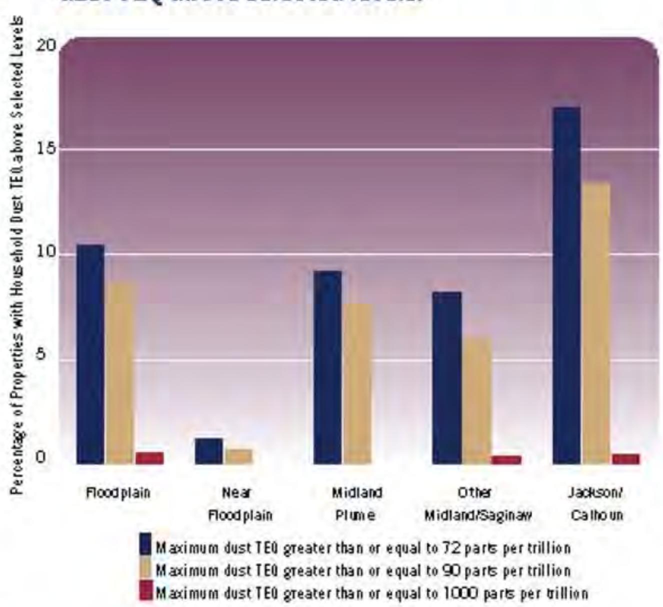
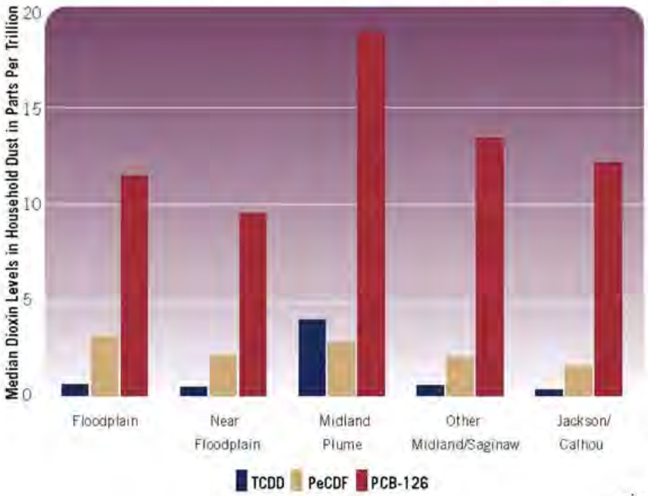


Figure 6. Median concentrations of TCDD, PeCDF, and PCB-126 in household dust in the Midland/Saginaw area and Jackson/Calhoun.



in the Midland Plume, and 8 percent (n=14) of homes in Other Midland/Saginaw have levels higher than 72 parts per trillion.

• Seventeen percent (n=25) of the homes in Jackson/Calhoun have levels above 72 parts per trillion.

How frequently were homes found to exceed 90 parts per trillion TEQ?

• Nine percent (n=19) of homes in the Floodplain, 1 percent (n=2) of homes in the Near Floodplain, 8 percent (n=3) of homes in the Midland Plume, and 6 percent (n=10) of homes in Other Midland/Saginaw have levels higher than 90 parts per trillion.

• Thirteen percent (n=20) of the homes in Jackson/Calhoun have levels above 90 parts per trillion.

How frequently were homes found to exceed 1000 parts per trillion TEQ?

• One percent (n=1) of homes in the Floodplain, less than one half of 1 percent (n=1) of homes in the Other Midland/Saginaw, and no homes in the Near Floodplain and the Midland Plume have levels higher than 1,000 parts per trillion.

• Less than one half of 1 percent (n=1) of the homes in Jackson/Calhoun have levels above 1,000 parts per trillion.

The findings concerning these three levels are summarized by region in Figure 5. This figure shows the percentage of homes that exceeded these levels.

How do household dust results for TCDD, PeCDF, and PCB-126 in Midland/Saginaw compare to results in Jackson/Calhoun?

Median levels of TCDD in household dust in the Midland Plume are higher (4.1 parts per trillion) than in the other areas of Midland/Saginaw and Jackson/Calhoun (0.3–0.6 parts per trillion—see Figure 6). (The median is the concentration where half of the household dust samples are above and half are below.) Median levels of PeCDF in household dust are slightly higher in the Floodplain (3.2 parts per trillion) than in the other areas of Midland/Saginaw (2.1–2.9 parts per trillion) and Jackson/Calhoun (1.6 parts per trillion). Median levels of PCB-126 in household dust are higher in the Midland Plume (19.4 parts per trillion) than in the other areas of Midland/Saginaw (9.8–13.8 parts per trillion) and Jackson/Calhoun (12.5 parts per trillion).

What were the highest and lowest levels of dioxins (TEQ) in household dust?

Low levels of dioxins were measured in household dust in all of the study areas. The lowest level measured was 1.4 parts per trillion. The highest level measured was about 1,750 parts per trillion. This sample was taken from a property in the Floodplain.

Did you find evidence of the contamination from Dow Chemical?

In order to understand the evidence about whether the contamination came from a source such as Dow, we need to examine the patterns of the dioxins in the different dust samples. As in the previous section, when we say "patterns" of dioxins, we mean certain combinations of the 29 chemicals that suggest the source of the contamination. These patterns are sometimes called "fingerprints." Much less is known about patterns of dioxins in household dust compared to what is known about patterns of dioxins in soil.

Like soil, we found several patterns of dioxins in household dust. These patterns were seen in 96 percent of all household dust samples.

• The most common pattern was found in most household dust samples throughout Jackson/Calhoun and Midland/Saginaw. We do not know the source.

• The second-most common pattern in household dust was found mainly in the Floodplain and Near Floodplain. Like soil, this pattern is similar to the pattern found in Tittabawassee River sediment. We believe this pattern is the result of Dow's past discharges into the river.

• A third pattern was consistent with a combustion source. This pattern was found scattered throughout Midland/Saginaw and Jackson/Calhoun. We do not know the source of this pattern.

• A fourth pattern was found in the Midland Plume. There were elevated levels of TCDD in household dust in the Midland Plume. We believe this pattern is the result of Dow's past airborne emissions.

How do levels of dioxins in household dust from Jackson/Calhoun compare with levels across the nation?

There are no other national or statewide studies of dioxin levels in household dust. This study is the first study of its kind to look at dioxins in household dust for an area this large.

Is the level of dioxins in household dust related to levels of dioxins in soil?

Yes. Higher levels of dioxins in soil are associated with higher levels of dioxins in household dust. This was true for TEQ, TCDD, PeCDF, and PCB-126. However, not all properties with high levels of dioxins in soil had high levels of dioxins in household dust, and not all properties with high levels of dioxins in household dust had high levels of dioxins in soil.

What causes dioxins in household dust to be higher?

Median levels of dioxins in household dust are higher than median levels of dioxins in soil in the Floodplain, Near Floodplain, Other Midland/Saginaw, and Jackson/Calhoun. This suggests that there are sources of contamination for household dust other than soil. Previous scientific studies indicate that there are many commercial products that can release dioxins indoors, such as wood preservatives and old electrical appliances.

TCDD levels in household dust were higher in the Midland Plume than in Jackson/Calhoun, but the levels in the rest of Midland/Saginaw were not higher than in Jackson/Calhoun. TCDD in household dust was higher in the fall than in the summer. Burning trash in the yard and living with a Dow worker were both associated with higher levels of TCDD in household dust.

PeCDF levels in household dust were associated with older floors and were higher in the fall than in the summer. PCB-126 levels in household dust were higher in the Midland Plume than in Jackson/Calhoun, and were higher in homes with older floors.

Where can I find out more about the household dust results?

The UMDES website, www.umdioxin.org, contains detailed tables of the household dust results.

Information About People who Live in the Study Area

The people in the UMDES were chosen for participation because they are a representative sample of the populations of Midland/Saginaw and Jackson/Calhoun counties. We intentionally studied larger proportions of people who lived in the Floodplain, Near Floodplain, and Midland Plume because these are the areas where the soils are more likely to be contaminated with dioxins from Dow and where there is the greatest chance of exposure. Because the Floodplain, Near Floodplain, and Midland Plume areas have much smaller populations than the rest of Midland/Saginaw and all of Jackson/Calhoun counties, we ended up with different numbers of people in each of these areas.

In order to understand what the results for blood, soil, and household dust mean, it is valuable to know something about the population that was studied. This section describes various characteristics of the population such as age, how long they have lived in the area, and various activities that might bring them into contact with dioxins in the environment.

How many people answered the questionnaire?
Overall, 1,324 people answered questions in the questionnaire—326 in the Floodplain, 264 in the Near Floodplain, 71 people in the Midland Plume, 304 in Other Midland/Saginaw, and 359 people in Jackson/Calhoun. About 56 percent of the people were women and about 44 percent were men. Of these people, 946 also gave a blood sample and these people are the focus of the study because we measured their blood dioxin levels. All of the results we have discussed are based on these 946 people.

How old are the people in the study?
The median age for the entire study population is 51 years at the time of the survey in 2004–2005. Participants who live in Midland/Saginaw are slightly older on average than people who live in Jackson/Calhoun.

How long have people in Midland/Saginaw lived in that area? What about for Jackson/Calhoun?
On average, people living in Midland/Saginaw have lived in those counties for almost 40 years. People in the Floodplain have lived in Midland/Saginaw for 44 years, people in the Near Floodplain for 38 years, people in the Midland Plume for 35 years, and people in other areas of Midland/Saginaw for 40 years. People living in Jackson/Calhoun lived in those counties for an average of 38 years.

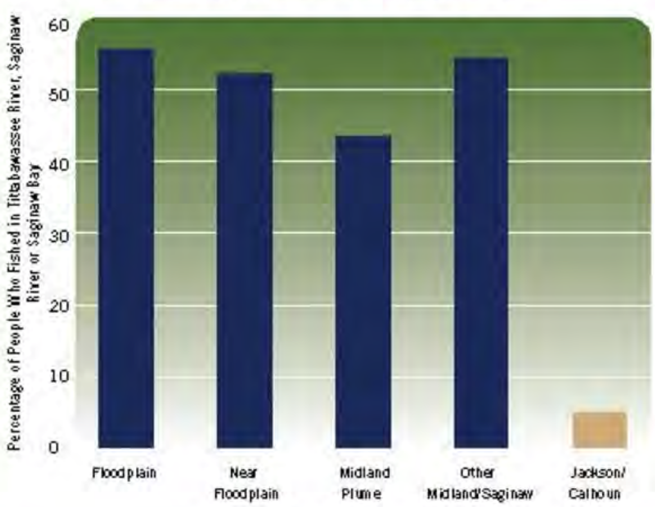
Do people in the study areas have gardens? What kind of gardens?
Between 22 and 37 percent of people across all study regions have a vegetable garden. Between 62 and 80 percent of people across all study regions have a flower garden.

Were people's properties or homes ever flooded by the Tittabawassee River?
Of people in the Floodplain, 81 percent report that their property had been flooded by the Tittabawassee River, and 38 percent reported that their home had been flooded. This is important because contaminated river sediments are potentially an important exposure pathway, and we intentionally

included as many properties as possible that were contaminated with sediments from the Tittabawassee River.

Do people who live in the study areas fish? Where do they fish?
About 83 percent of people in the study regions have fished in Michigan at some point during their lives. Not surprisingly, people who live in the Floodplain are more likely to have fished in the Tittabawassee River during their lifetime (33 percent of Floodplain residents) than are people who live elsewhere (24 percent of Near Floodplain residents, 8 percent of Midland Plume residents, and 22 percent of Other Midland/Saginaw residents). When we combined all the contaminated water bodies (Tittabawassee River, Saginaw River, and Saginaw Bay), between 44 and 57 percent of the Midland/Saginaw residents had fished in these areas, compared to 5 percent of Jackson/Calhoun residents (see Figure 7).

Figure 7. Percentage of people in each area who fished in the contaminated water bodies.



Do people in the study areas hunt? Where do they hunt?
Between 32 and 43 percent of people across all of the study areas have hunted in Michigan at some point during their lifetimes.

Do people in the study have much dioxin intake from eating fish from the Tittabawassee River, Saginaw River, or Saginaw Bay?
Roughly 63 percent of Floodplain residents ate fish from the Tittabawassee River, Saginaw River, or Saginaw Bay during their lifetime, and about 21 percent ate these fish during the last five years. Between 45 and 55 percent of people in the Near Floodplain, Midland Plume, and Other Midland/Saginaw have eaten fish from the Tittabawassee River, Saginaw River, or Saginaw Bay during their lifetimes, and between 20 and 30 percent ate these fish during the last five years.

In order to understand whether eating fish is an important contributor to blood dioxin levels, we calculated the amount of dioxin in each fish meal eaten by the study participants. We believe this is a better way to measure fish consumption than simply adding up the number of meals. Figure 8 shows the amount of dioxin intake (the summary TEQ) from fish from the contaminated areas.

Figure 8 shows that people got more dioxins from eating fish that came from outside of the contaminated area (from stores, restaurants, and sport caught elsewhere) than they got from eating fish from the contaminated area (Tittabawassee River, Saginaw River, and Saginaw Bay).

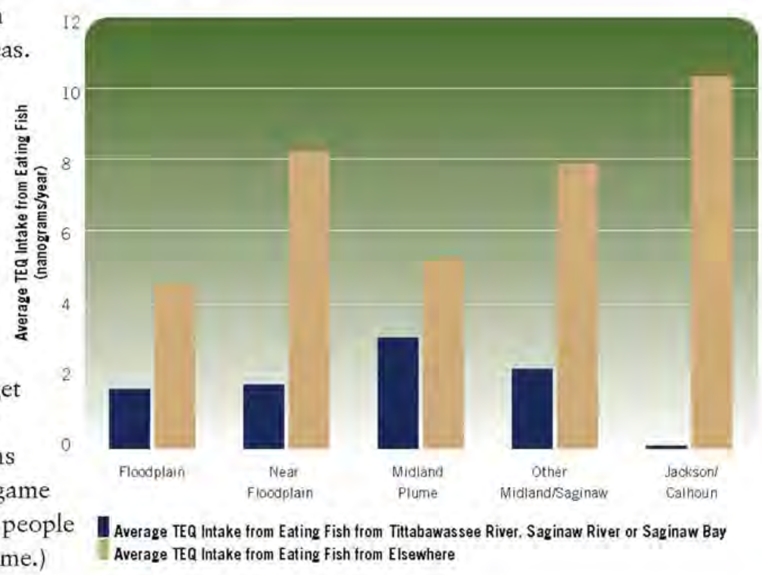
Do people in the study have much dioxin intake from eating wild game taken from the contaminated area?

Around 85 percent of people in all of the study areas have eaten game meat during their lifetime, and about 58 percent ate game during the last five years. In order to understand whether game meat is an important contributor to blood dioxin levels, we calculated the amount of dioxin in each game meal eaten by the study participants. We believe this is a better way to measure exposure to dioxins from game consumption than simply adding up the number of meals. Figure 9 shows that dioxin intake from game was much less than dioxin intake from fish from the contaminated areas. (Compare the scale on the vertical axis of the two figures: for game the maximum is about 0.15 nanograms/year, while for fish the maximum is about 10 nanograms/year. On average, people get between 10-fold and 100-fold more dioxins from fish than from game largely because most people eat more fish than game.)

The important issue is people's intake of dioxins from eating game rather than the type of game, the number of meals eaten, and where the game came from. We calculated the dioxin intake from game meat from the contaminated area (Tittabawassee River, Saginaw River, and Saginaw Bay floodplains) using information from the Michigan State University study of dioxins in wild game in the Midland/Saginaw region. We combined information from the Michigan State study with the amount of each type of game that our study participants reported eating. We believe this is a better way to assess exposure to dioxins from game meat than reporting what proportions of people ate different types of game from different areas.

Figure 9 shows that dioxin intake from game from the contaminated areas was greater than dioxin intake from game from elsewhere. However, the overall dioxin intake from game (see Figure 9, p. 40) was very small compared to the dioxin intake from fish (see Figure 8).

Figure 8. Eating fish from the Midland/Saginaw area contributes less to TEQ intake than eating fish from elsewhere.



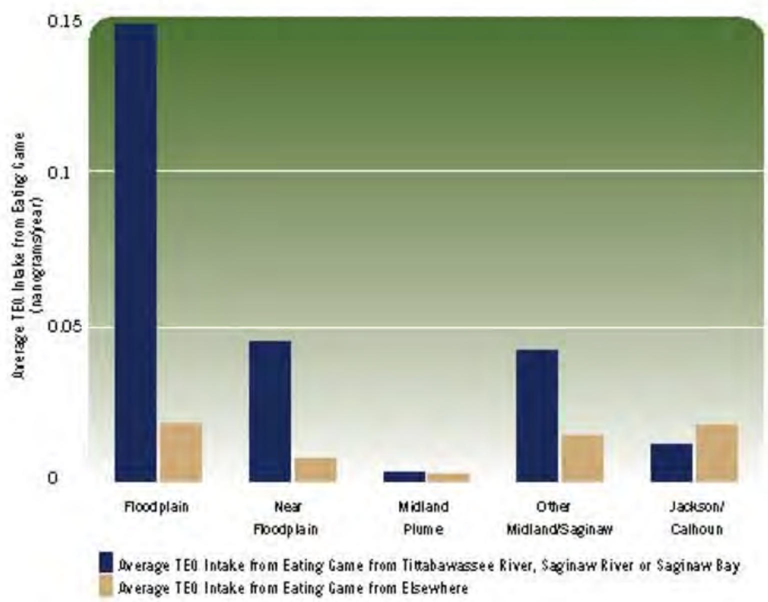
What percentage of the people in Midland/Saginaw participated in recreational activities around the Tittabawassee River, Saginaw River, or Saginaw Bay?
In the Floodplain, 44 percent of people swam, picnicked, hiked, boated, and participated in other recreational activities in and around the Tittabawassee River, compared to 31 percent in the Near Floodplain, 18 percent in the Midland Plume, and 22 percent in Other Midland/Saginaw.

Almost 43 percent of people in the Floodplain, 49 percent of people in the Near Floodplain, 15 percent of people in the Midland Plume, and 29 percent in Other Midland/Saginaw participated in these activities around the Saginaw River. Higher percentages have participated in these activities around Saginaw Bay—60 percent of people in the Floodplain and Near Floodplain, 45 percent of people in the Midland Plume, and 47 percent in Other Midland/Saginaw.

What percentage of the people in Midland/Saginaw worked at Dow?
Almost 10 percent of Floodplain residents, 8 percent of Near Floodplain residents, 10 percent from the Midland Plume, and 11 percent of people in Other Midland/Saginaw worked at Dow at some point in their lives.

How can I find out more about people who participated in the study?
The UMDES website, www.umdioxin.org, contains detailed tables on the questions asked of study participants.

Figure 9. Eating game from the Midland/Saginaw area contributes more to TEQ intake than eating game from elsewhere.



Frequently Asked Questions

Frequently Asked Questions

How can I tell if I have dioxins in my blood?
Everyone has some dioxins in their blood. The only way you can know the levels of dioxins in your blood is to have them measured.

How can I tell if I have dioxins in my household dust?
We found measurable levels of dioxins in all 764 of the household dust samples that were tested. The only way you can know the levels of dioxins in your household dust is to have them measured.

How can I tell if I have dioxins in my soil?
We found measurable levels of dioxins in all 766 properties that had soil samples tested. The only way you can know the levels of dioxins in your soil is to have them measured.

Where can I get my blood tested for dioxins?
Testing for dioxins should be done only by experienced, approved laboratories. Individual tests for dioxins cost between $1,200 and $1,500. See the Michigan Department of Community Health website for more information on testing for dioxins in blood: www.michigan.gov/documents/Blood_Testing_for_Dioxins_119419_7.pdf

Are there things that can happen when you are exposed to dioxins?
People who have been exposed to extremely high levels of dioxins (much higher than any that were observed in this study) sometimes develop chloracne, which looks like a severe form of acne. TCDD is classified as a human carcinogen, and other dioxins have been shown to cause cancer in animals and are suspected to cause cancer in people. There is also evidence that dioxins may cause diabetes and reproductive and developmental problems, and may have effects on the nervous and immune systems.

Why didn't you study health effects?
Chemicals cannot have health effects if they do not get into the body, so determining whether a chemical is in the human body is a critical first step in assessing health risks of chemicals in the environment.

How do dioxins move in the environment?
Dioxins attach to organic material such as humus (a degraded organic material) in soil and river sediments. Thus, they travel with sediment as it moves during flooding. Dioxins are very insoluble in water and are not detectable in the drinking water in Midland and Saginaw. This was verified by the Environmental Protection Agency (EPA). Dioxins can also be carried in air from burning and incineration.

Why didn't you test well water? Are we getting this from the air?
The EPA has tested the water supply in Midland and Saginaw and has not found any dioxins in the water. Dioxins are not water soluble and do not mix with water. Since the emissions from the Dow incinerators were reduced in the early 1980s, the levels of dioxins in air are believed to not be important. Our results suggest that airborne dioxins from Dow have been low since about 1980, and that air is not now a significant pathway of exposure to dioxins.

Why did you focus on these three dioxins?
This report focuses primarily on the three most important dioxins among the 29 that the World Health Organization (WHO) has identified as having so-called 'dioxin-like activity.' These three chemicals are known technically as:
• 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD);

• 2,3,4,7,8-pentachlorodibenzofuran (PeCDF); and

• 3,3',4,4',5-pentachlorobiphenyl (PCB-126). These are important contributors to the total amount of dioxins in people's blood in our study and in the United States. In 2006 we reported on TEQ (total dioxin-like activity) and seven specific dioxin compounds. In the current report we are not focusing on PCB-118 and PCB-156 because the WHO in 2006 lowered its estimate of the toxicity of these two chemicals, and they are much less important contributors to blood levels of dioxins. We are not focusing on 1,2,3,6,7,8-HxCDD and 1,2,3,7,8-PeCDD because they give very similar results to TCDD, which is a good representative for this family of dioxins.

How do I reduce my exposure to dioxins in the environment in Midland/Saginaw?
The best way to limit your exposure to dioxins is to follow the State of Michigan guidelines for eating fish and game. The Michigan Family Fish Consumption Guide will tell you about the fish you should avoid, to help reduce your exposure to dioxins. You can request a copy at www.michigan.gov/eatsafefish.

Why do some of the results in this booklet differ from the August 2006 results booklet?
Over the past four years we have completed new and more extensive analyses of the data and have added new data that were not previously available.

• We have incorporated data on the dioxin levels in fish and game from the Tittabawassee River and Saginaw River areas.

• We have also studied the air concentrations of dioxins coming from Dow's past incinerators.

• We have made minor corrections to the data set where we found errors.

• We have more thoroughly analyzed the associations between blood dioxin levels and past time periods.

• We have looked extensively to see if the results of our analyses are dependent on a single person (or two or three people). When the results changed dramatically depending on whether a single (or two or three) person was included or excluded in the analysis, we have identified the factors that changed as being "unstable." This is an important issue in evaluating the validity of statistical analyses. Because of these changes the results have changed slightly since 2006. However, the factors that have the most influence on blood dioxin levels have not changed. These include age, BMI, gender, breastfeeding, and smoking.

In the August 2006 booklet we discussed results for other dioxin compounds besides TCDD, PeCDF, and PCB-126. In this booklet, we present results for these three dioxins because they are important contributors to dioxins in people's blood. These three dioxins represent the three families of dioxins (PCDDs, PCDFs, and PCBs). Analyses for all of the other dioxin compounds have been completed and can be found on the UMDES website.

Where can I get more information?
If you have questions or would like more information, please visit the UMDES website at www.umdioxin.org.

General information about dioxins is available from the Michigan Department of Natural Resources and Environment and Michigan Department of Community Health websites: Michigan Department of Natural Resources and Environment at www.michigan.gov/deq/, and Michigan Department of Community Health at www.michigan.gov/mdch.

If you wish to talk with a health professional, contact your personal physician or health officials at your local county health department:

Bay County Health Dept.	989-895-4192
Calhoun County Health Dept.	269-966-1210
Jackson County Health Dept.	517-788-4420
Midland County Health Dept.	989-832-6380
Saginaw County Health Dept.	989-758-3800

Glossary

BMI: Body Mass Index is a measure of weight that adjusts for differences in height. People with a higher BMI tend to be overweight. People with a lower BMI tend to be underweight.

Combustion: Burning.

Congener: One specific chemical in a family of similar chemicals. One specific dioxin.

Demographic factors: Factors that relate to personal characteristics and habits, such as age, gender, height, weight, and smoking.

Dioxins: A group of polychlorinated compounds that are environmental pollutants that accumulate in the fat of humans and wildlife. Dioxins are unwanted by-products of combustion and some chemical processes.

Exposure Pathway: A chain of steps by which a chemical in the environment comes into contact with a human and is absorbed into the body.

Higher levels/Lower levels: Any mention in this booklet of "higher levels" or "lower levels" indicates a statistically significant difference with a probability of being wrong of less than 5 percent of the time, which is standard scientific practice. Mention of "not any higher" or "similar" indicates that the difference is not statistically significant.

Mean: The arithmetic average, which is the sum of the values on a list divided by the number of values on the list.

Median: The middle value of a list. The number for which half the numbers on a list are below and half of the numbers on the list are above. This is also known as the 50th percentile.

Midland/Saginaw: "Midland/Saginaw" refers to the combined geographic areas of the Floodplain, Near Floodplain, Midland Plume, and Other Midland/Saginaw.

Patterns of dioxins: The relative levels of the 29 dioxins in a given blood, household dust, or soil sample. This pattern is also called the congener profile. Sometimes a single pattern is found in many samples. These patterns can be informative about the source of the pollution.

"People who live in Midland/Saginaw (Jackson/Calhoun)": "People who live in Midland/Saginaw (Jackson/Calhoun)" refers to people who lived in their current residence during the 2000–2005 time period and who were 18 years of age or older.

Parts per trillion: Parts per trillion (ppt) is a unit of how much of one substance is mixed in another substance, or its concentration. One part per trillion is about the same as mixing one drop of ink into 20 Olympic-sized swimming pools. A part per trillion in soil means that there is one ounce of a substance in one trillion ounces (31,250,000 tons) of soil.

Random Sample: A procedure for choosing a sample of people out of a group so that everyone in the group has an equal chance of being chosen. The people who are selected are called a random sample, and they are expected to have on average the same characteristics as the whole group.

TEF: Dioxins vary in their effects on people. Some have more toxic effects than others. The Toxic Equivalency Factor, or TEF, is a measure of the relative toxicity of each of the specific dioxins compared to the most toxic dioxin, TCDD.

TEQ: The combined toxicity of all 29 dioxins is called the "TEQ" (for Toxic EQuivalency). The TEQ is a summary measure of the toxicity of the 29 dioxins in a sample, giving them different weights (the TEFs) depending on how toxic they are. The TEQ is a measure of total TCDD-like activity in a sample. The TEQ is the sum over all 29 dioxins of the TEF multiplied by the congener concentration in that sample.

Technical Notes

All blood, household dust, and soil samples collected were analyzed for the World Health Organization 29 dioxins (polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans and dioxin-like polychlorinated biphenyls), for which there are consensus toxic equivalency factors (TEFs—see above). Since dioxins in blood are dissolved in the lipids in blood (not in the water), and the amount of lipids in blood can vary, all blood dioxin results were adjusted for the amount of lipids in each individual's blood, as is customary in these types of studies.

The TEQs in this report reflect TEFs that were published by the World Health Organization in 2005. TEQs used in the 2006 report were based on TEFs published in 1998.

The present report focuses on the TEQ and three specific dioxins. These three dioxins, of the 29 dioxins measured, have the highest contribution to the TEQ in the study blood samples and in the U.S. population.

- 2,3,7,8-TCDD—2,3,7,8-tetrachlorodibenzo-*p*-dioxin. This is the most toxic chemical of all 29 types of dioxins; TEF=1.0.
- 2,3,4,7,8-PeCDF—2,3,4,7,8-pentachlorodibenzofuran; TEF=0.3.
- PCB-126—3,3',4,4',5-pentachlorobiphenyl; TEF=0.1.

Study Oversight

University of Michigan Investigators

David Garabrant, MD, MPH
Alfred Franzblau, MD
Brenda Gillespie, PhD
Peter Adriaens, PhD, PE
James Lepkowski, PhD
Avery Demond, PhD, PE

Scientific Advisory Board

- *Linda Birnbaum, PhD, DABT,* U.S. Environmental Protection Agency – through 2008, National Institute for Environmental Health Sciences – 2009 to present
- *Paolo Boffetta, MD, MPH,* Mount Sinai School of Medicine
- *Ronald Hites, PhD,* Indiana University
- *Marie Haring Sweeney, PhD,* National Institute for Occupational Safety and Health

The University of Michigan Dioxin Exposure Study is protected by a Certificate of Confidentiality issued by the National Institutes of Health.

The Certificate of Confidentiality ensures that study participants, the UMDES team, and the University of Michigan cannot be forced to reveal "sensitive," personally identifiable information. No court, agency or other body can compel release of information that could affect a subject's financial standing, employability, reputation or insurability, or have any other adverse effects.

Members of the study team and the scientific advisory board cannot be forced to reveal any information about the levels of dioxins in your body or on your property...nor your answers to any of the survey questions.

The Certificate of Confidentiality issued to the UMDES can be viewed at the study website: www.umdioxin.org.

The University of Michigan

School of Public Health

College of Engineering

Center for Statistical

Consultation & Research

Institute for Social Research

Phone: 989-372-0796

Email: um-dioxin@umich.edu

UMDES Website: www.umdioxin.org

Appendix E

Community Perceptions of Dioxins (CPOD) Study

Phase 1 Expert Interview Guide

This appendix presents a mental models interview guide created by the Community Perceptions of Dioxins (CPOD) study to examine expert beliefs about dioxins in Phase 1.

Interview Guide for
Dioxin Risk Interviews
DRAFT 2009-10-10

STARTING QUESTION:
What I'd like to ask you to do is just to talk to me about dioxins: that is, tell me what you know about dioxins and any risks that they pose.

Basic prompts:

- "Anything else?"
- "Can you tell me more?", *or*
- "Anything else – don't worry about whether it's right, just tell me what comes to mind."
- "Can you explain why?"

Draw a blank (try in order):

1. Have you ever heard the word "dioxin"? Can you remember anything at all about dioxin?
2. Let me see if I can jog your memory a bit. "Dioxins" or "dioxin-like compounds" are names used for a group of chemicals that can sometimes get released into the air, ground or water by factories. Does that help?
3. O.K., let me try a bit more. Once dioxins have gotten into the air, ground or water in a community, they can cause risks to the health of people who get it into their bodies. Have you ever heard of such a thing?

Instructions: For each main topic, check on the left of the line when the topic has been raised. Check on the right when all follow-up questions have been completed.

EXPOSURE PROCESSES

___|___**Source of Dioxin**

___Can you tell me (more) about the group of chemicals called dioxins or dioxin-like compounds?

___Can you tell me (more) about where dioxins come from?

___Can you tell me (more) about how dioxins get into people?

___|___**Concentration of Dioxin**

___Can you tell me (more) about the things that determine how much dioxins there are in the air, ground or water?

___Can you tell me (more) about the things that determine how much dioxins there are in someone's body?

___|___**Uncertainty About Exposure**

___Are dioxins found in every community?

Possible probe: Why is this community different from other ones?

___Are dioxins found in all people in this community?

___Can you tell me what causes some people to have more dioxins in their body than others?

*___|___**Role of Diet (Use only if brought up)**

___Can you tell me (more) about how a person's diet affects how much dioxins there are in someone's body?

EFFECTS PROCESSES

___|___**Nature of Effects**

___Can you tell me (more) about the harm that can result from dioxin exposure?
___Can you tell me (more) about how much dioxin it takes to cause harm?
___Can you tell me (more) about the effects of dioxin exposure on the environment?
___Can you tell me (more) about the effects of dioxin exposure on the body?
Probe: How else can dioxin affect you?
___Does dioxin affect some people more than others?
Probe: What things make some people more affected by dioxin than others?
___You told me that _____ (e.g., dioxin causes cancer). Can you tell me more about that?
Notes:____
____

___|___**Uncertainty of Effects**

___Do you have any sense of how certain or uncertain scientists are about the health risk of dioxin?
___What do you think scientists are certain about?
___What do you think scientists are uncertain about?

*___|___**Role of Smoking (Use only if brought up)**

___Can you tell me about how smoking affects the amount of dioxin in the body?

RISK ASSESSMENT AND MANAGEMENT

___|___**Learning About Dioxin, Sources of Information**

___Where have you heard or read about dioxin risks?
___What sources can people use to learn more about dioxin?
___Where else do people get information about dioxin?

___|___**Testing for Dioxin**

___Is there any way people can learn what the level of dioxin is at their homes (i.e., in dust or soil)?
___What can happen if someone gets his or her home tested for dioxin?
___Is there any way someone can learn what the level of dioxin is in his or her body?

___|___**Reducing Dioxin Risk**

___If somebody finds they have a lot of dioxin at their home, is there anything they can do about it?

RISK COMPARISONS (Ask at end whether brought up or not)

___Is dioxin really a significant risk in this community, or is it one of those risks that's not at all important?

___Can you please give me some idea of how the risk of dioxin compares with other risks, such as the risk of smoking?

___**Complete the interview data sheet**

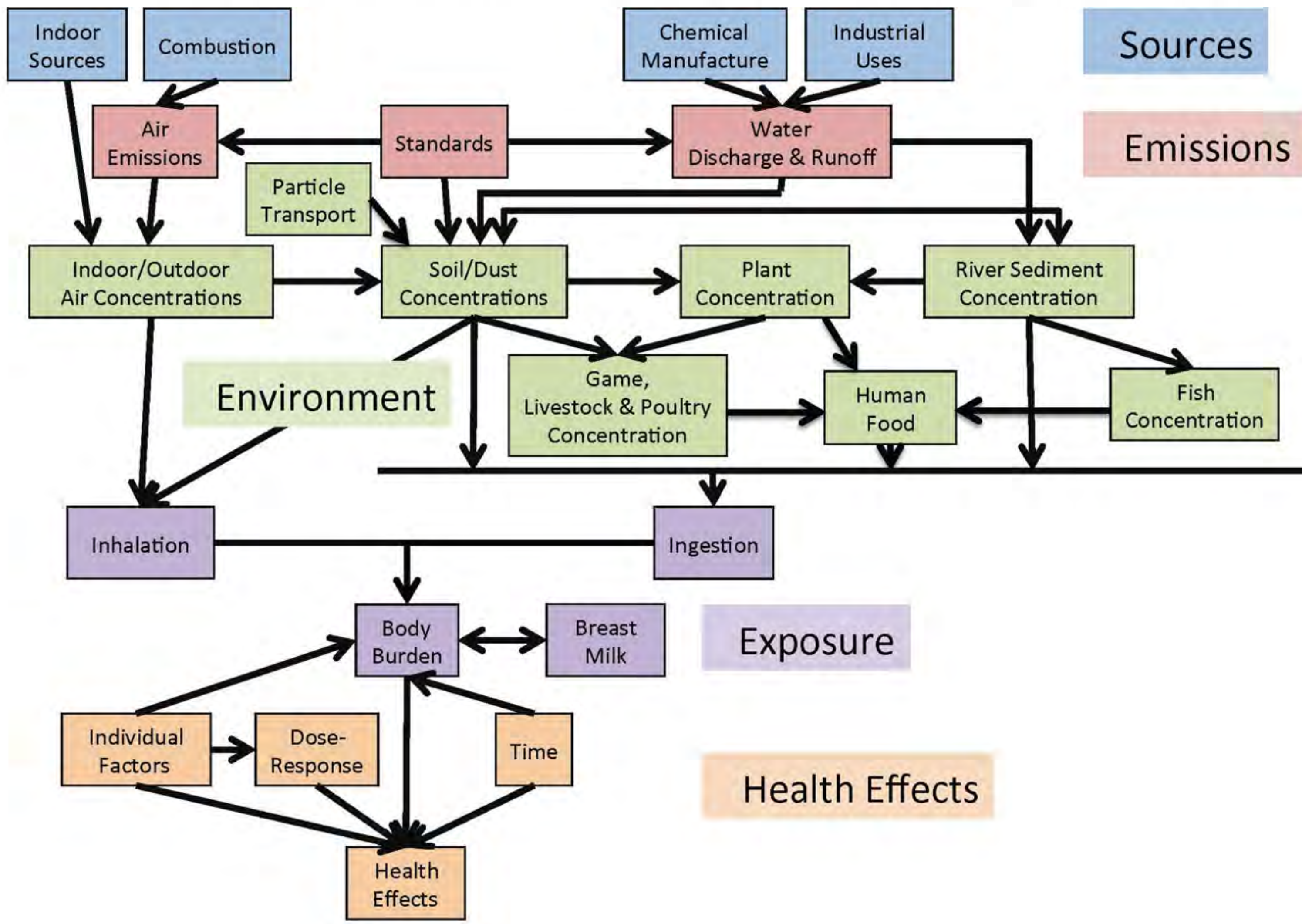
___**Complete the written survey**

Appendix F

CPOD Phase 1 Expert Model of Dioxins

This appendix presents the expert model of dioxins created by the Community Perceptions of Dioxins (CPOD) study based on interviews conducted in Phase 1.

Expert model of dioxin contamination



Appendix G

CPOD Phase 2 Lay Interview Guide

This appendix presents a mental models interview guide created by the Community Perceptions of Dioxins (CPOD) study to examine lay beliefs about dioxins in Phase 2.

Interview Guide

RECORD ON TAPE:
Today is [date] and this is the interview with participant [number, i.e., 2-U].

STARTING QUESTION:
I'm going to start by asking a very broad question just to get you talking. Don't worry about trying to think of everything. Also, don't worry about whether what you have to say is "right" or not. Just start talking and I'll help guide you from there.

What I'd like to ask you to do is just to talk to me about dioxins: that is, tell me what you know about dioxins and any risks that they pose.

Basic prompts:
- Anything else?
- Can you tell me more?
- Anything else – don't worry about whether it's right, just tell me what comes to mind.
- Can you be more specific?
- Can you explain why?

Draw a blank (try in order):
1. Have you ever heard the word "dioxin"? Can you remember anything at all about dioxins?
2. Let me see if I can jog your memory a bit. "Dioxins" or "dioxin-like compounds" are names used for a group of chemicals that can sometimes get released into the air, ground or water by factories. Does that help?
3. O.K., let me try a bit more. Once dioxins have gotten into the air, ground or water in a community, they can cause risks to the health of people who get it into their bodies. Have you ever heard of such a thing?

Instructions: For each main topic, check on the left of the line when the topic has been raised. Check on the right when all follow-up questions have been completed.

After the interview:

___Complete the interview data sheet
___Complete the written survey

DIOXINS

______|____**Description of Dioxins**

___Can you tell me (more) about the group of chemicals called dioxins or dioxin-like compounds?

______|____**Nature of Effects**

___Can you tell me (more) about what kinds of harm can result from exposure to dioxins?

Probe: Can you tell me (more) about how dioxin exposure affects the body?

Probe: How else can dioxins affect you?

___Can you tell me (more) about how much dioxins it takes to cause harm?

___Can you tell me (more) about the effects of dioxins on the environment?

___Do dioxins affect some people more than others?

Probe: What things make some people more affected by dioxins than others?

___You told me that _____ (e.g., dioxins cause cancer). Can you tell me more about that?

Notes:____

______|____**Sources of Dioxins**

___Can you tell me (more) about where dioxins come from?

EXPOSURE PROCESSES

______|____**Pathways of Exposure and Concentrations of Dioxins**

___Can you tell me (more) about how dioxins get out into the community and where they go? **Locations:** ____

___What determines whether there are more or less dioxins in the (air / ground / water)?

___What happens to dioxins once they get into the (air / ground / water)?

Use only after animals/plants have been brought up: What determines whether there are more or less dioxins in (plants / fish / game / livestock)?

___Can you tell me (more) about how dioxins get into people?

___Can you tell me (more) about why some people might have more dioxins in their bodies than others?

Possible probe: What things might people do that would make them have more dioxins in their bodies than others?

*____|____**Role of Diet/What You Eat (Use only if brought up)**

___Can you tell me (more) about how what a person eats affects how much dioxins there are in their body?

*____|____**Role of Smoking (Use only if brought up)**

___Can you tell me about how smoking affects the amount of dioxins in the body?

CERTAINTY/UNCERTAINTY

______|____**Uncertainty About Exposure**

___Are dioxins found in every community?

Possible probe: Why is this community different from other ones?

___Are dioxins found in all people in this community?

______|____**Uncertainty of Effects**

___Do you have any sense of how certain or uncertain scientists are about dioxins and the health risks from dioxins?

___What do you think scientists are certain about?

___What do you think scientists are uncertain about?

RISK ASSESSMENT AND MANAGEMENT

___|___**Learning About Dioxins, Sources of Information**

___Where have you heard or read about risks from dioxins?

___What sources can people use to learn more about dioxins?

Probe: Which do you think are most trustworthy?

___Where else do people get information about dioxins?

___Have you heard about any government or private activities to measure, study, or clean up dioxins?

___|___**Testing for Dioxins and Reducing Dioxin Risk**

___Is there any way someone can learn what the level of dioxins is in his or her body?

___If somebody finds they have a lot of dioxins in their body, is there anything they can do about it?

___Is there any way people can learn what the levels of dioxins are at their homes (for example, in the dust or soil)?

Probe: If someone did get their home tested, how would they use that information?

Probe: Are there any other things that can happen if someone gets his or her home tested for dioxins?

___If somebody finds they have a lot of dioxins at their home (for example, in the dust or soil), is there anything they can do about it?

___|___**Managing Dioxin Risk**

___Can you tell me (more) about who is responsible for managing the dioxins or dioxin-like compounds that already exist?

RISK COMPARISONS (Ask at end whether brought up or not)

___Are dioxins a significant risk in this community, or is it a risk that's not important?

___Can you give me some idea of how the risk from dioxins compares with other risks, such as the risk from smoking?

PERSONAL RISK (Ask at end whether brought up or not)

___Do you have any beliefs about whether your own risk from dioxins is low or high? Can you tell me more about that?

___How easy or hard is it for you to make that judgment?

___You said ______ (e.g., you're at high risk/low risk). Do you have a clear feeling about how dioxins might affect your own health or your family's health in the future? What about the health of others in your community?

___Do you or your family have any current health issues that you believe are related to dioxins? If so, could you tell me more about that? What about others in your community?

___Have you changed anything you do because of dioxins?

___Have you had your house or yard tested for dioxins?

Probe if no: Have you ever thought about doing it?

Probe if not clear if they received the results: Did you choose to receive the results of such testing?

___Have any of your friends or neighbors had their house tested for dioxins or had problems with dioxins?

Is there anything else you'd like to tell us about dioxins?

Appendix H

CPOD Phase 2 Post-Interview Questionnaire and Results Summary

This appendix presents the post-interview questionnaire created by the Community Perceptions of Dioxins (CPOD) study. Phase 2 participants (n=50) completed this questionnaire following their interviews. A summary of their aggregated responses is shown for each question.

Community Perceptions of Dioxins
Post-Interview Questionnaire

Thank you for your participation today. Before we finish, we have one last request. Please complete this short survey to give us some more of your thoughts, and to help us make sure we are interviewing a broad sample of the community. Your answers to this survey will also remain confidential.

First, we would like to know about the type of information you have received about dioxins. Please check the box that best reflects your answer:

1. Have you ever had chemical analyses done of dioxins in soil and/or vegetation on your property?

28 ☐	13 ☐	9 ☐
Yes, and I received my results	Yes, but I did not receive my results	No

2. Have you ever had chemical analyses done of dioxins in dust collected from your home?

28 ☐	10 ☐	11 ☐
Yes, and I received my results	Yes, but I did not receive my results	No

3. Have you ever had chemical analyses done of dioxins in your blood?

30 ☐	8 ☐	12 ☐
Yes, and I received my results	Yes, but I did not receive my results	No

4. A few years ago, you participated in a research study called the University of Michigan Dioxin Exposure Study (UMDES). After the study, UMDES sent a brochure of overall study findings to your household. Do you remember receiving that brochure?

37 ☐	5 ☐	*Omitted for non-UMDES participants (n=8)
Yes	No	

5. How much do you follow the news about dioxins in your community?

10 ☐	5 ☐	14 ☐	13 ☐	8 ☐
None				A lot

Next, we would like to know about how you think your situation compares to others. Please check the box that best reflects your answer:

6. Compared to other samples from the lower peninsula of Michigan, I believe the level of dioxins in my soil is:

Well below average		About average		Well above average
8 ☐	5 ☐	10 ☐	20 ☐	11 ☐

7. Compared to other samples from within my community, I believe the level of dioxins in my soil is:

Well below average		About average		Well above average
10 ☐	5 ☐	26 ☐	5 ☐	4 ☐

8. Compared to other samples from the lower peninsula of Michigan, I believe the level of dioxins in my house dust is:

Well below average		About average		Well above average	
7 ☐	7 ☐	26 ☐	6 ☐	3 ☐	Missing: 1

9. Compared to other samples from within my community, I believe the level of dioxins in my house dust is:

Well below average		About average		Well above average	
8 ☐	5 ☐	30 ☐	3 ☐	3 ☐	Missing: 1

10. Compared to other adults in the U.S. of similar age to me, I believe the level of dioxins in my blood is:

Well below average		About average		Well above average	
9 ☐	6 ☐	21 ☐	6 ☐	7 ☐	Missing: 1

11. Compared to other adults in my community of similar age to me, I believe the level of dioxins in my blood is:

Well below average		About average		Well above average	
10 ☐	5 ☐	24 ☐	5 ☐	5 ☐	Missing: 1

Next, we would like to ask a few questions about your level of concern about dioxins. Please check the box that best reflects your answer:

12. How concerned are you about your own exposure and your family's exposure to dioxins?

Not at all				Extremely
11 ☐	10 ☐	15 ☐	8 ☐	6 ☐

13. How concerned are you about your community's exposure to dioxin?

Not at all				Extremely
8 ☐	11 ☐	15 ☐	6 ☐	10 ☐

14. How concerned are you about the economic risks posed by dioxins to your community?

Not at all				Extremely
7 ☐	5 ☐	13 ☐	12 ☐	13 ☐

15. How concerned are you about the economic risks posed by dioxins to you and your family?

Not at all				Extremely
10 ☐	6 ☐	13 ☐	8 ☐	13 ☐

16. How concerned are you about the risk to your personal health, and to your family's health from dioxins?

Not at all				Extremely
13 ☐	6 ☐	12 ☐	8 ☐	11 ☐

17. How concerned are you about the risk to your community's health from dioxins?

Not at all				Extremely
7 ☐	7 ☐	18 ☐	7 ☐	11 ☐

Next, we would like to know how you feel about the information you've received about dioxins. Please check the box that best reflects your answer:

18. I have a clear feeling about the risks that dioxins pose to my community's health.

Disagree				Agree
13 ☐	6 ☐	12 ☐	5 ☐	14 ☐

19. I have a clear feeling about the risks that dioxins pose to <u>my personal health and my family's health</u>.

11 ☐ 12 ☐ 6 ☐ 6 ☐ 15 ☐

Disagree Agree

20. I am <u>satisfied</u> with the information I have received about dioxins.

12 ☐ 9 ☐ 11 ☐ 5 ☐ 13 ☐

Disagree Agree

21. I feel well informed about dioxins <u>in general.</u>

14 ☐ 11 ☐ 9 ☐ 7 ☐ 9 ☐

Disagree Agree

22. I feel well informed about the risks that dioxins pose to <u>my health and to my family's health.</u>

16 ☐ 10 ☐ 7 ☐ 5 ☐ 12 ☐

Disagree Agree

23. I feel well informed about the risks that dioxins pose to <u>my community's health.</u>

16 ☐ 11 ☐ 7 ☐ 6 ☐ 10 ☐

Disagree Agree

24. I feel well informed about the <u>economic risks</u> that dioxins pose to <u>my community.</u>

16 ☐ 10 ☐ 4 ☐ 7 ☐ 13 ☐

Disagree Agree

25. I feel well informed about the <u>economic risks</u> that dioxins pose to <u>me and my family.</u>

16 ☐ 8 ☐ 3 ☐ 10 ☐ 13 ☐

Disagree Agree

26. I have gotten <u>enough</u> information about dioxins.

20 ☐ 13 ☐ 8 ☐ 3 ☐ 6 ☐

Disagree Agree

27. I have <u>understood</u> the information I've gotten about dioxins.

11 ☐ 8 ☐ 11 ☐ 11 ☐ 9 ☐

Disagree Agree

28. The information I've gotten about dioxins has been <u>confusing</u> to me.

11 ☐	9 ☐	13 ☐	7 ☐	10 ☐
Disagree				Agree

29. I believe the information I've gotten about dioxins has <u>been accurate.</u>

3 ☐	2 ☐	16 ☐	12 ☐	17 ☐
Disagree				Agree

30. I believe the information I've gotten about dioxins has <u>reasonably represented what is known about dioxins.</u>

7 ☐	0 ☐	11 ☐	15 ☐	17 ☐
Disagree				Agree

31. I believe the information I've gotten about dioxins has <u>been biased.</u>

13 ☐	10 ☐	16 ☐	4 ☐	7 ☐
Disagree				Agree

Next, we have a few questions related to how you feel about industry. For each of the following questions, please check the box that best reflects your answer:

32. I am concerned about <u>health and safety risks</u> from industry in my community.

7 ☐	2 ☐	7 ☐	17 ☐	17 ☐
Disagree				Agree

33. Local industry provides <u>benefits</u> that are important to my community.

3 ☐	2 ☐	1 ☐	12 ☐	32 ☐
Disagree				Agree

34. The current <u>balance of benefits and risks</u> from industry in my community is…

15 ☐ Benefits outweigh risks

27 ☐ Benefits and risks are roughly equal

8 ☐ Risks outweigh benefits

Next, we have a few questions related to how you feel about government. For each of the following questions, please check the box that best reflects your answer:

35. How much of the time do you trust the federal, state and/or local government to do what is right?

5 ☐	20 ☐	15 ☐	10 ☐	0 ☐
Never				Always

36. Some people think criticism of the way the federal, state and/or local government does its job is justified, while others think the government often does a better job than it is given credit for. Which comes closer to your views?

8 ☐	6 ☐	23 ☐	8 ☐	5 ☐
Criticism is justified				Government does a better job than its given credit for

37. In general, do you agree or disagree with the following statement: Government has gone too far in regulating business and interfering with the free enterprise system?

12 ☐	6 ☐	14 ☐	6 ☐	12 ☐
Disagree				Agree

38. How much of a problem, if at all, is government corruption today?

0 ☐	5 ☐	13 ☐	12 ☐	20 ☐
Not at all a problem				Very much a problem

Finally, we would like to ask some questions related to how you feel about numbers. Please check the box that best reflects your answer:

39. How good are you at working with fractions?

5 ☐	3 ☐	9 ☐	17 ☐	16 ☐
Not at all good				Extremely good

40. How good are you at working with percentages?

2 ☐	6 ☐	7 ☐	20 ☐	25 ☐
Not at all good				Extremely good

41. How good are you at calculating a 15% tip?

0 ☐	1 ☐	5 ☐	15 ☐	29 ☐
Not at all good				Extremely good

42. How good are you at figuring out how much a shirt will cost if it is 25% off?

0 ☐	0 ☐	3 ☐	11 ☐	36 ☐
Not at all good				Extremely good

43. When reading the newspaper, how helpful do you find tables and graphs that are parts of a story?

5 ☐	0 ☐	10 ☐	12 ☐	23 ☐
Not at all helpful				Extremely helpful

44. When people tell you the chance of something happening, do you prefer that they use words ("it rarely happens") or numbers ("there's a 1% chance")?

12 ☐	1 ☐	7 ☐	8 ☐	22 ☐
Always prefer words				Always prefer numbers

45. When you hear a weather forecast, do you prefer predictions using percentages (e.g., "there will be a 20% chance of rain today") or predictions using only words (e.g., "there is a small chance of rain today")?

10 ☐	3 ☐	7 ☐	6 ☐	24 ☐
Always prefer* percentages	* Corrected to "Always prefer words" for n=6 participants			Always prefer numbers

46. How often do you find numerical information to be useful?

0 ☐	0 ☐	8 ☐	10 ☐	32 ☐
Never				Very often

Demographic Information

47. **Age:** Range 37-90, Mean 62.3

48. **Gender**
30 ☐ Male
20 ☐ Female

49. **Ethnicity**
50 ☐ Hispanic or Latino
0 ☐ Not Hispanic or Latino

50. **Race (Check all that apply)**
0 ☐ American Indian or Alaska Native
1 ☐ Asian
0 ☐ Native Hawaiian or Other Pacific Islander
0 ☐ Black or African American
49 ☐ White

51. **Highest level of school**
1 ☐ Some high school
12 ☐ High school diploma or GED
16 ☐ Some college, associates degree, professional training
9 ☐ Bachelor's degree (BA, BS)
10 ☐ Master's degree (MA, MBA)
1 ☐ Professional school degree (MD, JD, DDS)
1 ☐ Doctoral degree (PhD, EdD)

52. **How long have you lived in your current house?**
1 ☐ Less than 1 year
1 ☐ 1-5 years
13 ☐ 6-15 years
35 ☐ 16+ years

53. **Do you have any children?**
43 ☐ Yes
7 ☐ No

If so, what are their ages? (Check all that apply)
0 ☐ 0-2 years
1 ☐ 3-5 years
2 ☐ 6-10 years
5 ☐ 11-15 years
5 ☐ 16-18 years
37 ☐ Over 18 years

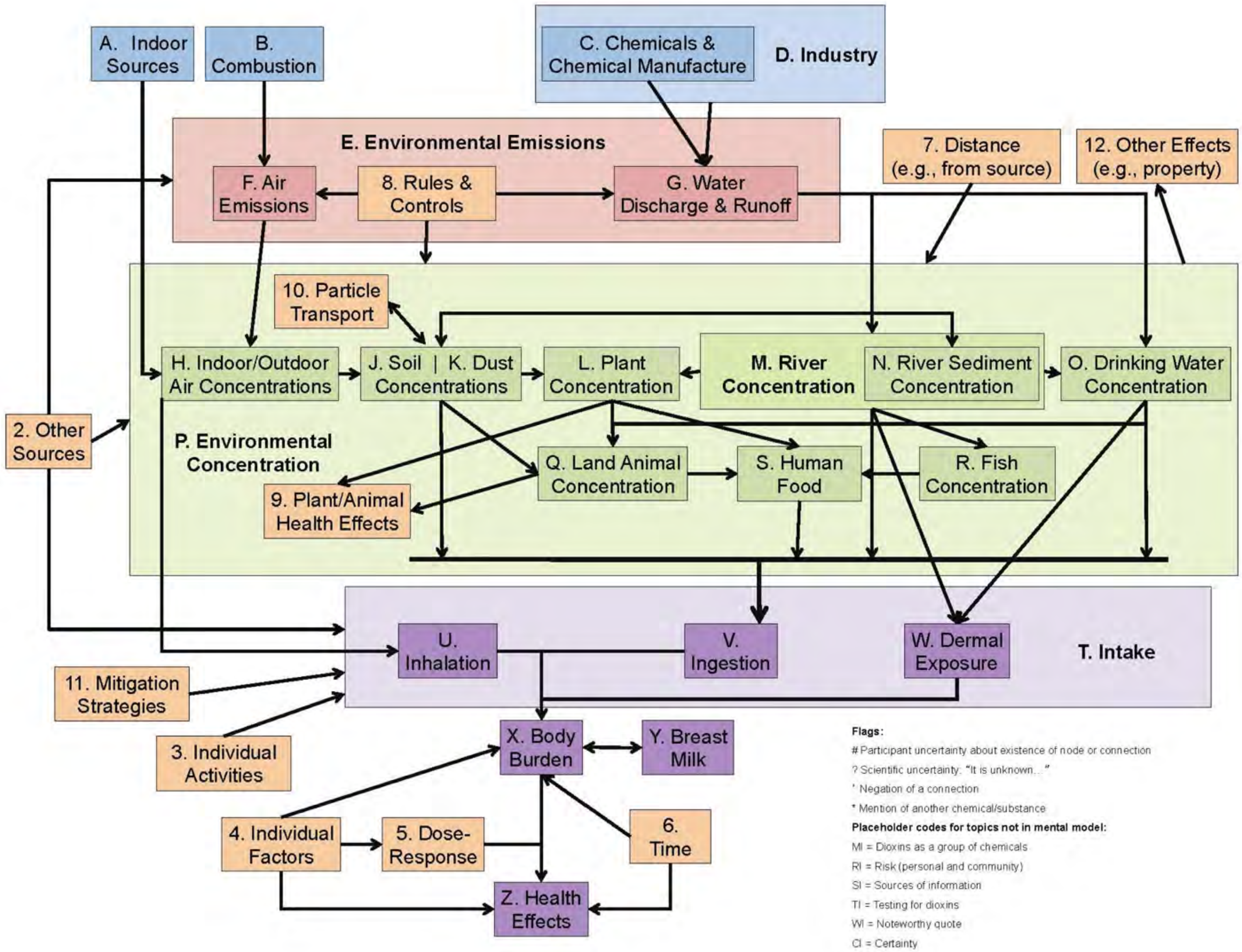
54. **Have you ever worked at a chemical company?**
9 ☐ Yes
41 ☐ No

If so, what type of work did you do there? (Check all that apply)
3 ☐ Maintenance/repair/contractor
2 ☐ Management
0 ☐ Office or administrative support (e.g. customer service, clerical)
6 ☐ Production (e.g. assembly, inspection, packaging, processing, quality)
2 ☐ Professional (e.g. scientist, engineer, computer specialist)
1 ☐ Sales
0 ☐ Transportation (e.g. shipping, driving)

Appendix I

CPOD Phase 2 Lay Interview Coding Model

This appendix presents the model of dioxins created by the Community Perceptions of Dioxins (CPOD) study to code lay interviews conducted in Phase 2.


A. Indoor Sources
B. Combustion
C. Chemicals & Chemical Manufacture
D. Industry
E. Environmental Emissions
F. Air Emissions
8. Rules & Controls
G. Water Discharge & Runoff
7. Distance (e.g., from source)
12. Other Effects (e.g., property)
10. Particle Transport
H. Indoor/Outdoor Air Concentrations
J. Soil | K. Dust Concentrations
L. Plant Concentration
M. River Concentration
N. River Sediment Concentration
O. Drinking Water Concentration
2. Other Sources
P. Environmental Concentration
Q. Land Animal Concentration
S. Human Food
R. Fish Concentration
9. Plant/Animal Health Effects
U. Inhalation
V. Ingestion
W. Dermal Exposure
T. Intake
11. Mitigation Strategies
3. Individual Activities
X. Body Burden
Y. Breast Milk
4. Individual Factors
5. Dose-Response
6. Time
Z. Health Effects
Flags:
Participant uncertainty about existence of node or connection
? Scientific uncertainty: "It is unknown…"
' Negation of a connection
* Mention of another chemical/substance
Placeholder codes for topics not in mental model:
MI = Dioxins as a group of chemicals
RI = Risk (personal and community)
SI = Sources of information
TI = Testing for dioxins
WI = Noteworthy quote
CI = Certainty

Appendix J

CPOD Phase 3 Midland/Saginaw Survey and Results Summary

This appendix presents the mailed survey created by the Community Perceptions of Dioxins (CPOD) study and mailed to Midland/Saginaw participants. A total of 893 CPOD participants completed this version of the survey, including 453 Midland/Saginaw UMDES participants and 440 Midland/Saginaw non-UMDES participants.

An additional 143 CPOD participants completed the Jackson/Calhoun version of the survey (see Appendix K), including 132 Jackson/Calhoun UMDES participants and 11 Midland/Saginaw non-UMDES participants who were mailed the Jackson/Calhoun version in error.

The aggregated responses shown include both Midland/Saginaw and Jackson/Calhoun participants where the questions did not differ between the two versions.

Community Perceptions of Dioxins: Community Survey

Thank you for taking the time to complete this survey. Please read each question carefully. We understand that you may not be sure of the answer for some questions. We ask that you give your best guess and not look at other sources of information to help you.

When you are done, please return the completed survey in the stamped envelope provided. Once we receive your completed survey in the mail we will send you a $10 Visa gift card to thank you for your time.

First, we would like to ask a few questions about how you feel about the information you've received or gathered about dioxins. Please check the box that best reflects your answer:

Missing

21 1. How familiar are you with dioxins?

- 55 ☐ I have never heard of dioxins. ➔ **Skip to Question 14 (Page 3).**
- 598 ☐ I have heard a little about dioxins.
- 362 ☐ I have heard a lot about dioxins.

67 2. I have gotten enough information about dioxins.

85 ☐	485 ☐	364 ☐	35 ☐
Strongly Disagree	Disagree	Agree	Strongly Agree

66 3. I am satisfied with the information I have gotten about dioxins.

72 ☐	483 ☐	381 ☐	34 ☐
Strongly Disagree	Disagree	Agree	Strongly Agree

Missing

75 4. The information I've gotten about dioxins has been confusing to me.

30 ☐	396 ☐	488 ☐	47 ☐
Strongly Disagree	Disagree	Agree	Strongly Agree

78 5. I feel well-informed about dioxins.

98 ☐	572 ☐	257 ☐	31 ☐
Strongly Disagree	Disagree	Agree	Strongly Agree

Next, we would like to ask a few questions about your level of concern about dioxins. Please check the box that best reflects your answer:

76 6. How big of a threat do you believe dioxins are to your health?

50 ☐	142 ☐	387 ☐	243 ☐	138 ☐
No threat at all				Extremely large threat

72 7. How easy or difficult is it for you judge how big of a threat dioxins are to your health?

58 ☐	112 ☐	334 ☐	281 ☐	179 ☐
Extremely easy				Extremely difficult

72 8. How confident do you feel that you know how big of a threat dioxins are to your health?

203 ☐	239 ☐	274 ☐	173 ☐	75 ☐
Not at all confident				Extremely confident

71 9. How concerned are you about the threat to your health from dioxins?

60 ☐	150 ☐	304 ☐	251 ☐	200 ☐
Not at all concerned				Extremely concerned

Missing

69 10. How concerned are you about the threat to your family's health from dioxins?

64 ☐	143 ☐	258 ☐	270 ☐	232 ☐
Not at all concerned				Extremely concerned

69 11. How concerned are you about any economic effects dioxins may have on you and your family?

80 ☐	158 ☐	266 ☐	247 ☐	216 ☐
Not at all concerned				Extremely concerned

67 12. How concerned are you about the effects on your community from dioxins?

54 ☐	132 ☐	274 ☐	287 ☐	222 ☐
Not at all concerned				Extremely concerned

67 13. Overall, how concerned are you about your own exposure and your family's exposure to dioxins?

79 ☐	151 ☐	245 ☐	267 ☐	227 ☐
Not at all concerned				Extremely concerned

Next, we have a question related to how you feel about industry. Please check the box that best reflects your answer:

38 14. The current balance of benefits and risks from industry in my community is:

209 ☐ Benefits outweigh risks

527 ☐ Benefits and risks are roughly equal

262 ☐ Risks outweigh benefits

Next, we have a few questions related to how you feel about government. For each of the following questions, please check the box that best reflects your answer:

Missing

14 15. How much of the time do you trust the federal, state and/or local government to do what is right?

138 ☐	454 ☐	331 ☐	78 ☐	21 ☐
Never				Always

25 16. In general, do you agree or disagree with the following statement? "Government has gone too far in regulating business and interfering with the free enterprise system."

81 ☐	384 ☐	388 ☐	158 ☐
Strongly Disagree	Disagree	Agree	Strongly Agree

16 17. How much of a problem, if at all, is government corruption today?

13 ☐	64 ☐	228 ☐	278 ☐	437 ☐
Not at all a problem				Very much a problem

For each of the following statements, please check the box that best reflects how much you agree with each statement.

24 18. I am outraged whenever industry and/or government allows dioxin contamination to occur, no matter how they respond after the contamination is identified.

27 ☐	201 ☐	534 ☐	250 ☐
Strongly Disagree	Disagree	Agree	Strongly Agree

18 19. When there is a really serious health or environmental problem, then public officials will take care of it.

120 ☐	538 ☐	326 ☐	34 ☐
Strongly Disagree	Disagree	Agree	Strongly Agree

Missing

16 20. Until they alert me about a specific problem, I don't really have to worry.

186 ☐	603 ☐	211 ☐	20 ☐
Strongly Disagree	Disagree	Agree	Strongly Agree

15 21. I have very little control over risks to my health.

108 ☐	507 ☐	354 ☐	52 ☐
Strongly Disagree	Disagree	Agree	Strongly Agree

17 22. Those in power often withhold information about things that are harmful to us.

12 ☐	114 ☐	625 ☐	268 ☐
Strongly Disagree	Disagree	Agree	Strongly Agree

16 23. The land, air, and water around us are, in general, more contaminated now than ever before.

46 ☐	286 ☐	474 ☐	214 ☐
Strongly Disagree	Disagree	Agree	Strongly Agree

20 24. Continued economic growth can only lead to pollution and depletion of natural resources.

90 ☐	503 ☐	338 ☐	85 ☐
Strongly Disagree	Disagree	Agree	Strongly Agree

In this part of the questionnaire we are going to ask you to read a series of statements about dioxins. Some of these statements are TRUE. Some of these statements are FALSE (in other words, NOT TRUE).

Please read each statement and mark whether you believe the statement is TRUE or FALSE.

We understand that you may not be sure of the answer for some questions. That's okay. If you are not sure of your answer, please guess and mark whether you think it is more likely to be TRUE or more likely to be FALSE. **For each question, please also mark how confident you are about your answer.**

We have done three things to simplify the wording of the questions:

(1) When we say "elevated levels of dioxins" we mean an amount of dioxins that is higher than the national average.

(2) When we say an exposure to dioxins is "significant," we mean significant compared to other sources of dioxin exposure.

(3) When we say "Dow" we mean Dow Chemical Company's plant in Midland, Michigan.

Missing T/F			Do you think this statement is True or False?		How confident are you about your answer?			Missing Conf.
			True	False	Not at all	Some-what	Very	
21	25.	Any chemical may be classified as a dioxin based on its health effects.	455	560 *	85	574	336	41
17	26.	The word "dioxins" refers to a group of chemicals not just one chemical.	931 *	88	55	468	472	41
21	27.	The chemical manufacturing industry is the only type of industry that produces dioxins.	106	909 *	68	450	473	45

*"Correct" answer according to expert model.

Missing T/F			Do you think this statement is True or False?		How confident are you about your answer?			Missing Conf.
			True	False	Not at all	Some-what	Very	
16	28.	Dioxins found in the Midland area are believed to have come from Dow.	826 * Omitted	51 from	20 Jackson/	348 Calhoun	496 survey	29
15	29.	Much of the dioxins found in the Tittabawassee River came from past waste releases from Dow.	812 * Omitted	66 from	33 Jackson/	366 Calhoun	496 survey	31
38	30.	One source of dioxins in the past was an incinerator operated by Dow.	647 * Omitted	208 from	276 Jackson/	441 Calhoun	134 survey	42
37	31.	One of the ways Dow disposed of dioxins was to put them in large containers and bury them in the ground.	439 Omitted	417 * from	311 Jackson/	417 Calhoun	128 survey	37
18	32.	Over the last 40 years the average level of dioxins in the environment has been going up.	295	723 *	94	613	287	42
14	33.	A person who has lived in the Midland/Saginaw area for the past 40-50 years is likely to have more dioxins in their body than a person of the same age who recently moved to the Midland/Saginaw area.	635 * Omitted	244 from	84 Jackson/	497 Calhoun	282 survey	30

*"Correct" answer according to expert model.

Missing T/F			Do you think this statement is True or False?		How confident are you about your answer?			Missing Conf.
			True	False	Not at all	Some-what	Very	
26	34.	Elevated levels of dioxins can be found in well water in the Midland/Saginaw area.	610 Omitted	257 * from	175 Jackson	544 /Calhoun	137 survey	37
27	35.	Elevated levels of dioxins can be found in the city water supply ("tap water") of Midland and/or Saginaw.	267 Omitted	599 * from	143 Jackson	523 /Calhoun	188 survey	39
19	36.	Elevated levels of dioxins can be found in water from the Tittabawassee River even after all soil and sediment has been removed.	693 Modified	181 * in	100 Jackson	534 /Calhoun	222 survey	37
19	37.	Elevated levels of dioxins can be found in the sediment at the bottom of the Tittabawassee River.	842 * Omitted	32 from	67 Jackson	379 /Calhoun	412 survey	135
18	38.	Elevated levels of dioxins can be found in the soil on the banks of the Tittabawassee River.	814 * Omitted	61 from	76 Jackson	407 /Calhoun	378 survey	32
24	39.	Elevated levels of dioxins can be found in rainwater that falls in the Midland/Saginaw area.	258 Omitted	611 * from	184 Jackson	505 /Calhoun	166 survey	38

*"Correct" answer according to expert model.

Missing T/F			Do you think this statement is True or False?		How confident are you about your answer?			Missing Conf.
			True	False	Not at all	Some-what	Very	
19	40.	Skin contact with the Tittabawassee River water (for example, swimming) can significantly increase the amount of dioxins in a person's body.	469	405 *	148	530	176	39
			Modified in		Jackson/Calhoun		survey	
17	41.	If the Tittabawassee River floods onto someone's property, it is likely to leave behind dioxins.	744 *	132	105	489	261	38
			Modified in		Jackson/Calhoun		survey	
41	42.	Dow's incinerator is currently a major source of new dioxin contamination.	312	540 *	257	468	111	57
			Modified in		Jackson/Calhoun		survey	
38	43.	Car exhaust is currently a major source of new dioxin contamination.	419	579 *	263	530	181	62
27	44.	Backyard trash burning is currently a major source of new dioxin contamination.	354 *	655	228	568	189	51
30	45.	Municipal or hospital incinerators are currently a major source of new dioxin contamination.	398 *	608	270	595	119	52
27	46.	Coal-burning power plants are currently a major source of new dioxin contamination.	497	512 *	232	610	142	52

*"Correct" answer according to expert model.

Missing T/F			Do you think this statement is True or False?		How confident are you about your answer?			Missing Conf.
			True	False	Not at all	Some-what	Very	
28	47.	It is possible for household products (such as paints, caulks, carpets and furniture) to be a source of dioxins.	719 [*]	289	190	617	179	50
42	48.	All dioxins are manmade.	333	661 [*]	200	541	236	60
75	49.	Most chemicals applied to farm fields contain dioxins.	509	452 [*]	229	574	141	92
35	50.	Older people tend to have higher levels of dioxins in their bodies than younger people.	624 [*]	377	166	605	213	52
34	51.	Cigarette smoking increases the levels of dioxins in the body.	712	290 [*]	192	525	264	55
25	52.	Dioxins can be found in fish raised in contaminated water.	991 [*]	20	56	427	507	46
23	53.	Fish caught in the Tittabawassee River tend to have more dioxins in them than fish from other rivers and lakes in Michigan.	780 [*]	90	65	408	381	39

Modified in Jackson/Calhoun survey

*"Correct" answer according to expert model.

Missing T/F			Do you think this statement is True or False? True	False	How confident are you about your answer? Not at all	Some-what	Very	Missing Conf.
23	54.	Bottom-feeding fish (for example, catfish) from the Tittabawassee River tend to have more dioxins in them than surface fish (for example, walleye) that live in the same parts of the river.	755 *	115	107	432	313	41
31	55.	Thoroughly washing homegrown lettuce, zucchini, and other vegetables removes almost all of the dioxins they may have.	518 *	487	168	674	148	46
40	56.	Processed foods have more dioxins in them than fresh foods do.	316	680 *	256	602	127	51
31	57.	Cutting off extra fat or fatty skin from meats can help to reduce the amount of dioxins in food.	590 *	415	197	563	227	49
36	58.	Having a lot of trees or plants on your property or in the area helps to reduce the amount of dioxins in the soil.	452	548 *	279	563	139	55

*"Correct" answer according to expert model.

Missing T/F			Do you think this statement is True or False?		How confident are you about your answer?			Missing Conf.
			True	False	Not at all	Some-what	Very	
32	59.	Land owners are required to tell potential buyers if their land is known to have elevated levels of dioxins.	726 *	278	145	516	322	58
30	60.	Land that is known to have elevated levels of dioxins is often worth less than non-contaminated land.	888 *	118	106	484	396	50
39	61.	People can get dioxins in their bodies if they touch contaminated water or soil even if they wash their skin after contact.	466	531 *	218	599	168	51
38	62.	People can get dioxins in their bodies if they breathe contaminated air.	740 *	258	192	572	211	61
29	63.	A person who lives on land with elevated levels of dioxins will usually have elevated levels of dioxins in their body.	824	183 *	111	620	253	52
27	64.	People can get dioxins in their bodies by eating food that has dioxins in it.	978 *	31	101	521	364	50

*"Correct" answer according to expert model.

Missing T/F			Do you think this statement is True or False?		How confident are you about your answer?			Missing Conf.
			True	False	Not at all	Some-what	Very	
26	65.	Eating game animals (for example, deer, turkeys) that live on contaminated land will increase the amount of dioxins a person has in their body.	900 [*]	110	119	569	297	51
27	66.	Land that is far away from a source of dioxins can become contaminated if someone brings soil from a contaminated source (for example, by adding soil to a garden or to fill a hole).	861 [*]	148	142	566	281	47
31	67.	Dioxins can move from place to place if they get on people's clothes or pets.	499 [*]	506	246	587	154	40
39	68.	There are medications and/or treatments available that will remove dioxins from the body.	258	739 [*]	307	518	154	57
32	69.	Exercise helps remove dioxins from the body.	281	723 [*]	299	519	165	53
30	70.	Drinking lots of water helps remove dioxins from the body.	398	608 [*]	290	543	152	51

*"Correct" answer according to expert model.

Thank you for answering the above questions. We now would like to get your opinion on several topics about dioxins, some of which scientists are still uncertain about. These statements may or may not be true, but we would like to better understand how people in your community feel about them.

Please mark whether you think each statement is MOST LIKELY TRUE or MOST LIKELY FALSE and mark how confident you are about your answer.

Missing T/F			Do you think this statement is Most Likely True or Most Likely False?		How confident are you about your answer?			Missing Conf.
			Most Likely True	Most Likely False	Not at all	Some-what	Very	
25	71.	Dioxins can cause birth defects.	859 ☐	152 ☐	145 ☐	555 ☐	287 ☐	49
28	72.	In very high doses, dioxins can cause cancer.	954 ☐	54 ☐	94 ☐	472 ☐	419 ☐	51
42	73.	In low doses, dioxins can cause cancer.	636 ☐	359 ☐	191 ☐	583 ☐	203 ☐	59
31	74.	People naturally get rid of most of the dioxins that get into their bodies within a few weeks.	215 ☐	790 ☐	238 ☐	568 ☐	179 ☐	51
24	75.	A person's health will be negatively affected if they are exposed to any amount of dioxins, no matter how small.	378 ☐	634 ☐	187 ☐	600 ☐	200 ☐	49

Missing T/F			Do you think this statement is Most Likely True or Most Likely False?		How confident are you about your answer?			Missing Conf.
			Most Likely True	Most Likely False	Not at all	Some-what	Very	
25	76.	A person exposed to a small amount of dioxins has the same risk of health effects as someone exposed to a large amount.	211 ☐	800 ☐	149 ☐	624 ☐	219 ☐	44
17	77.	You can have a certain level of dioxins in your body without any impact on your health.	829 ☐	190 ☐	166 ☐	623 ☐	205 ☐	42
30	78.	Some people can build up an immunity to dioxins.	239 ☐	767 ☐	249 ☐	561 ☐	177 ☐	49
27	79.	Dioxins affect women's health more than they do men's.	360 ☐	649 ☐	269 ☐	588 ☐	130 ☐	49
22	80.	People with weakened immune systems are more likely to have health effects from dioxin exposure than people with normal immune systems.	888 ☐	126 ☐	172 ☐	580 ☐	239 ☐	45
23	81.	Dioxins can pass from a mother to a child through breast milk.	903 ☐	110 ☐	191 ☐	524 ☐	276 ☐	45
23	82.	Bottled water typically has lower levels of dioxins than city water ("tap water").	485 ☐	528 ☐	214 ☐	595 ☐	180 ☐	47

In this section, we would like you to answer whether or not you think each of the following has in the past been or currently is a significant source of dioxin exposure for most people in your community.

- As a reminder, when we say an exposure to dioxins is "significant," we mean significant compared to other sources of dioxin exposure.

For each question, please answer either YES, this IS a significant source of dioxin exposure or NO, this IS NOT a significant source of dioxin exposure for BOTH in the past and currently.

Missing Past		In the Past		Currently		Missing Curr.
		Yes	No	Yes	No	
40	83. Breathing air	520 ☐	476 ☐	411 ☐	580 ☐	45
37	84. Eating food	583 ☐	416 ☐	611 ☐	368 ☐	57
40	85. Eating soil (accidentally)	645 ☐	351 ☐	689 ☐	294 ☐	53
41	86. Drinking water	578 ☐	417 ☐	530 ☐	448 ☐	58
35	87. Touching water (for example, swimming)	490 ☐	511 ☐	510 ☐	470 ☐	56
40	88. Touching things (soil, plants, animals)	430 ☐	566 ☐	466 ☐	514 ☐	56
36	89. Living on contaminated soil	819 ☐	181 ☐	844 ☐	149 ☐	43

Missing
116 90. For most people in your community, which of the following is **CURRENTLY** the single **LARGEST** source of dioxin exposure? (**Check ONLY one**)

- 98 ☐ Breathing air
- 105 ☐ Eating food
- 40 ☐ Eating soil (accidentally)
- 81 ☐ Drinking water
- 24 ☐ Touching water (for example, swimming)
- 17 ☐ Touching things (soil, plants, animals)
- 555 ☐ Living on contaminated soil

Sometimes information about dioxins is presented using numbers. We would like to ask a few questions about your preferences in using numbers. Please check the box that best reflects your answer:

Missing

17 91. How good are you at working with fractions?

107 ☐	91 ☐	184 ☐	197 ☐	234 ☐	206 ☐
Not at all good					Extremely good

15 92. How good are you at working with percentages?

76 ☐	62 ☐	158 ☐	182 ☐	282 ☐	261 ☐
Not at all good					Extremely good

14 93. How good are you at calculating a 15% tip?

42 ☐	51 ☐	98 ☐	124 ☐	253 ☐	454 ☐
Not at all good					Extremely good

13 94. How good are you at figuring out how much a shirt will cost if it is 25% off?

26 ☐	33 ☐	85 ☐	103 ☐	256 ☐	520 ☐
Not at all good					Extremely good

Missing

16 95. When reading the newspaper, how helpful do you find tables and graphs that are parts of a story?

50 ☐	62 ☐	123 ☐	230 ☐	291 ☐	264 ☐
Not at all helpful					Extremely helpful

19 96. When people tell you the chance of something happening, do you prefer that they use words ("it rarely happens") or numbers ("there's a 1% chance")?

105 ☐	53 ☐	82 ☐	151 ☐	225 ☐	401 ☐
Always prefer words					Always prefer numbers

18 97. When you hear a weather forecast, do you prefer predictions using percentages (e.g., "there will be a 20% chance of rain today") or predictions using only words (e.g., "there is a small chance of rain today")?

471 ☐	221 ☐	80 ☐	79 ☐	76 ☐	91 ☐
Always prefer percentages					Always prefer words

17 98. How often do you find numerical information to be useful?

26 ☐	35 ☐	120 ☐	177 ☐	323 ☐	338 ☐
Never					Always

In this section, we have a few questions about information you may or may not have received about dioxins.

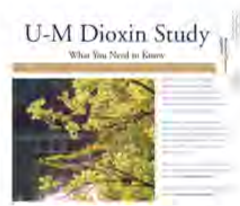
Missing

72 99. In 2006, the University of Michigan Dioxin Exposure Study (UMDES) published a brochure of the results of their study. You may or may not have received this brochure. Did you receive this brochure?

387 ☐ Yes → → → → If yes, did you read it? ☐ Yes 304

577 ☐ No Missing 565 ☐ No 167

73 100. In January 2011, the UMDES published a second brochure of results from their study. You may or may not have received this brochure. Did you receive this brochure?



217 ☐ Yes → → → → If yes, did you read it? ☐ Yes 148

746 ☐ No Missing 693 ☐ No 195

18 101. Did you participate in the University of Michigan Dioxin Exposure Study (UMDES) in 2004-2006?

484 ☐ Yes

404 ☐ No

126 ☐ Unsure

14 102. At the beginning of this survey, we asked you to answer the questions without looking at other sources of information. However, we recognize that some people may have missed that instruction. If so, that's okay, but please answer this last question honestly so we can better understand your answers. In answering the questions in this survey, did you look up any information from any source?

45 ☐ Yes

977 ☐ No

Demographics

Missing

Range 20-90+, Mean 58.3

27 103. Age:__________ years

23 104. Gender

- 474 ☐ Male
- 539 ☐ Female

76 105. Ethnicity

- 27 ☐ Hispanic or Latino
- 933 ☐ Not Hispanic or Latino

24 106. Race (check all that apply)

- 14 ☐ American Indian or Alaska Native
- 3 ☐ Asian
- 0 ☐ Native Hawaiian or Other Pacific Islander
- 58 ☐ Black or African American
- 941 ☐ White

61 107. Highest level of education

- 53 ☐ Some high school
- 242 ☐ High school diploma or GED
- 348 ☐ Some college, associates degree, professional training
- 208 ☐ Bachelor's degree (BA, BS)
- 97 ☐ Master's degree (MA, MBA)
- 16 ☐ Professional school degree (MD, JD, DDS)
- 11 ☐ Doctoral degree (PhD, EdD)

24 108. How long have you lived in your current home?

- 23 ☐ Less than 1 year
- 95 ☐ 1-5 years
- 296 ☐ 6-15 years
- 598 ☐ 16+ years

Missing
45 109. Do you have any biological or adopted children?

761 ☐ Yes ➔➔ If yes, what are their ages? (**Check all that apply**)

230 ☐ No

Missing
252

25 ☐ 0-2 years

31 ☐ 3-5 years

88 ☐ 6-10 years

105 ☐ 11-15 years

75 ☐ 16-18 years

620 ☐ Over 18 years

25 110. Have you ever worked at a chemical company?

155 ☐ Yes ➔➔ If yes, what type of work did you do there?

856 ☐ No (**Check all that apply**)

Missing
863

52 ☐ Maintenance/repair/contractor

10 ☐ Management

34 ☐ Office or administrative support (e.g. customer service, clerical)

63 ☐ Production (e.g. assembly, inspection, packaging, processing, quality)

28 ☐ Professional (e.g. scientist, engineer, computer specialist)

10 ☐ Sales

13 ☐ Transportation (e.g. shipping, driving)

Thank you for completing our questionnaire, please return it in the stamped envelope provided.

Appendix K

CPOD Phase 3 Jackson/Calhoun Survey and Results Summary

This appendix presents the mailed survey created by the Community Perceptions of Dioxins (CPOD) study and mailed to Jackson/Calhoun participants. A total of 143 CPOD participants completed this version of the survey, including 132 Jackson/Calhoun UMDES participants and 11 Midland/Saginaw non-UMDES participants who were sent this survey in error.

Aggregated responses are shown only for those questions that differed from Midland/Saginaw version.

Community Perceptions of Dioxins:
Community Survey

Thank you for taking the time to complete this survey. Please read each question carefully. We understand that you may not be sure of the answer for some questions. We ask that you give your best guess and not look at other sources of information to help you.

When you are done, please return the completed survey in the stamped envelope provided. Once we receive your completed survey in the mail we will send you a $10 Visa gift card to thank you for your time.

First, we would like to ask a few questions about how you feel about the information you've received or gathered about dioxins. Please check the box that best reflects your answer:

1. How familiar are you with dioxins?

   ☐ I have never heard of dioxins. ➔ **Skip to Question 14 (Page 4).**

   ☐ I have heard a little about dioxins.

   ☐ I have heard a lot about dioxins.

2. I have gotten enough information about dioxins.

   ☐ Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree

3. I am satisfied with the information I have gotten about dioxins.

   ☐ Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree

4. The information I've gotten about dioxins has been confusing to me.

☐ Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree

5. I feel well-informed about dioxins.

☐ Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree

Next, we would like to ask a few questions about your level of concern about dioxins. Please check the box that best reflects your answer:

6. How big of threat do you believe dioxins are to your health?

☐ ☐ ☐ ☐ ☐

No threat at all — Extremely high threat

7. How easy or difficult is it for you judge how big of a threat dioxins are to your health?

☐ ☐ ☐ ☐ ☐

Extremely easy — Extremely difficult

8. How confident do you feel that you know how big of a threat dioxins are to your health?

☐ ☐ ☐ ☐ ☐

Not at all confident — Extremely confident

9. How concerned are you about the threat to your health from dioxins?

☐ ☐ ☐ ☐ ☐

Not at all concerned — Extremely concerned

10. How concerned are you about the threat to your family's health from dioxins?

☐ ☐ ☐ ☐ ☐

Not at all concerned ... Extremely concerned

11. How concerned are you about any economic effects dioxins may have on you and your family?

☐ ☐ ☐ ☐ ☐

Not at all concerned ... Extremely concerned

12. How concerned are you about the effects on your community from dioxins?

☐ ☐ ☐ ☐ ☐

Not at all concerned ... Extremely concerned

13. Overall, how concerned are you about your own exposure and your family's exposure to dioxins?

☐ ☐ ☐ ☐ ☐

Not at all concerned ... Extremely concerned

Next, we have a question related to how you feel about industry. Please check the box that best reflects your answer:

14. The current balance of benefits and risks from industry in my community is:

☐ Benefits outweigh risks

☐ Benefits and risks are roughly equal

☐ Risks outweigh benefits

Next, we have a few questions related to how you feel about government. For each of the following questions, please check the box that best reflects your answer:

15. How much of the time do you trust the federal, state and/or local government to do what is right?

☐	☐	☐	☐	☐
Never				Always

16. In general, do you agree or disagree with the following statement? "Government has gone too far in regulating business and interfering with the free enterprise system."

☐	☐	☐	☐
Strongly Disagree	Disagree	Agree	Strongly Agree

17. How much of a problem, if at all, is government corruption today?

☐	☐	☐	☐	☐
Not at all a problem				Very much a problem

For each of the following statements, please check the box that best reflects how much you agree with each statement.

18. I am outraged whenever industry and/or government allows dioxin contamination to occur, no matter how they respond after the contamination is identified.

☐	☐	☐	☐
Strongly Disagree	Disagree	Agree	Strongly Agree

19. When there is a really serious health or environmental problem, then public officials will take care of it.

☐	☐	☐	☐
Strongly Disagree	Disagree	Agree	Strongly Agree

20. Until they alert me about a specific problem, I don't really have to worry.

☐ Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree

21. I have very little control over risks to my health.

☐ Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree

22. Those in power often withhold information about things that are harmful to us.

☐ Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree

23. The land, air, and water around us are, in general, more contaminated now than ever before.

☐ Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree

24. Continued economic growth can only lead to pollution and depletion of natural resources.

☐ Strongly Disagree ☐ Disagree ☐ Agree ☐ Strongly Agree

In this part of the questionnaire we are going to ask you to read a series of statements about dioxins. Some of these statements are TRUE. Some of these statements are FALSE (in other words, NOT TRUE).

Please read each statement and mark whether you believe the statement is TRUE or FALSE.

We understand that you may not be sure of the answer for some questions. That's okay. If you are not sure of your answer, please guess and mark whether you think it is more likely to be TRUE or more likely to be FALSE. **For each question, please also mark how confident you are about your answer.**

We have done three things to simplify the wording of the questions:

(1) When we say "elevated levels of dioxins" we mean an amount of dioxins that is higher than the national average.

(2) When we say an exposure to dioxins is "significant," we mean significant compared to other sources of dioxin exposure.

(3) When we say "contaminated areas", we mean areas known to have elevated levels of dioxins.

		Do you think this statement is True or False?		How confident are you about your answer?		
		True	False	Not at all	Some-what	Very
25.	Any chemical may be classified as a dioxin based on its health effects.	☐	☐	☐	☐	☐
26.	The word "dioxins" refers to a group of chemicals not just one chemical.	☐	☐	☐	☐	☐
27.	The chemical manufacturing industry is the only type of industry that produces dioxins.	☐	☐	☐	☐	☐

Missing T/F			Do you think this statement is True or False?		How confident are you about your answer?			Missing Conf.
			True	False	Not at all	Some-what	Very	
	28.	Over the last 40 years the average level of dioxins in the environment has been going up.	☐	☐	☐	☐	☐	
4	29.	Elevated levels of dioxins can be found in water from rivers and streams in contaminated areas even after all soil and sediment has been removed.	128 ☐	11 *	15 ☐	80 ☐	41 ☐	7
4	30.	Skin contact with water from rivers or streams in contaminated areas (for example, swimming) can significantly increase the amount of dioxins in a person's body.	107 ☐	32 *	26 ☐	68 ☐	39 ☐	10
4	31.	If a river or stream in a contaminated area floods onto someone's property, it is likely to leave behind dioxins.	135 *	4 ☐	13 ☐	65 ☐	57 ☐	8
5	32.	Industrial incinerators are currently a major source of new dioxin contamination.	98 ☐	40 *	33 ☐	72 ☐	30 ☐	8
	33.	Car exhaust is currently a major source of new dioxin contamination.	☐	☐	☐	☐	☐	

		Do you think this statement is True or False?		How confident are you about your answer?		
		True	False	Not at all	Some-what	Very
34.	Backyard trash burning is currently a major source of new dioxin contamination.	☐	☐	☐	☐	☐
35.	Municipal or hospital incinerators are currently a major source of new dioxin contamination.	☐	☐	☐	☐	☐
36.	Coal-burning power plants are currently a major source of new dioxin contamination.	☐	☐	☐	☐	☐
37.	It is possible for household products (such as paints, caulks, carpets and furniture) to be a source of dioxins.	☐	☐	☐	☐	☐
38.	All dioxins are manmade.	☐	☐	☐	☐	☐
39.	Most chemicals applied to farm fields contain dioxins.	☐	☐	☐	☐	☐
40.	Older people tend to have higher levels of dioxins in their bodies than younger people.	☐	☐	☐	☐	☐
41.	Cigarette smoking increases the levels of dioxins in the body.	☐	☐	☐	☐	☐

Missing T/F			Do you think this statement is True or False?		How confident are you about your answer?			Missing Conf.
			True	False	Not at all	Some-what	Very	
	42.	Dioxins can be found in fish raised in contaminated water.	☐	☐	☐	☐	☐	
3	43.	Fish caught in rivers and streams in contaminated areas tend to have more dioxins in them than fish from other rivers and lakes in Michigan.	121 [*]	19 ☐	10 ☐	79 ☐	49 ☐	5
3	44.	Bottom-feeding fish (for example, catfish) from local rivers and streams tend to have more dioxins in them than surface fish (for example, walleye) that live in the same parts of the river.	96 [*]	44 ☐	23 ☐	82 ☐	33 ☐	5
	45.	Thoroughly washing homegrown lettuce, zucchini, and other vegetables removes almost all of the dioxins they may have.	☐	☐	☐	☐	☐	
	46.	Processed foods have more dioxins in them than fresh foods do.	☐	☐	☐	☐	☐	

		Do you think this statement is True or False?		How confident are you about your answer?		
		True	False	Not at all	Some-what	Very
47.	Cutting off extra fat or fatty skin from meats can help to reduce the amount of dioxins in food.	☐	☐	☐	☐	☐
48.	Having a lot of trees or plants on your property or in the area helps to reduce the amount of dioxins in the soil.	☐	☐	☐	☐	☐
49.	Land owners are required to tell potential buyers if their land is known to have elevated levels of dioxins.	☐	☐	☐	☐	☐
50.	Land that is known to have elevated levels of dioxins is often worth less than non-contaminated land.	☐	☐	☐	☐	☐
51.	People can get dioxins in their bodies if they touch contaminated water or soil even if they wash their skin after contact.	☐	☐	☐	☐	☐
52.	People can get dioxins in their bodies if they breathe contaminated air.	☐	☐	☐	☐	☐

		Do you think this statement is True or False?		How confident are you about your answer?		
		True	False	Not at all	Some-what	Very
53.	A person who lives on land with elevated levels of dioxins will usually have elevated levels of dioxins in their body.	☐	☐	☐	☐	☐
54.	People can get dioxins in their bodies by eating food that has dioxins in it.	☐	☐	☐	☐	☐
55.	Eating game animals (for example, deer, turkeys) that live on contaminated land will increase the amount of dioxins a person has in their body.	☐	☐	☐	☐	☐
56.	Land that is far away from a source of dioxins can become contaminated if someone brings soil from a contaminated source (for example, by adding soil to a garden or to fill a hole).	☐	☐	☐	☐	☐

		Do you think this statement is True or False?		How confident are you about your answer?		
		True	False	Not at all	Some-what	Very
57.	Dioxins can move from place to place if they get on people's clothes or pets.	☐	☐	☐	☐	☐
58.	There are medications and/or treatments available that will remove dioxins from the body.	☐	☐	☐	☐	☐
59.	Exercise helps remove dioxins from the body.	☐	☐	☐	☐	☐
60.	Drinking lots of water helps remove dioxins from the body.	☐	☐	☐	☐	☐

Thank you for answering the above questions. We now would like to get your opinion on several topics about dioxins, some of which scientists are still uncertain about. These statements may or may not be true, but we would like to better understand how people in your community feel about them.

Please mark whether you think each statement is MOST LIKELY TRUE or MOST LIKELY FALSE and mark how confident you are about your answer.

		Do you think this statement is Most Likely True or Most Likely False?		How confident are you about your answer?		
		Most Likely True	Most Likely False	Not at all	Some-what	Very
61.	Dioxins can cause birth defects.	☐	☐	☐	☐	☐
62.	In very high doses, dioxins can cause cancer.	☐	☐	☐	☐	☐
63.	In low doses, dioxins can cause cancer.	☐	☐	☐	☐	☐
64.	People naturally get rid of most of the dioxins that get into their bodies within a few weeks.	☐	☐	☐	☐	☐
65.	A person's health will be negatively affected if they are exposed to any amount of dioxins, no matter how small.	☐	☐	☐	☐	☐

		Do you think this statement is <u>Most Likely True</u> or <u>Most Likely False</u>?		How <u>confident</u> are you about your answer?		
		Most Likely True	Most Likely False	Not at all	Some-what	Very
66.	A person exposed to a small amount of dioxins has the same risk of health effects as someone exposed to a large amount.	☐	☐	☐	☐	☐
67.	You can have a certain level of dioxins in your body without any impact on your health.	☐	☐	☐	☐	☐
68.	Some people can build up an immunity to dioxins.	☐	☐	☐	☐	☐
69.	Dioxins affect women's health more than they do men's.	☐	☐	☐	☐	☐
70.	People with weakened immune systems are more likely to have health effects from dioxin exposure than people with normal immune systems.	☐	☐	☐	☐	☐
71.	Dioxins can pass from a mother to a child through breast milk.	☐	☐	☐	☐	☐
72.	Bottled water typically has lower levels of dioxins than city water ("tap water").	☐	☐	☐	☐	☐

In this section, we would like you to answer whether or not you think each of the following has in the past been or currently is a significant source of dioxin exposure for most people in your community.

- As a reminder, when we say an exposure to dioxins is "significant," we mean significant compared to other sources of dioxin exposure.

For each question, please answer either YES, this IS a significant source of dioxin exposure or NO, this IS NOT a significant source of dioxin exposure for BOTH in the past and currently.

	In the Past		Currently	
73. Breathing air	☐ Yes	☐ No	☐ Yes	☐ No
74. Eating food	☐ Yes	☐ No	☐ Yes	☐ No
75. Eating soil (accidentally)	☐ Yes	☐ No	☐ Yes	☐ No
76. Drinking water	☐ Yes	☐ No	☐ Yes	☐ No
77. Touching water (for example, swimming)	☐ Yes	☐ No	☐ Yes	☐ No
78. Touching things (soil, plants, animals)	☐ Yes	☐ No	☐ Yes	☐ No
79. Living on contaminated soil	☐ Yes	☐ No	☐ Yes	☐ No

80. For most people in your community, which of the following is **CURRENTLY** the single **LARGEST** source of dioxin exposure? (**Check ONLY one**)
    - ☐ Breathing air
    - ☐ Eating food
    - ☐ Eating soil (accidentally)
    - ☐ Drinking water
    - ☐ Touching water (for example, swimming)
    - ☐ Touching things (soil, plants, animals)
    - ☐ Living on contaminated soil

Sometimes information about dioxins is presented using numbers. We would like to ask a few questions about your preferences in using numbers. Please check the box that best reflects your answer:

81. How good are you at working with fractions?

☐ ☐ ☐ ☐ ☐ ☐

Not at all good — Extremely good

82. How good are you at working with percentages?

☐ ☐ ☐ ☐ ☐ ☐

Not at all good — Extremely good

83. How good are you at calculating a 15% tip?

☐ ☐ ☐ ☐ ☐ ☐

Not at all good — Extremely good

84. How good are you at figuring out how much a shirt will cost if it is 25% off?

☐ ☐ ☐ ☐ ☐ ☐

Not at all good — Extremely good

85. When reading the newspaper, how helpful do you find tables and graphs that are parts of a story?

☐ ☐ ☐ ☐ ☐ ☐

Not at all helpful — Extremely helpful

86. When people tell you the chance of something happening, do you prefer that they use words ("it rarely happens") or numbers ("there's a 1% chance")?

☐ ☐ ☐ ☐ ☐ ☐

Always prefer words — Always prefer numbers

87. When you hear a weather forecast, do you prefer predictions using percentages (e.g., “there will be a 20% chance of rain today”) or predictions using only words (e.g., “there is a small chance of rain today”)?

☐ ☐ ☐ ☐ ☐ ☐

Always prefer percentages — Always prefer words

88. How often do you find numerical information to be useful?

☐ ☐ ☐ ☐ ☐ ☐

Never — Always

In this section, we have a few questions about information you may or may not have received about dioxins.

89. In 2006, the University of Michigan Dioxin Exposure Study (UMDES) published a brochure of the results of their study. You may or may not have received this brochure. Did you receive this brochure?

- ☐ Yes ➔ ➔ ➔ ➔ If yes, did you read it? ☐ Yes ☐ No
- ☐ No

90. In January 2011, the UMDES published a second brochure of results from their study. You may or may not have received this brochure. Did you receive this brochure?

- ☐ Yes ➔ ➔ ➔ ➔ If yes, did you read it? ☐ Yes ☐ No
- ☐ No

91. Did you participate in the University of Michigan Dioxin Exposure Study (UMDES) in 2004-2006?

- ☐ Yes
- ☐ No
- ☐ Unsure

92. At the beginning of this survey, we asked you to answer the questions without looking at other sources of information. However, we recognize that some people may have missed that instruction. If so, that's okay, but please answer this last question honestly so we can better understand your answers. In answering the questions in this survey, did you look up any information from any source?

- ☐ Yes
- ☐ No

Demographics

93. Age:__________ years

94. Gender
- ☐ Male
- ☐ Female

95. Ethnicity
- ☐ Hispanic or Latino
- ☐ Not Hispanic or Latino

96. Race (check all that apply)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Black or African American
- ☐ White

97. Highest level of education
- ☐ Some high school
- ☐ High school diploma or GED
- ☐ Some college, associates degree, professional training
- ☐ Bachelor's degree (BA, BS)
- ☐ Master's degree (MA, MBA)
- ☐ Professional school degree (MD, JD, DDS)
- ☐ Doctoral degree (PhD, EdD)

98. How long have you lived in your current home?
- ☐ Less than 1 year
- ☐ 1-5 years
- ☐ 6-15 years
- ☐ 16+ years

99. Do you have any biological or adopted children?

- ☐ Yes ➔ ➔ If yes, what are their ages? (**Check all that apply**)
- ☐ No
  - ☐ 0-2 years
  - ☐ 3-5 years
  - ☐ 6-10 years
  - ☐ 11-15 years
  - ☐ 16-18 years
  - ☐ Over 18 years

100. Have you ever worked at a chemical company?

- ☐ Yes ➔ ➔ If yes, what type of work did you do there?
- ☐ No (**Check all that apply**)
  - ☐ Maintenance/repair/contractor
  - ☐ Management
  - ☐ Office or administrative support (e.g. customer service, clerical)
  - ☐ Production (e.g. assembly, inspection, packaging, processing, quality)
  - ☐ Professional (e.g. scientist, engineer, computer specialist)
  - ☐ Sales
  - ☐ Transportation (e.g. shipping, driving)

Thank you for completing our questionnaire, please return it in the stamped envelope provided.

Appendix L

Mental Models True-False Questions

The Phase 3 survey included a series of true-false questions regarding dioxins. These questions appear in Table L.1 below, together with the objectively "correct" answer according to the expert model.

Table L.1 Mental Models True-False Questions, with "Correct" Answers According to Expert Model

M/S Q. No.	J/C Q. No.	Question Topic	Question Wording	"Correct" Answer
25	25	Chemical Classification	Any chemical may be classified as a dioxin based on its health effects.	False
26	26	Multiple Chemicals	The word "dioxins" refers a group of chemicals not just one chemical.	True
27	27	Chemical Mfg.	The chemical manufacturing industry is the only type of industry that produces dioxins.	False
28	--	Dow as a Source	Dioxins found in the Midland area are believed to have come from Dow.	True
29	--	Dow River Waste	Much of the dioxins found in the Tittabawassee River came from past waste releases from Dow.	True
30	--	Dow Incinerator	One source of dioxins in the past was an incinerator operated by Dow.	True
31	--	Dow Burying Waste	One of the ways Dow disposed of dioxins was to put them in large containers and bury them in the ground.	False
32	28	Levels Increasing	Over the last 40 years the average level of dioxins in the environment has been going up.	False
33	--	Past Residence	A person who has lived in Midland/Saginaw for the past 40-50 years is likely to have more dioxins in their body than a person of the same age who recently moved to the Midland/Saginaw area.	True

34	--	Well Water	Elevated levels of dioxins can be found in well water in the Midland/Saginaw area.	False
35	--	Tap Water	Elevated levels of dioxins can be found in the city water supply (“tap water”) of Midland and/or Saginaw.	False
36	29(M)	Filtered Water	Elevated levels of dioxins can be found in water from [the Tittabawassee River / rivers and streams in contaminated areas] even after all soil and sediment has been removed.	False
37	--	River Sediment	Elevated levels of dioxins can be found in the sediment at the bottom of the Tittabawassee River.	True
38	--	River Banks	Elevated levels of dioxins can be found in the soil on the banks of the Tittabawassee River.	True
39	--	Rain Water	Elevated levels of dioxins can be found in rainwater that falls in the Midland/Saginaw area.	False
40	30(M)	Swimming	Skin contact with [the Tittabawasee River water / water from rivers and streams in contaminated areas] (for example, swimming) can significantly increase the amount of dioxins in a person’s body.	False
41	31(M)	River Flooding	If [the Tittabawassee River / a river or stream in a contaminated area] floods onto someone’s property, it is likely to leave behind dioxins.	True
42	32(M)	Industrial Incin.	[Dow’s incinerator is / Industrial incinerators are] currently a major source of new dioxin contamination.	False
43	33	Car Exhaust	Car exhaust is currently a major source of new dioxin contamination.	False
44	34	Trash Burning	Backyard trash burning is currently a major source of new dioxin contamination.	True
45	35	Municipal Incin.	Municipal or hospital incinerators are currently a major source of new dioxin contamination.	True
46	36	Power Plants	Coal-burning power plants are currently a major source of new dioxin contamination.	False
47	37	Products	It is possible for household products (such as paints, caulks, carpets and furniture) to be a source of dioxins.	True
48	38	Manmade	All dioxins are manmade.	False
49	39	Farm Chemicals	Most chemicals applied to farm fields contain dioxins.	False
50	40	Older Age	Older people tend to have higher levels of dioxins in their bodies than younger people.	True
51	41	Smoking	Cigarette smoking increases the levels of dioxins in the body.	False

52	42	Fish	Dioxins can be found in fish raised in contaminated water.	True
53	43(M)	River Fish	Fish caught in [the Tittabawassee River / rivers and streams in contaminated areas] tend to have more dioxins in them than fish from other rivers and lakes in Michigan.	True
54	44(M)	Bottom Fish	Bottom-feeding fish (for example, catfish) from [the Tittabawassee River / local rivers and streams] tend to have more dioxins in them than surface fish (for example, walleye) that live in the same parts of the river.	True
55	45	Washing Vegetables	Thoroughly washing homegrown lettuce, zucchini, and other vegetables removes almost all of the dioxins they may have.	True
56	46	Processed Foods	Processed foods have more dioxins in them than fresh foods do.	False
57	47	Trimming Meat	Cutting off extra fat or fatty skin from meats can help to reduce the amount of dioxins in food.	True
58	48	Trees	Having a lot of trees or plants on your property or in the area helps to reduce the amount of dioxins in the soil.	False
59	49	Property Disclosure	Land owners are required to tell potential buyers if their land is known to have elevated levels of dioxins.	True
60	50	Property Values	Land that is known to have elevated levels of dioxins is often worth less than non-contaminated land.	True
61	51	Touching/Washing	People can get dioxins in their bodies if they touch contaminated water or soil even if they wash their skin after contact.	False
62	52	Breathing Air	People can get dioxins in their bodies if they breathe contaminated air.	True
63	53	Living on Soil	A person who lives on land with elevated levels of dioxins will usually have elevated levels of dioxins in their body.	False
64	54	Eating Food	People can get dioxins in their bodies by eating food that has dioxins in it.	True
65	55	Eating Game	Eating game animals (for example, deer, turkeys) that live on contaminated land will increase the amount of dioxins a person has in their body.	True
66	56	Moving Soil	Land that is far away from a source of dioxins can become contaminated if someone brings soil from a contaminated source (for example, by adding soil to a garden or to fill a hole).	True
67	57	Transport	Dioxins can move from place to place if they get on people’s clothes or pets.	True

68	58	Treatments	There are medications and/or treatments available that will remove dioxins from the body.	False
69	59	Exercise	Exercise helps remove dioxins from the body.	False
70	60	Water Drinking	Drinking lots of water helps remove dioxins from the body.	False

-- = Omitted
(M) = Modified
Note: Wording in brackets shows alternate wording for Jackson/Calhoun participants (listed second).

Appendix M

Alternate Analyses Regarding Mental Models

Chapter 7 described a method for screening mental models misconceptions for their influence on risk judgments. This method involved omitting questions that were not asked in the Phase 3 Jackson/Calhoun survey, in order to analyze responses from the full sample of participants. This appendix provides an alternate method of analyzing the full set of mental models true/false questions using only the Midland/Saginaw participants.

M.1 Dimension Reduction Process

The series of true/false questions asked about dioxins each had a “correct” answer according to the expert model, so “wrong” answers were coded as misconceptions. The frequency of misconceptions among Midland/Saginaw participants is shown in Table M.1 below. An empirical method was used to screen these variables for inclusion in further analyses to examine the effects of specific misconceptions on risk judgments. Regressions of risk judgment variables were conducted using the individual misconception variables one at a time, controlling for receiver characteristics and information received. For each risk judgment variable, those mental models variables with p-values less than 0.10 were chosen for use in further analyses.

Table M.1 Results of Mental Models True/False Questions, with Univariate Regressions for Effects on Risk Judgment Variables: Midland/Saginaw Participants Only

			Screening for Effects on Risk Judgment Variables [a]			
			Ease of Judgment	Confidence in Judgment	Judgment of Risk	Concern about Risk
M/S Q. No.	Question Topic	% With Miscon-ception	p-value	p-value	p-value	p-value
25	Chemical Classification	43%	.440	.025*	.524	.052*
26	Multiple Chemicals	10%	.196	.554	.596	.674
27	Chemical Mfg.	13%	.260	.013*	.827	.509
28	Dow as a Source	8%	.004*	.047*	.467	.597
29	Dow River Waste	9%	.028*	.016*	.717	.619
30	Dow Incinerator	28%	.740	.539	.769	.462
31	Dow Burying Waste	53%	.164	.044*	.122	.352
32	Levels Increasing	69%	.363	.045*	.016*	.002*
33	Past Residence	29%	.003*	.032*	.019*	.001*
34	Well Water	71%	.011*	.344	.016*	.007*
35	Tap Water	33%	.357	.253	.018*	.037*
36	Filtered Water	80%	.497	.986	.009*	.071*
37	River Sediment	6%	.250	.379	.226	.033*
38	River Banks	9%	.050*	.116	.167	.014*
39	Rain Water	32%	.763	.240	.040*	.653
40	Swimming	54%	.587	.621	<.001*	<.001*
41	River Flooding	17%	.300	.290	<.001*	<.001*
42	Industrial Incin.	40%	.376	.037*	.018*	.004*
43	Car Exhaust	42%	.880	.185	.040*	.030*
44	Trash Burning	68%	.374	.009*	.061*	.130
45	Municipal Incin.	65%	.590	.029*	.011*	.025*
46	Power Plants	48%	.359	.195	.276	.141
47	Products	33%	.644	.085*	.153	.220
48	Manmade	36%	.353	.965	.558	.079*
49	Farm Chemicals	55%	.367	.012*	.754	.379
50	Older Age	38%	.314	.802	.017*	.021*
51	Smoking	70%	.156	.182	.004*	.005*
52	Fish	5%	.169	.842	.044*	.009*
53	River Fish	13%	.139	.125	.082*	.059*
54	Bottom Fish	15%	.277	.508	.159	.742
55	Washing Vegetables	49%	.415	.925	.109	.153
56	Processed Foods	33%	.042*	.132	.983	.350
57	Trimming Meat	43%	.016*	.574	.763	.720
58	Trees	46%	.189	.491	.986	.382
59	Property Disclosure	28%	.687	.790	.186	.661
60	Property Values	13%	.086*	.012*	.481	.346
61	Touching/Washing	48%	.469	.133	.001*	<.001*
62	Breathing Air	30%	.423	.041*	.011*	.002*
63	Living on Soil	82%	.436	.709	.016*	.007*

64	Eating Food	5%	.008*	.076*	.640	.089*
65	Eating Game	13%	.003*	.194	<.001*	<.001*
66	Moving Soil	17%	.436	.922	.292	.085*
67	Transport	52%	.356	.738	.008*	.001*
68	Treatments	28%	.926	.955	.796	.807
69	Exercise	29%	.946	.855	.622	.543
70	Water Drinking	39%	.263	.041*	.752	.865

*Selected for further analyses (p<.10)

[a] Individual predictor p-values from regressions (ordered logistic regression for all except Concern about Risk, which used linear regression) controlling for Receiver Characteristics (age, gender, minority status, numeracy, education, having any children, mistrust of government and industry, working for a chemical company, living in the floodplain, living in Jackson/Calhoun) and Information Received (being very familiar with dioxins, UMDES participation, receipt or reading of UMDES brochures, looking up information in completing survey).

M.2 Regression Analyses Regarding Risk Judgments

Those mental models variables selected for further analysis using the screening process shown in Table M.1 were added to existing regression of risk judgment variables to check for potential mediation effects. Average mental models confidence was also included in each regression. Results of these regressions are shown in Tables M.2 through M.5 below.

Table M.2 Ordered Logistic Regression of Ease of Judgment by Receiver Characteristics and Information Received, With and Without Selected Mental Models Variables

	Ease of Judgment			
	Ordered logistic regression Without mental models N=749 LR chi2(13)=67.87 p-value <0.001		Ordered logistic regression With mental models N=746 LR chi2(24)=112.6 p-value <0.001	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	-0.078	0.108	-0.111	0.026*
Female Gender	-0.126	0.373	-0.098	0.489
Minority Status	-0.219	0.402	-0.195	0.464
Numeracy	0.005	0.952	-0.002	0.976
Education	-0.030	0.692	-0.021	0.792
Having a Child	-0.130	0.425	-0.119	0.471
Mistrust	-0.706	<0.001**	-0.576	<0.001**
Working for a Chemical Co.	0.389	0.031*	0.369	0.045*
Floodplain Resident	-0.094	0.499	-0.042	0.767
Jackson/Calhoun Resident	(omitted)	(omitted)	(omitted)	(omitted)
Information Received				
Familiarity with Dioxins	0.513	0.001**	0.395	0.011*
UMDES Participation	0.180	0.245	0.213	0.174
UMDES Brochures	0.090	0.575	0.023	0.887
Looking up Information	-0.396	0.302	-0.561	0.146
Mental Models				
Confidence in Mental Model	--	--	0.550	0.004*
Dow as a Source	--	--	0.524	0.124
Dow River Waste	--	--	0.043	0.886
Past Residence	--	--	0.303	0.065
Well Water	--	--	-0.296	0.059
River Banks	--	--	0.108	0.698
Processed Foods	--	--	0.292	0.048*
Trimming Meat	--	--	-0.385	0.007*
Property Values	--	--	0.108	0.627
Eating Food	--	--	0.495	0.216
Eating Game	--	--	0.304	0.234

*Significant (p<.05)
*Highly significant (p≤.001)

Table M.3 Ordered Logistic Regression of Confidence in Judgment by Receiver Characteristics and Information Received, With and Without Selected Mental Models Variables

	Confidence in Judgment			
	Ordered logistic regression Without mental models N=749 LR chi2(13)=86.87 p-value <0.001		Ordered logistic regression With mental models N=746 LR chi2(30)=154.1 p-value <0.001	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	-0.074	0.120	-0.085	0.083
Female Gender	-0.114	0.411	-0.172	0.230
Minority Status	0.153	0.553	0.059	0.825
Numeracy	0.031	0.667	0.087	0.254
Education	-0.084	0.270	-0.054	0.492
Having a Child	-0.037	0.820	-0.098	0.550
Mistrust	-0.363	0.004*	-0.348	0.012*
Working for a Chemical Co.	0.390	0.029*	0.425	0.020*
Floodplain Resident	-0.049	0.721	-0.020	0.890
Jackson/Calhoun Resident	(omitted)	(omitted)	(omitted)	(omitted)
Information Received				
Familiarity with Dioxins	1.066	<0.001**	0.952	<0.001**
UMDES Participation	0.043	0.781	0.029	0.852
UMDES Brochures	0.223	0.161	0.258	0.111
Looking up Information	-0.182	0.623	-0.373	0.324
Mental Models				
Confidence in Mental Model	--	--	0.712	<0.001**
Chemical Classification	--	--	0.143	0.349
Chemical Mfg.	--	--	-0.395	0.072*
Dow as a Source	--	--	0.266	0.431
Dow River Waste	--	--	0.252	0.378
Dow Burying Waste	--	--	-0.267	0.059
Levels Increasing	--	--	-0.230	0.136
Past Residence	--	--	0.158	0.319
Industrial Incin.	--	--	0.355	0.026*
Trash Burning	--	--	-0.264	0.120
Municipal Incin.	--	--	-0.063	0.713
Products	--	--	-0.093	0.554
Farm Chemicals	--	--	0.223	0.120
Property Values	--	--	0.442	0.040*
Breathing Air	--	--	-0.238	0.138

Eating Food	--	--	0.353	0.314
Water Drinking	--	--	-0.427	0.003*

*Significant (p<.05)
*Highly significant (p≤.001)

Table M.4 Ordered Logistic Regression of Judgment of Risk by Receiver Characteristics and Information Received, With and Without Selected Mental Models Variables

	Judgment of Risk			
	Ordered logistic regression Without mental models N=749 LR chi2(13)=250.5 p-value <0.001		Ordered logistic regression With mental models N=746 LR chi2(35)=323.4 p-value <0.001	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	-0.166	0.001**	-0.133	0.010*
Female Gender	0.124	0.389	0.002	0.987
Minority Status	0.592	0.028*	0.444	0.113
Numeracy	0.029	0.707	0.062	0.440
Education	0.010	0.900	0.050	0.533
Having a Child	-0.087	0.605	-0.037	0.833
Mistrust	1.874	<0.001**	1.618	<0.001**
Working for a Chemical Co.	-0.286	0.129	-0.258	0.183
Floodplain Resident	0.033	0.817	-0.044	0.767
Jackson/Calhoun Resident	(omitted)	(omitted)	(omitted)	(omitted)
Information Received				
Familiarity with Dioxins	0.235	0.117	0.230	0.146
UMDES Participation	-0.187	0.250	-0.079	0.633
UMDES Brochures	-0.340	0.041*	-0.345	0.044*
Looking up Information	0.057	0.883	0.134	0.737
Mental Models				
Mental Models Confidence	--	--	0.121	0.551
Levels Increasing	--	--	0.178	0.275
Past Residence	--	--	-0.176	0.321
Well Water	--	--	-0.047	0.793
Tap Water	--	--	0.158	0.362
Filtered Water	--	--	0.023	0.909
Rain Water	--	--	-0.022	0.901
Swimming	--	--	0.378	0.025*
River Flooding	--	--	-0.505	0.027*

Industrial Incin.	--	--	0.054	0.750
Car Exhaust	--	--	0.047	0.781
Trash Burning	--	--	-0.151	0.407
Municipal Incin.	--	--	-0.191	0.280
Older Age	--	--	0.661	<0.001**
Smoking	--	--	0.230	0.175
Fish	--	--	-0.243	0.553
River Fish	--	--	-0.058	0.819
Touching/Washing	--	--	0.183	0.263
Breathing Air	--	--	-0.043	0.806
Living on Soil	--	--	0.186	0.373
Eating Game	--	--	-0.669	0.007*
Transport	--	--	-0.060	0.705

*Significant (p<.05)
*Highly significant (p≤.001)

Table M.5 Linear Regression of Concern about Risk by Receiver Characteristics and Information Received, With and Without Selected Mental Models Variables

	Concern about Risk			
	Linear regression [a] Without mental models N=751 F(13, 737)=26.43 p-value <0.001		Linear regression [b] With mental models N=748 F(38, 709)=12.32 p-value <0.001	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	-0.083	<0.001**	-0.062	0.008*
Female Gender	0.147	0.032*	0.082	0.224
Minority Status	0.262	0.027*	0.169	0.149
Numeracy	-0.043	0.234	-0.042	0.240
Education	-0.012	0.751	-0.002	0.964
Having a Child	-0.020	0.799	0.014	0.856
Mistrust	0.911	<0.001**	0.728	<0.001**
Working for a Chemical Co.	-0.147	0.102	-0.132	0.134
Floodplain Resident	0.008	0.912	-0.016	0.810
Jackson/Calhoun Resident	(omitted)	(omitted)	(omitted)	(omitted)
Information Received				
Familiarity with Dioxins	0.006	0.938	0.012	0.870
UMDES Participation	-0.224	0.004*	-0.168	0.025*
UMDES Brochures	-0.019	0.814	-0.021	0.780

Looking up Information	0.063	0.738	0.167	0.367
Mental Models				
Mental Models Confidence	--	--	0.121	0.186
Levels Increasing	--	--	0.120	0.109
Past Residence	--	--	-0.162	0.044*
Well Water	--	--	<0.001	0.997
Tap Water	--	--	0.034	0.662
Filtered Water	--	--	-0.107	0.237
River Sediment	--	--	-0.125	0.499
River Banks	--	--	0.026	0.862
Swimming	--	--	0.177	0.022*
River Flooding	--	--	-0.175	0.096
Industrial Incin.	--	--	0.061	0.424
Car Exhaust	--	--	0.074	0.320
Municipal Incin.	--	--	-0.067	0.378
Manmade	--	--	0.029	0.670
Older Age	--	--	0.305	<0.001**
Smoking	--	--	0.102	0.183
Fish	--	--	-0.257	0.169
River Fish	--	--	0.034	0.771
Touching/Washing	--	--	0.092	0.214
Breathing Air	--	--	-0.053	0.510
Living on Soil	--	--	0.076	0.425
Eating Food	--	--	0.012	0.946
Eating Game	--	--	-0.324	0.006*
Moving Soil	--	--	0.059	0.554
Transport	--	--	-0.069	0.340
Constant	--	--	0.967	0.016*

*Significant (p<.05)
*Highly significant (p≤.001)
[a] Residual df=737, R-squared=0.3180, Adjusted R-squared=0.3059
[b] Residual df=709, R-squared=0.3978, Adjusted R-squared=0.3655

M.3 Summary and Discussion of Effects of Mental Models on Risk Judgments

M.3.1 Ease of Judgment and Confidence in Judgment

Effects of mental models variables on ease of judgment and confidence in judgment were similar in the Midland/Saginaw only sample to those seen with the full sample (see Chapter 7). This was as expected, since Jackson/Calhoun residency was not a significant predictor of ease of judgment or confidence in judgment in the full sample. However, two exceptions were noted.

First, unlike in the full sample, working for a chemical company was a significant predictor of confidence in judgment. In addition, unlike in the full sample, the effect of working for a chemical company remained a significant predictor of both ease of judgment and confidence in judgment even after mental models variables were added. It is not surprising that the effect of working for a chemical company should be different in the Midland/Saginaw only sample, since working for a chemical company in Midland and Saginaw (most likely Dow Chemical Company) is much more likely to be related to one's understanding of dioxins than working for a chemical company in Jackson and Calhoun, where no dioxin contamination linked to Dow had occurred.

Second, the effects of several misconceptions were slightly different than in the full sample. Unlike in the full sample, misconceptions regarding the effects of trimming fat from meat and the effects of eating food were significant predictors of ease of judgment, and a misconception regarding current contributions of industrial incinerators was a significant predictor of confidence in judgment. In addition, unlike in the full sample, the misconception regarding eating game was not a significant predictor of ease of judgment. The effects of other misconceptions significant in the full sample remained significant in the Midland/Saginaw only sample.

M.3.2 Judgment of Risk and Concern about Risk

In the full sample, controlling for mental models variables caused Jackson/Calhoun residency to become a significant predictor of concern about risk, with

Jackson/Calhoun residents less concerned about the risk. These effects are one important outcome of analysis of the full sample that could not be replicated in these alternate analyses. Still, effects of mental models variables on judgment of risk and concern about risk were similar in the Midland/Saginaw only sample to those seen with the full sample (see Chapter 7). Three exceptions were noted. First, unlike in the full sample, recalling receiving or reading the 2006 or 2011 UMDES brochures was a significant predictor of judgment of risk. Participants who recalled these brochures reported judgments of lower risk. As these brochures were specific to the situation in Midland/Saginaw, it is not surprising that they would have a larger impact among Midland/Saginaw participants. Second, numeracy, which had been a significant predictor of concern about risk in the full sample ($p=.039$), was not significant in the Midland/Saginaw sample. In the full sample, however, the effect of numeracy became insignificant when mental models variables were added. Third, one mental models misconception that had not been assessed among Jackson/Calhoun participants was a significant predictor of concern about risk among Midland/Saginaw participants. This misconception, regarding the effect of living in Midland/Saginaw in for the past 40-50 years, significantly predicted lower concern about risk. That is, concern about the risk was lower among those participants who believed that someone who had lived in Midland/Saginaw for the past 40-50 years was not likely to have higher dioxin levels than someone of the same age who had recently moved there. The effects of other misconceptions significant in the full sample remained significant in the Midland/Saginaw only sample.

M.4 Regression Analyses Regarding Satisfaction

Linear regression was used to test models of satisfaction including all receiver characteristic and information received variables from previous regressions (to control for non-significant effects). These analyses were repeated for only the Midland/Saginaw sample of participants (see Table M.6), using the mental models variables found to be significant in the analyses presented in Tables M.2 through M.5.

Table M.6 Linear Regression of Satisfaction with Information by Receiver Characteristics, Information Received, and Mental Models, With and Without Risk Judgment Variables: Midland/Saginaw Participants Only

	Satisfaction with Information			
	Linear regression [a] Without risk judgments N=758 F(27, 730)=11.07 p-value <0.001		Linear regression [b] With risk judgments N=744 F(31, 712)=15.63 p-value <0.001	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	0.013	0.345	0.017	0.194
Female Gender	-0.065	0.110	-0.039	0.302
Minority Status	-0.048	0.501	-0.047	0.478
Numeracy	0.036	0.091	0.027	0.175
Education	-0.047	0.036*	-0.037	0.076
Having a Child	-0.035	0.458	-0.034	0.429
Mistrust	-0.270	<0.001**	-0.116	0.003*
Working for a Chemical Co.	0.149	0.005*	0.105	0.032*
Floodplain Resident	-0.057	0.161	-0.053	0.160
Jackson/Calhoun Resident	(omitted)	(omitted)	(omitted)	(omitted)
Information Received				
Familiarity with Dioxins	0.300	<0.001**	0.225	<0.001**
UMDES Participation	0.014	0.764	-0.028	0.507
UMDES Brochures	0.200	<0.001**	0.178	<0.001**
Looking up Information	-0.237	0.030*	-0.210	0.044*
Mental Models				
Confidence in Mental Model	0.117	0.035*	0.069	0.180
Chemical Mfg.	-0.028	0.651	0.019	0.742

Dow Burying Waste	-0.008	0.843	0.009	0.815
Past Residence	0.129	0.006*	0.073	0.093
Well Water	0.007	0.879	0.044	0.303
Swimming	-0.054	0.214	-0.031	0.444
River Flooding	0.034	0.560	-0.020	0.709
Industrial Incin.	0.033	0.464	0.009	0.821
Older Age	0.008	0.844	0.047	0.236
Processed Foods	0.069	0.108	0.043	0.287
Trimming Meat	-0.053	0.200	-0.040	0.300
Property Values	0.035	0.565	0.004	0.944
Eating Game	0.121	0.064	0.039	0.522
Water Drinking	-0.079	0.050	-0.044	0.234
Risk Judgment				
Ease of Judgment	--	--	0.067	0.001**
Confidence in Judgment	--	--	0.111	<0.001**
Judgment of Risk	--	--	-0.044	0.102
Concern about Risk	--	--	-0.096	0.001**
Constant	2.741	<0.001**	2.328	<0.001**

*Significant (p<.05)
**Highly significant (p≤.001)
[a] Residual df=730, R-squared=0.2904, Adjusted R-squared=0.2642
[b] Residual df=712, R-squared=0.4050, Adjusted R-squared=0.3791

M.5 Summary and Discussion of Effects on Satisfaction

Results from analysis of only Midland/Saginaw participants were very consistent with results from the full sample, as expected, since the variable representing Jackson/Calhoun residency was not a significant predictor of satisfaction in the full sample. Three exceptions were noted. First, and most significantly, judgment of the risk was no longer a significant predictor of satisfaction. However, in the full sample, it had been the least significant of the risk judgment variables, and it still had a p-value close to 0.10 (p=0.102). Second, the variable representing looking up information, which had not been significant in any analyses in the full sample, significantly negatively affected satisfaction in the Midland/Saginaw only sample. Only a small number of

Midland/Saginaw participants (<4%) or Jackson/Calhoun participants (10%) looked up information in completing the survey. Those participants in Midland/Saginaw may have looked up information because they were dissatisfied with the information they had, or attempted to look up information and been dissatisfied with what they found. Third, the misconception regarding eating game was no longer a significant predictor of satisfaction, and was replaced by the misconception regarding past residence in Midland/Saginaw. As in the full sample, the effect of this misconception was no longer significant when risk judgment variables were added to the regression.

M.6 Conclusions Regarding Alternate Analyses

In these alternate analyses using the sample of participants residing in Midland/Saginaw only, several differences were seen. As expected, many of these were regarding mental models misconceptions that were not assessed among Jackson/Calhoun residents. Despite some changes in the effects of these and other variables, overall conclusions regarding the effects of other mental models variables on risk judgments (i.e., effects of average mental models confidence) and the effects of risk judgment variables on satisfaction did not change. Specifically, the effects of risk judgments on satisfaction remained similar in magnitude, direction, and significance, as shown in Table M.7 below.

Table M.7 Effects of Risk Judgments on Satisfaction, in Full Sample and in Midland/Saginaw Only Sample

	Effect on Satisfaction in Regression with Full Sample (From Chapter 8)		**Effect on Satisfaction in Midland/Saginaw Only Sample (From Table M.6)**	
	Coef.	**p-value**	**Coef.**	**p-value**
Ease of Judgment	0.074	<0.001**	0.067	0.001**
Confidence in Judgment	0.113	<0.001**	0.111	<0.001**
Judgment of Risk	-0.051	0.041*	-0.044	0.102
Concern about Risk	-0.103	<0.001**	-0.096	0.001**

Appendix N

Regressions for Use in Mediation Analyses in Chapter 8

In Chapter 8, mediation of the effects of receiver characteristics, information received, and mental models variables on satisfaction by risk judgments were assessed. To conduct these assessments, regressions were needed to assess the effects of these variables on risk judgments, controlling for the other variables used in regressions of satisfaction. These regressions are reported in Tables N.1 and N.2 below.

Table N.1 Ordered Logistic Regression of Ease of Judgment and Confidence in Judgment by Receiver Characteristics and Information Received, and Selected Mental Models Variables

	Ease of Judgment		Confidence in Judgment	
	Ordered logistic regression N=847 LR chi2(25)=98.62 p-value <0.001		Ordered logistic regression N=847 LR chi2(25)=144.29 p-value <0.001	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	-0.090	0.052	-0.083	0.068
Female Gender	-0.074	0.583	-0.071	0.594
Minority Status	-0.338	0.194	-0.044	0.862
Numeracy	-0.008	0.912	0.021	0.767
Education	0.021	0.771	-0.055	0.443
Having a Child	-0.066	0.672	0.058	0.707
Mistrust	-0.635	<0.001*	-0.448	<0.001*
Working for a Chemical Co.	0.334	0.052	0.259	0.129
Floodplain Resident	-0.065	0.645	-0.048	0.731
Jackson/Calhoun Resident	-0.214	0.373	-0.380	0.111
Information Received				
Familiarity with Dioxins	0.347	0.020*	0.899	<0.001*
UMDES Participation	0.186	0.226	0.058	0.706
UMDES Brochures	0.060	0.683	0.173	0.240
Looking up Information	-0.209	0.509	0.116	0.709
Mental Models				
Confidence in Mental Model	0.597	0.001*	0.834	<0.001*
Chemical Mfg.	-0.246	0.238	-0.499	0.017
Levels Increasing	-0.065	0.662	-0.238	0.104
Swimming	-0.026	0.852	-0.038	0.788
River Flooding	0.157	0.437	0.127	0.512
Industrial Incin.	0.242	0.085	0.409	0.004*
Older Age	-0.167	0.211	0.000	0.998
Trimming Meat	-0.249	0.066	-0.113	0.405
Property Values	0.283	0.141	0.517	0.007*
Eating Game	0.523	0.015*	-0.012	0.952
Water Drinking	-0.159	0.223	-0.276	0.033*

*Significant (p<.05)
**Highly significant (p≤.001)

Table N.2 Regression of Judgment of Risk and Concern about Risk by Receiver Characteristics and Information Received, and Selected Mental Models Variables

	Judgment of Risk		Concern about Risk	
	Ordered logistic regression N=749 LR chi2(25)=319.5 p-value <0.001		Linear regression [a] N=748 F(25, 823)=19.11 p-value <0.001	
Parameter	**Coef.**	**p-value**	**Coef.**	**p-value**
Receiver Characteristics				
Age (per 10 years)	-0.151	0.002*	-0.082	<0.001**
Female Gender	0.074	0.592	0.090	0.157
Minority Status	0.441	0.097	0.174	0.122
Numeracy	0.070	0.338	-0.048	0.146
Education	0.018	0.803	-0.003	0.925
Having a Child	-0.037	0.820	0.042	0.567
Mistrust	1.589	<0.001**	0.769	<0.001**
Working for a Chemical Co.	-0.107	0.556	-0.077	0.353
Floodplain Resident	-0.051	0.727	-0.010	0.881
Jackson/Calhoun Resident	-0.578	0.021*	-0.240	0.038
Information Received				
Familiarity with Dioxins	0.182	0.238	0.003	0.961
UMDES Participation	-0.097	0.545	-0.170	0.020*
UMDES Brochures	-0.289	0.061	-0.004	0.951
Looking up Information	0.270	0.407	0.198	0.189
Mental Models				
Confidence in Mental Model	0.043	0.820	0.118	0.169
Chemical Mfg.	-0.142	0.501	-0.031	0.749
Levels Increasing	0.181	0.235	0.125	0.080
Swimming	0.477	0.001**	0.238	<0.001**
River Flooding	-0.625	0.003*	-0.243	0.010*
Industrial Incin.	0.191	0.192	0.092	0.171
Older Age	0.538	<0.001**	0.210	0.001**
Trimming Meat	-0.057	0.683	-0.001	0.981
Property Values	0.033	0.872	0.015	0.867
Eating Game	-0.640	0.004*	-0.315	0.002*
Water Drinking	-0.011	0.935	0.005	0.940
Constant	--	--	0.929	0.006*

*Significant (p<.05)
**Highly significant (p≤.001)
[a] Residual df=823, R-squared=0.3672, Adjusted R-squared=0.3480

Appendix O

Tables of Additional Descriptive Results

This appendix provides tables of additional descriptive data regarding survey responses, as well as composite variables and scales created from survey responses.

O.1 Scales and Composite Variables

O.1.1 Numeracy Scale

Table O.1 Items in Scale Regarding Numeracy

Survey Item	Coding of Responses
91. How good are you at working with fractions?	1=Not at all good, 2, 3, 4, 5=Extremely good
92. How good are you at working with percentages?	1=Not at all good, 2, 3, 4, 5=Extremely good
93. How good are you at calculating a 15% tip?	1=Not at all good, 2, 3, 4, 5=Extremely good
94. How good are you at figuring out how much a shirt will cost if it is 25% off?	1=Not at all good, 2, 3, 4, 5=Extremely good
95. When reading the newspaper, how helpful do you find tables and graphs that are parts of a story?	1=Not at all helpful, 2, 3, 4, 5=Extremely helpful
96. When people tell you the chance of something happening, do you prefer that they use words ("it rarely happens") or numbers ("there's a 1% chance")?	1=Always prefer words, 2, 3, 4, 5=Always prefer numbers
97. When you hear a weather forecast, do you prefer predictions using percentages (e.g., "there will be a 20% chance of rain today") or predictions using only words ("e.g., there is a small chance of rain today")?	1=Always prefer percentages, 2, 3, 4, 5=Always prefer words[a]
98. How often do you find numerical information to be useful?	1=Never, 2, 3, 4, 5=Always

[a] Anchors for item 97 were reversed for this scale.

Table N.2 Inter-Item Correlations in Eight-Item Numeracy Scale

	Item 91	Item 92	Item 93	Item 94	Item 95	Item 96	Item 97	Item 98
Item 91	1.00							
Item 92	.82	1.00						
Item 93	.69	.75	1.00					
Item 94	.61	.69	.84	1.00				
Item 95	.42	.49	.44	.43	1.00			
Item 96	.42	.44	.49	.43	.47	1.00		
Item 97	.21	.24	.24	.24	.22	.41	1.00	
Item 98	.51	.52	.50	.48	.57	.59	.38	1.00

Scale mean=4.55, SD=1.08, Cronbach's alpha=0.87

O.1.2 Mistrust of Government and Industry Scale

Table O.3 Items Considered for Scale Regarding Mistrust of Government/Industry

Survey Item	Original Coding of Responses [a]
14. The current balance of benefits and risks from industry in my community is:	1=Benefits outweigh risks, 2=Benefits and risks are roughly equal, 3=Risks outweigh benefits
15. How much of the time do you trust the federal, state and/or local government to do what is right?	1=Never, 2, 3, 4, 5=Always [b]
16. In general, do you agree or disagree with the following statement? "Government has gone too far in regulating business and interfering with the free enterprise system." [c]	1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree [b]
17. How much of a problem, if at all, is government corruption today?	1=Not at all a problem, 2, 3, 4, 5=Very much a problem
18. I am outraged whenever industry and/or government allows dioxin contamination to occur, no matter how they respond after the contamination is identified.	1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree
19. When there is a really serious health or environmental problem, then public officials will take care of it.	1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree [b]
20. Until they alert me about a specific problem, I don't really have to worry.	1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree [b]
21. I have very little control over risks to my health. [c]	1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree
22. Those in power often withhold information about things that are harmful to us.	1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree
23. The land, air, and water around us are, in general, more contaminated now than ever before.	1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree
24. Continued economic growth can only lead to pollution and depletion of natural resources.	1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree

[a] Anchors were converted to a five-point scale. Three-point anchors (item 14) were converted as follows: 1=1, 2=3, 3=5. Four-point anchors (items 16, 18-24) converted as follows: 1=1, 2=2.33, 3=3.67, 4=5.
[b] Anchors for items 15, 16, 19, and 20 were reversed for this scale.
[c] Removed from scale.

Table O.4 Inter-Item Correlations in Eleven-Item Mistrust of Government and Industry Scale, and Reduction to Nine Items

	Item 14	Item 15	Item 16 [a]	Item 17	Item 18	Item 19	Item 20	Item 21 [a]	Item 22	Item 23	Item 24
Item 14	1.00										
Item 15	.14	1.00									
Item 16 [a]	.17	-.13	1.00								
Item 17	.10	.43	-.26	1.00							
Item 18	.33	.17	.09	.19	1.00						
Item 19	.14	.30	<.01	.27	.18	1.00					
Item 20	.30	.24	.13	.15	.39	.29	1.00				
Item 21 [a]	.12	.11	-.01	.07	.14	.09	-.01	1.00			
Item 22	.26	.38	-.05	.32	.41	.25	.36	.17	1.00		
Item 23	.29	.18	.06	.18	.37	.13	.29	.12	.40	1.00	
Item 24	.23	.04	.04	.07	.27	.02	.16	.13	.25	.51	1.00

Scale mean=3.38, SD=0.52, Cronbach's alpha=0.70

[a] Removed from scale. Reduced scale mean=3.50, SD=0.59, Cronbach's alpha=0.74

O.1.3 Receipt and Use of UMDES Communications

Table O.5 Phase 3 Participants' Receipt and Use of UMDES Brochures

Survey Item	Overall	M/S Non-UMDES	M/S UMDES	J/C UMDES
2006 Brochure				
In 2006, the University of Michigan Dioxin Exposure Study (UMDES) published a brochure of the results of their study. You may or may not have received this brochure. Did you receive this brochure?	40.2% (of 964)	12.4% (of 442)	57.3% (of 407)	50.4% (of 115)
If yes, did you read it?	64.5% (of 471)	35.8% (of 109)	74.3% (of 292)	68.6% (of 70)
2011 Brochure				
In January 2011, the UMDES published a second brochure of results from their study. You may or may not have received this brochure. Did you receive this brochure?	22.5% (of 963)	11.8% (of 442)	27.6% (of 404)	11.1% (of 117)
If yes, did you read it?	43.2% (of 343)	36.9% (of 103)	48.8% (of 207)	27.3% (of 33)
Composite Variable				
Recalled Receipt or Reading of Either Brochure	42.0% (of 1036)	16.8% (of 464)	66.8% (of 440)	47.7% (of 132)

Table O.6 Phase 3 Participants' Receipt of UMDES Results

UMDES Data Item	M/S UMDES	J/C UMDES
Blood		
Sampled	78.9% (of 440[a])	75.0% (of 132)
Received results	75.6% (of 438)	71.2% (of 132)
Received high[b] results	25.8% (of 431)	12.2% (of 131)
Soil		
Sampled	66.8% (of 440)	57.6% (of 132)
Received results	43.5% (of 439)	29.6% (of 132)
Received high[b] results	11.6% (of 440)	0.8% (of 132)
Dust		
Sampled	67.3% (of 440)	63.6% (of 132)
Received results	45.8% (of 439)	36.4% (of 132)
Composite Variables		
Received one or more results	76.0% (of 438)	72.7% (of 132)
Received one or more high results	33.0% (of 434)	13.0% (of 131)

[a] Sample sizes are not uniform due to missing data.
[b] High blood results defined as over 75th percentile for age range reported in UMDES results letter; high soil results defined as over 90 ppt TEQ; no reference point available for dust results.

O.2 Descriptive Results Regarding Variables Analyzed

O.2.1 Summary Statistics

Table O.7 provides descriptive results (mean, standard deviation, min, and max) for each variable. Variable names are also provided for reference to the larger CPOD dataset.

Table O.7 Descriptive Results Regarding Variables Analyzed

Parameter (Description) / Variable Name	Mean	Std. Dev.	Min	Max
Receiver Characteristics				
Age (divided by 10 years) / age10	5.39	1.47	2	9
Female (Binary, 1=female) / female	53%	50%	0	1
Minority (Binary, 1=minority)/minority	10%	30%	0	1
Numeracy (1-6, eight-item scale) / snsscore	4.55	1.08	1	6
Education (1-4 grouping) / educ4	2.17	1.00	1	4
Having a Child (Binary, 1=having any children) / child_all	78%	42%	0	1
Mistrust (1-5, nine-item scale) / scale_mistrust_iterated	3.50	0.58	1.74	5
Working for a Chemical Co. (Binary, 1=having ever worked for a chemical company) / workchem_all	17%	37%	0	1

Residing Near Contamination (Binary, 1=residing in Tittabawassee River Floodplain or Near Floodplain) / fp_all	52%	50%	0	1
Residing Far from Contamination (Binary, 1=residing in Jackson/Calhoun counties) / jc	13%	33%	0	1
Information Received				
Familiarity with Dioxins (Binary, 1=having heard "a lot" about dioxins) / familiarvery_all	35%	47%	0	1
UMDES Participation (Binary, 1=UMDES participant) / umdes	55%	50%	0	1
UMDES Brochures (Binary, 1=recalled receipt or reading of 2006 or 2011 UMDES brochures) / brochures_either_all	42%	49%	0	1
Looking Up Information (Binary, 1=looking up information in completing survey) / lookupinfo	4%	21%	0	1
Mental Models				
Confidence in Mental Model (Average of 1-3 rating of confidence in mental models answers) / avgconf	2.08	0.38	1	3
Risk Judgments				
Ease of Judgment (1-5 rating) / easejudge	2.57	1.10	1	5
Confidence in Judgment (1-5 rating) / confjudge	2.68	1.21	1	5
Judgment of Risk (1-5 rating) / threatjudge	3.28	1.04	1	5
Concern about Risk (1-5, five-item scale) / scale_concern	3.42	1.07	1	5
Satisfaction				
Satisfaction Scale (1-4, three-item scale) / scale_informed	2.33	0.61	1	4

O.2.2 Missing Data

Table O.8 Missing Data for Variables Analyzed

Parameter	Observations (n)	Percent Missing
Receiver Characteristics		
Age (per 10 years)	1009	2.61%
Female Gender	1013	2.22%
Minority Status	975	5.89%
Numeracy	1031	0.48%
Education	975	5.89%
Having a Child	1013	2.22%
Mistrust	1031	0.48%
Working for a Chemical Co.	1013	2.22%
Floodplain Resident	1036	0% [a]
Jackson/Calhoun Resident	1036	0% [a]
Information Received		
Familiarity with Dioxins	1036	0% [b]
UMDES Participation	1036	0% [a]

UMDES Brochures	1036	0% [b]
Looking up Information	1022	1.35%
Mental Models		
Confidence in Mental Model	1026	0.97%
Risk Judgments		
Ease of Judgment	955	7.82% [c]
Confidence in Judgment	955	7.82% [c]
Judgment of Risk	953	8.01% [c]
Concern about Risk	958	7.53% [c]
Satisfaction		
Satisfaction	966	6.76% [c]

[a] Location of residence and UMDES participation was known for all participants.
[b] Those participants with missing data regarding familiarity were assumed not to be very familiar with dioxins. Those participants with missing data regarding receipt or reading of UMDES brochures were assumed not to have received or read them.
[c] Percent missing for risk judgment and satisfaction variables includes those participants whose responses were removed due to skip logic requesting them to skip these questions.

Table O.9 Means/Proportions of Variables Analyzed, by UMDES Group

	Mean				One-Way ANOVA	
Variable	**Overall**	**M/S Non-UMDES**	**M/S UMDES**	**J/C UMDES**	**F Statistic**	**p-value**
Receiver Characteristics						
Age (per 10 years)	5.39	5.25	5.48	5.58	3.84	.02*
Female Gender	53%	49%	55%	63%	4.47	.01*
Minority Status	10%	14%	7%	7%	7.99	<.01*
Numeracy	4.55	4.61	4.55	4.33	3.55	.03*
Education	2.16	2.22	2.16	1.98	3.07	.05*
Having a Child	78%	80%	75%	80%	2.04	.13
Mistrust	3.50	3.49	3.45	3.68	7.53	<.01*
Working for a Chemical Co.	17%	19%	16%	12%	1.97	.14
Floodplain Resident	52%	55%	65%	(0%)	--	--
Jackson/Calhoun Resident	13%	(0%)	(0%)	(100%)	--	--
Information Received						
Familiarity with Dioxins	35%	34%	44%	10%	26.99	<.01*
UMDES Participation	55%	(0%)	(100%)	(100%)	--	--
UMDES Brochures	42%	17%	67%	48%	150.62	<.01*
Looking up Information	4%	4%	3%	10%	6.27	<.01*
Mental Models						
Confidence in Mental Model	2.08	2.08	2.09	2.05	0.49	.61
Risk Judgments						
Ease of Judgment	3.28	2.53	2.67	2.41	3.25	.04*

Confidence in Judgment	3.43	2.66	2.77	2.39	4.44	.01*
Judgment of Risk	3.28	3.38	3.18	3.32	3.96	.02*
Concern about Risk	3.43	3.53	3.31	3.47	4.60	.01*
Satisfaction						
Satisfaction	2.33	2.26	2.42	2.26	8.49	<.01*

O.2.3 Inter-Variable Correlations

Table O.10 Correlations Between Variables Analyzed

	Receiver Characteristics	Age (per 10 years)	Female Gender	Minority Status	Numeracy	Education	Having a Child	Mistrust	Working for a Chemical Co.	Floodplain Resident	Jackson/Calhoun Resident
Receiver Characteristics											
Age (per 10 years)		1.00									
Female Gender		-.07	1.00								
Minority Status		-.02	.11	1.00							
Numeracy		-.09	-.16	-.12	1.00						
Education		-.15	-.06	-.12	.39	1.00					
Having a Child		.10	-.02	-.06	.07	-.05	1.00				
Mistrust		-.05	.17	.04	-.09	-.23	.00	1.00			
Working for a Chemical Co.		.00	-.16	-.01	.00	-.05	-.03	-.11	1.00		
Floodplain Resident		.02	-.05	-.09	.10	.12	.03	-.11	-.07	1.00	
Jackson/Calhoun Resident		.06	.08	-.06	-.05	-.06	.05	.12	-.03	-.38	1.00
Information Received											
Familiarity with Dioxins		.11	-.04	-.05	.20	.17	-.01	-.06	.04	.17	-.19
UMDES Participation		.08	.06	-.11	-.06	-.08	-.07	.02	-.04	-.03	.31
UMDES Brochures		.01	-.04	-.09	.03	.04	-.01	-.06	.00	.11	.09
Looking up Information		.09	.11	-.04	-.02	-.05	.01	.07	-.03	-.08	.15
Mental Models											

Confidence in Mental Model		.07	-.01	.03	.12	-.02	-.01	.13	.00	.04	-.03
Risk Judgments											
Ease of Judgment		-.02	-.08	-.04	.06	.07	-.02	-.19	.09	.03	-.06
Confidence in Judgment		.00	-.06	.00	.07	.03	.00	-.12	.09	.06	-.11
Judgment of Risk		-.13	.13	.10	-.03	-.09	-.04	.48	-.07	-.05	.00
Concern about Risk		-.15	.17	.12	-.11	-.13	-.01	.52	-.10	-.04	.00
Satisfaction											
Satisfaction		.11	-.13	-.06	.13	.06	-.02	-.30	.16	.03	-.04

	Information Received	Familiarity with Dioxins	UMDES Participation	UMDES Brochures	**Mental Models**	Looking up Information	Confidence in Mental Model	**Risk Judgments**	Ease of Judgment	Confidence in Judgment	Judgment of Risk	Concern about Risk
Information Received												
Familiarity with Dioxins		1.00										
UMDES Participation		.01	1.00									
UMDES Brochures		.21	.47	1.00								
Looking up Information		-.04	.04	.04		1.00						
Mental Models												
Confidence in Mental Model		.28	.01	.10		.04	1.00					
Risk Judgments												
Ease of Judgment		.16	.03	.08		-.04	.13		1.00			
Confidence in Judgment		.29	.00	.10		-.01	.21		.53	1.00		
Judgment of Risk		-.02	-.09	-.12		.03	.05		-.23	-.04	1.00	
Concern about Risk		-.06	-.11	-.09		.05	.08		-.26	-.08	.76	1.00
Satisfaction												
Satisfaction		.33	.09	.23		-.06	.15		.39	.40	-.34	-.39

Appendix P

Summary of Regressions

This appendix presents a summary table of the regressions conducted in this research, both in the primary set of analyses with the full dataset and the alternate set of analyses with Midland/Saginaw participants only.

P.1 Primary Analyses with Full Dataset

A summary table of results from the main regression models conducted in results chapters 6-8 is shown in Table P.1 below. Each column pertains to a single regression model, with cells denoting positive and negative regression coefficients. Significant ($p<.05$) and highly significant ($p\leq.001$) regression coefficients are marked with asterisks. Variables, arranged by row, are those included in each model, with blank cells signifying variables that were not included in that model.

Table P.1 Summary of Regression Models Regarding Risk Judgments and Satisfaction with Information

	Regression Models									
	Ease of Judgment		Confidence in Judgment		Judgment of Risk		Concern about Risk		Satisfaction with Information	
Parameter	**1** [a]	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**2**	**3**
Receiver Characteristics										
Age (per 10 years)	– [b]	–	–	–	–**	–*	–**	–**	+	+
Female Gender	–	–	–	–	+	+	+*	+	–	–
Minority Status	–	–	+	–	+*	+	+*	+	–	–
Numeracy	+	–	+	+	+	+	–*	–	+	+
Education	+	+	–	–	–	+	–	–	–	–
Having a Child	–	–	+	+	–	–	+	+	–	–
Mistrust	–**	–**	–**	–**	+**	+**	+**	+**	–**	–*
Working for a Chemical Co.	+*	+	+	+	–	–	–	–	+*	+*
Floodplain Resident	–	–	–	–	+	–	+	+	–	–
Jackson/Calhoun Resident	–	–	–	–	–	–	–	–*	+	+
Information Received										
Familiarity with Dioxins	+**	+*	+**	+**	+	+	+	+	+**	+**
UMDES Participation	+	+	+	+	–	–	–*	–*	+	–
UMDES Brochures	+	+	+	+	–	–	–	+	+**	+**
Looking up Information	–	–	+	+	+	+	+	+	–	–
Mental Models										
Confidence in Mental Model		+**		+**		+		+	+*	+
Chemical Mfg.				–*					–	+
Levels Increasing				–		+		+	–	+
Swimming						+*		+*	–	–
River Flooding						–*		–*	+	–
Industrial Incin.				+		+		+	+	+
Older Age						+**		+**	+	+
Trimming Meat		–							–	–
Property Values		+		+*					+	–
Eating Game		+*				–*		–*	+*	+
Water Drinking				–*					–	–
Risk Judgments										
Ease of Judgment										+**
Confidence in Judgment										+**
Judgment of Risk										–*
Concern about Risk										–**

[a] Key to regression models:
1 = Regression with receiver characteristics and information received only
2 = Regression with receiver characteristics, information received, and mental models variables

3 = Regression with receiver characteristics, information received, mental models, and risk judgment variables

[b] Key to cell entries:

+ = Positive regression coefficient

– = Negative regression coefficient

* = Significant (p<.05)

** = Highly significant (p≤.001)

Blank = Parameter not included in regression

P.2 Alternate Analyses with Midland/Saginaw Participants Only

A summary table of results from the alternate regression models conducted in Appendix M is shown in Table P.2 below. As with the full dataset, each column pertains to a single regression model, with cells denoting positive and negative regression coefficients. Significant (p<.05) and highly significant (p≤.001) regression coefficients are marked with asterisks. Variables, arranged by row, are those included in each model, with blank cells signifying variables that were not included in that model.

Table P.2 Summary of Regression Models in Alternate Analyses Regarding Risk Judgments and Satisfaction with Information

	Regression Models									
	Ease of Judgment		Confidence in Judgment		Judgment of Risk		Concern about Risk		Satisfaction with Information	
Parameter	**1 [a]**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**2**	**3**
Receiver Characteristics										
Age (per 10 years)	– [b]	–*	–	–	–**	–*	–**	–*	+	+
Female Gender	–	–	–	–	+	+	+*	+	–	–
Minority Status	–	–	+	+	+*	+	+*	+	–	–
Numeracy	+	–	+	+	+	+	–	–	+	+
Education	–	–	–	–	+	+	–	–	–*	–
Having a Child	–	–	–	–	–	–	–	+	–	–
Mistrust	–**	–**	–*	–*	+**	+**	+**	+**	–**	–*
Working for a Chemical Co.	+*	+*	+*	+*	–	–	–	–	+*	+*
Floodplain Resident	–	–	–	–	+	–	+	–	–	–
Jackson/Calhoun Resident										
Information Received										
Familiarity with Dioxins	+**	+*	+**	+**	+	+	+	+	+**	+**
UMDES Participation	+	+	+	+	–	–	–*	–*	+	–
UMDES Brochures	+	+	+	+	–*	–*	–	–	+**	+**
Looking up Information	–	–	–	–	+	+	+	+	–*	–*
Mental Models										
Confidence in Mental Model		+*		+**		+		+	+*	+
Chemical Classification				+						
Chemical Mfg.				–*					–	+
Dow as a Source		+		+						
Dow River Waste		+		+						
Dow Burying Waste				–					–	+
Levels Increasing				–		+		+		
Past Residence		+		+		–		–*	+*	+
Well Water		–				–		+	+	+
Tap Water						+		+		
Filtered Water						+		–		
River Sediment								–		
River Banks		+						+		
Rain Water						–				
Swimming						+*		+*	–	–
River Flooding						–*		–	+	–
Industrial Incin.				+*		+		+	+	+
Car Exhaust								+		
Trash Burning				–		–				
Municipal Incin.				–		–		–		

Products				–						
Mannmade								+		
Farm Chemicals				+						
Older Age						+**		+**	+	+
Smoking						+		+		
Fish						–		–		
River Fish						–		+		
Processed Foods		+*							+	+
Trimming Meat		–*							–	–
Property Values		+		+*					+	+
Touching/Washing						+		+		
Breathing Air				–		–		–		
Living on Soil						+		+		
Eating Food		+		+				+		
Eating Game		+				–*		–*	+	+
Moving Soil								+		
Transport						–		–		
Water Drinking				–*					–	–
Risk Judgments										
Ease of Judgment										+**
Confidence in Judgment										+**
Judgment of Risk										–
Concern about Risk										–**

[a] Key to regression models:
1 = Regression with receiver characteristics and information received only
2 = Regression with receiver characteristics, information received, and mental models variables
3 = Regression with receiver characteristics, information received, mental models, and risk judgment variables

[b] Key to cell entries:
+ = Positive regression coefficient
– = Negative regression coefficient
* = Significant ($p<.05$)
** = Highly significant ($p\leq.001$)
Blank = Parameter not included in regression