A CASE STUDY OF BISPHENOL A (BPA) RISK COMMUNICATION: GOVERNMENT AGENCIES, INTEREST GROUPS AND THE MEDIA

by
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A dissertation submitted to Johns Hopkins University in conformity with the requirements for the degree of Doctor of Philosophy.

Baltimore, Maryland

October 2014

Dissertation Abstract

Bisphenol A (BPA) is a high-production chemical found in the food supply that has been the subject of public health concerns over the last decade. Government agencies, public health and environmental organizations, industry interest groups and the media have presented conflicting information and conclusions about BPA's safety. This topic provided a rich context to explore risk communication on a politicized and scientifically complex issue with implications for effective risk management and regulatory decision-making. This case study of BPA risk communication includes a qualitative review of stakeholder website documents using the risk assessment framework, a quantitative news media content analysis and an analysis of semi-structured key stakeholder interviews. Findings confirmed that mixed messages were prevalent in the news media. Key stakeholders disagreed on the public health impacts of BPA. Secondly, distrust among stakeholders and perceived lacks of objectivity were highlighted as key challenges in conveying risks to the public. Third, risk management of BPA lacked focus on comprehensive solutions.

The success of risk management efforts depends on the ability of public health professionals to translate data and communicate about complex scientific issues. Although BPA is just one example of the many common chemical exposures people face, it is emblematic of environmental policy and risk assessment in the U.S., with its history of controversy, conflicting messages and complicated regulatory structure. BPA and other environmental chemicals present emerging challenges to public health professionals in different capacities as researchers, advocates, and regulators. This research fills a gap

in the literature on risk communication and news media coverage of a major risk issue of worldwide importance with implications for current and future generations.

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Acknowledgements

I owe a huge debt of gratitude to the staff of the Center for a Livable Future (CLF) and the funders of the CLF-Lerner Fellowship. Without the continuing financial and academic support of the CLF, this dissertation would not be possible. Additionally, I very much appreciate the sense of community I experienced at the CLF. In addition to their unique and important mission, the kindness and camaraderie of its staff, fellows and research assistants made the Center a really fantastic organization to be a part of. I particularly want to thank Bob Lawrence, Shawn McKenzie, Keeve Nachman, Anne Palmer, Dave Love, Amanda Behrens, Meg Burke, Chris Stevens, Joci Raynor, Shawnel McClendon, and Darlene Jackson for all their assistance, and for their faith in me. I would be remiss if I didn't highlight the contributions of Roni Neff as my mentor. Since I knocked on her office door in 2008, she has been a phenomenal teacher and allowed me many opportunities that have enhanced my training—from coauthoring a textbook chapter to developing and analyzing a research survey, among many others. I will spend my career attempting to repay my debt to the CLF through my work as a public health practitioner focusing on the environmental health and food system issues that the Center holds dear.

A huge thank you to my advisor, Tom Burke, who from day one has assured me that I deserve to be here and that I have what it takes to make it to this finish line. Tom's guidance and thoughtful advice were critical over the past four years, and I have learned a great deal by watching him teach, lead and inspire others. When I would come into his office confused about what I wanted to research and why, Tom always very clearly helped me step back and see the forest, not just the trees. I also very much appreciate his

recognition of the importance of both hard work and well-deserved downtime (or a stress-relieving run). I feel very privileged to have been his advisee and thus benefit from the immense expertise of a true public health leader.

I would also like to thank the faculty members who have been incredibly helpful in shaping my dissertation research and very generous with their time. In particular, Colleen Barry, Keshia Pollack, Kate Clegg Smith, Shannon Frattaroli and Lainie Rutkow have all been important mentors to me and taught me a great deal about public health policy as well as the research methods I employ in this dissertation. Special thanks to Beth Resnick not only for her advice and thoughtful feedback related to my dissertation, but also for the many opportunities she has afforded me in the Office of Public Health Practice and Training and as a teaching assistant. Some of the most valuable learning experiences of my training were working on community projects with Beth and other colleagues.

Other faculty members who have not been directly involved in my dissertation but nonetheless were very important to my training include Edyth Schoenrich, Josh Horwitz, and Mary Fox. Thank you for allowing me to learn from you. I also thank Robin Dranbauer and Mary Sewell in the Department of Health Policy and Management for their hard work and always being there to help with a question or problem. I also wish to thank the Johns Hopkins Bloomberg School of Public Health at large for all the opportunities it has afforded me in my time as a masters and doctoral student.

I am grateful to my fellow students in Health Policy and Management and the CLF-Lerner Fellows who have been fantastic colleagues and friends (especially Juleen Lam, Meghan McGinty, Megan Clayton and Kyle Dunn). I have learned a great deal

from you and I hope to continue to cross paths throughout our careers. Thank you to former students Jillian Fry, Linnea Laestadius and Beth McGinty for your invaluable advice on my research proposal and dissertation. Betsy Donaldson—thank you for serving as my double coder for my news media content analysis. Although the process was much more involved than we anticipated, I had a lot of fun getting to know you. You are a joy to work with and being responsive to you helped me stay on track.

I also thank the interviewees who participated in this research. I'm grateful for your willingness to provide your perspectives and for seeing value in this work. A heartfelt thank you to Debbie Anderson, who generously helped me with the tedious task of interview transcription. She did a fantastic job (and actually seemed to enjoy it)! I'm so lucky to have you in my life!

To my dad, Allan Truant, thanks for always believing we were capable of anything we wanted to do (and for pushing the benefits of continued education). Now I can to bore you to tears about how *everything* is related to public health, the way you do with microbiology. To my mom, Mary McCarthy, thank you for your constant love and readiness to help in any way you can. My sister Kathleen Truant Rosa and my brother Steven Truant—thank you for your constant spoken and unspoken support. You all make me a better person.

To Flora Truant, or as I knew her, Nona—who often reminded me how my grandfather Joe finished his PhD in just 2½ years—well, it took me a little longer than that but it eventually happened! Although she often told me that school was the most important thing—I have to disagree. There are some things that are much more important—and relationships with friends and family is chief among them. I thank Nona

for teaching me that lesson by example, as well as how to make the absolute best of each situation and squeeze every little bit of joy out of life that you possibly can. This dissertation is dedicated to her memory.

To Russ Anderson—thank you for being my unwavering supporter and best friend. I couldn't imagine having a better person standing by my side. At the end of a long day, you are always there with a big hug. I feel your support constantly, and know you are always there for me. Having you in my life during this process made it infinitely better and a thousand percent more fun. I look forward to many more great times. I love you!

To all my other loved ones and friends—each of you have influenced me and made me stronger. I am lucky to have so many wonderful people in my life. Thank you for making me laugh and helping me enjoy life in the wonderful, fleeting moments that make it up.

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List of Acronyms

ABA: American Beverage Association
ACC: American Chemistry Council
BCF: Breast Cancer Fund
BPA: Bisphenol A
CDC: Centers for Disease Control and Prevention
CU: Consumers Union
DDT: dichlorodiphenyltrichloroethane
DES: Diethylstilbestrol
EDC: Endocrine Disrupting Compound
EFSA: European Food Safety Agency
EPA: Environmental Protection Agency
EWG: Environmental Working Group
FDA: Food and Drug Administration
GMA: Grocery Manufacturers Alliance
HHS: Department of Health and Human Services
IBWA: International Bottled Water Association
IRB: Institutional Review Board
IRIS: Integrated Risk Information System
LOAEL: Lowest Observed Adverse Effects Level
NAMPA: North American Metal Packaging Alliance
NGO: Non-governmental organization
NIEHS: National Institute for Environmental Health Sciences
NOAEL: No Observed Adverse Effects Level
NRC: National Research Council
NRDC: Natural Resources Defense Council
NTP: National Toxicology Program
PBDE: Polybrominated diphenyl ether
PCB: Polychlorinated biphenyl
RfD: Reference Dose
TDI: Tolerable Daily Intake
TSCA: Toxic Substances Control Act

Chapter 1. Introduction

Bisphenol A (BPA) is a common industrial chemical often found in food and beverage containers.[1] The two most common food-related sources are polycarbonate plastics and canned goods. BPA is used as a building block in polycarbonate plastics, a type of hard, clear plastic in some reusable water bottles and baby bottles. Epoxy resins, which line metal food and beverage cans to prevent corrosion, are also commonly made with BPA.[2] While BPA is not a new compound—it was first synthesized in 1891[3]—its production and uses in everyday consumer products has grown tremendously. In 1964, nearly 84,000 pounds of BPA were produced in the U.S. annually; by 2003 that figure was more than 2 billion pounds.[4] In 2011, worldwide BPA production was estimated at more than 8 billion pounds per year,[5] making it one of the highest volume chemicals in use.[6] Other commonly used products containing BPA include thermal receipt paper, power plugs, car parts, dental sealants, flame-retardants, eyeglasses, toys, compact discs (CDs), kitchen appliances and medical equipment.[7-9]

Public Health Significance

Over the past decade, BPA has been the source of public health concerns in light of its definition as an endocrine disrupting compound (EDC).[10,11] Endocrine disruptors are defined by the World Health Organization as "an exogenous substance or mixture that alters function(s) of the endocrine system and consequently causes adverse health effects in an intact organism, or its progeny or (sub)populations."[10] EDCs may mimic or block the effects of natural hormone functions. Endocrine disruptors are of particular concern on a global level due to what is known about the widespread presence of manmade chemicals that affect human and wildlife development. Pesticides, plasticizers and flame-

retardants are common products containing EDCs.[12] Other endocrine disruptors include: polychlorinated biphenyls (PCBs), a group of persistent industrial chemicals banned for most uses since 1979; polybrominated diphenyl ethers (PBDEs) which are flame retardants used in furniture, electronics and other consumer products; phthalates used in plastic products; and dichlorodiphenyltrichloroethane (DDT), a pesticide that is banned in most countries.[13]

Health effects that have been associated with endocrine disruption include reproductive dysfunctions, preterm birth and low birth weight, behavioral disorders, endocrine-related cancers (breast, endometrial, ovarian, prostate, testicular, and thyroid), obesity and Type II diabetes.[13] Fetal and early life are particularly sensitive time periods in development and of higher concern with regard to EDCs. Epidemiological trends over recent decades indicate increases in endocrine-related disorders that are occurring too quickly to be explained by genetic changes alone.[10]

Data from animals and humans has linked BPA with a range of adverse health effects, including cardiovascular effects, sexual dysfunction, infertility, obesity, early puberty, prostate and mammary gland cancers, behavior changes and diabetes.[7,8] BPA is often described as a weak estrogen, meaning it is not as potent as other compounds with similar properties such as estradiol and diethylstilbestrol (DES).[14] In animal tests, BPA has been shown to be a "reproductive, developmental and system toxicant," according to the Environmental Protection Agency (EPA).[15] The estrogenic properties of BPA are of concern because EDCs can mimic naturally occurring hormones and result in biological changes.[16] In the mid-1930s, BPA was used as an estrogen replacement prior to use of DES. DES is a carcinogen to daughters of women treated with the chemical while

pregnant.[12] While causal links to human disease are difficult to establish in light of multiple simultaneous chemical exposures, uncertainty of low dose effects and other factors, BPA exposure has been associated with a variety of health conditions.

The issue of low doses relevant to human exposure levels—and whether they pose health risks—is the subject of ongoing debate. Despite the large body of literature on BPA, uncertainties remain about the risks of human health effects of BPA at current exposure levels, particularly in sensitive populations such as infants and young children.[9] There are also weaknesses in the tools scientists have at their disposal to estimate low dose effects.[23] Further, there is discord among stakeholders about risk management solutions from the individual consumer level to the national policy level.[17]

BPA and Risk Communication

The WHO defines risk communication as "an interactive process of exchange of information and opinion on risk among risk assessors, risk managers, and other interested parties."[18] The definition used by the U.S. Food and Drug Administration (FDA) in a 2011 guidance document reflects the broader reach to the general public: "Risk communication is the term of art used for situations when people need good information to make sound choices."[19] A dilemma for public health practitioners is how to communicate about BPA risks when the science is imperfect (as it will always be) and causal links to disease may be impossible to prove. This is important because risk communication is an essential component of effective risk management.[20]

The media play an important role in conveying the messages from stakeholders as well as influencing the public and policymakers. The majority of Americans get health information from the media.[21] The topics covered in the news convey to the public what is new and worthy of attention. At the same time, controversial stories may be of special

interest to reporters and their readers/viewers, but could lead to conflicts or ambiguity in the overall message.[21] How issues are framed in the media may influence opinions on who is responsible for addressing the problem and the range of potential solutions.[22]

In the case of BPA, there have been conflicting conclusions from key stakeholders, the news media and in the scientific literature itself about the risks posed by BPA. Given the important roles of key stakeholders and the news media in informing consumers about risks and setting a policy agenda, BPA presents a relevant and timely case study on the risk communication of a complex public health concern.

Study Aims and Approach

The success of risk management efforts depends in part on the ability of public health professionals to translate data and communicate about complex scientific issues. Although BPA is just one example of the many common chemical exposures people face, it is emblematic of environmental policy and risk assessment in the U.S., with its history of controversy, conflicting messages and complicated regulatory structure. There is very limited research on the communication of risks relating to food contaminants and EDCs in general. BPA and EDCs in general present emerging challenges to public health professionals in different capacities as researchers, advocates, and regulators. Thus, the intent of this research is to shed light on U.S. based risk communication and news media coverage of BPA—a major public health concern of national and worldwide importance and with implications for current and future generations. Regardless of any ultimate determination on BPA safety, this work provides insights and recommendations for public health practitioners faced with translating complex science and uncertain health risks.

A case study approach was chosen to examine the issue of BPA risk communication in the United States. The topic of BPA provides a rich context to explore risk communication on a politicized and scientifically challenging issue with implications for effective risk management and regulatory decision-making. Within a case study framework, this dissertation combines mixed methods including document review, quantitative news media content analysis and in-depth key stakeholder interviews. The three specific aims of the research are as follows:

Aim 1/Manuscript 1: Using the risk assessment framework, evaluate BPA-related communication from key stakeholders, including main messages about risks, use of scientific evidence and policy goals.

Aim 2/Manuscript 2: Analyze the volume and content of national news media coverage of BPA.

Aim 3/Manuscript 3: Characterize key stakeholders' perceptions of BPA risk communication challenges.

Overview of Chapters

This dissertation consists of seven chapters. Chapter 2 reviews the scientific literature on BPA and human health, as well as provides an overview of U.S. regulatory and policy action to date. Chapter 3 details the methodological approach to this research. Chapter 4 presents the first manuscript, entitled *Stakeholder Communications on BPA: A Qualitative Analysis Using the Risk Assessment Framework.* This manuscript characterizes risk messaging from key stakeholder groups' websites using the risk assessment framework. Chapter 5 presents a quantitative news media content analysis, entitled *U.S. News Media Framing of Bisphenol A (BPA) from 2006-2012.* This study describes television and print news framing of BPA and health, including how risk and scientific evidence are presented, what products are mentioned, and the discussion of sensitive populations, health endpoints, policy solutions and replacements. Chapter 6 is

the third and final manuscript, *"A Poster Child of Endocrine Disruption": The Challenges of Risk Communication on BPA*. This chapter presents findings from semi-structured interviews with key stakeholders on challenges to effective risk communication about BPA and approaches for improving messaging on complex and uncertain public health issues. Chapter 7 discusses overall findings and implications of this research as well as opportunities for future analyses.

Chapter 2. Literature Review

This chapter summarizes current evidence related to potential health impacts of BPA. First, sources and routes of exposure are outlined. Next, population exposures and research on health associations are reviewed. A brief overview of risk assessment and risk communication is also provided to provide context and grounding in those fields, as they were critical in the development, conduct and interpretation of this thesis. Finally, this section also provides an overview of U.S. and international policy actions and the key stakeholders involved in research, advocacy and communication to the public about BPA.

Exposure Assessment

Ingestion is the main route of exposure to BPA, especially in children, who in addition to exposure from food and drink may experience hand-to-mouth and direct oral contact with BPA-containing items.[7,9] Dermal absorption is also a route under evaluation, particularly in regard to use in thermal paper receipts (a type of paper used in cash registers that is coated with BPA). People may inhale BPA as well, especially in occupational settings, however current research suggests BPA inhalation is a small proportion of total exposure in the general population.[7,23] Some dental fillings and sealants contain BPA, and exposure from this source appears to be variable and uncertain for relevant populations.[24] Leaching from dental work may vary depending on the manufacturer, and more research is needed on this source of exposure.[25] While these non-food related sources of BPA are important for understanding cumulative exposure and environmental and wildlife impacts, they are believed to comprise a much smaller portion

of human exposure. In their review, Geens et al. reported that non-food exposures to BPA are typically at least one order of magnitude lower than food-related exposures.[3]

It is well established that BPA is present in the U.S. food supply. While the EPA notes that food and drink containers comprise only five percent of BPA uses in the U.S., these sources nonetheless provide the largest portion of human exposure.[15] Diet is the main route of exposure to people when BPA leaches from food containers into the food itself.[8]

BPA has been measured in canned food and drinks around the world.[3,7] Canned foods are believed to be the largest contributor to total exposure of the general public based on human intervention studies.[3] During processing and storage of canned foods, BPA concentrations in the parts per billion (PPB) range can come in contact with the can's contents.[26] In a review of studies from the U.S., Canada, Japan, Korea, Belgium, Spain and Portugal, the majority of canned food and beverage samples contained BPA (59-100%).[3] A 2011 study which tested concentrations in popular canned foods detected BPA in 71 of 78 canned samples, but not in frozen (non-canned) food samples. While BPA was found in the majority of samples, concentrations were wide-ranging both between products of the same type and between different batches of the same product (as much as a 100-fold difference was observed in peas).[26] Variations in BPA levels by product type and even among the same product was confirmed in other studies as well.[4] Variations in different products are believed to be due primarily to differences in the compositions of the epoxy resins used by various manufacturers for various products.[26] Variations within the same foods are not well understood. High temperatures, and acidic or basic foods may also increase leaching of BPA from can linings or plastics.[6] The range

of BPA levels identified in beverage cans is narrower than for canned food products, and the concentrations are generally lower.[3]

Traces of BPA have been measured in foods that are not canned as well. Glass jars with metal lids may contain BPA, as do other foods packaged with epoxy resins or plastic parts (such as cheese, bread, cereals and fast foods).[3] A 2010 study, which measured BPA in 63 out of 105 samples of fresh meats, plastic wrapped food, canned food and pet food, found that BPA level was associated with pH level of the food but not type of food or type of food packaging.[7] Overall, the evidence suggests that non-canned foods make up a small percentage of exposure to BPA.[27] While it is clear from existing evidence that the food supply is a major contributor to human BPA exposure, more representative sampling of foods is needed to determine types of food with higher BPA levels.

Toxicology and Metabolism

BPA is commonly measured in urine to determine recent exposures. As BPA is considered non-persistent, with a half-life of a few hours, it is quickly excreted from the body. BPA levels in blood decrease quickly as it is almost completely excreted in the urine.[28] As such, urine is the standard metric to evaluate both the total amount of BPA and its conjugates from all exposure sources.[6,9] Importantly, while BPA is non-persistent and quickly excreted, its presence has been described as "pseudo-persistent" because exposure is continuous.[29]

For oral exposures, BPA is quickly conjugated to a non-active version in the intestine and liver.[3] The half-life has been reported as less than 6 hours,[30] and even less than 2 hours.[31] Only the unconjugated form, "free BPA" is associated with estrogenic

activity.[3] Inhalation and dermal exposures are not subject to first-pass metabolism and are thus eliminated more slowly.[3]

Biomonitoring

As BPA is present in the U.S. food supply, it is likewise found in the bodies of the vast majority of Americans. BPA has been detected in the populations of other developed countries, although there is little information available on BPA levels is less developed nations.[25] While there is discord on the health significance of BPA exposure, the fact that BPA is measurable in blood, urine, semen and other biological samples is not disputed in the literature.[6] Research has also highlighted the presence of BPA during pregnancy and early development. BPA can be found in breast milk, placental tissue, amniotic fluid and umbilical cord blood, indicating that the chemical can cross the placental barrier.[25]

Biomonitoring data show nearly ubiquitous BPA exposure in Americans. National Health and Nutrition Examination Survey (NHANES) data from the Centers for Disease Control and Prevention (CDC) in their Fourth National Report on Human Exposure to Environmental Chemicals showed 94 percent of a nationally representative sample had detectable BPA in urine samples.[9] Slightly higher concentrations for children and non-Hispanic blacks were also observed in data, although in all years reported BPA was prevalent in all groups.[9] People with lower household income were also found to have higher BPA concentrations.[32]

There is some preliminary evidence that there may be a relationship between length of residency for immigrants and BPA levels (suggesting that some ethnic diets with less packaged foods may be lower in BPA than the typical American diet). In a study of immigrant Mexican-American women in California, researchers found higher BPA levels in women who had lived in the U.S. their entire lives versus women who had

been in the U.S. one year or less. Overall, BPA levels in this group were lower than in women of the same age group in the NHANES nationally representative sample.[33] Internationally, the evidence also points to widespread exposures. A summary of small to medium scale urinary biomonitoring studies in North America, Europe and Asia shows fairly comparable concentrations between countries, and in nearly all the studies the vast majority of participants had detectable BPA in their urine.[2]

Health Effects

As previously mentioned, there has been a significant amount of interest and research on BPA, particularly in the past decade. Despite this, there is still uncertainty about the potential human health effects of BPA, for a variety of reasons. Ongoing controversies in the field include the potential non-monotonic dose-response curve, low-dose effects, and the importance of critical stages of development.[34] There is also debate about the appropriateness of animal models and extrapolating effects to humans, critiques of various experimental approaches, the mechanisms of BPA action and its metabolism, levels of human exposure, effects on animals, carcinogenicity and concerns about insufficient replicability of some studies.[34,35]

Simultaneous exposures to multiple other chemicals, as well as ethical considerations of conducting controlled human experiments also pose challenges in understanding the role of BPA in human health. According to the World Health Organization, there has been a global failure in addressing and preventing environmental causes of endocrine-related diseases and disorders. Of the more than 800 known EDCs, very few have been adequately tested.[10] However, there are several examples of effective government actions to reduce harmful environmental exposures, including lead, PCBs and some persistent organic pollutants.[10] The following section will briefly review

existing evidence on health impacts from animal and human studies on BPA, as well as sensitive populations and low dose effects.

Animal Studies

A 2008 report from the U.S. National Toxicology Program (NTP) evaluated the weight of evidence on BPA and adverse effects in laboratory animals. The NTP is an interagency program housed at the U.S. National Institute for Environmental Health Sciences (NIEHS). NTP concluded there is "clear evidence of adverse effects" (their highest point on a 7-point scale with the lowest point being "clear evidence of no adverse effects") for developmental toxicity at high doses (at least 50 mg/kg/day).[35] This determination was based on studies showing reduced survival in animal fetuses or newborns, reduced fetal/birth weight or early life growth, and delayed puberty. NTP reported "some evidence of adverse effects" (the second highest point on the scale) with regard to developmental effects based on potential lower fertility, changes to estrous cycling, and cellular effects on male rat testis.[35] "Limited evidence of adverse effects" (the third highest point) was the determination on low-dose developmental toxicity, based on early puberty onset, neural and behavior changes, altered prostate and urinary tract development, and potentially pre-cancerous prostate and mammary lesions.[35] These low-dose studies are more comparable to human exposure levels. While NTP noted that these findings are inconclusive with regard to human effects because the impacts on animals occur at doses orders of magnitude larger than estimated human exposures, they expressed "some concern" for fetuses, infants and children.[35]

In a review by Hengsler et al, the authors criticized existing evidence on BPA as flawed and insufficient in light of "large and well-designed" studies with negative outcomes (no significant effects).[31] They recommended baseline requirements for study

design addressing sample size, endpoints, statistical procedures, routes of exposure and transparency.[31] NTP reported that many of the animal studies they reviewed had flawed designs, technical shortcomings or failed to provide adequate details, all of which factored into their weight-of-evidence determination.[35] Despite the concerns, the volume of evidence on adverse effects in animals from hundreds of studies in the 1990s and early 2000s led the NIEHS to convene a targeted research program to increase knowledge on the human effects.[8]

Human Studies

The human evidence on BPA is by all accounts somewhat limited. Some studies have found associations between health endpoints of interest and BPA levels. Using the 2003-2004 NHANES data, Lang et al found higher urinary concentrations of BPA to be associated with diabetes, cardiovascular disease and liver abnormalities.[36] In women, BPA levels in blood have been associated with obesity, endometrial hyperplasia, recurrent miscarriages, and polycystic ovarian syndrome.[25] The NTP found three human studies that suggest hormonal effects of BPA exposure in adults.[14] They include an occupational study of male epoxy resin sprayers,[37] a study of women with ovarian dysfunctions and obesity,[38] and an investigation of serum BPA levels and gender differences.[39]

However, epidemiological studies of BPA and health effects are methodologically difficult and unlikely to present causal evidence. Hengstler et al.'s critique pointed out some limitations to cross-sectional epidemiologic studies in that they often use a single urinary BPA measurement to link to health outcomes.[31] A urinary measurement only estimates exposure in recent days and sensitivity to BPA may be dependent on stage of development.[2] Further, self-reported health outcomes with long latency periods make the

results (and any causal implications) difficult to interpret.[31] Small sample sizes and cross-sectional designs with potential confounding factors are also limiting factors.[25] As Geens et al. note, BPA is just one of the EDCs that people are routinely exposed to, and an epidemiologic study cannot separate out these effects in the absence of a control population.[2]

Sensitive Populations

Evidence on effects in fetuses, infants and children, while of great interest, is also insufficient.[35] There is some evidence of a relationship between gestational BPA exposure and behavioral and emotional effects, especially among girls.[40] Altered neurodevelopment, early puberty, and obesity are also of concern during fetal growth.[41] Endocrine disruptors are of the greatest concern at sensitive developmental periods, namely during prenatal development, infancy and early childhood. The "fetal basis of adult disease" and "developmental origins of health and disease" are terms coined by researchers to describe the differential impact of an EDC during development that may set the stage for disease later in life.[42]

During development, it is feasible that low doses of EDCs could produce effects long after the actual exposure and not manifest until later in life. Even very slight exposure to chemicals with hormone-like activity—at levels much lower than would be harmful in an adult—can hinder normal development in prenatal through adolescent periods of endocrine system maturation.[42] This concept was conveyed in NTP's assessment that BPA exposures to fetuses, infants and children were of "some concern."[35]

Low-dose effects and non-monotonic dose-response relationships

The effect of BPA at lower doses relevant to human exposure levels has also been debated in the literature. Like natural hormones, EDCs can work at extremely low doses

and stray from typical dose-response curves.[42] Low doses may have more impact than higher doses for certain endpoints.[42] As such, traditional models which first extrapolate high to low doses based on a No Observed Adverse Effects Level (NOAEL) or Lowest Observed Adverse Effects Level (LOAEL) and then apply safety factors may not be appropriate for chemicals like BPA.[16]

While critics argue that exposures showing effects in animal studies are far higher than realistic human exposures, others maintain that adverse effects have been shown at levels close to human concentrations.[25,43] A 2006 review by vom Saal reported more than 100 studies with effects at low doses, and 40 studies with effects below the EPA and FDA's safe dose of 50 mg/kg/day.[44] While the evidence is still emerging on low dose effects, it is important to keep in mind complicating factors such as potential interactions with other environmental exposures and variability in the doses that may affect different endpoints.[16]

Another complication of toxicological risk assessments is the possibility of non-monotonic dose-response relationships, in which the relationship is non-linear and the slope of the curve changes signs. In these cases, high dose effects cannot be used to predict low dose effects.[16] In 2012, Vandenberg et al discussed the biological plausibility of non-monotonic relationships and determined that while they are controversial in the regulatory setting, they are common in the EDC literature for both manmade chemicals and natural hormones.[16] They found several BPA studies with a non-monotonic effect, and while the health impact is unknown, the authors argue that low dose and non-monotonic relationships should be considered in regulatory science for the benefit of public health.

Risk Assessment and Risk Communication Overview

Risk assessments are an important tool for government agencies, industry and academia seeking to understand public health and environmental hazards, and inform public policy decisions.[20] Risk assessments are conducted to help understand and make decisions about hazards that may threaten the environment and public health. Following the four-step process of hazard identification, dose-response assessment, exposure assessment and risk characterization detailed in the foundational 1983 National Academies report *Risk Assessment in the Federal Government: Managing the Process* (also known as the Red Book*)*, risk assessors take this scientific information into consideration along with political, social, economic and engineering factors in what is known as risk management.[45] When new information about a hazard becomes available, risk management decisions can evolve and agencies may take steps to reduce or eliminate the production of the hazard, reduce exposures to the hazard, and/or change perceptions about the hazard in order to be protective of public health.[31]

The risk communication literature is also a critical field of research underpinning this thesis. The National Research Council (NRC) describes risk communication as "an interactive process of exchange of information and opinion among individuals, groups and institutions. It often involves multiple messages about the nature of risk or expressing concerns, opinions or reactions to risk messages or to legal and institutional arrangements for risk management."[46] Risk communication is important because it is an integral and essential component of effective risk management.[20] In other words, a key aspect of addressing risks in society involves responsible parties relaying information about the risk assessment findings and risk management solutions. Much inquiry has focused on

best practices for risk communication, but it is difficult to provide clear and concise recommendations applicable for all situations.[46]

Another important factor to consider with regard to risk assessment and risk communication is risk perception—in other words, how experts and the public come to conclusions about risks and benefits. Sandman makes the distinction between hazard—an expert's assessment of risk, and outrage—the public perception of risk.[47] Some risks may be a high hazard with low outrage—such as traffic accidents. Other risks may be a low hazard but have a high degree of outrage and fear associated with them—for example, nuclear accidents.[48] According to the risk perception literature, some characteristics contribute to elevated fears, including: man-made risks, involuntary exposures, new or unfamiliar risks, widespread media coverage, lack of trust in communicators, and potential effects on children.[47-50]

U.S. Risk Assessments, Regulation and Policy Actions

Agencies in the U.S. and around the world have evaluated the risks of BPA. In 1993, the EPA's Integrated Risk Information System (IRIS) determined the LOAEL for BPA to be 50 mg/kg/day in animal studies. After dividing the LOAEL by an uncertainty factor of 1000 (10 for animal to human data, 10 for sensitive human populations and 10 for uncertainty regarding chronic to sub-chronic doses), the reference dose (RfD) for oral exposure was set at .05 mg/kg/day. In this case, the RfD—defined as an estimate of a dose believed to be unlikely to cause adverse human health effects[51]—is based on the critical effect of reduced mean body weight.[52] This figure has been criticized given that this LOAEL— from a traditional toxicology study in 1982—has not been adjusted given the concern over low-dose EDC effects.[43] The EPA's Action Plan Summary on BPA states that the agency is considering several actions. Under its Toxic

Substances Control Act (TSCA) authority, EPA added BPA to their chemicals of concern list due to potential risks to the environment and aquatic life. Also under TSCA, EPA may develop more data on environmental impacts. With their Design for the Environment Program, EPA has assessed alternatives to BPA in thermal receipt paper and other uses. Notably, the agency is not planning any action on BPA in response to concerns about human health risks.[15]

The U.S. Food and Drug Administration (FDA) is responsible for regulating BPA as an indirect food additive or food contact substance. The FDA's stance on the overall safety of BPA exposure is that current low-level human exposures are safe based on standard toxicity testing, but the agency (along with NIEHS and NTP) has some concerns about effects on fetuses, infants and young children and are continuing to support research to clarify uncertainties.[1]

In 2008, FDA's Draft Assessment of Bisphenol A For Use In Food Contact Applications used a NOAEL of 5 mg/kg/day for systemic toxicity, based on two multigenerational rodent studies.[53] In their report, FDA estimated a margin of safety (MOS) of 2,000 for infants, and 27,000 for adults based on food-related exposures.[53] FDA determined this was an adequate difference between an established No Observed Adverse Effects Level (NOAEL) and human exposure levels—as a 1,000-fold difference for children and a 100-fold difference for adults are typically considered the lower limits of an adequate MOS. While acknowledging complete certainty of safety is impossible to prove, FDA defines safe in this context as "reasonable certainty in the minds of competent scientists that the substance is not harmful under the intended conditions of use."[53] In the years following release of this report, FDA became increasingly concerned

about BPA exposure in the food supply. In July 2012, FDA officially banned the use of BPA in baby bottles and children's' cups.[54] By the time the agency took this action, many manufacturers had already ceased using BPA in these products and this move was seen as mostly a symbolic response because the American Chemistry Council requested this measure to boost consumer confidence.[54]

Over the past decade, NIEHS has invested $30 million in BPA research[55] to address gaps in knowledge that still existed despite the 800 published studies on BPA health effects prior to the research program's establishment.[8] The NTP has also been heavily involved in this research program. The CDC has been an important source of data on human exposures to BPA with their National Biomonitoring Program. All of these agencies, with the exception of EPA, are housed under the umbrella of the U.S. Department of Health and Human Services (HHS).

BPA has been approved for its current uses in food packaging in the U.S. since the 1960s. Manufacturers may use approved food additives without providing details on the specific formulations used or their characteristics. FDA estimates hundreds of different types of BPA epoxy linings in production, and modifying the approval of any of these uses would involve a complex rulemaking process.[1] Policy efforts thus far have focused on elimination of BPA from polycarbonate bottles and largely ignored uses in metal can linings, with the possible exception of infant formula cans.

On the state and local level, proposals to limit BPA began as early as 2005. That year, Maryland, California and Minnesota proposed legislation to restrict BPA in toys and products for children less than three years, but none of the bills passed. Another attempt in California in 2008 to ban BPA in children's food containers and formula cans

was also defeated. Besides California, six other states proposed action on BPA in children's products between 2007-2008: Connecticut, Hawaii, Maryland, Massachusetts, Minnesota, and New York.[43] While these initiatives were also not successful, Suffolk County, New York became the first jurisdiction to ban BPA use in baby bottles and "sippy" cups in 2009.[56] In 2012, they followed up with a ban of BPA in thermal receipt paper.[57]

In 2009, Chicago and Minnesota also both passed laws to remove BPA from baby bottles and children's cups (cans of formula and baby food were not affected).[58,59] By this time, these actions were seen as mostly symbolic because BPA had been voluntarily removed from baby bottles and sippy cups by many manufacturers and retailers including Wal-mart, Toys R Us and CVS.[59] That same year, Connecticut went even farther, becoming the first state to ban all reusable food and drink containers with BPA (not just children's products), as well as in infant food and drinks in BPA-laden containers. In 2011, Connecticut also banned BPA in thermal receipt paper, which will go into effect in 2013, or 2015 if a safe alternative is not available prior to the former date.[60]

Besides Connecticut and Minnesota, other states that eventually implemented some restrictions on BPA include California, Delaware, Maine, Maryland, Massachusetts, New York, Vermont, Washington, Wisconsin, and the District of Columbia. Of these policies, those in Washington State, the District of Columbia, Vermont and Connecticut extend to cover non-children's items as well, but none address metal food containers (not counting formula cans).[60]

The U.S. Congress responded to concerns about childhood BPA exposure with the BPA-Free Kids Act of 2008. [61] The bill was introduced in the Senate, but was quickly

referred to committee and died. The proposed legislation aimed to limit exposure to children by banning the use of BPA in food and beverage containers intended for children aged three and younger, with the exception of metal cans. It was reintroduced in 2009 in both the House and Senate and again died in committee.[62]

Some state and city legislative bodies did not want to wait for federal action, and took matters into their own hands to limit exposures. A legislative approach was successful in some areas, but it was not the only strategy. Richard Blumenthal, the attorney general of Connecticut in 2008 wrote letters urging baby bottle manufacturers and formula companies to stop using BPA in their products. The attorneys general in New Jersey and Delaware also joined in the letter. Blumenthal also urged the FDA to restrict BPA in baby products. The letter from the attorneys general may have been influential, as it came before many companies and retailers decided to stop using BPA.[63]

International Risk Assessments and Policies

Countries around the world are continuing to investigate the health impacts of BPA, while cautiously assuring the population that current exposure levels are not expected to pose health risks, particularly to adults. In some cases, governments have been inconsistent. In 2008, Health Canada's risk assessment concluded BPA in food packaging is safe (and set a provisional tolerable daily intake of .025 mg/kg/day), but in light of emerging evidence on sensitive points of development and the limitations of available studies, supported an approach to limit BPA in infant and children's products to "as low as reasonably achievable."[64] In 2010, Canada became the first country to act on BPA, by banning the compound from baby bottles and declaring it toxic.[65] However, in 2012, Health Canada's updated assessment concluded that current exposures to BPA are not expected to pose a health risk, including to infants and young children.[65,66]

In the European Union, the European Food Safety Authority (EFSA) completed its risk assessment of BPA in 2006, setting a NOAEL of 5 mg/kg/day and an uncertainty factor of 100. Thus, the Tolerable Daily Intake (TDI) was set at .05 mg/kg/day.[67] This level was reconsidered in light of emerging evidence in 2008 and 2010, but the TDI was not changed. In 2011, the European Union banned BPA use in baby bottles, and like all materials that come in contact with plastic food materials in the EU, BPA is subject to limits on the migration of the compound into food and drink.[2] In 2012, EFSA announced plans to reevaluate the human health risks of BPA, which will take into account potential low-dose effects and total exposures (including non-dietary sources) and is expected to be completed by the end of 2014.[67]

France banned use in baby bottles in 2010, the year before the EU at large and went further by banning the compound in food containers of any type in 2014, making it the first country to approve an outright ban in food packages.[68] In 2010, Danish officials instituted a national ban on BPA-containing cups, bottles and food packaging for children under three unless future studies show low doses do not impact development, the nervous system or behavior of rats.[31] China and Malaysia also banned BPA in infant bottles in 2011.[69] Australia and New Zealand found the scientific evidence does not point to human health risk, but is supporting a voluntary phaseout.[70] Japan's risk assessment from 2007 found that human and environmental risks are below levels of concern,[31] but as early as 1998, manufacturers in Japan began voluntarily reducing BPA use.[71]

Stakeholder Overview

The public interpret risks with the help of "amplification stations" including the media, scientists, government agencies and advocacy groups. These groups may increase or decrease the amount of information about a topic and influence whether concern about

an issue is amplified or attenuated.[72] Beyond communication directly from government officials charged with conducting research and ensuring the safety of BPA, other stakeholders including public health and environmental advocacy groups and industry trade associations have weighed in on the debate.

Stakeholders can also play a role in informing policy and regulatory decisions. According to the National Academies' 2009 report *Science and Decisions: Advancing Risk Assessment*, stakeholder involvement is important throughout the process of assessing and managing risks.[20] To improve the outcome and utility of risk assessments and ensuing regulatory and policy decisions, stakeholders should be involved in the process and play a role in identifying important questions and potential solutions. Stakeholder groups have come to very different conclusions about safety of BPA exposure.[73] This section introduces three main categories of stakeholders that have communicated to the public about BPA (government, health and environmental groups, and industry groups). Actions of retailers and consumers are also briefly outlined, although these groups are not key groups of interest in this research.

Federal Government Agencies

As previously discussed, the EPA and several branches of HHS (FDA, NIEHS, NTP, and CDC) have been involved in research, risk assessment and regulation of BPA. These agencies represent the official voice of the government, and as such, are frequently the go-to source for safety information. The various agencies have communicated their findings and positions on BPA to the public regularly through media interviews, publicly available reports, published research and consumer updates on their website. They also have solicited comments from stakeholders and the public through the Federal Register, provided research funding and convened meetings with experts.[1,8,15]

Environment, Public Health and Consumer Groups

Several health and environmental-focused non-governmental organizations (NGOs) have been vocal in the BPA debate. Consumers Union, the nonprofit publisher of Consumer Reports, has conducted their own tests of BPA-containing products, advised the public on ways to lower their exposure and called on the FDA to ban its use in food and beverage containers and children's products.[74] Environmental Working Group, Environmental Defense Fund, and Breast Cancer Fund, national research and advocacy organizations, have urged stricter limitations on BPA, supported state policies and provided information to the public.[75-77] Likewise, the Natural Resources Defense Council's "Fix the FDA" campaign speaks out about BPA and other contaminants in food, beverages and household products.[78] The American Public Health Association has supported a cautionary approach to reducing exposures to endocrine disruptors like BPA.[70]

Some professional medical associations have also made public statements on BPA. In 2011, the American Medical Association (AMA) spoke out in favor of banning BPA in baby products and recommended the labeling of BPA containing products. They also supported the development of alternatives to BPA and a "more robust, science-based, and transparent federal regulatory framework for oversight of bisphenol A."[79] The American Academy of Pediatrics favors reducing exposures, and the American Nurses Association and the Endocrine Society have also advocated for tighter BPA restrictions and criticized the FDA's stance as flawed and weak.[80-82]

Industry Groups and Manufacturers

Companies including Bayer, Dow Chemical, Sunoco and General Electric Plastics make a reported $1 million per day in profits from BPA production.[43] The American

Chemistry Council (ACC), a trade group that represents the chemical industry, including major BPA producers, has been outspoken in criticism of scientific studies showing health effects. The ACC has campaigned against BPA legislation and criticized EPA's IRIS process.[43,83] The ACC also publishes websites that promote the safety of BPA, including bisphenol-a.org and factsaboutbpa.org.[84,85] They maintain that legislation banning BPA use is reactionary and unnecessarily alarms the public.[63] The Grocery Manufacturers Association, the American Beverage Association, and the North American Alliance for Metal Packaging, which each represent companies using BPA, are also industry interest groups who have opposed BPA restrictions.[86-88]

At times, producers have broke with the stances of trade groups. Sunoco announced in 2008 they would no longer sell BPA to its customers without confirmation that it would not be used in food and beverage containers aimed at children younger than three years.[89] Other manufacturers also acknowledged public concern, and discontinued BPA use. Nalgene, the water bottle company, started phasing out production of their popular line of bottles with BPA in 2008. Playtex, Tupperware, Gerber, Evenflow, Avent America, Dr. Brown's and Disney First Years also stopped using BPA.[43,63]

Retailers

Even in the absence of scientific consensus, the public concern about BPA in children's products was enough to convince major retailers to pull BPA-containing products from the shelves. Wal-mart and Toys R Us were among the major retailers who decided not to sell polycarbonate bottles and other BPA-containing plastic products.[43] Nationally, Whole Foods has perhaps done the most to cut down on BPA use in its merchandise. First, in 2006, they stopped selling baby bottles and sippy cups with BPA (the first national retailer to do so, according to the grocer's website).[90] They also do not

use receipt paper with BPA, and have been working with suppliers to find alternatives to BPA use in can liners and other types of packaging. For store brands, they are no longer accepting new canned items with BPA and encouraging transitions to "safe" alternatives.[90]

Consumers

Consumers have had an important voice in the BPA case. There have been several reports of consumers filing lawsuits against companies using BPA in their products.[43] Concern from consumers, particularly mothers of young children, was widely reported and perhaps played a role in the decision of retailers and manufacturers to discontinue BPA use as a public relations advantage. Blogs like MomsRising,[91] Mommyish[92] and groups such as Mom to Mom of Maine[93] and the Moms Clean Air Force[94] have spoken out against BPA. However, there has been some amount of backlash to these concerns from mothers. As Sarah Vogel describes in her book *Is It Safe? BPA and the Struggle to Define the Safety of Chemicals*, worried mothers have been portrayed as "hysterical, overprotective and overeducated."[95]

Chapter 3. Methods

This research used a case study approach[96] with both qualitative and quantitative aspects to address three research aims on risk communication about BPA in the United States. This chapter details the research questions of interest, methodological approaches for data collection and analysis, strengths and limitations, and strategies used to enhance study quality.

Research Questions

The purpose of this study was to better understand how key stakeholders in the United States—including government agencies, industry trade groups, health and environment-focused non-governmental organizations and researchers have communicated to the public about BPA. Additionally, we examined the role of the news media in framing potential risks of BPA. The specific research aims and questions were as follows:

Aim 1: Evaluate stakeholders' messaging on BPA in public documents using the risk assessment framework.

RQ1: What are the key stakeholders' main messages to the public about the safety of BPA?
RQ2: How do government agencies, industry groups, and health and environment focused non-governmental organizations compare in their risk communication messages?

Aim 2: Describe the content of national news media coverage of BPA over a 7-year time span.
RQ3: How has the news media framed BPA risks?
RQ4: What sources, exposure routes, sensitive populations, health endpoints and solutions are discussed in the news media coverage?

Aim 3: Characterize key stakeholders' perceptions of BPA risk communication challenges.
RQ5: What are the challenges inherent in risk communication on BPA?

RQ6: How do stakeholders define effective risk communication and what recommendations do they offer for improved public health messaging?

Case Study Approach

A case study approach using mixed methods was chosen because it allowed for rich, in-depth exploration of the issue of BPA risk communication in the United States. Case study research refers to studying a topic within the context of a specific and defined "bounded system."[97] This type of research focuses on understanding why and how a particular phenomenon occurs, while also considering the context in which the phenomenon is observed.[96] While some scholars characterize case studies as the topic of study and not a research method, others argue it is a methodological approach in which a case or cases are examined "over time through detailed, in-depth data collection involving multiple sources of information."[97] The data sources used in a case study are often qualitative, however quantitative components can also be useful and appropriate. In fact, using multiple methods, including both quantitative and qualitative components, adds value and context to case study research projects.[98] The use of multiple data sources and qualitative techniques allows for triangulation and contextual factors to shape understanding of the case.[99] Given the research questions of interest, a case study framework was used to analyze BPA risk communication.

Defining the boundaries of a case study and identifying the specific case(s) of interest is very important in case study research.[97] The type of case study used is best described as an instrumental case study—"aimed at providing insight into an issue or problem or to refine a theory."[100,101] This research was focused on two specific aspects of the case.[96,97] The first aspect is the role of stakeholders in communicating to the public about potential risks from BPA. Stakeholders were defined as national, U.S. based groups

who have authority over the risk assessment and risk management of BPA, or will be affected by the risk itself or efforts to manage the risk. We identified three main "domains", or types of stakeholder organizations who communicated to the public about BPA: 1) government agencies, 2) industry associations, and 3) health and environment-focused non-governmental organizations (NGOs). In the semi-structured interviews presented in Manuscript 3, researchers and news media representatives were also included due to their roles in communicating about BPA and in-depth knowledge about BPA. The second aspect of the analysis includes the news media framing of BPA risks. The news media were identified as an important social institution due to their role in delivering information, framing issues, and influencing public perception.[102,103] Further, the news media play a key role in setting policy agendas and influencing which issues are viewed as important and worthy of action within the public sphere.[103] Thus, the three manuscripts analyze these two aspects of the case—stakeholder and news media roles in communicating BPA risks. Manuscript 1 focuses on stakeholder risk communication from organizations' websites, Manuscripts 2 assesses news media content, and Manuscript 3 includes analysis of stakeholder perceptions on BPA risk communication. Chapter 7 integrates the findings of the research.

Theory and Conceptual Frameworks

Theories and conceptual frameworks relevant to the scientific basis of the research should inform the design of mixed methods research.[104] Given the focus on a common, well-publicized chemical regulated by the federal government, the risk assessment and risk communication literatures were very influential in the development of this research and provided conceptual grounding (See Chapter 2). Other concepts that

were influential in the development of this research included Kingdon's windows of opportunity theory and Downs' description of the issue attention cycle. Kingdon describes how three "streams"—a problem stream, a politics stream and a policy stream, which come together to create "windows of opportunity" for advocates to push for their preferred solutions.[105] In the issue attention cycle described by Downs, attention peaks for a relatively short period, after which the costs of solving the problem are realized and interest fades—often before the problem that originally attracted media attention has been resolved.[106] In light of these concepts, this research sought to explore how stakeholders and the media harnessed attention on this issue and communicated about BPA risks. This has relevance and implications for risk management of environmental chemicals and the specific solutions that were implemented with regard to BPA—including voluntary industry actions, regulatory actions, and legislative actions.

Ethical Review

The Johns Hopkins Bloomberg School of Public Health Institutional Review Board (IRB) reviewed the dissertation research in October 2013 and determined that the research was not human subjects research and thus did not require IRB oversight (Appendix A). This determination was made because research involves publicly available data from organizations' websites, news media content, and interviews with key informants in the context of their professional capacities (rather than about the participants as individuals). While the research was declared exempt from review, several efforts were made to ensure the privacy and protection of the research participants, as described below in the description of Aim 3 procedures.

Data Collection and Analysis

This section describes how data were collected and analyzed in the three research studies comprising this dissertation. Within the case study, Aim 1 involved document review of stakeholder website content; Aim 2 was a quantitative news media content analysis; and Aim 3 consisted of semi-structured interviews with key stakeholders. Aims 1 and 3 utilized a qualitative approach. Qualitative methods are often used to produce in-depth knowledge and explore a topic using open-ended research questions and textual data.[107] Qualitative methods are warranted when research questions are not conducive to quantitative methods and statistical analysis. A qualitative approach allows for a systematic yet flexible design that is able to incorporate new and emerging information as appropriate.[107] In order to conduct a news media content analysis that helps triangulate an overall case study, the research questions in Aim 2 were achieved using a quantitative approach. Quantitative content analysis as a research method is defined as "the systematic assignment of communication content to categories according to rules, and the analysis of relationships involving those categories using statistical methods."[108] The advantage of such an approach with the news media content analysis is the methodology emphasizes reliability, objectivity and replicability.[108]

Aim 1: Document Review

Sampling and Data Collection

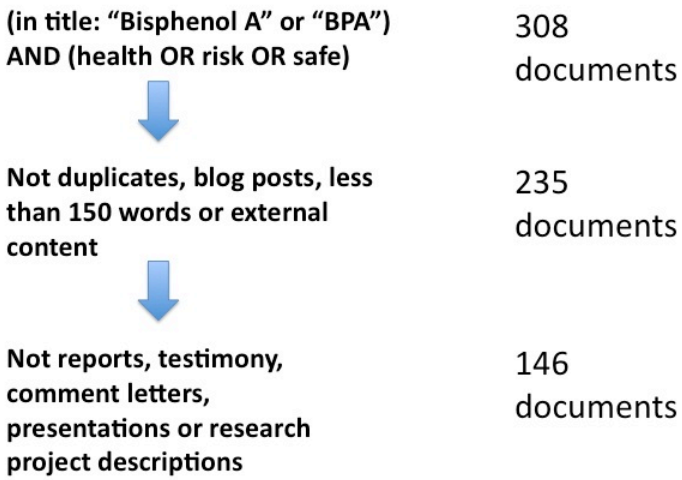
This study used the NRC's risk assessment framework to qualitatively examine how key stakeholders communicated about BPA through publicly available documents on their websites. Thus, key stakeholders were defined as national, U.S. based groups who have authority over the risk assessment and risk management of BPA, or will be affected by the risk itself or efforts to manage the risk. The three included "domains", or types of

stakeholder organizations were: 1) government agencies, 2) industry associations, and 3) health or environment-focused NGOs. Thirteen organizations and agencies from the three domains were purposefully selected for analysis due to their roles in research, communications, and/or advocacy regarding BPA. Organizations were identified and selected from background research, news media content and/or references from in-depth stakeholder interviews.

Four U.S. federal government agencies with regulatory authority over BPA and/or involved in funding or conducting research related to BPA were included in the analysis: Centers for Disease Control and Prevention (CDC), Environmental Protection Agency (EPA), Food and Drug Administration (FDA), and National Institute of Environmental Health Sciences (NIEHS). Five national industry trade associations representing the major food-related producers and users of BPA in plastic products and metal food cans were included: American Beverage Association (ABA), American Chemistry Council (ACC), Grocery Manufacturers Association (GMA), International Bottled Water Association (IBWA) and North American Metal Packaging Alliance (NAMPA). In the case of the ACC, both the organization's primary website and their BPA-specific website (factsaboutbpa.org) were included. Four NGOs concerned with public health, the environment and consumer advocacy were also selected for analysis: Breast Cancer Fund (BCF), Consumers Union (CU), Environmental Working Group (EWG) and the Natural Resources Defense Council (NRDC). Several additional organizations besides these 13 were considered for analysis, but excluded due to lack of website documents focused on BPA.

Documents were obtained directly from the 13 organizations' websites in June 2014 using the website's search function (All data, such as webpages and press releases, are referred to here as "documents"). Search terms were pilot tested and refined in order determine the most inclusive set of search terms for obtaining relevant documents, while omitting documents without a primary focus on BPA. Initial searches intended to maximize inclusiveness (such as searching simply "BPA" or "Bisphenol A") resulted in a significant number of hits, but captured many documents that were not related to BPA risk communication. In order to increase precision, and reduce the number of "false positives,"[109] the final search strategy entailed searching each stakeholder website using the following terms: BPA or Bisphenol A in the document title and at least one of the following words: risk, health or safe. Including only documents with BPA or Bisphenol A in the title ensured that BPA was the main subject of the document. Refining the search by "risk or health or safe" was broad enough to capture stakeholders' risk communications on BPA while specific enough to omit documents that were not focused on potential health risks or safety of BPA. Using these search terms, a total of 308 documents were identified from the 13 organizations. Due to the intended focus on risk messages geared to consumers and the scope of the study, the following documents were excluded: reports, official testimony and comment letters, meeting presentations, and outlines of specific research projects. Blog posts were excluded due to feasibility and the possibility that blog posts did not reflect the official position of the organization. Duplicates, documents less than 150 words and links or reprints from other parties were also excluded. After applying exclusions, 146 documents (47 percent) remained for analysis (Figure 1).

Figure 1: Schematic of Document Review Search Criteria



All relevant documents posted during data collection were eligible for inclusion and not restricted by date of publication. Details on search results and proportion of documents retained is available in Appendix B. Documents remaining in the sample consisted of BPA-dedicated web pages, report briefs, fact sheets and press releases. For government documents, research project summaries and documents without a primary focus on BPA comprised the majority of exclusions. Industry documents were predominantly web pages focused on BPA and press releases, and as such this category had the lowest exclusion rate of the three domains. The majority of the NGO exclusions were blog posts.

Analysis

A coding extraction instrument was developed to pull relevant information from website documents (Appendix C). The instrument development was guided by a literature review (Chapter 2) and structured around the stages of risk assessment and risk management.[20,45] First, basic descriptive information was collected from each document,

including the title, organization, domain, date of publication and/or date of last update, document type and document purpose. The first substantive section of the instrument coded information on hazard identification. Specifically, information on the language used to describe BPA was collected, for example: chemical, toxic, estrogen, or hormone. Next, BPA-containing products or sources were coded (i.e., in food and drink containers, receipt paper, consumer goods and the environment). The second section coded discussion of dose-response assessment—in other words, the quantitative risk estimates or points of departure used to quantify risk (i.e. a reference dose of 5 micrograms per kilogram body weight per day). The third section covered exposure assessment, or how the documents described people's exposure to BPA. Information was extracted from the documents on populations exposed, sensitive populations, and route(s) of exposure. The fourth section coded for risk characterization messages, comprising the documents' main messages on BPA safety or risk. Finally, the fifth section of the instrument extracted any risk management discussion in the documents, for example the type of solutions described and discussion of potential BPA replacements. For each substantive item in the instrument, multiple-choice responses as well as text extraction were collected. Extraction of relevant portions of text was done to aid in analysis and allowed for contextualization and use of quotes.

Data were collected using the Qualtrics online survey tool.[110] Documents were coded and analyzed by a single author (PT). After coding the 146 documents, the database was examined and checked for errors and missing data. Using Qualtrics reporting features, several reports were run to sort data and run descriptive statistics (for example, the number of NGOs that described children as a sensitive population in their

documents). The unit of analysis used was the individual stakeholder organization. This level of analysis was chosen because the intent was to understand the overall messaging coming from each organization through their website, as opposed to the content of an individual document, i.e. a single web page or press release. To facilitate comparisons within and between domains, data were analyzed both at the organization level, and at the domain level (government, industry and NGO). Thus, a unique report for each organization, summarizing all document data was created. Reports were also created for each of the three domains (government, industry and NGO), which summarized all data and organized it by coding instrument item. Using the reports, Microsoft Excel spreadsheets were created for each domain to further summarize for comparisons. The spreadsheets and reports were analyzed for each step of the risk assessment and risk management process.

Aim 2: News Media Content Analysis

Sampling and Data Collection

Aim 2 consisted of a quantitative news media content analysis to understand how BPA was framed in print and television news coverage. News media content analysis is a method for systematically examining and categorizing content of news coverage. The effect of news media content on readers is dependent on a variety of factors and conditions, but conducting a content analysis is an important tool for understanding the nature of those effects.[108] This approach has been described as "a formal system for doing something we all do informally rather frequently—draw conclusions from observations of content."[111] The sample included twenty-two U.S. newspaper, news magazine and television news sources. The time frame of 2006 to 2012 was chosen to correspond with a period of increasing attention on BPA in the form of scientific research, government

reports, and public policy. Preliminary database searches confirmed that this 7-year period was inclusive of the majority of news coverage on BPA; coverage prior to 2006 was negligible. Searches were conducted in mid-2013, so an end date of 2012 was chosen to include the last full year of news media coverage.

In order to analyze the news coverage reaching the most Americans, the top three U.S. daily newspapers by circulation were selected, as well as three top circulation papers from each of the four Census regions based on circulation rates from the Alliance for Audited Media for 2006, 2009 and 2012 (corresponding to the beginning, middle and end of the sampling period).[112] All included newspapers were among the top 25 for national circulation rates at least two of those three years. The top three national newspapers in the sample were *The New York Times*, *USA Today* and *The Wall Street Journal*. The 12 regional papers were *The Boston Globe*, *The Philadelphia Inquirer*, *The Washington Post, Chicago Tribune*, *Minneapolis Star Tribune*, *Milwaukee Journal Sentinel, Houston Chronicle*, *Atlanta Journal Constitution*, *Tampa Bay Times, Los Angeles Times*, *The Oregonian* and *The Denver Post*. *Time* and *Newsweek*, the top two circulation news magazines, were also included in the sample.[113] Television news coverage was based on viewership rates and included three major networks (ABC, CBS, and NBC) as well as cable news channels CNN and Fox News.[114]

Lexis Nexis Academic and ProQuest Central were used to collect newspaper and news magazine articles and television transcripts in September and October 2013 using a single search term, "Bisphenol A." This search term was chosen in order to be inclusive of all news content mentioning the chemical. This was feasible because Bisphenol A is a fairly specific topic as opposed to study topics with more common language such as trans

fat, childhood obesity or food safety,[115-117] which required more complex search strings. The database searches identified 926 news stories. A total of 448 articles, or 48 percent of articles were included. News stories were included in the final dataset if they had a substantial focus on BPA. Substantial focus was defined as at least 100 words of text specifically related to BPA (assessed using Microsoft Word's word count feature). This allowed for capturing content on BPA within larger news stories on a related topic (for example, chemicals in food in general). In those cases, word counts reflect only the portion of the news story on BPA. The following types of content were excluded: letters to the editor, corrections, duplicates and news stories less than 100 words. A 50 percent random sample of included articles (n=224) was chosen for content analysis due to feasibility, and achieved using a random number generator in Microsoft Excel. While 22 sources were sampled, a total of 20 sources are represented in the analysis. One television source, Fox News, had no identified television news stories on BPA during the time period of interest. The *Tampa Bay Times* had one article that was eligible for analysis, however it was not included in the 50 percent random sample chosen for content analysis. Appendix D provides details on the number of news stories sampled from each source.

Analysis

A 38-item instrument was developed to analyze news content (Appendix E). The coding instrument was pilot-tested by two authors (P.Truant and E. Donaldson) using articles from news sources outside the sample. Items were revised for clarity, and a codebook was developed to facilitate reliable coding. The final coding instrument was entered into a Qualtrics online survey tool, which was used to code news stories. Kappa statistics for inter-rater reliability were calculated using Stata 13.1 statistical software.[118]

Sufficient inter-rater reliability was achieved by double coding a total of 40% of the sample (89 articles).

The coding instrument was organized into four modules. Module 1 covered the types of BPA-containing products mentioned in news coverage. Five items assessed mentions of food-related products as sources of BPA: any food or drink containers; plastic food and drink containers; baby bottles or children's cups; infant formula or baby food containers; and canned food or beverages. Three items assessed mentions of other BPA-containing items: any other non-food related products; paper register receipts; and dental fillings or sealants.

Module 2 examined risk framing and health endpoints mentioned, such as whether BPA was mentioned as an endocrine disruptor or having hormonal effects. Mentions of sensitive populations were also assessed (for example, pregnant women or developing fetuses; and infants or young children). Four items further assessed the context of the risk discussion: mentions of widespread exposures to BPA; mentions of potential adverse effects at low doses of BPA; mentions that BPA does not pose health risks or is safe; and mentions that a U.S. government agency has found BPA safe. Eight health endpoints were chosen from a review of the scientific literature (See Chapter 2) and refined during pilot testing of the coding instrument. Mentions of the following health endpoints linked to BPA exposure were quantified: cancer; brain, development or neurological effects; immune system or endocrine effects; reproductive or sexual effects; diabetes; obesity or weight; behavior; or heart disease.

Module 3 assessed mentions of solutions discussed to address BPA risks. Five items covered the government venues mentioned: any government policy action; local

policy; state policy; U.S. federal policy; and foreign policy. Two items captured the type of action mentioned: banning BPA; and labeling products with BPA. Mention of a policy did not necessarily mean that legislation was introduced or enacted. Rather, mentions of policy were interpreted broadly and included policies under consideration or the subject of advocacy. Three items focused on voluntary industry actions: mention of any voluntary industry action to limit BPA; target population for voluntary action; and type of products voluntary action would affect. The final item in this module assessed whether news stories mention ways consumers could avoid BPA. The fourth and final module captured how BPA replacements and their potential risks were discussed. The three items include: mentions of a specific compound which could replace BPA; mentions of difficulty in finding replacements; and mentions of replacements in cans.

Using the news story as the unit of analysis, descriptive statistics on the volume and content of news coverage were calculated and reported. Logistic regressions to test for shifts in coverage over the study time period, controlling for word count and adjusting standard errors for lack of independence among news outlets. Two time periods were compared: 2006 to 2008 and 2009 to 2012. The study period was divided into earlier and later years to tests for differences in news coverage by time. Differences in print versus television coverage, and in "hard" news versus op-eds or editorials were also examined, controlling for word count and adjusting for non-independence of news sources.

Aim 3: Stakeholder Interviews

Sampling and Data Collection

Semi-structured key informant interviews were conducted to understand key stakeholder perspectives on the goals and challenges of effective risk communication on BPA. Interviews are often one of the most important sources of information in case

studies.[96] Typically, qualitative interviewing is more of a "guided conversation" than a rigid set of questioning.[96] A semi-structured approach was used to facilitate the collection of rich context and detailed perspectives from respondents about BPA risk communication.[119] In semi-structured interviews, participants are asked a set of similar questions using an interview guide.[120] This method was chosen because of its flexibility while also retaining the ability to make comparisons across stakeholder organizations. In semi-structured interviews, the interviewer can modify question order and probes based on the respondent's answers, and the respondents have some control over the topics and focus of the interview. Yet, because respondents are generally asked the same questions, comparisons across interviews are possible.[120]

The selection strategy for the interviews included both stratified purposeful sampling and snowball sampling. These selection methods are considered useful in cases of in-depth examinations in which representativeness and generalizability are not predominant concerns.[121] The sample was stratified in order to include the relevant groups who have communicated to the public about BPA. This approach facilitates comparisons between groups and includes varied perspectives.[97] The stratifications included: 1) government agency representatives, 2) researchers/academics 3) industry groups and consultants, 4) health or environment-focused non-governmental organizations, and 5) news media representatives/journalists. Purposeful selection allows for individuals to be selected deliberately due to their unique knowledge or perspective on the subject.[107] Potential participants were identified during background review of the scientific literature and news media reports. Snowball sampling was used to identify additional experts from the initial set of contacts.[97] This allowed for maximizing the

diversity of perspectives and including additional relevant organizations and individuals involved in risk communication on BPA.

Contacts with potential respondents were first made by email. The email described the purpose of the study and the anticipated interview length (Appendix F). Follow-up emails and/or phone calls were used to contact people who did not respond to the first email within two weeks. In order to encourage participation and minimize any risk to participants, interviewees were advised that their names or organizations would not be identified in the study results. Interviewees were read an oral informed consent document (Appendix G) and given the opportunity to ask questions prior to the start of the interview. Interviews were conducted until reasonable expectations of saturation and data sufficiency were achieved.[97] Approximately 30 interviews were planned, and a total of 39 interviews with 36 organizations were conducted in order to include additional respondents referred during snowball sampling and ensure data sufficiency within each stratification. Saturation refers to the concept of collecting data until new information does not provide new insights or perspectives on the research questions. Data sufficiency means having a sample large enough to reflect the variety of perspectives.[97]

The interviews covered several topic areas, including 1) background information on the individual's or organization's efforts related to BPA; 2) BPA communication goals, strategies and main messages 3) the state of the scientific evidence and the use of scientific information in communications; and 4) the challenges of BPA risk communication, evaluation of messaging about BPA and advice for effective risk communication. An interview guide was used in each interview to facilitate comparisons. Probes were tailored by the researcher based on interviewee's responses and the

interviewees could introduce topics not directly highlighted in the questioning. This approach allowed for additional context and understanding of important issues that emerged in the interviews.[122] In some cases not all questions were applicable to all respondents. For example, questions focusing on organizational communication and policy goals were not necessarily relevant for media representatives or researchers. Thus, the interview guide was tailored to participants' roles but remained as similar as possible to facilitate comparable responses (Appendix H).

Between December 2013 and March 2014, representatives from 78 organizations were contacted for interviews. Of these, 12 groups declined to participate and 27 did not respond to interview requests or follow-up contact. Reasons provided for declining included time constraints and lack of knowledge or current involvement on the issue. Of those who declined to participate, three were from NGOs. Additionally, there were two decliners each from industry/consulting, government, research, and the news media. Of the 27 groups that did not respond to initial or follow-up contact, nine were from industry/consulting, eight were individual researchers, five were from NGOs, three were from government, and two were from the news media.

Thirty-six organizations comprising participants from federal government agencies, researchers, industry/consulting, NGOs and the news media were interviewed between December 2013 and March 2014. Thirty-nine total interviews were conducted with respondents from the 36 organizations. In one case, two individuals from one NGO were interviewed separately due to scheduling; and in another case three representatives from the same government agency were interviewed separately. In some cases, more than one respondent participated in the interview. Four interviews were conducted with two

individuals (one interview each with government, researcher, NGO and industry). One interview with a government agency was conducted with three representatives. The unit of analysis used in this study is the organization (n=36). Interviews lasted an average of 47 minutes and were conducted primarily by phone. Due to distance and interviewee scheduling preferences, the majority of interviews were conducted by phone (34). Four interviews were conducted in person, and one interview was conducted via Skype. In order to encourage participants to feel comfortable in sharing potentially controversial opinions or details about their organization's risk communication strategies, interviewees were granted anonymity and identified only by the type of stakeholder group they represented (i.e. government, industry/consultant, NGO, researcher, or news media.

Interviews were digitally recorded except in one instance where the interviewee did not grant permission for audio recording. In that case, the researcher's (PT) notes were analyzed. Audio recording allowed for more natural conversation, as minimal note-taking was necessary. Audio recordings of interviews and transcription files will be deleted after the final defense and publication of dissertation manuscripts. Recording also facilitated the use of direct quotations in results. The interviews were transcribed verbatim by the lead author using Express Scribe software[123] (36) and by D. Anderson (2) without software. Following this process, transcripts were reviewed for completeness and accuracy.

Analysis

Analyzing, representing and drawing meaning from qualitative data is a challenging task,[97] but critical to the validity of a study. Common data analysis strategies in qualitative research include taking notes, identifying codes, reducing codes to themes, counting the frequency of codes, noticing patterns, relating categories to theoretical

frameworks, and contextualizing and displaying the findings.[97] Importantly, in qualitative research the steps of data collection, analysis and report writing are often interrelated and overlapping steps.[97] The analysis process began with the lead author (PT) reading through the interview transcripts (and/or notes) several times and creating relevant structural and thematic code based on the research questions and interview guides.[120] The transcription process also allowed for increasing familiarity with the data set. After reading, re-reading and managing the data set, detailed description and categorization of the data into codes is an important step in case study research.[97] A codebook was developed with definitions of each code and when to apply them (Appendix I). Some codes were developed *a priori* based on knowledge of the questions in the interview guide, while others emerged iteratively during review and re-review of transcripts. Structural codes, or organizational categories, serve to sort the data for further analysis but do not directly answer the research questions.[96] An example of an organizational category included identification of interviewee's stakeholder group (i.e., government) or denoting a particularly cogent quotation. Substantive categories, or thematic codes, more directly describe the content of the statements and facilitate analysis.[120] Examples of thematic codes included discussion scientific literacy, objectivity and evaluation of the news media. During this process, central themes were identified and some codes were expanded to include broader concepts, while others were collapsed or eliminated if they were too specific or repetitive with other codes.[107]

All transcripts were coded using HyperRESEARCH Version 3.5.2 qualitative analysis software.[124] Due to the quantity of data in and the scope of this study, the coding process was focused on topics and themes that directly answered the research questions

of interest. This process has been defined as selective or focused coding. Selective coding is used to sort large amounts of data on recurring themes, categorize the data precisely across interviews and outline the next phase of analysis by generating theory.[125] The next steps of case study analysis commonly involve classifying codes into themes or patterns, interpreting and representing the case using narrative and tables.[97] After all the transcripts were coded, the interview content was organized by stakeholder domain and theme to inform the research questions.[97]

Techniques to Improve Study Quality

Several resources for assessing methodological quality of mixed methods resources were used during the development and conduct of this research.[97,101,104,120,121,126-128] Particularly relevant for evaluating qualitative research are the concepts of credibility, confirmability, dependability, transferability, and authenticity.[97,129] Credibility and confirmability are similar to the quantitative concept of internal validity, and can be enhanced by triangulation.[97] Triangulation refers to the use of multiple data sources to inform research inquiry.[101] Dependability requires the research process is documented. Transferability is similar to external validity refers to whether the findings are applicable to other contexts.[126] Whether case findings are transferable to other situations is often determined by the person wanting to apply the findings elsewhere and this process is aided by the researcher fully detailing the study methods. Authenticity is concerned with the value of the research to society and its impact on participants.[130] While the utility of these concepts has been debated in the literature and various scholars favor different descriptions of valid qualitative research,[97] they provide guidance to researchers in rigorous conduct of qualitative and mixed methods research.

Specific strategies to address these quality standards were implemented in this case study research (Table 1). First, the use of three separate methodologies of document analysis, quantitative news media content analysis and semi-structured interviewing with distinct data sets serves to triangulate the data. Within the framework of a case study, this approach allowed for analysis of BPA risk communication from key stakeholders and the media. Further, the structure and grounding of a case study approach helped to orient the research. Chapter 7 provides synthesis of the case study.

Another technique that added to the quality of this research was the inclusion of diverse perspectives via the selection of stakeholders for interview and document analysis. This is particularly important on a topic like BPA, where there is disagreement among stakeholders and public policy debates.[131] Also, advice from senior researchers was an important component of the quality assurance of this project. Advice from thesis committee members and other senior researchers was incorporated into the research during each stage—including designing, collecting data, analyzing and reporting this work. This process improved and increased the rigor of this dissertation.

Finally, acknowledging and discussing the role of the researcher in qualitative work is necessary and important for accountability and quality of qualitative research. In qualitative research, the researcher is considered the research instrument and should discuss their perspective in order to reduce any effects it many have on the study.[127] As a researcher, I considered my role and perspectives that influenced my understanding and interpretation of the case study. As a public health researcher with a background in journalism and environmental health policy, I was primarily interested in the BPA case as an interesting scientific and communications issue and was not concerned with

determining whether BPA is safe, or not. Despite this, I am based within a discipline that emphasizes the precautionary principle and may have more support for advocacy than industry perspectives. I addressed researcher bias and my role as a research instrument with the use of reflexivity tools such as taking notes and reflecting on interviews. Further, transparency in the discussion of methods and the reporting of limitations is important for accountability and minimizing biases. Thus, as the original researcher, I took efforts to increase transparency and provide detailed descriptions of data and methods in order to address this limitation. Additionally, training in research ethics and qualitative research methodologies, the use of quotations, the inclusion of diverse perspectives, and the use of qualitative software were all used in an effort to be transparent and reduce any inappropriate researcher influences on the study findings. The overall strengths and limitations of this research are discussed in Chapter 7.

Table 1: Practices Used to Enhance Case Study Research Quality (Adapted from J. Fry, 2012)[132]

Quality Concept	Practices Used
Credibility (internal validity)	• Detailed description of data analysis • Triangulation from multiple data sources • Use of quotations in results • Use of inter-rater reliability statistics
Confirmability (objectivity/neutrality)	• Description of multiple views/stakeholder stratifications • Discussion of reflexivity • Triangulation from multiple data sources • Use of quotations in results
Dependability (reliability)	• Detailed description of data analysis • Triangulation from multiple data sources
Authenticity (fairness)	• Description of multiple views/stakeholder stratifications • Detailed description of data analysis • Triangulation from multiple data sources

Chapter 4. Manuscript 1

Stakeholder Communications on BPA: A Qualitative Analysis Using the Risk Assessment Framework

Abstract

Bisphenol A (BPA) is a high-volume industrial chemical found in the food supply and consumer goods. It is well established that diet is the primary route of exposure, and the vast majority of Americans are exposed to BPA. BPA has been found to have endocrine-disrupting properties, and hundreds of studies have researched its potential health effects. Despite the vast literature on BPA, scientists and regulatory bodies have disagreed on whether BPA poses risks to public health. This study used a qualitative approach to understand how federal government agencies, industry trade groups and non-governmental organizations communicated BPA risks to the public. We used the National Research Council's risk assessment paradigm to analyze stakeholders' risk communication, and found very different risk characterizations and risk management approaches across the three domains. Industry groups uniformly concluded that BPA is safe for use; while non-governmental organizations uniformly concluded that BPA poses threats to public health, particularly for sensitive populations such as developing fetuses and young children. Risk communication from the federal government was mixed – with agencies presenting contradictory conclusions to the public. Further, the Food and Drug Administration, which regulates BPA as a food contact substance, has offered conflicting guidance to consumers—both assuring safety of BPA and recommending reducing exposures. There is a need for increased collaboration between government agencies to present unified risk communication messages, particularly in controversial and high-profile cases such as BPA.

Introduction

Bisphenol A (BPA) is a common chemical and endocrine disruptor found in the food supply and in the environment. BPA, which is often described as a weak estrogen[14], has been the subject of increasing research attention and public policy debate in the U.S. and worldwide. While a causal connection to human disease is difficult to establish, BPA exposure has been associated with a variety of health conditions in animals from cancer and obesity to infertility and behavioral effects.[7,8,35,40,44,133] A number of other studies have concluded that exposures to BPA likely do not pose human health risks.[134-137] In the midst of conflicting and complex science on BPA, stakeholders played an important role in informing the public about BPA and influencing policy and regulatory decisions.

BPA is used as a building block in polycarbonate, a hard, clear plastic. Epoxy resins, which line metal food and beverage cans to prevent corrosion, are also commonly made with BPA.[1,2] In 2011, worldwide BPA production was estimated at more than 8 billion pounds per year,[5] making it one of the highest volume chemicals in use.[6] BPA's market value and use in a variety of consumer product applications, particularly in children's products such as baby bottles, have made the chemical a research priority and focus of public attention.

Despite the hundreds of studies conducted over the past decade, there continues to be discord among scientists, regulators, environmental health advocates and industry representatives about whether typical BPA exposures pose health risks.[17,138] Uncertainties remain about the potential for health effects from BPA, particularly in sensitive populations such as developing fetuses, infants and young children.[8] Further, there are weaknesses in the tools scientists have at their disposal to estimate low dose effects.[16] Other controversies have included the appropriateness of animal models and

extrapolation to humans, critiques of various experimental approaches and sample sizes, the mechanisms of BPA action and its metabolism, true levels of human exposure, and concerns about contamination and replicability of some studies.[34,134]

The Risk Assessment Framework

Over the past 30 years, the risk assessment process has been an important tool for government agencies, industry and academia seeking to understand public health and environmental hazards, and inform public policy decisions.[20] Risk assessments are conducted to help understand and make decisions about hazards that may threaten the environment and public health. The National Research Council's *Risk Assessment in the Federal Government: Managing the Process* established the four-step process of hazard identification, dose-response assessment, exposure assessment and risk characterization, which is used by regulatory agencies to assess environmental contaminants.[45] Following the risk assessment, decision makers take this scientific information into consideration along with political, social, economic and engineering factors in what is known as risk management.[45] As shown in Figure 2, available research informs the steps of the risk assessment, which in turn informs decision-making.

Figure 2: National Research Council Risk Assessment and Risk Management Paradigm[20]

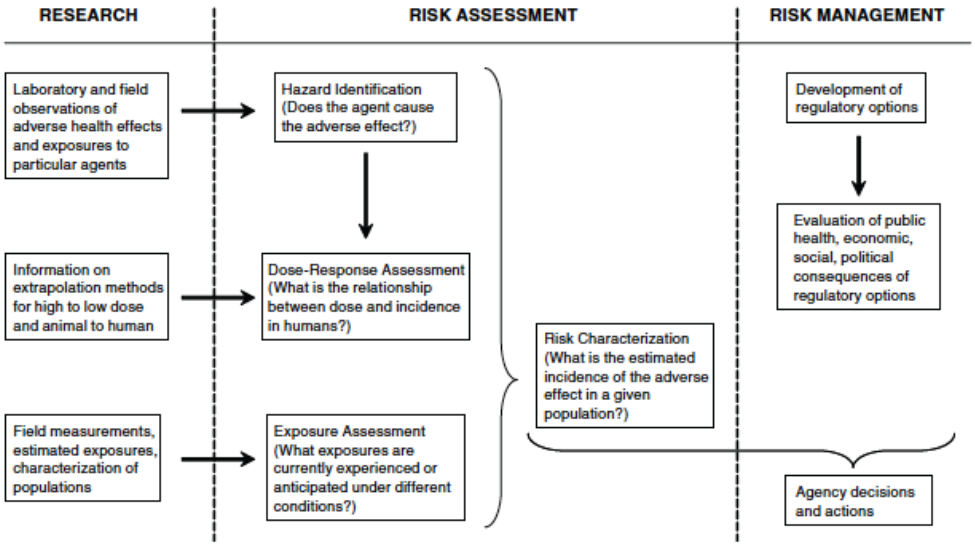


FIGURE 2-1 The National Research Council risk-assessment–risk-management paradigm. Source: NRC 1983.

While the science of risk assessment has advanced over the past three decades, uncertainties often remain and may lead to varying interpretations by stakeholders. The disconnects between available data and desired information impede decision-making.[20] In 2009, a National Research Council panel identified improved characterizations of uncertainty and variability as a top priority in advancing risk assessments. They recommended a "coherent, consistent and transparent process that would provide risk assessments that are relevant to the problems and decisions at hand and that would be sufficiently comprehensive to ensure that the best available options for managing risks were considered."[20]

U.S. Risk Assessments of BPA

Federal agencies have conducted risk assessments of BPA. In 1993, the EPA's Integrated Risk Information System (IRIS) determined the Lowest Observed Adverse Effects Level (LOAEL) for BPA to be 50 mg/kg/day in animal studies. After dividing the

LOAEL by an uncertainty factor of 1000 (10 for animal to human data, 10 for sensitive human populations and 10 for uncertainty regarding chronic to sub-chronic doses), the reference dose (RfD) for oral exposure was set at .05 mg/kg/day. In this case, the RfD—defined as an estimate of a dose believed to be unlikely to cause adverse human health effects[51]—is based on the critical effect of reduced mean body weight.[52]

The Food and Drug Administration (FDA) is responsible for regulating BPA as an indirect food additive or food contact substance. In 2008, FDA's Draft Assessment of Bisphenol A For Use In Food Contact Applications used a NOAEL of 5 mg/kg/day for systemic toxicity, based on two multigenerational rodent studies.[53] In its report, FDA estimated a margin of safety (MOS) of 2,000 for infants, and 27,000 for adults based on food-related exposures.[53] A margin of safety represents the ratio between exposure levels that can harm lab animals and human exposure levels. A 1,000-fold difference for children and a 100-fold difference for adults is typically considered adequate. Thus, FDA determined there was a sufficient margin of safety for both children and adults. While acknowledging complete certainty of safety is impossible to prove, FDA defines safe in this context as "reasonable certainty in the minds of competent scientists that the substance is not harmful under the intended conditions of use."[53]

In 2010, the FDA announced that they had some concerns about effects on fetuses, infants and young children (based on a report from the National Toxicology Program) and were continuing to support research to clarify uncertainties.[1] The FDA's current stance on the overall safety of BPA exposure is that current low-level human exposures appear safe based on standard toxicity testing.[1]

Other federal agencies have also been involved in researching BPA, albeit not necessarily conducting formal risk assessments. Over the past few years, the National Institute of Environmental Health Sciences (NIEHS) invested $30 million in BPA research[55] to address gaps in knowledge that still existed despite the 800 published studies on BPA health effects prior to the research program's establishment.[8] The National Toxicology Program (NTP), an interagency program housed at NIEHS, has also been deeply involved in this research program and has released its own assessments of BPA, notably a 2008 report noting "some concern" for effects on the prostate and brain and behavioral effects in developing fetuses, infants and children.[35] The CDC has been an important source of data on human exposures to BPA with their National Biomonitoring Program.[9]

Stakeholder Risk Messaging

Stakeholder involvement is critical throughout the process of assessing and managing risks.[20] According to the Presidential/Congressional Commission on Risk Management, stakeholders are "groups that are affected or potentially affected by the risk, the risk managers, and groups that will be affected by any efforts to manage the source of the risk."[139] To improve the outcome and utility of risk assessments and ensuing regulatory and policy decisions, stakeholders should be involved in the process and play a role in identifying important questions and potential solutions. Further, the public filters and interprets risks with the help of stakeholders via the news media and other communication venues. These groups may influence what solutions are considered and whether concern about an issue is heightened by the news media and others.[72] A separate analysis found mixed messages in news media content on BPA in national television and newspaper sources between 2006 and 2012 (See Chapter 5).

Several health and environment-focused non-governmental organizations (NGOs) have been vocal on both the science on BPA and their preferred risk management approaches. For example, Consumers Union, the nonprofit publisher of Consumer Reports, has conducted its own tests of BPA-containing products, advised the public on ways to lower their exposure and called on the FDA to ban its use in food and beverage containers and children's products.[74] Other NGOs have likewise urged stricter limitations on BPA, supported state policies and provided information to the public.[71,140,141]

Industry trade associations have also played an important role in representing the voices of BPA manufacturers and users. Companies including Bayer, Dow Chemical, Sunoco and General Electric Plastics make a reported $1 million per day in profits from BPA production.[43] The American Chemistry Council (ACC), a trade group that represents the chemical industry, including major BPA producers, has campaigned against BPA legislation and criticized EPA's IRIS process.[43,83] The ACC also publishes websites that promote the safety of BPA, including factsaboutbpa.org.[84,85] Other industry associations such have also publicly supported BPA's safety and opposed restrictions on its use.[86,87]

Despite the large body of scientific research on BPA from peer-reviewed and government sources, this is the first study to analyze how stakeholders communicated to the public about BPA. This study applied the risk assessment framework[20] as a guide for evaluating key stakeholders' publicly available BPA documents. This study analyzed how key stakeholders characterized public health concerns about BPA and discussed risk management solutions. While not all stakeholder groups conducted a risk assessment, their public statements describe BPA and its properties (hazard identification), how it

may affect human health (dose-response assessment), who is exposed, and how (exposure assessment), and whether consumer exposures pose health risks (risk characterization). Also assessed were stakeholders' discussion of risk management solutions including public policies, voluntary industry actions and replacements for BPA in consumer products. Given the important roles of stakeholders in setting regulatory and policy agendas and influencing public opinion, it is critical to understand how these groups translated scientific data about BPA to the public.

Methods

Sampling and Data Collection

The NRC's risk assessment framework was used to qualitatively examine how key stakeholders communicated about BPA through publicly available documents on their websites. Thus, key stakeholders were defined as national, U.S. based groups who have authority over the risk assessment and risk management of BPA, or will be affected by the risk itself or efforts to manage the risk. We identified three "domains", or types of stakeholder organizations: 1) government agencies, 2) industry associations, and 3) health or environment-focused NGOs. Thirteen organizations and agencies from the three domains were purposefully selected for analysis due to their prominent roles in research, communications, and/or advocacy regarding BPA. Organizations were identified and selected from background research, news media content and/or references from in-depth stakeholder interviews (Manuscript 3).

Four U.S. federal government agencies with regulatory authority over BPA and/or agencies involved in funding or conducting research related to BPA were identified: Centers for Disease Control and Prevention (CDC), Environmental Protection Agency

(EPA), Food and Drug Administration (FDA), and National Institute of Environmental Health Sciences (NIEHS).

The industry's perspective on BPA was communicated primarily through industry trade associations. Five national industry trade associations representing the major food-related producers and users of BPA in plastic products and metal food cans were included: American Beverage Association (ABA), American Chemistry Council (ACC), Grocery Manufacturers Association (GMA), International Bottled Water Association (IBWA) and North American Metal Packaging Alliance (NAMPA). In the case of the ACC, both the organization's primary website and their BPA-specific website (factsaboutbpa.org) were included. Four NGOs concerned with public health, the environment and consumer advocacy were also selected for analysis: Breast Cancer Fund (BCF), Consumers Union (CU), Environmental Working Group (EWG) and the Natural Resources Defense Council (NRDC). All stakeholder organizations are listed in Table 2.

Table 2: Included Government, Industry and Non-governmental organizations

Government	Industry	Non-governmental organizations
• Centers for Disease Control and Prevention (CDC) • Environmental Protection Agency (EPA) • Food and Drug Administration (FDA) • National Institute of Environmental Health Sciences (NIEHS)	• American Beverage Association (ABA) • American Chemistry Council (ACC) • Grocery Manufacturers Association (GMA) • International Bottled Water Association (IBWA) • North American Metal Packaging Alliance (NAMPA)	• Breast Cancer Fund (BCF) • Consumers Union (CU) • Environmental Working Group (EWG) • Natural Resources Defense Council (NRDC)

Documents from 13 groups were obtained directly from the organizations' websites in June 2014. In order to evaluate the stakeholder's public messaging about

BPA, each stakeholder website was searched with the following terms: BPA or Bisphenol A in the document title and at least one of the following words: risk, health or safe.

From the 13 organizations included, a total of 308 documents were identified. Due to the intended focus on risk messages geared to consumers, the following types of data were excluded: reports, blog posts, official testimony and comment letters, meeting presentations, and outlines of specific research projects. To ensure documents included sufficient detail, documents less than 150 words were excluded. To capture the full range of relevant documents over time, the documents were not limited by publication date. After applying exclusions, 146 documents remained for analysis. The Johns Hopkins Bloomberg School of Public Health Institutional Review Board (IRB) exempted this study from review, determining it non-human subjects research.

Data Analysis

In order to evaluate how stakeholders publicly communicated about BPA, a coding instrument was created to extract relevant information from website documents. (Appendix C). The instrument development was guided by a preliminary literature review and structured around the stages of risk assessment and risk management. The instrument was refined during initial review of included documents and finalized prior to document coding. First, basic information was collected from each document, including the title, organization, domain, date of publication and/or date of last update, document type and document purpose. The first substantive section of the coding instrument collected information on hazard identification. Specifically, words used to describe BPA were coded, for example: chemical, toxic, estrogen, or hormone. Next, BPA-containing products or locations were coded (i.e. food and drink containers, receipt paper, consumer goods and the environment). The second part of the coding instrument collected data on

dose-response assessment —in other words, the risk estimates or points of departure used to quantify risk. The third section, covering exposure assessment, collected data on how the documents described people's exposure to BPA. Information was extracted from the documents on populations exposed, sensitive populations, and route(s) of exposure. Fourth was the assessment of risk characterization, comprising the documents' main messages on BPA safety or risk. Finally, the fifth section of the instrument coded risk management discussion in the documents, for example the type of solutions described and discussion of potential BPA replacements. For each document, relevant portions of text were also collected to aid in analysis and put results in context.

Data were collected using the Qualtrics online survey tool[110] and analyzed using Microsoft Excel and Qualtrics. Data were extracted, coded and analyzed by a single author (PT). The unit of analysis used was the individual stakeholder organization. This level of analysis was chosen because the intent was to understand the overall messaging coming from each organization through their website, as opposed to the content of an individual document, i.e. a single web page or press release. To facilitate comparisons, data were analyzed both at the organizational level, and at the domain level (government, industry and NGO). Beyond basic descriptive information provided about the sample, reporting of numerical measures in the results was limited due to the non-representativeness of the data and to avoid overstating generalizability.[128] Further, because the unit of analysis was the organization, findings are aggregated to that level as opposed to contrasting individual documents.

The 146 documents included for analysis were categorized by their primary purpose: 1) to provide general information about BPA, 2) to release news, 3) to

summarize a report, or 4) to describe the organization's overall position and actions related to BPA. Notably, there was some overlap in the purpose of the documents. For example, some documents were news releases detailing the organization's actions related to BPA, or summarizing a new report. In these cases, the primary purpose was coded as news release.

Results

Eighty documents from NGOs, 48 industry documents and 18 government documents comprised the sample. (See Appendix B for the tally of included documents by organization). As shown in Table 3, the majority of documents were news releases. While most industry and NGO documents were news releases, most government documents provided general information about BPA or described the agency's actions on BPA. The range of years observed was 2005 to 2014, with most documents published between 2008 and 2012 (85% of the documents identified by year were created or last updated in these five years).

Table 3: Included Documents by Purpose and Stakeholder Domain

	Government	Industry	NGO	*Total*
About BPA	5	10	6	21
News release	3	34	61	98
Report brief	2	2	13	17
Describe organization's stance or actions	8	2	0	10
Total	18	48	80	146

Table 4 summarizes risk messages from each stakeholder group for each of the risk assessment and risk management steps. The table displays only the uniform risk messages that were prevalent in documents from *all* organizations within each domain. For example, all four of the NGOs described BPA as a chemical, estrogen, toxin and hormone-disrupting. When all organizations within a domain did not present consistent

messages (for example, three out of four government agencies referred to developing fetuses and young children as sensitive populations), the item is denoted as "not uniform" in Table 4. This approach allows for a summary of the most consistent messaging by domain, with more nuanced results presented in subsequent sections.

Table 4: Uniform Risk Messages by Stakeholder Domain

	Government	**Industry**	**NGO**
Hazard Identification: Description	Chemical	Chemical	Chemical, estrogen, toxin, hormone-disrupting
Hazard Identification: Products	Food and drink containers, receipts	Food and drink containers	Food and drink containers
Hazard Identification: Health endpoints	Development, reproductive	*Not uniform*	Cancer, development, reproductive, diabetes, obesity, heart disease, behavior
Dose-Response Assessment	*Not uniform*	Current exposure levels do not cause health effects	Current exposure levels could cause health effects
Exposure Assessment: Who is exposed	Everyone	*Not uniform*	Everyone, young children
Exposure Assessment: Sensitive populations	*Not uniform*	*Not uniform*	Pregnant women and developing fetuses, young children
Exposure Assessment: Route of exposure	Ingestion of food or drink	*Not uniform*	Ingestion of food or drink
Risk Characterization	*Not uniform*	Safe	Not safe
Risk Management	*Not uniform*	*Not uniform*	State and federal legislation, FDA regulation, and voluntary industry actions to reduce BPA exposure; safer alternatives needed

"Not uniform" denotes that organizations within the domain presented different messages.

Hazard Identification

First, stakeholders' hazard identification messages were analyzed. General descriptions of BPA were relatively consistent across the three domains, with all groups describing BPA as a chemical. Two government agencies also referred to BPA as an estrogen (EPA, CDC), and EPA and NIEHS referred to BPA as an endocrine disruptor and a toxin. All of the NGOs described BPA as an estrogen, toxin, and hormone-disrupting. Industry groups typically did not use these terms to describe BPA, although one group (NAMPA) used the terms "toxic" and "endocrine disruptor" in quotations,[142,143] and two organizations indicated BPA is as not a reproductive and developmental toxin and not a carcinogen (IBWA and NAMPA).

All three domains consistently identified food and drink containers as BPA sources. All government agencies also mentioned receipt paper as a source of BPA. Two agencies (CDC, NIEHS) mentioned dental sealants. Three government agencies (CDC, EPA, NIEHS) also mentioned the presence of BPA in the environment. Three NGOs also mentioned receipt paper and dental sealants as sources (NRDC, EWG and BCF). Two industry groups (ACC, IBWA) and three NGOs (NRDC, EWG and BCF) mentioned generally that other consumer goods may contain BPA.

With regard to health endpoints discussed in the documents, disparities in health endpoints linked— or potentially linked— to BPA exposure were observed by domain. All four government agencies mentioned potential developmental and reproductive effects. Behavioral effects were mentioned by three agencies (FDA, EPA, NIEHS). FDA and NIEHS also cited diabetes and heart disease. NIEHS documents referred to several additional health endpoints such as cancer, asthma and epigenetic effects. As shown in Table 3, the NGOs consistently referenced the most health endpoints. All of the NGOs

referred to the following health endpoints: cancer, developmental effects, reproductive effects, diabetes, obesity, heart disease and behavior.

By and large, industry groups did not name specific health conditions. In the instances where health endpoints were named, they were routinely presented in the context that effects were not proven. For example, an undated NAMPA web page titled "Common Misperceptions about BPA," states "there is no conclusive scientific evidence that shows a causal relationship between BPA exposure and human health effects."[144]

Dose-Response Assessment

Second, dose-response discussion was evaluated. The stakeholder documents provided little discussion and quantification of what a safe exposure level would be, or what points of departure (such as a Reference Dose or No Observed Adverse Effects Level) were used in assessing the dose-response relationship. Among the 13 organizations, three of the industry groups (ACC, NAMPA, IBWA) and one of the NGOs (CU) cited specific safety limits (i.e. a point of departure). Government agency documents in the sample did not specify points of departure, although some risk estimates reported by industry groups and CU did cite U.S. agency data. For example, the IBWA cited EPA's Reference dose (RfD) and NOAEL. Consumers Union referred to FDA's safety limit of .05 mg/kg/day, which is the same as the EPA's RfD. CU also referred to FDA's cumulative exposure daily intake (CEDI), an estimate of an individual's exposure. Foreign government figures were also cited in some instances. For example, the ACC and NAMPA reported Tolerable Daily Intake (TDI) estimates from the European Food Safety Authority.

Some patterns were identified by domain in the discussion of dose-response: some industry groups reported that unrealistically high daily exposures would be

necessary to reach unsafe doses of BPA, while some NGOs reported that a single serving could be harmful. In some instances, stakeholders translated risk quantifications into more readily understandable language to explain the dose-response relationship. For example, IBWA noted that a consumer would have to drink 1,000 gallons of water in a day to reach Canada's TDI.[145] A 2009 NAMPA document stated that a 130-pound individual would have to consume more than 7,400 twelve-ounce cans in order to exceed Canada's TDI.[143] In contrast, the Breast Cancer Fund stated in a report brief that of the Thanksgiving foods they tested for BPA, half of the foods contained enough BPA in one serving to cause health effects in lab studies.[146] Government documents in the sample did not describe this relationship or list points of departure used in risk assessments, although other government sources (such as publicly available reports not included in the sample) do detail dose-response assessment approaches.[52,53]

Exposure Assessment

The third step of the risk assessment framework evaluated was exposure assessment. Government agencies and NGOs consistently identified the general public as exposed to BPA, commonly referring to biomonitoring data indicating that the majority of Americans have detectable BPA in their urine. Three government agencies (EPA, CDC and NIEHS) and all four NGOs also referred to exposures in young children. Two NGOs also identified pregnant women and developing fetuses as an exposed group (EWG, BCF). EWG additionally mentioned heightened exposures of cashiers from handling receipt paper.[147]

Industry documents did not consistently describe the general population as exposed, but two groups (NAMPA and ACC) did refer to exposures of the general population and among children. More commonly, the industry groups referred more

generally to typical or average human exposures, without explicitly stating widespread exposure, or what groups are commonly exposed. For example, a 2010 ACC press release stated: "typical consumer exposure to BPA, from all sources, is more than 1,000 times lower than government-established safe intake levels."[148]

Many stakeholder documents characterized routes of exposure to BPA. As previously mentioned, food and drink containers were the primary source of BPA mentioned, and likewise, ingestion of food and drink was the main exposure route. All government agencies and NGOs specified the route of exposure as ingestion of food and drink, as well as three of the industry groups (IBWA, ACC and NAMPA).

Three government agencies (FDA, EPA and NIEHS) identified developing fetuses and young children as sensitive populations. CDC's documents were focused on its biomonitoring efforts of children over six and adults, and thus did not provide information on sensitive populations. ACC described workers without sufficient occupational safety measures as a sensitive group.[148] IBWA noted FDA had determined "some concern" for infants and developing fetuses.[145] In contrast, all four NGOs identified pregnant women or developing fetuses, and young children as sensitive populations. BCF also specified that breast cancer patients may be particularly vulnerable to BPA exposure due to interference with chemotherapy.[149] EWG additionally defined adolescents, African Americans, and the poor as sensitive populations.[150]

Table 5 presents quotations in italics from key stakeholder documents for hazard identification and dose-response items. This table provides context on the type of language that was extracted from the documents for each item of interest, but does not provide representative samples of the content or convey every finding. Each stakeholder

group did not specify information relevant to every item; therefore, the organizations that provided more details may appear more frequently in the table. Bolded text was added for emphasis of the extracted text.

Table 5: Hazard Identification, Dose-Response and Exposure Assessment Messaging Examples By Stakeholder Domain

	Government	Industry	NGO
Hazard Identification: Description	*BPA is an **endocrine disruptor**, with **estrogenic** activity, which means that it has the potential to interfere with the body's natural hormones.* -NIEHS 2014[151]	*BPA is one of the most thoroughly tested **chemical**s in commerce today.* -ACC 2010[152]	*BPA is a **hormone-disrupting chemica**l that **mimics estrogen the** female sex hormone essential for development and function of reproductive organs.* -NRDC 2010[153]
Hazard Identification: Sources	*Humans appear to be exposed primarily through food packaging manufactured using BPA, although those products account for less than 5 percent of the BPA used in this country.* -EPA 2014[88]	*The use of bisphenol A (BPA)-derived epoxy resins to make protective coatings for **metal food and beverage packaging** helps provide safe, wholesome and nutritious food and beverages for people throughout the world.* -NAMPA 2008[154]	*…common products like the linings of **aluminum cans, water bottles, food storage containers, eating utensils, food cans, and other plastic containers**.* -CU 2013[155]
Hazard Identification: Health Endpoints	*Reports from some animal studies have raised potential concerns that BPA exposure may cause multiple health problems, including **reproductive disorders, diabetes and cardiovascular disease**.* -FDA 2013[77]	*Research has shown that bisphenol A is **not a carcinogen**, **not a reproductive or developmental hazard**, and is **not bioaccumulative** because it is rapidly metabolized and eliminated from the body.* -IBWA 2005[156]	*Even miniscule exposures increase risks for **breast cancer, prostate cancer, infertility, early puberty, metabolic disorders and type-2 diabetes.*** -BCF (date unknown)[157]
Dose-Response Assessment	Not specified.	*As noted by Health Canada, **an adult would have to drink approximately 1,000 liters (or 264 gallons) of water** from polycarbonate water cooler bottles every day to approach the science-based safe intake limit for BPA established in Canada.* –IBWA (date unknown)[158]	*For 1 in 10 cans of all food tested, and 1 in 3 cans of infant formula, a single serving contained enough BPA to expose a woman or infant to BPA levels **more than 200 times the government's traditional safe level** of exposure for industrial chemicals.* -EWG 2007[159]
Exposure Assessment: Who is exposed	*CDC scientists found BPA in the urine of nearly all of the people tested, which indicates **widespread exposure to BPA in the***	*Numerous BPA biomonitoring studies have been conducted and have found **measurable levels in peoples' urine.***	*CDC found BPA present in the urine of **93 percent of all Americans over the age of six**. A groundbreaking report released late last*

	U.S. population -CDC 2013[160]	-NAMPA (date unknown)[144]	*year by EWG discovered the plastics chemical in **9 of 10 umbilical cord blood samples** the group tested.* -EWG 2010[161]
Exposure Assessment: Route of exposure	*People are exposed to low levels of BPA because, like many packaging components, very small amounts of **BPA may migrate from the food packaging into foods or beverages**.* -FDA 2014[162]	*People are exposed to BPA almost entirely **through food contact materials**.* -NAMPA (date unknown)[144]	*Consumers **eating just one serving of the canned vegetable soup** tested by Consumer Reports would get about double what the FDA has considered **typical average dietary daily exposure**.* -CU 2012[163]
Exposure Assessment: Sensitive populations	*Another reason for concern, especially for parents, may be because some laboratory animal studies report subtle developmental effects in **fetuses and newborns** exposed to low doses of BPA.* -NIEHS 2010[151]	*What You May Have Read: Children are more susceptible to harmful effects of BPA. What the Science Says: Studies have shown that **infants metabolize BPA in a similar manner to adult humans**.* -NAMPA (date unknown)[144]	*But the science is now showing that **fetal exposure** to BPA is of even greater concern, spurring public health advocates to refocus on protecting **women who are or may become pregnant**.* -BCF 2013[149]

Risk Characterization

Patterns in the overall characterization of BPA risks by stakeholder domain were observed. Industry sources were consistent in their messaging that BPA is safe. All industry organizations in the sample concluded in their public documents that BPA does not pose risks to human health from food-related exposures. Frequently, industry sources cited U.S. and international regulatory bodies' findings that current BPA uses are safe. NGOs were also consistent in their messaging, but with the opposite conclusion—that BPA does pose human health risks at doses relevant to human exposure. All four NGOs in the sample concluded that BPA is a public health concern. Government documents were varied in their conclusions and recommendations—even within individual agencies. For example, several FDA documents reiterated their finding that BPA is safe at current exposure levels. Yet, a FDA webpage created in 2010 and last updated in 2013 advises consumers on how to reduce their exposure, explaining, "FDA believes that recent animal

studies provide reasons for some concern about the potential effects of BPA on infants and children."[165]

Other agencies discuss uncertainty and the need for more research (CDC, EPA and NIEHS). For example, the EPA noted that it continues to work with other agencies to evaluate BPA.[154] NIEHS documents explained and described its finding of "some concern" for potential effects on the brain, behavior and prostate gland in fetuses, infants and children.[151] To illustrate the range of risk characterization messages, Table 6 provides messaging examples from each of the 13 organizations.

Table 6: Risk Characterization Messaging Examples by Stakeholder Organization

Domain	Organi-zation	Year	Risk Characterization Messages	Overall Risk Characterization
Government	FDA	2014	***Is BPA safe? Yes.*** *Based on FDA's ongoing safety review of scientific evidence, the available information continues to support the safety of BPA for the currently approved uses in food containers and packaging.* [162]	Safe
	EPA	2014	*Studies employing standardized toxicity tests used globally for regulatory decision-making indicate that the levels of BPA in humans and the environment are* ***below levels of potential concern for adverse effects****.*[154]	Safe
	CDC	2013	*Human health effects from bisphenol A at … biomonitored levels from low environmental exposures are* ***unknown****.*[160]	Uncertain
	NIEHS	2014	*The studies in humans are really inadequate to reach any kind of a conclusion, but the* ***studies in animals have shown a variety of effects at very, very low levels****….The fact that there are so many levels of uncertainty make it very difficult for us to make any kind of overall recommendations as to how exactly the U.S. public should view bisphenol A*[166]	Uncertain
Industry	ACC	2010	*The consensus of government agencies across the world is that* ***BPA is safe*** *for use in food contact materials.*[153]	Safe
	NAMPA	2012	*BPA-based coatings, when used in food packaging,* ***do not pose a health risk*** *to the general population, including infants and young children.*[167]	Safe
	IBWA	2013	*The consensus among these regulatory*	Safe

			*agencies is that the **current levels of exposure to BPA through food packaging are safe**.*[168]	
	ABA	Un-known	*The beverage industry's products and containers are **safe and pose no public health risk**, including any alleged risk associated with BPA.*[169]	Safe
	GMA	2010	*We agree with today's reaffirmation by HHS and FDA that baby bottles, infant sipping cups, canned infant formula and other foods in cans with linings that utilize BPA are safe, and that there is no need for consumers to change their consumption habits.*[170]	Safe
NGO	NRDC	2011	*As thousands of studies have already shown, BPA is **a dangerous chemical that has no place in the food chai**n.*[171]	Risk
	EWG	2012	*This latest research implicates BPA in **one of the most serious public health emergencies** faced by young Americans.*[172]	Risk
	CU	2010	*The scientific evidence is clear that BPA poses **serious health risks**, especially to children and the developing fetus.*[173]	Risk
	BCF	2011	*…mounting scientific evidence that exposure to **even extremely low levels of BPA can negatively impact health**.*[174]	Risk

Risk Management

The fifth and final aspect of the risk messaging assessed was stakeholders' discussion of risk management. Separate from the four risk assessment steps, stakeholders' discussion of potential solutions and replacements for BPA was evaluated. Government agencies' discussion of appropriate solutions was varied. CDC documents did not mention solutions. EPA discussed possible solutions within its jurisdiction (such as rulemaking under the Toxic Substances Control Act, or acting on the basis of negative environmental impacts of BPA). NIEHS recommended reducing consumer exposures and more research.

FDA documents had the most varied discussion of solutions. FDA recommended reducing consumer exposures in some instances, but not for infants, stating: "FDA is not recommending that families change the use of infant formula or foods, as the benefit of a stable source of good nutrition outweighs the potential risk of BPA exposure."[1] FDA

documents explained its regulatory decision-making, such as their denial of a NRDC petition to ban BPA[175], and the approval of a petition to remove the approved use of BPA in formula containers due to industry abandonment.[176] FDA documents also supported voluntary industry efforts to develop BPA alternatives.[165] EPA was the only other agency to discuss replacements—as the agency conducted an alternatives assessment for BPA in thermal receipt paper.[154]

NGO documents had the most extensive focus on solutions of the three domains. All the NGOs supported legislation at the state and national levels, FDA regulation, and voluntary industry actions to reduce BPA exposure. Three of the NGOs also recommended consumers reduce their exposures (BCF, CU, EWG). Some NGO documents included discussion of multiple solutions, as demonstrated in the CU quotation in Table 7. NGOs also uniformly highlighted the need for safer alternatives. Some groups mentioned available alternatives that had been used as replacements in other settings. In some cases NGOs cited concern about unnamed replacements, such as in this undated Breast Cancer Fund document:

> "Can manufacturers are beginning to use alternative liners to BPA in cans. Any alternatives to BPA, however, must be studied for their effects on health—switching out a chemical we know is harmful for one that's unknown and untested is just kicking the can down the road. We're proud to say that many canned food makers, including industry leader Campbell's, are phasing out BPA. Problem solved? Not exactly. Most of these companies aren't telling us what they're using instead of BPA, and we have concerns about the alternatives."[149]

The industry discussion of solutions was limited and focused on opposing public policies and voluntary measures. One industry group, ABA, did not discuss risk management. Of the other four industry groups, two were opposed to consumer actions to reduce exposures (IBWA, GMA), and IBWA also cautioned against industry changes

that could negatively impact food safety. Two industry groups (NAMPA and GMA) stated opposition to policy or regulatory efforts to limit BPA. In terms of replacements, all industry groups either cautioned against regrettable substitutions or reported that they are not safe and viable BPA replacements.

Table 7: Risk Management Messaging Examples By Domain

	Government	Industry	NGO
Solutions	*FDA is supporting the industry's actions to stop producing BPA-containing bottles and infant feeding cups for the U.S. market.* -FDA 2013[165]	*Given the serious implications on food safety from any action to ban BPA, we believe FDA is pursuing a prudent course of action. A ban without conclusive scientific evidence of risk would compromise the safety of canned foods and beverages enjoyed by millions of Americans everyday.* -NAMPA 2012[177]	*"CU continues to urge FDA to act immediately to remove BPA from food and beverage containers…. CU continues to advise consumers to choose fresh or frozen foods whenever possible and to lower their consumption of canned foods…. . CU also urges federal action to ban BPA in all food and beverage containers so that all consumers will be protected."* -CU 2011[178]
Replacements	*FDA will support changes in food can linings and manufacturing to replace BPA or minimize BPA levels where the changes can be accomplished while still protecting food safety and quality.* –FDA 2014[1]	*"Basing decisions on emotions and controversy alone risks "regrettable substitutions" that compromise performance and/or safety…For both polycarbonate plastic and epoxy resins, it is not a simple matter to find a material that can match the attributes and performance of these materials…Replacement of BPA can only be defended for alternatives that, in fact, deliver better performance or are safer than BPA."* -ACC (date unknown)[179]	*BPA-free alternatives are already available and on the market. The FDA has no good reason to drag their feet on banning it…the FDA should act now to ban this unnecessary risk.* -NRDC 2010[180]

Discussion

Key stakeholders from government, industry and health and environmental NGOs agreed on some aspects of BPA risks. The three domains were generally consistent that

BPA is a chemical in food and drink containers, and that consumers are exposed through their diets. The stakeholders differed on the health endpoints associated with BPA, sensitive populations, and whether current exposure levels are potentially harmful. As expected, NGO and industry stakeholders disagreed on whether BPA is safe as currently used, and what, if anything should be done about it. Government risk communication, even within just the FDA, was not consistent.

Industry groups consistently presented similar messages on BPA. Industry groups noted scientific studies and government assessments that downplayed any public health risks from BPA exposure. Industry groups also highlighted BPA's benefits, cautioned against replacing BPA, and opposed legislative and regulatory efforts to reduce population exposures. One notable exception to this was the ACC's 2012 petition to the FDA to remove the approved use of BPA in baby bottles, which was not based on safety but rather market abandonment.[181]

Likewise, risk communication from the four NGOs was uniform. However, NGOs came to the opposite conclusions as industry. NGO documents showed concerned that human exposure levels could cause health impacts, particularly for sensitive populations such as fetuses, infants and children. NGOs linked BPA to a host of diseases and advocated for legislation, regulation, and voluntary industry actions to remove the compound from food and drink containers. In some cases, NGOs recommended ways consumers could reduce their exposure.

Risk messaging from government agencies was the most varied of the three domains and did not present a unified risk characterization message. It is important to note that for government agencies, some inconsistencies are to be expected given the

various missions of the agencies analyzed. For example, EPA and CDC, because of limited or non-existent jurisdiction over BPA, do not report their own conclusions on risk characterization, leaving those statements to the FDA as the regulating body. However, inconsistencies in the FDA's risk communication were noted as well, which corresponded with the agency's pronouncement of "some concern" in 2010 while continuously maintaining BPA is safe for approved uses. Notably, FDA reported their finding of BPA safety in several documents,[162] while another document recommends consumers reduce their exposures.[165]

It is important to note that the type and purpose of documents varied between stakeholder domains, which was expected given the different jurisdictions and missions of federal government agencies, industry groups and NGOs. For example, most government agency documents were intended to inform the public about BPA and summarize what actions their agencies were undertaking, as opposed to issuing press releases or providing detailed technical reporting. U.S. agencies have released technical reports on BPA, which were outside the scope of this study. Industry groups and NGOs, on the other hand, frequently disseminated BPA-related news through press releases.

In the case of BPA, NGOs consistently cited evidence suggesting harm from BPA, while industry groups consistently cited evidence suggesting that BPA poses little to no public health risk. While there was much discussion (particularly from NGOs) about public policies to remove BPA from consumer products, there was limited discussion of replacement compounds for BPA. Further, the existing discussion of replacements was fractured—with industry groups mentioning that safe alternatives are not available, and NGOs stating that viable replacements are available.

Strengths and Limitations

This study is the first to analyze stakeholder BPA risk communication. As in any study, there are limitations. Notably, this study included public documents available on stakeholders' websites in June 2014. Any relevant information removed prior to this time, or posted thereafter, is not captured in this study. The changing content of websites and potential variability in the completeness of archived documents on stakeholder websites could also produce bias that cannot be measured. Document reviews can also be biased by the researcher's selection schema.[96] It is possible that a different selection of organizations, or restricting the documents to a specific time period of interest could have produced different results. The dataset used in this study reflects publicly available information that any consumer could theoretically access as of June 2014. While documents ranged from 2005 to 2014, newer results would likely be prioritized in web search results. In order to capture the full range of stakeholder communications to date, inclusion criteria were not limited to any particular time period.

The documents evaluated were aimed for a general audience and not risk assessors or experts. Thus, the documents did not necessarily include all of the critical information needed for a risk assessment. It was beyond the scope of this research to evaluate the merits of the research cited in the documents; rather the goal was to describe key stakeholders' public risk communication on BPA. However, given the vast array of scientific literature on BPA, it is possible to cite published research supporting nearly any conclusion about BPA's safety.

There are also some key strengths of this study. The documents analyzed were an existing source of information; they provided specific and detailed background information that did not exist elsewhere.[96] The data analyzed represent a unique

summation of risk communication geared toward consumers from the major stakeholders in the United States. The documents provided messaging directly from each organization—and thus represent official statements that were not filtered through the media or other avenues. This study is the first to evaluate stakeholder's risk communication using the risk assessment framework. This is also the first study to assess how key stakeholders in the United States have characterized human health risks associated with BPA.

Conclusion

This analysis confirms that there has been conflicting risk communication about BPA from government agencies, industry associations and NGOs in the United States. Such fractured information about the potential hazards about BPA confuses the public and muddies the distinction between risk assessment and risk management. Successful risk management depends in part on the ability of public health practitioners to translate data and communicate about complex and uncertain scientific issues. BPA presents a challenging case due to conflicting research results, advocacy efforts, and different, evolving conclusions from government agencies. However, years after the industry voluntarily removed the chemical from some products, and legislative bodies passed BPA bans, scientists and regulators continue to disagree on the public health implications and a clear message on BPA safety is still elusive. Government agencies in particular, given their intended roles as impartial arbiters, should work together to ensure that consistent risk information is presented to the public in spite of their different missions and goals.

Chapter 5. Manuscript 2

U.S. News Media Framing of Bisphenol A (BPA) from 2006-2012

Abstract

Bisphenol A (BPA), a chemical found in food packaging and other consumer goods, has been investigated as a potential public health threat over the past decade. Despite much research, stakeholders remain in disagreement about human health risks. This study assessed U.S. news media coverage of BPA sources, risk framing and discussion of health endpoints, solutions and replacements. A quantitative content analysis was conducting using a selection of major newspaper, news magazine and television news sources between 2006 and 2012. News coverage focused on food-related exposures and peaked in 2008. News stories in the sample (n=224) often mentioned baby bottles or children's cups (80%) and framed infants and young children as a sensitive population (61%). The majority of news stories linked BPA to health endpoints (89%), and two-thirds mentioned BPA as safe. Reproductive conditions, cancer and developmental effects were most reported. Solutions were discussed in most news stories (80%), with 2009 to 2012 news stories and print sources more likely to mention U.S. government policies to restrict BPA. Replacements for BPA were rarely mentioned. Opposing risk messages were present in much of the news coverage, which is reflective of conflicting stakeholder views on BPA's risks. This study provides insights on news media framing of a complex environmental health issue amid scientific uncertainty.

Introduction

Bisphenol A (BPA) is a common chemical found in the food supply and in the environment that has been linked to health concerns in the United States and around the world. A weakly estrogenic compound, BPA has been associated with a range of adverse health effects, including cardiovascular effects, sexual dysfunction, infertility, obesity, early puberty, prostate and mammary gland cancers, behavior changes, and diabetes. [7,8,14]

The two most common food-related sources of BPA are polycarbonate plastics and canned goods. BPA is used as a building block in polycarbonate plastics, a type of hard, clear plastic in some reusable water bottles and baby bottles. Epoxy resins, which line metal food and beverage cans to prevent corrosion, are also commonly made with BPA.[1] Other non-food related sources include dental sealants and cash register receipt paper.[8] Biomonitoring data show nearly ubiquitous BPA exposure in Americans. The Centers for Disease Control and Prevention (CDC) reported 94 percent of a nationally representative sample had detectable BPA in urine samples.[9] While BPA has a short half-life and is quickly excreted from the body, its presence has been described as "pseudo-persistent" because exposure is frequently recurring.[29]

Safety concerns first emerged in the late 1990s and early 2000s, when researchers began reporting adverse health effects in animals. More widespread awareness from the public and policy makers began in the mid-2000s. In 2006, a U.S. National Toxicology Program (NTP) advisory panel report concluded that BPA was safe.[182,183] Two years later, in 2008, the NTP changed course and determined there was reason for "some concern" (the midpoint on a 5-point scale) about BPA's potential impacts on the brain, behavior and the prostate gland in fetuses, infants and children.[35] Also in 2008, the FDA released a draft risk assessment concluding that current BPA exposures are safe for

children and adults. Despite the FDA's safety determination, manufacturers of BPA and retailers begin voluntarily phasing out baby bottles with BPA due to advocacy efforts and consumer demand.[182,183]

In 2009, policymakers responded to continued public concern with a host of legislative proposals at the local, state and federal level to restrict BPA use, particularly in children's products. A federal bill, the "BPA-Free Kids Act of 2009," was introduced in the Senate, but later died in committee. In 2010, the FDA announced agreement with NTP's finding of "some concern" and supported reducing consumer exposures. In July 2012, the FDA approved a request from the American Chemistry Council (ACC) on behalf of industry to abandon the approved use of BPA in baby bottles. The ACC noted this decision was not based on safety concerns, but rather industry's desire to clarify that BPA was no longer being used in children's food and drink containers.[181] By the end of 2012, 12 states, the District of Columbia and 2 localities (Chicago and Suffolk County, NY) had enacted restrictions on BPA.[60] Figure 3 presents a brief timeline of major U.S. actions on BPA over the time period from 2006 to 2012.

Despite a large body of research on BPA, uncertainties remain about whether BPA poses risks to human health at current exposure levels.[8] In addition, there has been discord among government agencies, industry and public health advocates about the level of risk and appropriate solutions.[17] The news media serve an important function in informing and influencing the public and policymakers about important public health issues. The topics covered in the news highlight potential safety concerns and convey to the public what is worthy of attention. The news media filter and interpret scientific data, as well as provide a venue for stakeholders to present their views and preferred

solutions.[102] In cases of uncertainty about an issue, the role of the news media may be particularly influential, as how issues are framed in the news media may influence public perceptions of the significance of the problem.[103]

Figure 3: Major U.S. Government Actions on BPA, 2006-2012

December 2006: The National Toxicology Program (NTP) releases health assessment on BPA, concluding that BPA is safe.

June 2008: California becomes the first state to propose a ban on BPA in children's products.

August 2008: FDA releases draft risk assessment concluding that current exposures are well below levels of concern in children and adults.

September 2008: NTP releases report noting "some concern" (the midpoint on a 5-point scale) for reproductive, behavioral and brain impacts from fetal and infant BPA exposure.

March 2009: A federal bill to ban BPA in children's food and drink containers, "The BPA-Free Kids Act" is introduced in the Senate, but later died in committee.

March-June 2009: Minnesota, Connecticut, Suffolk County, NY, and Chicago become the first jurisdictions to pass laws restricting BPA.

January 2010: FDA announces increased concern about BPA and agreement with NTP finding of "some concern." FDA describes ways parents can reduce their children's exposure to BPA and supports "reasonable steps to reduce human exposure to BPA in the food supply."

March 2010: U.S. Environmental Protection Agency announces plan to assess risks from non-food sources of BPA, and evaluate BPA substitutes in register receipts.

2010: Maryland, New York, Vermont, Washington, and Wisconsin pass restrictions on BPA in food containers.

2011: California, Delaware, Illinois, Maine, Massachusetts, and Washington D.C. pass legislation regarding BPA. Connecticut and Maryland pass further measures affecting BPA in additional products.

July 2012: FDA disallows the approved use of BPA in baby bottles and sippy cups in response to an industry request.

No study to date has examined how potential health risks have been framed by the news media. In order to fill this research gap, we collected and analyzed U.S. news media content from major newspapers, news magazines and television sources. In particular, we were interested in assessing the types of products mentioned as sources of BPA, the

discussion of BPA exposures and risk, and health endpoints linked to BPA. We also assessed discussion of solutions: government actions, voluntary industry measures, and individual consumer action. Finally, we examined news media coverage of BPA replacements.

Methods

A quantitative news media content analysis was conducted to understand how BPA was framed in print and television news coverage. Twenty-two U.S. newspaper, news magazine and television news sources were examined. The time frame of 2006 to 2012 was selected to correspond with a period of increasing attention on BPA in the form of scientific research, government reports, and public policy. Preliminary database searches confirmed that this 7-year period was inclusive of the majority of news coverage on BPA; coverage prior to 2006 was negligible.

In order to analyze the news coverage reaching the most Americans, the top three U.S. daily newspapers by circulation were purposefully selected, as well as three of the top circulation papers from each of the four Census regions based on circulation rates from the Alliance for Audited Media for the years 2006, 2009 and 2012.[112] All included newspapers were among the top 25 for national circulation rates at least two of those three years. The top three national newspapers in the sample were *The New York Times*, *USA Today* and *The Wall Street Journal*. The 12 regional papers were *The Boston Globe*, *The Philadelphia Inquirer*, *The Washington Post, Chicago Tribune*, *Minneapolis Star Tribune*, *Milwaukee Journal Sentinel, Houston Chronicle*, *Atlanta Journal Constitution*, *Tampa Bay Times, Los Angeles Times*, *The Oregonian* and *The Denver Post*. *Time* and *Newsweek*, the top two circulation news magazines, were also included in the sample.[113]

Television news coverage included three major networks (ABC, CBS, and NBC) as well as cable news channels CNN and Fox News.

News Coverage Selection

Lexis Nexis Academic and ProQuest Central were used to collect newspaper and news magazine articles and television transcripts in September and October 2013 using a single search term, "Bisphenol A." The database searches identified 926 news stories. A total of 448 articles, or 48.4% of articles were included. News stories were included in our final dataset if they had a substantial focus on BPA. A substantial focus on BPA was defined as at least 100 words of text specifically related to BPA. In order to capture content on BPA within larger news stories on a related topic (for example, chemicals in food in general), news stories were included if at least 100 words focused on BPA. In those cases, word counts reflect only the portion of the news story on BPA. News articles and op-eds or editorials were included; letters to the editor and corrections were excluded. News stories were also excluded if they were less than 100 words or duplicates.

A 50% random sample of included articles (n=224) was chosen for content analysis. While 22 sources were sampled, a total of 20 sources are represented in the analysis. One television source, Fox News, had no identified television news stories on BPA during the time period of interest. The *Tampa Bay Times* had one article that was eligible for analysis, however it was not included in the 50% random sample chosen for content analysis (Appendix D).

Content Analysis

To analyze U.S. news media content on BPA, a 38-item coding instrument was developed and pilot-tested by two authors (P.Truant and E. Donaldson) using articles from news sources outside the sample. Items were revised for clarity, and a codebook

was developed to facilitate reliable coding. The final coding instrument was entered into a Qualtrics online survey tool, which was used to code news stories. Kappa statistics for inter-rater reliability were calculated using Stata 13.1 statistical software. A total of 40% of the sample (89 articles) was double coded by the two coders. Raw agreement for each item ranged from 81% to 100% (average raw agreement 92%). The per-item kappa statistics ranged from 0.61 to 1.00 with an average kappa of 0.81 (Appendix E). A kappa statistic of greater than 0.60 can be considered good agreement, and 0.80 or higher is excellent agreement.[184]

Measures

The coding instrument was organized into four modules. Module 1 covered the types of BPA-containing products mentioned in news coverage. Five items assessed mentions of food-related products as sources of BPA: any food or drink containers; plastic food and drink containers; baby bottles or children's cups; infant formula or baby food containers; and canned food or beverages. Three items assessed mentions of other BPA-containing items: any other non-food related products; paper register receipts; and dental fillings or sealants.

Module 2 examined risk framing and health endpoints mentioned. This module assessed whether BPA was mentioned as an endocrine disruptor or having hormonal effects. This module also collected data on sensitive populations mentioned: pregnant women or developing fetuses; and infants or young children. Four items further assessed the context of the risk discussion: mentions widespread exposures to BPA; mentions potential adverse effects at low doses of BPA; mentions BPA does not pose health risks or is safe; and mentions that a U.S. government agency has found BPA safe. Eight health endpoints were chosen from a review of the scientific literature and refined during pilot

testing of the coding instrument. Mentions of the following health endpoints linked to BPA exposure were assessed: cancer; brain, development or neurological effects; immune system or endocrine effects; reproductive or sexual effects; diabetes; obesity or weight; behavior; and heart disease.

Module 3 assessed mentions of solutions discussed to address BPA risks. Five items covered the government venues mentioned: any government policy action; local policy; state policy; U.S. federal policy; and foreign policy. Two items captured the type of action mentioned: banning BPA; and labeling products with BPA. Mention of a policy did not necessarily mean that legislation was introduced or enacted. Rather, mentions of policy were interpreted broadly and included policies under consideration or the subject of advocacy. For example, the statement "And Congress is considering a bill…that would ban BPA from baby bottles, sports water bottles, reusable food containers, infant formula liners and food can liners," was coded as U.S. federal government action and policy action to ban BPA. Three items focused on voluntary industry actions: mention of any voluntary industry action to limit BPA; target population for voluntary action; and type of products voluntary action would affect. The final item in this module assessed whether news stories mention ways consumers could avoid BPA.

Module 4 captured how BPA replacements and their potential risks were discussed. The three items include: mentions of a specific compound which could replace BPA, mentions of difficulty in finding replacements and mentions of replacements in cans.

Data Analysis

Using the news story as the unit of analysis, descriptive statistics were calculated on the volume and content of news coverage over the seven-year study period. Logistic

regressions tested for shifts in coverage over the study time period, controlling for word count and adjusting standard errors for lack of independence among news outlets. Comparisons of two time periods were conducted: 2006 to 2008 and 2009 to 2012. Logistic regressions also tested for differences in news coverage in print versus television coverage and "hard" news versus op-eds or editorials, controlling for word count and adjusting for non-independence of news sources.

Results

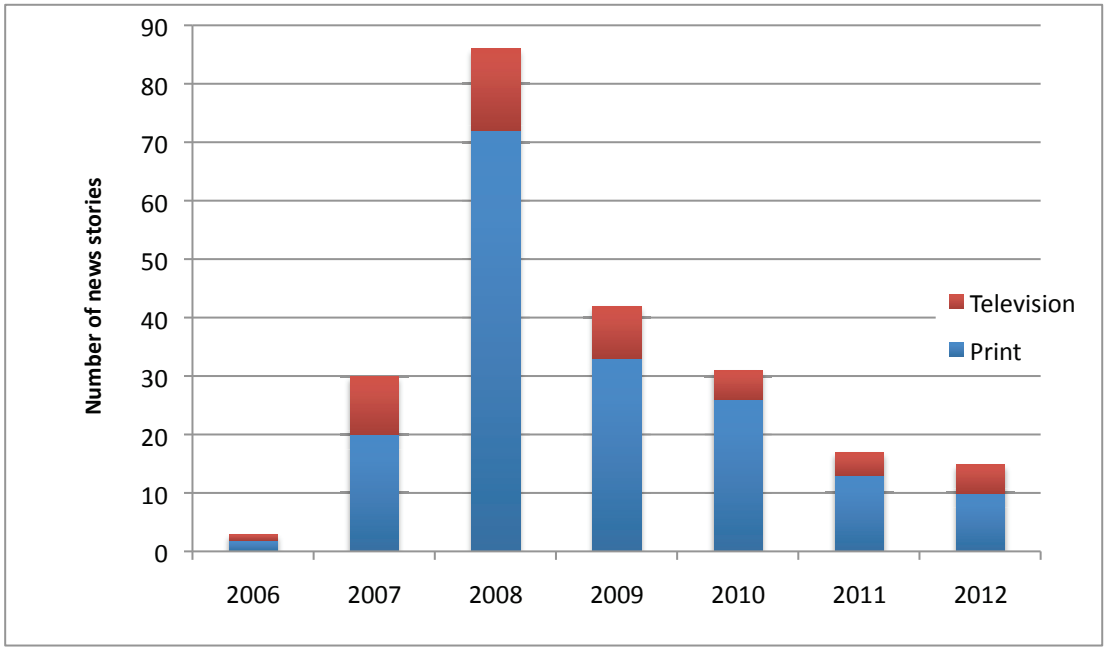
As shown in Table 8, the majority of news coverage analyzed was from print sources (79%). Print news stories were slightly longer on average than TV news (631 versus 536 words).

Table 8: Descriptive Information on News Stories Focusing on Bisphenol A from 2006-2012

Total News Stories, % (n)	100 (224)
Television	21 (48)
Print	79 (176)
Print News Story Type, % (n)	
Newspaper news articles	66 (147)
Newspaper op-eds or editorials	11 (25)
News magazines	2 (4)
Word Count (mean)	
Television	536
Print	631

Figure 4 illustrates that coverage peaked in 2008 and the majority of news stories were published in 2008 or 2009 (57%), with declining coverage in later years for both print and television coverage.

Figure 4: Volume of News Stories Focused on Bisphenol A from 2006-2012 by Story Type



Products Mentioned as Sources of BPA

Almost all news stories referred to food and drink containers as a source of BPA (97%), as shown in Table 9. Baby bottles or children's cups were mentioned in 80% of news stories. Baby bottles or children's cups were significantly more likely to be mentioned during the earlier time period of 2006-2008 than in later years of the study period (88% vs. 71%). Canned foods or beverages (72%) and plastic food or drink containers (68%) were also mentioned in the majority of news stories, but infant formula or baby food containers were mentioned only in a quarter of news stories overall (26%). Print news stories were significantly more likely to mention infant formula or baby food containers (30% versus 10%). Print news stories were also significantly more likely than television news to mention a specific non-food related source of BPA (39% versus 15%). Overall, one-fifth of news stories mentioned dental fillings or sealants as sources of BPA (21%) and 7% mentioned paper register receipts. Hard news and op-eds/editorials did not differ in their mention of BPA sources, except in a single instance. Hard print news

stories were significantly more likely to mention plastic food and drink containers as a BPA source (69%) compared with op-eds/editorials (44%).

Table 9: BPA Sources, Risk Framing and Health Endpoints: Overall and in Print versus Television News

	Overall (n=224) %	Print (n=176)%	Television (n=48)%
Products Mentioned As Source of BPA			
Food or drink containers	97	96	100
Baby bottles/children's cups	80	79	81
Plastic food or drink containers	68	66	75
Infant formula/baby food containers	26	30	10*
Canned foods	72	74	65
Specific non-food related products	34	39	15*
Paper register receipts	7	9	2
Dental fillings/sealants	21	23	10
Risk Framing of BPA			
Hormone or estrogenic effects	42	47	25
Mentions BPA is an endocrine disruptor	8	10	NM
Widespread human exposures to BPA	42	44	33
BPA may cause effects at low doses	26	28	17
BPA does not pose risks/is safe	67	66	67
A U.S. government agency said BPA is safe	50	51	46
Pregnant women/developing fetuses as sensitive populations	44	48	29*
Infants/young children as sensitive populations	61	60	63
Health Endpoints Linked to BPA			
Any health condition	89	88	94*
Cancer	57	57	56
Development, brain or neurological effects	50	49	54
Immune or endocrine effects	9	7	19*
Reproductive effects/sexual dysfunction	60	64	44*
Diabetes	37	36	40
Obesity/weight	17	19	10
Behavioral effects	48	51	40
Heart disease	25	23	35*

*p-value <0.05 indicating items in news stories that differ significantly between print and television sources controlling for news story word count and adjusting standard errors for non-independence of news outlets.

Risk Framing of BPA

Table 3 also shows how news coverage framed potential risks associated with BPA. Relatively few articles (8%) specifically referred to BPA an "endocrine disruptor," but 42% discussed BPA's hormonal or estrogenic qualities. About two-fifths of news stories noted that nearly all Americans are exposed to BPA (42%). A quarter of news stories (26%) stated that BPA might cause effects at low doses.

On the other hand, a large portion of news stories also presented the viewpoint that BPA is safe and poses no risk to humans. Two-thirds of news stories (67%) included statements that BPA is safe. Half of all news stories mentioned that a U.S. government agency has deemed BPA safe. Mentions of BPA safety along with simultaneous mentions of potential health risks were used to examine the extent of mixed messages in news stories. News stories that mentioned BPA safety were often in the context of quoting industry representatives or noting that the Food and Drug Administration (FDA) has deemed current uses of BPA in food contact applications safe. Table 10 presents proportions of news stories mentioning health risk items among the subset of news stories mentioning BPA as safe as an indication of mixed messaging in news stories. Of news stories that mention BPA is safe (n= 149), nearly half (46%) also mention that BPA has hormonal or estrogenic effects, and 28% mention that BPA may cause negative health effects at low doses.

Table 10: Among News Stories Mentioning BPA As Safe (N=149), Proportion Noting Specific Health Risks

	% (n)
Mentions hormone/estrogenic effects of BPA	46 (68)
Mentions BPA may cause negative health effects at low doses	28 (41)
Mentions infants/young children as sensitive population	66 (99)
Mentions pregnant women/developing fetuses as sensitive population	48 (72)
Mentions at least one health endpoint	91 (135)

Many news stories mentioned specific populations of concern with regard to BPA exposure. Pregnant women or developing fetuses were mentioned in 44% of articles (Table 3). Print news stories were significantly more likely to mention pregnant women or developing fetuses as sensitive populations than television sources (48% versus 29%). Infants or young children were mentioned as a sensitive population in 61% of news stories, with no differences in reporting between print and TV sources. Of news stories that mention BPA is safe, two-thirds (66%) refer to infants or young children as a sensitive population, and 48% refer to pregnant women or developing fetuses as a sensitive population.

Health Endpoints Linked to BPA

Overall, 89% of news stories reported at least one health endpoint linked to BPA (Table 9). The mean number of conditions reported in news stories was three (SD 1.8). Television sources were significantly more likely to report any health condition.

Reproductive effects were most likely to be mentioned as linked to BPA (60%). Cancer (57%) and developmental, brain or neurological effects (50%), were the second and third most common health endpoints mentioned. Television sources were more likely to report immune or endocrine effects and heart disease compared to print sources (19% versus 7%). Print sources were more likely to mention reproductive effects or sexual dysfunction (64% versus 44%). Of news stories mentioning BPA is safe, the vast majority also list at least one health endpoint linked to BPA (91%), as shown in Table 10.

Solutions

Table 11 displays government policy solutions to address BPA risk overall, by both print versus TV and comparing earlier (2006 to 2008) and later (2009 to 2012) years. Eighty percent of news stories discussed at least one solution (government action,

voluntary industry action or individual consumer action)—with news stories in the later time period significantly more likely than earlier news stories to mention any solution (84% versus 77%). Slightly more than half of news stories mentioned any policy action related to BPA (53%). Common examples of policy action discussion included mention of proposed or enacted laws to ban BPA in children's products or mention of advocates fighting for such a law. Print news stories were significantly more likely than television sources to discuss policy, and news stories published between 2009 and 2012 were more likely to discuss policy solutions compared to stories published in earlier years.

Local, state and federal government actions on BPA were mentioned in 12%, 26% and 28% of news stories, respectively. For all three categories, print news stories and news stories published in the later period were significantly more likely to mention these policies than in earlier years. For example, state government actions were mentioned in 40% of later news stories as opposed to 14% of news stories from 2006-2008. The most common policy item, mentioned in 49% of news stories, was banning BPA. Print news stories were significantly more likely than television news to mention banning BPA (54% versus 29%, p value <.05). Nearly three-fifths of news stories in the later years of the sample mentioned banning BPA (58%) versus 40% of news stories from the earlier time period. There was little discussion of policies that would label products with BPA (4% overall). Among print news sources, op-eds or editorials (n=25) were more likely than hard news to discuss several policy related items: any government policy action (80% versus 54%); banning BPA (68% versus 52%) and labeling BPA (12% versus 3%).

Table 11 also presents results on news media reporting of voluntary industry actions related to BPA. An example of a voluntary action commonly mentioned involved

retailers such as Wal-mart and Toys R Us removing children's products with BPA from their shelves. Another type of voluntary action mentioned was the manufacturer (for example, Playtex) ceasing to produce baby bottles with BPA. Overall, 40% of news stories mentioned any voluntary actions, with no significant differences by news source type or by time period. Of news stories discussing voluntary actions (n=90), the majority referred to food or drink containers (87%) and restrictions on products for children under 3 (58%).

Nearly 40% of news stories provided information on how consumers could avoid BPA exposure. For example, avoiding canned foods or switching to glass bottles instead of hard plastic bottles were common recommendations. TV sources were more than twice as likely to discuss consumer actions—73% in TV news stories versus 31% in print news stories. Op-eds and editorials were also significantly more likely to discuss individual consumer actions—34% mentioned things consumers could do to avoid BPA, versus 12% of hard print news.

Replacements for BPA

As shown in Table 11, there were very few mentions of replacements to BPA. For the small minority of articles that did discuss replacements, common examples of the discussion included mention of the need for replacements or the existence of viable replacements. Only 3% of news stories named a specific compound that could replace BPA. Discussion of the difficulty in finding replacements occurred in 2% of news stories. Some articles also mentioned replacements specifically for canned foods and beverages (4%). While there is a trend toward more mentions of replacements in the later years, this observation is not statistically significant.

Table 11: News Coverage Mentioning Solutions: Policy, Industry and Consumer Actions and Replacements to BPA

	Overall (n=224), %	Print (n=176), %	Television (n=48), %	Earlier Years 2006-2008 (n=119), %	Later Years 2009-2012 (n=105), %
Policy, Industry and Consumer Actions					
Any action	80	78	90	77	84*
Any government policy regarding BPA	53	58	35*	46	61*
Local government policy	12	14	4*	2	23*
State government policy	26	28	17*	14	40*
U.S. federal government policy	28	32	10*	19	37*
Foreign government policy	29	32	21	26	33
Government policy to ban BPA	49	54	29*	40	58*
Government policy to label BPA	4	5	NM	4	3
Voluntary industry action to limit BPA	40	42	35	35	46
Consumer recommendations to avoid BPA	40	31	73*	41	38
Replacements for BPA					
Specific compound to replace BPA	3	3	2	2	4
Difficulty in finding replacements	2	3	NM	1	4
Replacements in food or beverage cans	4	5	NM	1	7

* p-value <0.05 indicating items in news stories that differ significantly between print and television sources or earlier and later time periods controlling for news story word count and adjusting standard errors for non-independence of news outlets.
NM= no mentions within news stories

Discussion

Given the influence of the news media in framing which health issues are worthy of the public's attention, and the disagreements related to the nature of health risk attributable to BPA exposure, it is important to understand how this issue has been discussed in U.S. news coverage. Coverage patterns over the seven-year study period indicated that media attention peaked in 2008, and has decreased substantially in more recent years. BPA sources mentioned were largely food-related (i.e. baby bottles or food and beverage cans). News stories often focused on children's exposure—most mentioned baby bottles or children's cups as a BPA source, and a majority of news stories framed

infants and young children as a sensitive population. Reproductive effects, cancer, and developmental effects were the most often cited negative health effects linked to BPA. Many articles presented both sides of the issue—mentioning both the potential health risks of BPA and that the compound has been deemed safe by some stakeholders. Solutions such as government policy, industry and consumer actions to reduce BPA exposures were discussed in the majority of news articles, but mentions of replacements to BPA were largely absent. Print sources and news stories from the later period of the sample (2009 to 2012) were more likely to mention U.S. government policies to restrict BPA than stories from earlier years.

The news coverage spike in 2008, followed by decreasing numbers of news stories in the following years is consistent with both the timeline of key U.S. actions related to BPA**,** as well as the issue attention cycle described by Downs.[106] In this cycle, attention peaks for a relatively short period, after which the costs of solving the problem are realized and interest fades—often before the problem that originally attracted media attention has been resolved.

Given the focus of policy efforts on children's polycarbonate drink containers, the widespread news media coverage of baby bottles was expected. However, our findings can not inform whether news media coverage drove public concern about baby bottles with BPA or vice versa. Canned food and beverages were mentioned in a majority of news stories, indicating that this was a commonly reported source of BPA in U.S news media coverage between 2006 and 2012. Despite this, most government policies and voluntary industry actions have focused on polycarbonate plastic uses. This may be due to difficulty in finding suitable replacements for BPA's use in epoxy resins in can

liners.[185,186] Food and drink containers are believed to be the primary source of human exposures, [25,187] and likewise the news media coverage also focuses on food containers. Other non-food related sources, such as cash register receipt paper, received much less coverage in our print and television news sources. Current evidence suggests that handling cash register receipt paper may contribute to overall human exposure levels, especially for people in occupations such as cashiers.[188,189] However, more research is needed on the dermal absorption of BPA.[190,191] During the years of the study period, news media coverage focused predominantly on food-related sources and thus for some populations, other relevant exposure sources may have been underrepresented.

Of the top three health endpoints most often linked to BPA, cancer was the only condition that was not cited by the NTP in their finding of "some concern" for fetuses, infants and children. More than half of news stories (57%) mentioned cancer, which may be reflective of advocacy campaigns by health and environmental organizations.[77] It is also possible that in light of the "fear factor" associated with cancer, research linking BPA with cancer was highlighted in the news media.[192]

Two-thirds of news stories also included some mention that BPA is safe—and half of all articles specified that a U.S. government agency has found BPA safe. This indicates that government actions were reported in many news stories at least briefly. Many articles mentioning safety also reported on potential health risks. This indicates that opposing viewpoints were represented in much of the news media coverage. Notably, this does not mean that the news stories were equally balanced. For example, some news stories briefly mentioned that FDA considers BPA safe, or quoted an industry representative stating that there is no evidence that BPA causes harm, while overall

focusing on BPA as a health risk. Conversely, some news stories (particularly op-ed/editiorials) argued that BPA is safe while dismissing links to health endpoints as unproven.

Removing BPA from the marketplace and reducing consumer exposures was a prime focus of news coverage, but discussion of viable replacements was nearly nonexistent. This is an important finding as in recent years there has been increasing health concerns about some BPA replacements with similar hormonal activity.[193,194] In the discussion of BPA and other emerging chemical risk issues, public health advocates should work to ensure that, when warranted, safe replacements are an integral part of the discussion in order to avoid regrettable substitutions. Researchers have emphasized the need for chemical alternatives assessments to distinguish between alternatives and ensure that replacements do not pose equal or higher or risk as the original compound. [195,196] This would help ensure that chemicals like BPA are not quickly replaced with "BPA-free" alternatives, without sufficient knowledge of the replacement material or its safety.

This study has several limitations to note. First, as news outlets were chosen for their broad reach based on circulation and television viewership rates, the sample did not represent the entire landscape of U.S. mainstream media. Secondly, the analysis is limited to traditional news media and does not capture content including blogs, special interest publications or web-only sources. Further research is needed to understand whether the patterns of coverage of BPA in emerging news sources resembled those found in traditional news. One newspaper in the sample, the *Milwaukee Journal-Sentinel,* published a special series called "Chemical Fallout" focusing largely BPA during the study period, and thus its coverage is not representative of all news sources. Third, it was

beyond the scope of this research to assess causal relationships related to news media coverage and policy or consumer actions. Finally, this study cannot extrapolate any findings to the attitudes or knowledge of the general public about BPA. However, this study provides the first systematic analysis of news media content on BPA in the United States. This study characterized the discussion of key BPA sources, populations of concern, health endpoints and solutions. This study demonstrated mixed and conflicting risk messages were prevalent in the news media content, and comprehensive discussion of solutions was lacking, particularly with regard to BPA replacements.

Conclusion

The news media is an important avenue for communicating complex scientific and risk information to the public. In the midst of uncertainty, this is an even more challenging and critical task. In the case of BPA, mixed messages in news coverage may reflect both scientific uncertainties and conflicting opinions and actions of government agencies and other stakeholders. Risk communicators and public health practitioners should be careful to distinguish scientific uncertainty from disagreement on appropriate solutions (risk management), in order to avoid undermining the credibility of the science and contributing to further confusion. Future research could address how readers interpret news stories with mixed messages, and how news media framing affects behaviors and beliefs about BPA and other common environmental health exposures. Additionally, future research could study the public's perception of federal government agency decision-making on chemical risk assessment and other environmental health issues. These efforts could enhance the understanding and effectiveness of public health risk communication.

Chapter 6. Manuscript 3

"A Poster Child of Endocrine Disruption": The Challenges of Risk Communication on BPA

Abstract

BPA has been at the center of scientific and public policy debate in the U.S. over the last decade. Key stakeholders including government agencies, industry groups, health and environment-focused non-governmental organizations, researchers and the media have been engaged in studying, advocating and communicating about the safety of this ubiquitous component of food packaging and other consumer goods. Despite the public scrutiny on the chemical's safety, there is little understanding of the role of stakeholders in the debate. Semi-structured interviews with key stakeholders were conducted to understand key stakeholder perspectives on the goals and challenges of effective risk communication on BPA. This study found that the risk communication was driven by the science to some extent, but also characterized by accusations of subjectivity and conflicts of interest among communicators. Understanding the health impacts of low-level environmental exposures is scientifically challenging, and perhaps an even bigger challenge is risk communication in a politicized atmosphere. There is a continued need for more clear and comparable scientific reporting, as well as credible messengers who can deliver accurate information to the public without overstating knowledge. This study provides insights on translating complex scientific information to the public and recommendations for more effective risk communication.

Introduction

Bisphenol A (BPA) is a common industrial chemical often found in food and beverage containers such as hard plastic bottles and canned goods.[1] There has been much research and public interest in BPA in the U.S. in recent years, due to its definition as an endocrine disrupting compound (EDC) with weakly estrogenic properties.[10,11,14] Endocrine disruptors are defined by the World Health Organization as "an exogenous substance or mixture that alters function(s) of the endocrine system and consequently causes adverse health effects in an intact organism, or its progeny or (sub)populations."[10] EDCs may mimic or block the effects of natural hormone functions. Data from animals and humans has linked BPA with a range of adverse health effects, including cardiovascular effects, sexual dysfunction, infertility, obesity, early puberty, prostate and mammary gland cancers, behavior changes, and diabetes.[7,8]

As documented in prior analyses (Chapters 4 and 5), stakeholders have come to opposing conclusions about the safety of BPA and presented conflicting and confusing messages to the public through the news media and other venues. As part of a case study on BPA risk communication from stakeholders and in the news media, this study sought to understand the goals and challenges of communicating about BPA risks from the perspective of U.S. experts from government, industry, health or environment-focused non-governmental organizations (NGOs), the media, and academic and other research organizations. Risk communication has been defined as "the term of art used for situations when people need good information to make sound choices."[19] Risk communication is an essential component of effective risk management and in particular, sound public policymaking.[20] A dilemma for public health practitioners is how to

communicate about potential health risks when the research is imperfect or uncertain, as is often the case in science.

Much research has focused on best practices for risk communication, but it is difficult to provide clear and concise recommendations applicable for all situations.[46] Another important factor to consider with regard to risk communication is risk perception—in other words, how experts and the public come to conclusions about risks and benefits. The risk communication literature distinguishes between hazard—an expert's assessment of risk, and outrage—the public perception of risk. Some risks may be a high hazard with low outrage—such as traffic accidents. Other risks may be a low hazard but have a high degree of outrage and fear associated with them—for example, nuclear accidents.[48] Some characteristics contribute to elevated fears, including: man-made risks, involuntary exposures, new or unfamiliar risks, widespread media coverage, lack of trust in communicators, and potential effects on children.[47-50]

In light of these concepts, this research explored how stakeholders described the challenges of researching and communicating about BPA. This work has relevance and implications for risk management of environmental chemicals and the specific solutions that were implemented with regard to BPA—including voluntary industry actions, regulatory actions, and legislative actions. Specific research questions included: 1) How do key stakeholders describe the scientific literature and their risk communication strategies with regard to BPA? 2) What are the challenges inherent in risk communication on BPA? 3) How do stakeholders define effective risk communication?

Methods

Procedures

Between December 2013 and March 2014, semi-structured interviews were conducted with key stakeholders about the goals and challenges of BPA risk communication. The selection strategy for the interviews included both purposeful sampling and snowball sampling.[107,121] The sample was stratified in order to include the relevant groups who have communicated to the public about BPA. This approach facilitates comparisons between groups and includes varied perspectives.[97] The stratifications included: 1) government agency representatives, 2) industry groups and consultants, 3) researchers/academics 4) non-governmental organizations, and 5) news media representatives/journalists. Potential participants were identified during background review of the scientific literature and news media reports. Snowball sampling was used to identify additional experts from the initial set of contacts. This allowed for maximizing the diversity of perspectives and including additional relevant organizations and individuals involved in risk communication on BPA.[97]

Potential respondents were contacted by email requesting an interview. The initial email described the purpose of the study and the anticipated interview length of one hour (Appendix F). Follow-up emails and/or phone calls were used to contact people who did not respond to the first email within two weeks. In order to encourage participation and minimize any risk to participants, interviewees were advised that their names or organizations would not be identified in the study results. Interviewees were read an oral informed consent document (Appendix G) and given the opportunity to ask questions prior to the start of the interview and skip any questions they did not want to answer. Interviews were conducted until theoretical saturation and data sufficiency were achieved.[97]

A semi-structured interview guide was used in each interview to facilitate comparisons. The interviews covered several domains, including 1) background information on the individual's or organization's efforts related to BPA; 2) BPA communication goals, strategies and main messages 3) the state of the scientific evidence and the use of scientific information in communications; and 4) the challenges of BPA risk communication, evaluation of messaging about BPA and advice for effective risk communication. Probes were tailored by the researcher based on interviewee's responses and the interviewees could introduce topics not directly highlighted in the questioning. This approach allowed for additional context and understanding of important issues that emerged in the interviews.[122] In some cases not all questions were applicable to all respondents. For example, questions focusing on organizational communication and policy goals were not necessarily relevant for media representatives or researchers. Thus, the interview guide was tailored to participants' roles but remained as similar as possible to facilitate comparable responses. Appendix H provides the interview guide.

In October 2013, the Johns Hopkins Bloomberg School of Public Health Institutional Review Board (IRB) determined that this study was not human subjects research and thus did not require IRB oversight (Appendix A). Interviews were digitally recorded and transcribed verbatim (with the exception of one interviewee who did not give consent for recording).

Data Analysis

Interview data were analyzed using HyperRESEARCH Version 3.5.2 qualitative analysis software.[124] The analysis process began with the lead author (PT) reading through the interview transcripts (or the researcher's notes) several times and creating relevant structural and thematic codes[120] based on the research questions and interview

guide. Structural codes, or organizational categories[96] included identification of interviewee's stakeholder group (i.e., government) or denoting a particularly cogent quotation. Substantive categories, or thematic codes, more directly describe the content of the statements and facilitate analysis.[120] Examples of thematic codes included discussion of scientific literacy, objectivity and evaluation of the news media. Some codes were developed *a priori* based on knowledge of the questions in the interview guide, while others emerged iteratively during review and re-review of transcripts. During this process, central themes were identified and some codes were expanded to include broader concepts, while others were collapsed or eliminated if they were too specific or repetitive with other codes.[107] The final codebook is provided in Appendix I.

Results

Between December 2013 and March 2014, representatives from 74 organizations were contacted to participate in the study. Eleven groups declined to participate. Reasons provided for declining included time constraints and lack of knowledge or current involvement on the issue. Of those who declined to participate, three were from NGOs. Additionally, there were two persons who declined each from industry/consulting, research, and the news media, and one decliner from government. Twenty-seven groups did not respond to initial or follow-up contact. Of the organizations that did not respond, nine were from industry/consulting, eight were individual researchers, five were from NGOs, three were from government, and two were from the news media.

A total of 36 organizations were interviewed in 39 interviews. In two cases, individuals from the same organization were interviewed separately (one NGO and one government agency). In five cases, two to three respondents from the organization respondent participated in the interview. The unit of analysis used in this study is the

organization (n=36). Table 12 presents the breakdown of interviews and participants within each stakeholder category. Interviews lasted an average of 47 minutes. In-person interviews were preferred, however, due to distance and interviewee scheduling preferences, the majority of organizations were interviewed by phone (n=31). Four interviews were conducted in person, and one interview was conducted via Skype.

Table 12: Number and Type of Stakeholder Organizations Represented in Semi-Structured Interviews

Organization Type	Number of Interviews	Total number of individual participants	Number of Organizations Interviewed
Government	6	9	4
Industry/Consultant	8	9	8
NGO	11	12	10
Researcher	9	10	9
News media	5	5	5
Total	*39*	*45*	*36*

Results were organized into four categories: 1) discussion of the scientific evidence on BPA, 2) factors influencing risk perception of BPA, 3) BPA risk communication challenges, and 4) risk communication recommendations.

Scientific Evidence on BPA

Interviewees were asked to describe the state of the scientific evidence on BPA. Many respondents noted the vast number of studies that have been conducted about BPA, but some noted that the scientific literature can be confusing and is still lacking in some areas. Several respondents, particularly from NGOs, government and research, noted the difficulty of keeping abreast of the scientific literature and keeping findings in perspective, as illustrated in Table 13. A few respondents also described the multi-disciplinary perspectives needed to understand the literature—including toxicology and endocrinology.

Other respondents reported that the literature is clear and compelling. For example, most NGOs and some researchers noted that there is clear cause for concern about BPA exposure end enough evidence to warrant precautionary actions. Other researchers and most industry respondents noted that the evidence is compelling in the other direction—that there is *not* convincing evidence of harm from BPA exposure. Table 13 provides examples of the state of the evidence discussion.

Table 13: Examples of Stakeholders' Discussion of BPA Literature

Theme	Quote	Respondent Category
BPA literature is complex	*Sure is difficult when you are talking about all the different endpoints that people have published on for BPA…even scientists sometimes have a hard time putting all that information together and thinking about it.*	Government
	I think it's definitely confusing to a non-technical audience and it's also hard for people to understand the whole field of endocrine disruption being an emerging area of research... It is hard even for regulatory agencies to evaluate and grapple with it.	NGO
	There has been an incredible amount of research done on BPA, but a lot of it is not terribly informative. A lot of the earlier research was done with methodology that the government has since decided it doesn't think is valid, and having to do with the way that BPA was administered to animals and things like that…There's not been a lot of good science on the impact on people.	Media
BPA literature provides sufficient evidence of harm	*So while we may not be clear on exactly what level is risky and exactly for who and exactly what is the increased risk of various illnesses, it's very clear that there's a relationship between BPA and high blood pressure, heart disease, even when you're controlling for obesity, and so on…but I don't really think that any unbiased person would say that it's unclear whether BPA can be dangerous. I think industry's the only people, or the only folks saying that there's no clear evidence that it's dangerous.*	NGO
	Well, I think there's a growing body of evidence that makes it very clear that endocrine disrupting chemicals in general and BPA in particular have risks…We don't know that much about exactly what impact it has and it's very hard to measure because people are exposed to it all the time and the levels in their bodies change from day to day so its, you know, it would be impossible to do the perfect study on it but we already have a growing body of evidence that tells us we should be concerned.	NGO
	The reason BPA has exploded the way it is, and so many people are getting grants and the National Institute of Environmental Sciences puts 30 million dollars of their funding into just BPA as a model endocrine disruptor is because it was absolutely clear, from a scientific perspective, that this was a really bad news chemical. I mean, there's no argument about this in the scientific community. You can argue about specific details, but not that there's no evidence for harm. That's ludicrous.	Researcher
BPA literature provides	*Well I think it is far more clear today than in has been in the last couple of years… The European Food Safety Authority just recently released its latest risk assessment on BPA and came to some significant findings, which basically*	Industry

sufficient evidence of safety	*state that the current exposure is safe from basically all of the sources that consumers would come from. So the science around it is becoming far more conclusive about the safety of the materials at the current use levels. So I would say it's becoming very solid.*	Industry
	So I'm fully convinced that the weight of the evidence of Bisphenol A basically says that under today's conditions of use…that the current exposures of Bisphenol A are well within and well below actually the current levels of regulatory standards for Bisphenol A, designed to protect public health.	Industry
	The fears are overblown, and are not supported by the preponderance of evidence…Of course with any topic you can always find a study to back up any view that you may have. But what we should do in the world of science is look at all of the evidence available and not cherry pick the data. We need to shake the whole tree until all the cherries come down and then mash those together and taste that.	Researcher

Overall, NGOs noted concerns about public health impacts from BPA exposure. There was one notable exception, as one NGO stated "there basically are no risks." The majority of respondents from the industry or consulting category cited skepticism that human exposures to BPA pose human risks, discussed limitations of existing research suggesting harm, and referred to the safety determinations of U.S. and international regulatory bodies. Some industry organizations indicated that BPA may produce clear effects at high doses, but the evidence doesn't suggest the need for concern at typical consumer level exposure levels. For example, one industry/consulting respondent stated:

> "I am not convinced that the perturbations that have been reported, if in fact they are reproducible and real—of which I have some skepticism—produces adverse effect. So I acknowledge it has biological activity, in very high amounts... I would never as a scientist absolutely close the door… But…in my opinion I'm skeptical...that it serves as an...environmental risk."

Researchers, government agencies and the news media presented varied perspectives. Some researchers highlighted concerns about BPA based on their own study findings or findings from fellow researchers. Other researchers described study findings supporting BPA safety and offered critiques on the existing body of scientific literature. Government respondents from relevant federal agencies also presented divergent opinions—with some interviewees indicating concerns and lingering questions regarding

the health effects of BPA, while others maintained BPA safety based on the weight of the evidence. News media respondents were also varied in their discussion of BPA risks and description of how the issue has unfolded. While not all media respondents indicated a clear stance on BPA risk, some described how they perceived their role in communicating about the issue. For example, one media interviewee stated:

> "We have highlighted the absence of critical data from the public debate or the mistaken data within the media coverage. And as such, the overwhelming conclusion of all of that research is that the public has been misled about the risks of BPA and we believe the…risk assessment process conducted by the FDA and EFSA has reached a correct conclusion. Again, based on the most rigorous methodological research on the subject. "

Another media respondent categorized their role in the following way:

> "So because we're not scientists, we're not equipped to pass judgment on whether or not this chemical… is a… hazard of any kind. What our role was is to look at how pure or how unadulterated the government's examination of those risks are, and so that's why we looked for unholy alliances or any kind of inappropriate pressure on government regulators… It was obvious that there was a heck of a lot of pressure from the plastics and chemical industry to minimize any kind of concern about bisphenol A."

Overall, stakeholder organizations agreed that BPA is a challenging topic to research for a variety of scientific reasons. In light of the multi-disciplinary nature of the research, stakeholder organizations varied in their perceptions of appropriate methodological approaches to study BPA. Many organizations highlighted the differences between traditional toxicology based approaches (often large studies using "good laboratory practices" or a "guideline" approach) and studies designed to explore hormonal effects informed by the endocrinology and epidemiology disciplines. One government respondent described the disparity between different research approaches in the following way:

> "I think one of the issues is there is very little study repetition that actually goes on, or study replications. The settings that the industry tends to rely on are the guideline kind of study. On the other side, people tend to look at exposures in different models which are not guideline...and it would be very nice if they were telling you the same thing, but they are asking very different questions and using different models. And I think that is very important to understand. So that, the fact that person A finds something and person B doesn't— doesn't necessarily mean that either of them is wrong."

Stakeholder organizations with concerns about the health risks of BPA often pointed out that traditional toxicological approaches may not be sensitive enough to capture hormonal effects and evaluate potential endocrine disruptors. Stakeholder organizations that erred toward BPA safety often mentioned limitations in smaller scale "academic" studies and the lack of standardization and reproducibility among some studies showing BPA effects. Figure 5 provides a summary of key findings on BPA scientific literature from stakeholder organizations.

Figure 5: Summary of Key Points on BPA Scientific Literature from the Perspective of Stakeholder Organization Respondents (n=36)

- There is a large body of research on BPA, which can be difficult to interpret and requires understanding of multiple disciplines, including toxicology, endocrinology and risk assessment.
- Some respondents perceive the literature to provide compelling evidence of health effects from BPA exposure.
- Other respondents perceive the literature to provide compelling evidence of the safety of BPA at human exposure levels.
- Respondents identified two distinct types of BPA research—studies using a toxicological approach (often large-scale studies using good laboratory practices) or an approach designed to assess more subtle hormonal effects (sometimes referred to as academic studies).

Factors Shaping Risk Perceptions of BPA

Respondents were asked for their perceptions on why BPA has been the subject of public attention and research scrutiny. Overall, respondents agreed that BPA has been the focus of much research and public attention. Respondents from government and NGOs frequently cited potential effects on children and BPA's presence in baby bottles as a reason for heightened awareness and concern. Another reason mentioned was the

ubiquity of the chemical in common products and measurable in human bodies. As a high volume chemical to which nearly everyone is exposed, respondents also noted BPA's high market value and the fact that it is an "enormous commercial asset" (according to a government agency).

Others noted factors contributing to heightened risk perception among the public, as described in the following response from a news media respondent:

> "Well if you talk to people who study risks, this is one of those things that kind of meets the criteria for worrying people. One, it's described as a chemical… and people are worried about chemicals. It's described as something that companies are putting in, are exposing you to against your will or without your knowledge. That tends to make people especially worried, and it's been described as affecting infants or developing fetus, and those are groups that we particularly worry about, so it's the trifecta of fear, right? It has all of the elements that most make people afraid. It's a chemical that we're being exposed to by companies, and it could affect our children."

Industry respondents noted reasons such as high levels of research funding and BPA emerging as the "chemical du jour" as reasons for public attention. Another theme that emerged from some industry respondents (as well as a few research and NGO respondents) is the concept of "chemophobia" among the public and an "emotional" response that is less influenced by the science and more influenced by distrust of industry. According to one industry respondent:

> "I think our society is cancer-phobic. The public confuses endocrine disruption with cancer and if a researcher can get the money to investigate that and go up against quote—big business and big chemical—and they can force a scary result, they'll get more research money and they'll get more notoriety."

A contrasting message from NGOs and researchers was the issue that the government is not adequately protecting them from potentially hazardous exposures, and that consumers should not have to worry about whether everyday products are harming their family. As one NGO described:

> "In the space of chemicals, I think it feels really unsafe because nobody is manning, no one is watching over us and I think that… when you hear just how outdated and antiquated our chemicals management system is, that freaks people out too. So this sense that well, I should be able to pick up a receipt or get a baby bottle that isn't going to put my child at risk. That message resonates with people like 'Bingo'! That's why that baby bottle thing was just like whoa, over the top messaging. It was like—hit it out of the park, right?"

Interestingly, several others noted that BPA has received heightened attention because it is easy to spell and pronounce. A NGO respondent stated:

> "I think it's no small thing that everybody can pronounce BPA. To this day, I find that a lot more people know what BPA is than know what phthalates are, and they're both very similar in their potential risks and both similarly ubiquitous in our environment."

Additionally, many organizations noted that a reason BPA has been the subject of much public attention is due to the success of advocacy efforts—including local and state bans of BPA and industry abandonment of some uses. A critical theme that emerged from all five types of organizations was the identification of BPA as a "poster child of endocrine disruption." Both respondents who described BPA as harmful and respondents who described BPA as safe commented that BPA has become a symbol for the environmental movement, or a "flagship for endocrine disruptors." According to a research respondent:

> "There's a community of endocrine disruptor scientists who… have really seen BPA in some ways as the poster child of endocrine disruption, and that in and of itself has elevated it in the scientific discourse….It doesn't mean there's not a lot of other chemicals that are just as bad, so in some ways BPA is just a poster child of a system."

Another researcher elaborated on this concept of BPA as a poster child for a movement:

> "In the case of BPA, I very strongly feel that it has become the poster child for the group of people who are trying to promote, if you will, the idea that endocrine disruption and endocrine disrupting compounds are a major new threat to public

> and environmental health. It's gotten attention because of that, and that's some pretty scary stuff and the media reports on it regularly, so they fuel that. It's also gotten a tremendous amount of attention I think because remember…toxicologists don't get money to study non-toxic things... It's just, in my opinion it has very little to do with BPA anymore, and it has more to do with all these other things. And in some ways it has less to do with public health than some of these people would be willing to admit I think."

Several respondents from research and NGOs indicated concern that BPA's status as a poster child for endocrine disruptors could backfire for advocates if the science does not support continued public health concern. For example, one NGO respondent explained:

> "It's a problem when the science then starts to undermine possibly the assertion that it's a huge public health risk right now to everybody, and it's like it's threatening the whole enterprise, which we don't want, because it's representing something that is a real problem."

Figure 6 presents the main findings discussed by stakeholder organizations with regard to the public's perception of BPA risks.

Figure 6: Summary of Key Factors Shaping Risk Perceptions from the Perspective of Stakeholder Organization Respondents (n=36)

- BPA is a ubiquitous substance to which nearly everyone is exposed.
- BPA was present in baby bottles and items for children, who may be sensitive to exposure.
- BPA is a very lucrative, high volume chemical.
- BPA is easy to pronounce and spell.
- Public distrust of "big business" and chemicals in general.
- BPA has become a symbol, or "poster child" for endocrine disruption.

Risk Communication Challenges

Given the complexity of the science and opposing conclusions from various stakeholders on the public health implications of BPA, the vast majority of respondents described communicating to the public about BPA as challenging. Themes that emerged from the interviews on the topic of BPA risk communication challenges are described below.

Scientific Literacy and Translating Science

Many respondents mentioned difficulties in translating complex science and explaining the limitations of the research. For example, stakeholder organizations mentioned taking care to convey findings in a way that's relevant to human health. Many respondents from government and industry in particular spoke of the limited scientific literacy of the public and the media as a challenge of communicating nuanced scientific results. According to one government agency:

> "There's literacy issues. There's scientific literacy, which is a big thing with me. You know…a lot of people have made up their minds about BPA. I talked to a lot of people personally about it and they've made up their minds. There's nothing really we can say that will convince them otherwise… There's probably the vast majority of people really don't care what's in their food, and as long as it's in the grocery store, they feel it's safe you know. And then there's an active group of people who feel that BPA is dangerous and anything we say regarding its safety is just not to be trusted."

Further, expertise in multiple realms is needed to fully understand the science, prior to conveying the message, as the same government agency explained:

> "This isn't easy stuff because we work at the edges. We work at the edges of technology, we work at the edges of safety, we work at the edges of regulations and that's three areas that someone has to be an expert in before they can really understand what we do and it's very difficult for us to put a message out in that environment."

Other interviewees from multiple sectors also emphasized the difficulty in conveying uncertainty in communications. For example, an industry organization noted that an important challenge, which is not unique to BPA, is that "the uncertainty that is typically attached to results of studies doesn't necessarily get easily translated into popular media."

The complexity of BPA research noted in a prior section was also cited as a barrier to clear and effective communication to the public. A news media respondent described the difficulty as such:

> "I think it's extremely difficult because it involves a lot of scientific nuance. It involves complicated concepts having to do with dose response curves. It involves people understanding the difference between different administration routes. It involves concepts like clearance from the body. It involves active forms of circulating chemical versus ones that have been bound and are going to be eliminated from the body. These are all concepts that are really hard for the public to get across, and yet they are critical to understanding potential risks from this chemical."

Even when journalists were willing and able to go into technical detail on BPA science, venues for such stories are limited in the traditional news media due to the complexities of the subject, according to a news media respondent.

> "I actually had an assignment for a major magazine to write about BPA, and the magazine ended up killing the story because the science was so complicated. You know, what happens is you can get into the weeds really fast with BPA…It's very technical and quite dry and boring, but it's also really important in the discussion. So if you really want to write about BPA, you kind of have to get into that stuff but the fact is that most major news organizations don't want to write that up, it's too boring.

A counterpoint to the notion of insufficient scientific literacy among the lay public and the press was observed in several interviews—which was that that scientific literacy among the public is often underestimated and researchers often have difficulty adequately translating their findings. A government agency respondent said: "I think sometimes scientists especially tend to underestimate what the public can understand and I think scientists often have a problem in communicating their understandings because they forget that science is often spoken in a language which is not the same that everyone else speaks." Another researcher echoed the point that scientific translation is difficult for journalists and researchers alike:

> "What we do is very complicated, and a lot of times we see researchers who are trying to communicate the results of a recent animal study, and they get pushed to go too far with the relevance of that finding to humans. We also see people who have really cool fascinating results that downplay them, and the importance of those results don't get conveyed appropriately. It's a really difficult job for a reporter to explain scientific results. It's also a really difficult job for a scientist to appropriately put into context the results of their studies without overhyping it or underexplaining what it actually means."

Misinformation, Sensationalism and Objectivity

Other themes that arose in the interviews related to BPA risk communication challenges were the issues of misinformation, sensationalism, and a perceived lack of objectivity among some stakeholders and communicators. For example, a government respondent described BPA's conflicting and sometimes incorrect messaging:

> "It's kind of got a life of it's own because it's such a hot topic in the press, and I think some of the message has been driven by the science, conducted by the scientists…but a lot of the policy has been driven by advocacy groups as well. So there's just a lot of contention about this chemical. Some of it's true, some of it's not, some of it's unknown, and it gets driven in all sorts of directions because there's so many people talking about it."

Several researchers and industry representatives mentioned an imbalance in media reporting, where negative study findings do not receive sufficient attention. According to an industry organization:

> "Well, I guess the right way to talk about the challenges is the reporting from the media is all asymmetrical. Negative findings on the dangers of BPA, meaning the ones that don't have the 'skull and crossbones' appeal, never get published, never get circulated—that's not good news. But if somebody injects a million fold toxic dose of BPA into a lab rat, and the lab rat ends up getting ill, then that scientific—very unscientific research… gets into the popular press."

As demonstrated in Table 13, respondents' perceptions of the state of the scientific literature varied dramatically—with participants on both ends of the spectrum suggesting that those who disagree with their conclusion are inherently biased. Indeed, the discussion of objectivity in research and communication emerged as an important

theme in the interviews. Interviewees from all sectors noted concerns and distrust of other stakeholder groups. For example, one government agency respondent noted:

> "My opinion is that everybody who's working on it has lost their objectivity. So I'm hard pressed to find people who have approached the question truly objectively. Everyone who is currently investing in BPA research is almost entirely doing it because they have a position to fulfill. They have a fait accompli that they need to prove….So to me, I don't see an objective arbiter in here somewhere. So… if someone asked me to render a decision, I don't know, I would have to do a weight of evidence that's based on the studies that are available, but somehow I would have to be able to weigh in the known biases."

Given the existence of many studies on BPA drawing disparate conclusions, many stakeholder organizations also discussed the difficulty of determining trustworthy sources of information, and the negative impact this has on the public. As one researcher described it:

> "Everyone has their own little soapbox that they're standing on and because of the plethora of studies that are out there, it's cherry picking. You can always support almost any view that you have, and that just leaves the public in a state of confusion. They don't know who to believe, because every day there seems to be some new toxin du jour, you know."

Respondents from several sectors including industry, research and government also specifically discussed a lack of objectivity among researchers as a concern. While many respondents (particularly from NGOs, government, research and media) acknowledged that industry has a vested interest in establishing BPA as safe, several industry, news media and research respondents said that academic researchers too are subject to biases. For example, according to a researcher, academics have "pressing financial interests" to publish studies showing harm to attract grant funding and advance their own careers. Further, the same respondent stated the incentive structure in research promotes publishing "positive" results and "works towards the overemphasis of risks posed by chemicals in everyday life." Another researcher criticized some academics for

developing "preconceived ideas" that cause them to become "self-delusional in their research" and ignore findings that do not fit their opinion. However, one researcher presented a counterpoint to this concept of academics having vested interests in demonstrating a chemical's harm:

> "We've heard industry people say that academic scientists have a conflict of interest. We need to publish in order to get tenure, or we need to publish in order to get grants. That's true, but the thing is, I don't have to publish that BPA is safe or dangerous in order to get tenure. And if I find that a chemical has no effect on the endpoint that I'm interested in, I move on to something else. I'm not limited in the questions I can ask, and I'm not limited in the scope of what I can do in my work. So, it's almost offensive to suggest that somehow academic scientists have a reason to lie about the dangerousness of a chemical, because there is always going to be a dangerous chemical we can study."

The motives and interests of NGOs were also questioned, particularly by some industry and research organizations that were skeptical that BPA causes any harm to the public. Several stakeholder organizations criticized the work of NGOs as "irresponsible" and "alarmist." For example, one media interviewee said:

> "I think a number of advocacy groups have said things about BPA that are really scientifically unsupportable, and I also think…it has been a very convenient fundraising and you know, political issue for them. It's something that gets a lot of attention. And sometimes I think they are more concerned about giving a particular message that's going to get headlines than they are about truly telling people what risks out in the environment are greatest for them."

Despite this, others said the NGOs overall did a good job "sticking to the science," and many respondents from all sectors perceived NGOs as very effective in their communications on BPA— whether respondents agreed with their underlying conclusions or not. NGOs were described as particularly effective in garnering swift changes in the marketplace when manufacturers and retailers stopped selling BPA-laden baby bottles. A news media interviewee said the following about the work of prominent NGOs on the BPA issue:

> "I think they really took this substance and ran with it, and I think some of them profited tremendously from BPA. They really made this a big rallying cry for the work that they do and I think they have very effective campaigns revolving around BPA that generated more membership for them and more attention to their causes. I think they were fairly brilliant actually, whether you agree with them or not."

As previously alluded to, many respondents indicated that the industry's primary interest is to defend their product. Respondents from multiple sectors including government, NGOs, media and research described industry groups as ineffective in their communication, in part because they are poor messengers and not trustworthy due to economic motivations. Further, interviewees noted that industry communications were unwavering and, as one NGOs put it "frustratingly well-financed and consistent." Several media respondents noted industry group's predictable risk messaging on BPA. As a media respondent explained:

> "Well, the industry groups are pretty predictable. They have essentially disavowed any risk or even hypothetical risk, and they sometimes have good arguments to make, but they are so adamant and absolute in their statements that I don't need to call them to know what they are going to say. So I don't think that they've been terribly effective in this debate either."

Regarding BPA risk communication from the federal government, nearly all stakeholder organizations criticized the FDA's communications. While some respondents (particularly from industry and research) praised the quality of FDA's research, most agreed that the agency's risk communication was lacking and inconsistent on this issue. As one media respondent explained:

> "I find in general the FDA, in terms of broad strokes, is not very good at risk communication. It struck me that they were for a long time just—'it's safe it's safe it's safe', 'ok we're banning it in children's in baby bottles and sippy cups'. And it's like well, if it's safe, why is it being banned in baby bottles and sippy cups? And if it's not safe, why isn't it being banned more broadly? Why isn't it getting out of liners and other things? And it's hard, it's very hard to communicate when you have a nuanced response, you know. It's challenging and there's a lot of

> suspicion around the FDA anyway in terms of how decisions are made and who factors into those decisions that there's always skepticism in terms of was this a political decision or a science and health-related decision."

Several other media respondents also indicated that they have found the FDA reluctant to be interviewed about BPA. For example, one media respondent explained:

> "I think the FDA's sort of impossible, frankly. From a journalist's perspective, it's really hard to feel like you get a straight answer from them. It's really hard to even reach people from the agency who will talk to the media. I feel like I have a hard time trusting anything they say because they manage the media so tightly. They tend to be slow to respond to the substance, and then I felt like they responded inadequately. You know, BPA is sort of a big example of what's wrong with the FDA."

However, there was also a disconfirming case from a media organization, where the respondent praised the work of the FDA, explaining "I am certainly trying to amplify the kind of work the FDA is doing, because you know the FDA is constantly under attack in the media and I think it's really important to know when somebody is doing good science."

As indicated throughout this section, the issue of distrust of various messengers emerged as a key communication challenge in the case of BPA. Interestingly, several respondents from government, NGOs and research described the tone of the debate on BPA as unusually adversarial compared to other chemical issues. Several interviewees from government, media and research commented that the case of BPA was unusual in the level of personal attacks, hostility, and a "polarized" and "unhealthy" dynamic. According to a NGO: "You know it's rare to see such rancor among scientists but this sure did display that on the issue of whether or not BPA is safe and how much is safe. And it's just, again because it's a very difficult thing to get to the bottom of." Figure 7

summarizes the main risk communication challenges discussed by stakeholder organizations.

Figure 7: Summary of Key Risk Communication Challenges from the Perspective of Stakeholder Organization Respondents (n=36)

- Limited understanding of scientific concepts among the public and the media.
- Difficulty of translating complex and nuanced scientific information.
- Misleading or incorrect information from the media or various stakeholders.
- Higher likelihood of positive findings reported in research and the media (publication bias).
- Perceived lack of objectivity among stakeholders.
- BPA has become an adversarial, politicized issue.

Risk Communication Recommendations and Advice for Public Health Practitioners

Given the noted challenges in communicating about complex and uncertain scientific issues, respondents from stakeholder organizations were asked how they would define effective risk communication and provide their thoughts on how public health practitioners could improve risk communication in general. Overall, respondents from all sectors described effective risk communication as clear, factual, concise and using simple language. However, some respondents also said risk communication should not oversimplify or overstate knowledge, and must explain where there are uncertainties and admit limits in understanding. Putting findings in appropriate context for people's lives was also cited as important.

Among government respondents, interviewees noted the importance of ensuring that risk communication messages are not only delivered, but received and comprehended. Industry and media respondents noted that communicators—be they public health officials or the media— should adequately understand the science and consider whether the messaging will elicit undue alarm. As one media respondent explained:

> "Effective risk communication has to anticipate how people are going to hear a message. It's not enough to have a caveat included in the text somewhere. You actually have to think about what is the tone of my message, because I think people are much less sifting through facts in the public health message and much more listening for the should I be scared or shouldn't I. So I think … public risk communication has to ask the question: Are people going to be scared after they hear this or are they not? And if they are going to be scared, is that justifiable, and is this something where there's enough reason that we should make people afraid?"

Some NGOs challenged the notion that risk communication would incite undue fears and stressed the need to inform people of personal actions they can take to reduce risks. For example, one NGO said:

> "One of the things that we find really problematic is the stance that … you can't tell people about this because you're just going to scare them and there's nothing they can do about it…We absolutely have to explain to people the risk of chemicals and there are things they can do. There are things they can do, there are personal actions they can take to reduce their exposure and then they can also join together with others…to make system-wide change. So we really challenge the notion that you're just going to scare people and people will be paralyzed by fear. We think that there's a way of doing it, talking about BPA responsibly in a nuanced manner— that gives people information… We present them with the information, they understand the risk, and then they make decisions based on that, based on their perception of the risk."

Many researchers noted the difficulty of effectively communicating risks, especially considering that "there is nothing that is zero risk," according to one researcher. Other researchers stated that effective risk communication would highlight potential hazards and solutions, but allow people to weigh risks and benefits themselves. For example, a researcher described their role in the following way:

> "Our charge has to be to help the public health agencies sort out the difference between what chemicals are truly a risk to public health, and which are not. And the only way to do that is to stick to the science, not speculate, be objective and complete in their reporting, and also put things in a context that's understandable for folks that are laypeople. And if there's controversy, to be honest about that controversy."

Despite these challenges, stakeholder organizations from all sectors agreed on the importance of risk communication. Figure 8 provides a summary of key points from stakeholder organizations on the characteristics of effective risk communication.

Figure 8: Summary of Key Risk Communication Recommendations from the Perspective of Stakeholder Organization Respondents (n=36)

- Effective risk communication is clear, factual and concise.
- Risk communication messages should not oversimplified.
- Risk communication should acknowledge uncertainties.
- Risk communication should be a dialogue as opposed to a one-way message.
- Risk communication should put risks in context and consider how the audience will perceive messages.

Discussion

Semi-structured interviews with key stakeholders provided a diverse set of perspectives on scientific and communications issues related to BPA, a ubiquitous chemical that remains in common consumer goods such as canned food. As expected, the majority of industry groups were skeptical of any human health effects from BPA exposure, while the majority of NGOs continue to remain concerned about potential health impacts. Government agencies, researchers and media respondents included perspectives along the entire continuum— from confidence in BPA safety in consumer products to citing clear evidence of danger. Overall, respondents from the five sectors were in consensus that BPA is a challenging chemical to research and communicate about to the public. Many respondents from different sectors pointed out weaknesses and complexities in the scientific methodologies used to study BPA. Further, respondents noted a variety of risk communication challenges and critiqued the actions and motivations of government agencies, industry groups, NGOs, researchers, and the media.

Specific findings discussed below provide important context and understanding to the complexities of risk communication.

Scientific Methodology Issues

Stakeholder organizations have diverse expectations and divergent criteria for reliable, rigorous research on BPA. Respondents noted conflict between a toxicological "the dose makes the poison" paradigm and an endocrinology-based paradigm in which minute exposures, particularly during critical windows of development, may cause negative effects. Among respondents who were skeptical of BPA health effects, some noted that BPA—like many other environmental chemicals—has endocrine activity at certain levels. In other words, critics did not disagree that extremely high exposures could cause effects. The conflict was whether human exposure levels may approach (within several orders of magnitude) levels that could impact sensitive human populations.

In light of these conflicting perspectives, some efforts are underway to increase research comparability. For example, the NIEHS and NTP developed a collaborative approach aimed at answering lingering controversies on the effects of chronic low-level exposure to endocrine disruptors. The agency convened a consortium of research grantees to facilitate communication and data-sharing.[8] Additionally, an ongoing comprehensive toxicity study facilitated by the NIEHS/NTP and FDA began in 2012. Deemed CLARITY-BPA, the program features GLP-compliant protocols as well as data and specimen sharing to examine additional disease endpoints not traditionally assessed in regulatory assessments.[8] While this program is resource-intensive and still ongoing, the CLARITY-BPA program represents a unique and potentially valuable approach for bridging distinct methodological approaches.

BPA as a Poster Child

An important theme that emerged from the interviews was the description of BPA as a poster child for endocrine disruption. Respondents attributed this to a variety of factors that raised the level of concern among advocates, the media and the public. According to the risk perception literature, some risk characteristics contribute to elevated fears, including: involuntary exposure, little preventive control, and threatening future generations.[49] These elements were discussed by some stakeholder groups as reasons that BPA became the subject of media attention and public concern. Perhaps due to the ubiquity of BPA and its combination of risk perception factors, the chemical became a prime example for advocates to highlight and explain the threat of endocrine disruptors. Several interviewees (NGOs and researchers) pointed out that holding up BPA as an example could be detrimental to the field of endocrine disruption if research findings do not support continued concern. Despite its status as a symbol, BPA is only one of countless environmental exposures occurring simultaneously. Additional research and regulatory attention should be focused on understanding health effects of cumulative exposures, rather than solely a "one chemical at a time" approach.

Risk Communication Challenges

The case of BPA includes many elements that make risk communication challenging. An important theme that emerged in this case was the profound distrust and perceived lack of objectivity among various parties. No stakeholder group was immune to accusations of hidden (or not so hidden) conflicts of interest. As described by the National Research Council (NRC) in *Improving Risk Communication*, science may be sufficiently uncertain to allow for different interpretations, but experts are often "accused of hiding their subjective preferences behind technical jargon and complex, so-called

objective analyses."[46] While messaging for non-experts must be simplified and somewhat selective, this opens the door for critics to deem it inaccurate or misleading.[46]

This study noted criticism of both the media's coverage of BPA as well as the messaging from scientists in research, government, academia and interest groups. However, both the media and scientists need to better understand each other's roles and constraints.[46] There was much criticism of government agency actions on BPA, particularly the FDA. Respondents largely thought the FDA's risk communication on BPA was lacking and inconsistent – whether or not they considered BPA a public health concern. This presents a problem for the credibility of government agencies, which are intended to be impartial bodies that prioritize the public good.

Improving Risk Communication

It is important to note that there is no easy solution or quick fix to improve risk communication. Even when there is clear messaging and better understanding of an issue, this does not always lead to consensus, in part due to the varying priorities and values of society. As the NRC noted, "but even though good risk communication cannot always be expected to improve a situation, poor risk communication will nearly always make it worse."[46] When people are uninformed about an issue, they rely on social trust to make judgments.[197] In the case of BPA, there were a variety of communicators coming to opposite conclusions, and forcing the public to decide whom to trust. When there is a breakdown in credibility, the public questions the competency and objectivity of the communicator and potentially affects future efficacy in communications.[46] This is detrimental to society, particularly in regard to government agencies and their ability to effectively manage risks. The BPA issue showed that regardless of opinions on the rigor of scientific evaluations, poor communication hampers risk management. Although the

FDA largely maintained that BPA is safe, these findings were not trusted by advocates and legislators who supported BPA bans, and consumers who urged industry to remove BPA from their products. While it is true that proving a chemical is safe is more challenging than raising concern, replacing BPA is not without its own potential risks. In the rush to remove BPA from the marketplace and label baby bottles and other products "BPA-free," little attention was paid to whether replacement compounds were indeed safer than BPA. We are now learning more about similar endocrine disrupting properties in replacement compounds and similar health questions are being raised.[198] Better dialogue and contextualization of chemical risks could help reduce future problems with regrettable substitutions.

This research highlighted both needs and opportunities with regard to better dissemination of scientific information to the public. Even though it may sound counterintuitive, describing uncertainties, limits in knowledge and the limitations in the study design may actually result in more successful risk communication because it improves the base of accurate information that people use to make decisions. It is unrealistic to think there will always be a clear and compelling determination on public health risks. Successful risk communication satisfies people that they are adequately informed with the best available knowledge, despite the existence of uncertainties.

Strengths and Limitations

This study provides the first qualitative assessment of key stakeholders' perceptions of BPA risk communication challenges. However, there are some limitations worth noting. The findings of this study are not based on a representative sample of stakeholders. Rather, a purposeful and snowball selection strategy was used to recruit experts within key stakeholder organizations with particular knowledge and insight on

BPA research and communication. A limitation of these strategies can be key informant bias if the respondent's views are atypical of their group's experience, and self-selection since a number of groups declined to participate.[107] Notably, there was a higher proportion of respondents from the industry/consulting sector who declined the interview or did not respond to interview requests. Despite this, there was a sufficient number of interviews across the five categories to achieve saturation and capture a wide range of perspectives from high-profile stakeholder groups involved in researching and communicating about BPA in the U.S. Other potential limitations of key informant interviews include social desirability bias.[107] Indeed, it is possible that stakeholders were wary of saying anything that would reflect negatively on their organization and thus answer the questions in a way they view most flattering and desirable. We sought to reduce this bias by granting interviewee anonymity and only identifying quotes by stakeholder category. This step was intended reduce the risks to organizations and increase the likelihood that participants were candid and honest. While transferability to other settings is often best determined by those seeking to apply the findings elsewhere[199], it is anticipated that risk communication findings are transferable to other public health issues, particularly in challenging cases with unclear science, entrenched interests and regulatory and policy implications. The format of semi-structured interviews with key stakeholder organizations allowed for the collection of rich, contextual data that is unavailable through other data collection methods.

Conclusion

This study provides new understanding relevant for public health practitioners interested in improving translation of public health risks. In the case of BPA, concerns about lack of objectivity were rampant, and respondents described misinformation and

sensationalism in stakeholder communications and news media reports. Future research should address opportunities for improved translation of scientific information and risk communication by government and the news media, as the public relies on these groups as objective arbiters of information. Future research should also address best practices for increasing the comparability of research studies, particularly in the field of endocrine disruption.

Chapter 7. Discussion

The previous chapters provided a background review of the literature, described the methods used to conduct the dissertation research, and presented the study findings. This chapter summarizes the findings of the three manuscripts, presents public policy implications and opportunities for future research, and discusses overall strengths and limitations of the case study.

Summary of Findings

This research examined how key stakeholders in the United States communicated about potential health risks from BPA exposure. Together, these three studies present a compelling case study with important implications for how public health practitioners present scientific findings, communicate about uncertain health issues and translate science into regulations and public policies. The three main findings are summarized below.

1) Key stakeholders have come to opposing conclusions about the safety of BPA, and mixed messages were prevalent in the news media and from government agencies and interest groups.

The case of BPA demonstrated the pervasive challenge of conflicting risk communication messages. Stakeholders disagreed on whether BPA is safe as currently used, and what solutions are appropriate. As described in Manuscripts 1 and 3, health and environment-focused NGOs were fairly uniform in their descriptions of BPA risks and preferred risk management approaches. NGOs highlighted public health concerns and advocated for the removal of BPA in baby bottles and other consumer products. Industry groups also provided uniform messaging, but maintained that BPA is safe at typical human exposure levels. Industry groups referred to the safety determinations of

regulatory bodies and opposed policies to restrict BPA. While NGOs and industry groups have been consistent in their messaging, U.S government agencies been conflicting. The U.S. Food and Drug Administration has supported the safety of BPA, yet also agreed with the National Toxicology Program's determination of "some concern" and advised consumers on how to reduce their exposure. U.S. news media coverage reflected these mixed messages from stakeholders.

Mixed messaging on BPA is partially due to conflicting scientific evidence. Even experts in the field consider scientific literature on BPA to be confusing. Existing scientific evidence on BPA can be used to support nearly any conclusion about BPA risks. Hundreds, if not thousands of scientific studies have examined BPA's health effects, but stakeholders continue to disagree on where the weight of the evidence lies and what methodologies are appropriate for assessing the impacts of BPA exposure. Stakeholder organizations with concerns about the health risks of BPA often pointed out that traditional toxicological approaches may not be sensitive enough to assess potential endocrine disruptors. Further, they raised issues about the industry funding of the large-scale studies following good laboratory practices favored by government regulators. Stakeholders who erred on the side of BPA safety discussed the lack of standardization and replicability of smaller studies as a problem. Stakeholders perceived mixed messages to be the result of both scientific complexity and the politicized nature of the issue.

2) Mistrust and the perceived lack of objectivity among stakeholders complicates risk communication.

It was clear from the stakeholder interviews that lack of trust and accusations of bias were major barriers to effective risk communication on BPA. As expected, given their financial interest in BPA, industry groups' motivations were questioned by other

stakeholders. Advocates argued that studies supporting BPA safety were predominantly funded by industry. However, industry was not the only group accused of bias. Some NGOs and researchers were accused of financial and career benefits from raising concerns about BPA. Whether or not these criticisms are fair, the acrimony among some groups was apparent. This rancor is in some ways a natural product of the democratic process, but nonetheless presents an additional challenge in risk communication.

Establishing trustworthy messengers is a critical aspect of effective risk communication. The credibility of a messenger is an important factor in how an audience perceives a message. The public relies on experts to frame risks, but because they are not privy to all relevant information, they are unable to judge the fairness and accuracy of the message by its contents alone. Therefore, the reputation and credibility of the source, as perceived by the audience, could add or detract from their trust in the risk communication messages.[46] In the case of BPA, breakdowns in trust and concerns about the objectivity of messengers posed an additional challenge to stakeholders' risk communication efforts.

3) Risk management of BPA lacked focus on comprehensive solutions.

Although there were legislative and regulatory policy changes and voluntary industry actions limiting the presence of BPA in some consumer products, responses by decision-makers were fractured and reactive. The need for increased focus on comprehensive solutions for chemical risk issues was identified, particularly with regard to BPA replacements. Decision-making is complicated by uncertainties and the lack of short-term feedback about whether the decision was effective; however, risk management must consider risk tradeoffs. In stakeholder documents and news media coverage, the discussion of viable replacements was extremely limited. In the documents and

interviews, discrepancies in availability of appropriate replacements were also noted and stakeholders raised concerns about the possibility for regrettable substitutions. This is an important finding as in recent years there has been increasing health concerns about some BPA replacements with similar hormonal activity.[193,194]

Public Policy Implications and Recommendations

This analysis confirms that there has been conflicting risk communication about BPA from government agencies, industry associations, NGOs, researchers and the news media in the United States. Such fractured information about the potential hazards about BPA confuses the public and muddies the distinction between risk assessment and risk management. Successful risk management depends in part on the ability of public health practitioners to translate data and communicate about complex and uncertain scientific issues. BPA presents a challenging case due to conflicting research results, advocacy efforts, and different, evolving conclusions from government agencies. However, several years after the industry voluntarily removed the chemical from some products and legislative bodies passed BPA bans, scientists and regulators continue to disagree on the public health implications. Mixed messages undermine the credibility of the science and foster distrust of stakeholders tasked with risk management. Government agencies in particular, given their intended roles as impartial arbiters, should work together to ensure that consistent risk information to the public in spite of their different missions and goals.

In the case of BPA, mixed messages may reflect both scientific uncertainties and competing political interests. Risk communicators and public health practitioners should be careful to distinguish scientific uncertainty in risk assessment from disagreement on appropriate solutions (risk management), in order to avoid undermining the credibility of

science and contributing to further confusion. Further, the issue of "cherry-picking" data to support one's preferred conclusion undermines science and conflates science and advocacy. This issue was described in the NRC's *Improving Risk Communication* report:

> "The principle of separating science and politics seems to be a cornerstone of professional risk management. Many of the antagonisms surrounding risk management seem due to the blurring of this distinction, resulting in situations in which science is rejected because it is seen as tainted by politics…even technical experts may fall prey to partisanship as they advance views on political topics beyond their fields of expertise, downplay facts they believe will worry the public, or make statements that cannot be verified."[46]

This research also identified the need for more comprehensive evaluations of potential solutions. Integrative approaches to increase the comparability and transparency of research should be pursued, which would also help address the trust and objectivity issues highlighted above. However, the goal is not to squash scientific debate and ensure that diverse perspectives always agree. Future research should examine opportunities for fostering scientific advancements while increasing dialogue and transparency between stakeholders. As recommended in *Science and Decisions*, additional efforts are needed to increase the comparability of research and understand effects of cumulative exposures. Further, these processes need greater stakeholder involvement in both the design and interpretation.[20] The years of research and millions of dollars in research funding invested in BPA is not feasible to repeat for the thousands of other compounds for which knowledge is limited. Research on cumulative effects of typical consumer exposures is inadequate, and research and regulatory methodologies need to be strengthened in order to move away from a "one chemical at a time" approach to understanding health impacts.

In the discussion of BPA and other emerging chemical risk issues, public health advocates should work to ensure that, when warranted, safe replacements are an integral

part of the discussion in order to avoid regrettable substitutions. Researchers have emphasized the need for chemical alternatives assessments to distinguish between alternatives and ensure that replacements do not pose equal or higher or risk as the original compound.[195,196] This would help ensure that chemicals like BPA are not quickly replaced with "BPA-free" alternatives, without sufficient knowledge of the replacement material or its safety. Better dialogue about risk tradeoffs could help reduce future problems with regrettable substitutions.

According to interview respondents and the risk communication literature, effective risk communication puts risks into context, uses clear language without oversimplifying, and acknowledges uncertainties. In reality, there will not always be clear answers on public health risks. Successful risk communication provides accurate information while acknowledging lingering uncertainties. Improving risk communication is no easy task in our modern world. At the same time we are able to measure and investigate impacts of minute chemical exposures, it remains difficult to put findings into context within a complex world with innumerable risk tradeoffs. Effective risk communication requires open dialogue during the risk management process to foster trust between stakeholders and the public.

Strengths and Limitations

There are some on overarching limitations of a case study. Defining the boundaries of a case study and ensuring adequate explanation of methodologies are two of the challenges that were discussed in Chapter 3. Like any type of scientific inquiry, qualitative and mixed-methods research have methodological challenges that need to be disclosed. Limitations for each manuscript were reported in their individual chapters and

also summarized here. The document review of stakeholder websites conducted in Manuscript 1 presents a snapshot of public documents available in June 2014. As such, relevant information removed prior to this time, or posted thereafter, is not captured in this study. In light of the potential for changing website content and variability in website searches and archives, it was important to outline search strategies and inclusion criteria to clearly define the data set. It is possible that modifications such as a different selection of organizations, or restricting documents to a specific time period of interest could have impacted findings. Manuscript 2 presents a quantitative news media content analysis. While efforts were made to sample from high circulation newspapers in each census region and national television news sources, the sample may not represent the entire landscape of U.S. news media. Smaller media outlets and local news were not included. Newer or non-traditional sources of news including blogs, special interest publications and social media were also beyond the scope of this study. Further, the study does not assess any causal relationships regarding news media coverage and public policy actions or public opinion on BPA. The semi-structured interview analysis conducted in Manuscript 3 also has some distinct limitations. Purposeful and snowball selection strategies were used to recruit experts within key stakeholder organizations. A limitation of these strategies can be key informant bias if the respondent's views are atypical of their group's experience, and self-selection since a number of groups declined to participate.[107] Notably, there was a higher proportion of respondents from the industry/consulting sector who declined the interview or did not respond to interview requests. Other potential limitations of key informant interviews include social desirability bias.[107] Indeed, it is possible that stakeholders were wary of saying anything

that would reflect negatively on their organization. We sought to reduce this bias by granting interviewee anonymity and only identifying quotes by stakeholder category. Despite these limitations, several strategies were used optimize overall study quality, as discussed in Chapter 3.

This dissertation also has some noteworthy strengths. This case study approach using mixed methods and multiple data sources allowed for the collection and analysis of rich, contextual data that was not available elsewhere. The three distinct approaches provided strength to the overall study by triangulating the data. Triangulation refers to collecting data using variety of methods and sources to strengthen conclusions and minimize the possibility that systematic biases taint results. The combination of data directly from stakeholders in the document review, media reports in the news content analysis and key stakeholders interviews help diversify the data and strengthen the research design Manuscript 1 is believed to be the first study to evaluate stakeholder's risk communication using the risk assessment framework, and as such presents a novel framework for future analyses. This is also the first study to assess how key stakeholders in the United States have characterized human health risks associated with BPA. The documents consisted of risk communication directly from each organization—and thus represent official statements that were not filtered through the media or an individual's perspective. Manuscript 2 provides the first known systematic analysis of news media content on BPA in the United States. This study quantified the discussion of key BPA sources, populations of concern, health endpoints and solutions in major U.S. news sources and demonstrated mixed and conflicting risk messages were prevalent. Manuscript 3 presents the first known analysis of key stakeholders' perspectives on BPA

risk communication via semi-structured interviews. The findings of the study were based on the perspectives of 36 organizations from five sectors (government, industry/consulting, NGO, research and the news media) involved in research and communication on BPA. The stratification of different stakeholder groups, as well as the range of opinions within these groups reached at saturation enhanced the analysis and sought to reduce potential biases. Similar themes emerged both within each strata and overall, which supports the internal validity of the results. Together, these three studies provide a cohesive picture and unique insights into the challenges of communicating risks to the public. While transferability to other settings is often best determined by those seeking to apply the findings elsewhere,[199] it is anticipated that the findings of this case study may be applicable to other public health issues, particularly in challenging cases with unclear science, entrenched interests and regulatory and policy implications. In summary, a primary strength of this case study research is that it addresses a largely unexplored topic of significance and the missing link in the management of public health risks: effective risk communication.

Conclusion

The success of risk communication and risk management efforts depends on the ability of public health professionals to translate scientific information and communicate about complex risk issues. This research examined a high stakes, highly prevalent chemical and revealed just how divided stakeholders are in their risk perception and communication strategies. This study illustrated the challenges communicating about nuanced scientific findings and the resulting impact on risk management. Future research should address how mixed messages on BPA affected consumer risk perceptions.

Additional recommendations include supporting efforts to increase the comparability and translation of science, as well as to identify credible messengers who can deliver clear, accurate and useful information to the public without overstating knowledge. This case study is a step forward in understanding the risk communication process in action and provides a roadmap for addressing an important public health dilemma. Best practices in risk communication and risk management as described by experts over the last 30 years have not been adequately implemented.[19,20,46,48] There is a need for increased collaboration between government agencies to present unified risk communication messages, particularly in controversial and high-profile cases such as BPA. We undoubtedly need strong science to inform sound decision-making, but just as important is ensuring that the science is translated appropriately, and that risk tradeoffs are explained by credible and objective messengers. Without skilled risk communication, important public health efforts are at risk of failure and marginalization.

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Appendices

Appendix A: IRB Notification

FWA #00000287

JHSPH Institutional Review Board Office

615 N. Wolfe Street / Suite E1100
Baltimore, Maryland 21205
Office Phone: (410) 955-3193
Toll Free: 1-888-262-3242
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E-mail Address: irboffice@jhsph.edu
Website: www.jhsph.edu/irb

NOT HUMAN SUBJECTS RESEARCH
DETERMINATION NOTICE

REVISED

Date: October 3, 2013

To: Patricia Truant

Re: **PhD Dissertation Student Project Title:** "Government Agencies, Interest Groups and the Media: An Evaluation of Bisphenol A Risk Communication"

The JHSPH IRB reviewed the IRB Office Determination Request Form for Primary Data Collection (received 10/1//13) on **October 3, 2013**. We have determined that the proposed activities described in your application involves three components. The first two components involve secondary data analysis of existing, de-identified/de-linked, publicly available datasets, and you and your advisor were not involved in the original data collection. The third component involves subjects who are key informants and collects expert opinions and judgments designed to elicit information from them in their professional capacity about risk communication to the public about Bisphenol A (BPA). Data will be anonymous and will not include any personal or private information. Thus, the proposed activity does not qualify as human subjects research as defined by DHHS regulations 45 CFR 46.102, and does not require IRB oversight.

You are responsible for notifying the JHSPH IRB of any future changes that might involve human subjects and require IRB review.

If you have any questions regarding this determination, please contact the JHSPH IRB Office at (410) 955-3193 or via email at irboffice@jhsph.edu.

/teb

cc: Thomas Burke, PhD, MPH
Project Advisor
Professor, Health Policy & Management

JHSPH IRB NHSR Determination_Notice_Student Projects_V2_07-25-12

Appendix B: Tally of Included Documents By Stakeholder Organization

	Number of search results	Number of documents retained for analysis (% retained)
GOVERNMENT		
CDC	5	2 (40)
EPA	11	3 (27)
FDA	14	6 (43)
NIEHS	41	7 (17)
Total Government documents	*71*	*18 (25)*
INDUSTRY		
ABA	3	3 (100)
ACC	13	12 (92)
GMA	7	4 (57)
IBWA	3	3 (100)
NAMPA	31	26 (84)
Total Industry documents	*57*	*48 (84)*
NGOs		
BCF	90	28 (31)
CU	28	21 (75)
EWG	56	25 (45)
NRDC	6	6 (100)
Total NGO documents	*180*	*80 (44)*
Grand total	**308**	**146 (47)**

Appendix C: BPA Document Coding Extraction Instrument

1. Document Number
2. Document Title
3. Stakeholder Organization Type
- ❍ Government
- ❍ Industry
- ❍ Health Environment NGO

4. Organization Name
- ❍ FDA
- ❍ EPA
- ❍ NIEHS
- ❍ CDC
- ❍ ACC
- ❍ GMA
- ❍ IBWA
- ❍ ABA
- ❍ NAMPA
- ❍ NRDC
- ❍ BCF
- ❍ CU
- ❍ EWG

5. Primary Purpose of Document
- ❑ About BPA/Q and A/Basic Information/Fact Sheet
- ❑ Release news
- ❑ Information Brief/Report Brief
- ❑ Describe organization's actions/stance on BPA

6. Date created

7. Date last updated

HAZARD IDENTIFICATION

8. HI1: How is BPA described?
- ❑ Chemical
- ❑ Endocrine Disruptor/Endocrine Disrupting Compound
- ❑ Hormone disruptor
- ❑ Carcinogen
- ❑ Estrogenic/Estrogen
- ❑ Toxin/Toxic
- ❑ Other _____

9. HI 1: How is BPA described? Specify text.

10. HI2: Where is BPA found?
- ❑ In food or drink containers
- ❑ In receipt paper
- ❑ In dental sealants
- ❑ In other consumer goods (cds, car parts, etc)
- ❑ In the environment (air, water)

10. HI2: Where is BPA found? Specify text.

11. HI3. What health conditions are mentioned as linked or potentially linked to BPA?
- ❑ Cancer
- ❑ Development/brain/neurological
- ❑ Immune/Endocrine/Hormone
- ❑ Reproductive/Sexual Dysfunction
- ❑ Diabetes
- ❑ Obesity/Weight
- ❑ Behavioral effects
- ❑ Heart disease/cardiovascular
- ❑ Other _____

DOSE RESPONSE

18. DR1 What sources of scientific evidence are cited/What sources of information are mentioned?
- ❑ US Government- suggesting risk
- ❑ US Government-suggesting safety
- ❑ US Government- biomonitoring or neutral
- ❑ Foreign gov't - suggesting risk
- ❑ Foreign gov't -suggesting safety
- ❑ Foreign gov't- biomonitoring or neutral
- ❑ Scientific literature- suggesting risk
- ❑ Scientific literature- suggesting safety
- ❑ Scientific literature- neutral
- ❑ Grey literature - suggesting risk
- ❑ Grey literature- suggesting safety
- ❑ Grey literature- neutral

19. DR2 Overall State of the Evidence discussion.
What critical values are mentioned? /What sources of scientific evidence are cited? Specify text.

EXPOSURE ASSESSMENT

12. EA1: Who is exposed?
- ❑ Everyone/widespread
- ❑ Developing fetuses/Pregnant women
- ❑ Young children
- ❑ Other _____

13. EA1: Who is exposed? Specify text.

14. EA2: Who are sensitive populations/populations of concern?
- ❑ Developing fetuses/Pregnant women
- ❑ Young children
- ❑ Other _____

15. EA2: Who are sensitive populations/populations of concern? Specify text.

16. EA3: What is the route of exposure?
- ❑ Through food/drink (oral)
- ❑ Oral- general
- ❑ Dermal
- ❑ Inhalation
- ❑ Other _____

17. EA3: What is the route of exposure? Specify text.

RISK CHARACTERIZATION

20. RC1: Does BPA pose risks to human health?
- ❑ No, BPA is safe.
- ❑ Yes, BPA is a concern.
- ❑ "Some concern" (based on NTP language)
- ❑ It's uncertain.
- ❑ Other _____
- ❑ Not discussed

21. RC1: Does BPA pose risks to human health? Specify text.

22. RC4: Main Messages/ Public Position on Risk/Safety. Specify text.

RISK MANAGEMENT

23. RM1: Solutions Discussed

- ❑ Federal Policy affecting children- PRO
- ❑ Federal Policy affecting children- ANTI
- ❑ Federal policy affecting children- neutral
- ❑ Federal Policy general- PRO
- ❑ Federal Policy general- ANTI
- ❑ Federal policy general - neutral
- ❑ Consumer behavior (reducing exposures)- PRO
- ❑ Consumer behavior (reducing exposures)- - ANTI
- ❑ Consumer behavior (reducing exposures)- - neutral
- ❑ FDA regulation- PRO
- ❑ FDA regulation- ANTI
- ❑ FDA regulation- neutral
- ❑ State policy affecting children- PRO
- ❑ State policy affecting children- ANTI
- ❑ State policy affecting children- neutral
- ❑ State policy general- PRO
- ❑ State policy general- ANTI
- ❑ State policy general- neutral
- ❑ Voluntary industry actions to remove BPA- PRO
- ❑ Voluntary industry actions to remove BPA- ANTI
- ❑ Voluntary industry actions to remove BPA- neutral
- ❑ Other _____

24. RM1: Solutions Discussed. Specify text.

25. RM2: Alternates/Replacements discussed.

- ❑ 1 _____
- ❑ 2 _____
- ❑ 3 _____

26. RM2: Alternates/Replacements discussed. Specify text.

Appendix D: News Sources Used in Content Analysis Sample

Source	*Number of articles (%)*
New York Times	13 (5.8)
USA Today	21 (9.4)
Wall Street Journal	5 (2.2)
Los Angeles Times	15 (6.7)
The Oregonian	7(3.1)
Denver Post	1 (0.5)
Washington Post	26 (11.6)
Philadelphia Inquirer	2 (0.9)
Boston Globe	10 (4.5)
Houston Chronicle	9 (4.0)
Atlanta Journal Constitution	4 (1.8)
Tampa Bay Times	0 (0)
Chicago Tribune	20 (8.9)
Minneapolis Star Tribune	2 (0.9)
Milwaukee Journal Sentinel	37 (16.5)
Time Magazine	1 (0.5)
Newsweek Magazine	3 (1.3)
CNN	21 (9.4)
Fox News	0 (0)
ABC News	9 (4)
NBC News	11 (4.9)
CBS News	7 (3.1)

Appendix E: Coding Instrument with Raw Agreement and Inter-rater Reliability Kappa statistics

Item	*Kappa*	*Raw Agreement (%)*
Module 1: Products		
Food or drink containers mentioned as source of BPA?	1.0	100
• If yes, baby bottles or other children's cups?	.82	93
• If yes, plastic food or drink containers?	.61	83.5
• If yes, infant formula or baby food containers?	.80	91.8
• If yes, canned food or beverages?	.67	86.2
Other non-food related products mentioned as a source of/containing BPA?	.75	88.8
• If yes, paper register receipts?	1.0	100
• If yes, dental fillings?	1.0	100

Module 2: Health and Risk		
Mentions that BPA has hormone-like effects or mimics the effects of estrogen?	.82	91.0
Mentions BPA as an endocrine disruptor?	.63	93.3
Are pregnant women or developing fetuses mentioned as potential sensitive groups or populations of concern?	.83	91.5
Are infants or young children mentioned as potential sensitive groups or populations of concern?	.75	89.3
Are any of the following health conditions mentioned as linked, or potentially linked to BPA?		
• Cancer?	.85	92.9
• Brain, developmental or neurological effects?	.81	90.4
• Effects to endocrine system, hormone function, thyroid or metabolism?	.79	97.6
• Reproductive effects or sexual dysfunction?	.77	89.4
• Diabetes?	.80	91.6
• Obesity?	.87	96.3
• Behavioral effects?	.76	88.2
• Heart disease?	.84	94.7
Mentions widespread exposure to BPA?	.84	91.8
Mentions BPA (or endocrine disruptors in general) may cause effects at very low doses?	.81	94.2
Mentions that BPA does not pose risk to human health or is safe.	.77	88.8
Mentions that a U.S. government agency has found BPA uses safe.	.61	80.6

Module 3: Policy		
Any mention of government policy action regarding BPA?	.75	87.6
• If yes, any mention of local government policy action?	.93	97.9
• If yes, any mention of state government policy action?	.83	91.5
• If yes, any mention of federal government policy action?	.79	89.4

• If yes, any mention of foreign government policy action?	.71	85.1
• If yes, any mention of banning BPA?	.64	93.6
• If yes, any mention of labeling products with BPA?	.66	91.5
Any mention of industry self-regulation/voluntary action to limit BPA?	.72	86.5
• If yes, what target population would the voluntary action affect?	.79	86.7
• If yes, what type of BPA-containing products would be affected by the voluntary action?	.83	93.3
Mentions ways consumers can avoid BPA.	.75	88.8

Module 4: Replacements		
• Any mention of the specific compound that could replace BPA?	1	100
• Any mention of difficulty in finding replacements?	1	100
• Refers to replacements in food cans?	1	100

Appendix F: Initial Email to Potential Interviewees

Dear [Name],
My name is Patti Truant and I am a PhD candidate at Johns Hopkins University.

I am conducting a study on risk communication about Bisphenol A (BPA). The purpose of this research project is to better understand risk communication on BPA and the roles of researchers, stakeholder organizations and the media in conveying information to the public and policymakers.

I am contacting you to ask if you would be willing to be interviewed for this study.

The interview will last about an hour, and with your permission it will be audio recorded.

The questions will be focused on the state of the scientific evidence on BPA, how you/your organization communicates to the public about BPA, how you/your organization uses scientific evidence in your communications, and the challenges of effective risk communication.

You may skip any questions or stop the interview at any time. Quotes will not be made attributable to you or your specific organization in the written results of the study. Instead, they will be attributed by the type of stakeholder organization (media, government agency, trade association, health or environmental organization, academic researcher etc.).

If you are willing to participate, please let me know when would be a convenient time to schedule an interview.

Thank you very much.

Patti Truant, MPH, CPH
Johns Hopkins School of Public Health
Department of Health Policy and Management

Appendix G: Oral Informed Consent Script

JOHNS HOPKINS BLOOMBERG SCHOOL OF PUBLIC HEALTH
Oral Informed Consent for Interviewees

Study Title: *Government Agencies, Interest Groups and the Media: An Evaluation of Bisphenol A Risk Communication*
Principal Investigator: *Tom Burke, MPH, Ph.D.*

Purpose
You are invited to take part in a research study. The purpose of this study is to better understand risk communication on Bisphenol A (BPA) and the roles of scientific studies, stakeholder organizations and the media in conveying information to the public and policymakers.

Why You Are Being Asked to Participate
You are being asked to participate because you, or your organization, were identified as a stakeholder while conducting background research.

Procedures
Participating in the study involves one interview, which will last about an hour. With your permission, the interview will be audio recorded.

You may skip any questions or stop the interview at any time. In addition, if you would like any of your answers to be "off the record," notify the interviewer and those responses will not be reported in the study results.

Risks
All research studies have some degree of risk or discomfort. Risks from participating in this research study are minimal because the topics covered will focus on your professional activities. Potential risks include feeling uncomfortable discussing communication and policy strategies.

Benefits
There is no direct benefit to you from participating in this study. Indirect benefits include the opportunity to contribute your thoughts and expertise on this topic. Findings from this study could result in increased knowledge on BPA risk communication and improved public health communications on BPA and similar topics.

Data Confidentiality
Data collected during this study will be stored on a password-protected computer. Types of organizations may be linked to quotes when results of the study are shared. Notify the researcher if you do not want certain answers included in the written results of the study.

Voluntary Participation
You do not have to agree to be in this study, and you may change your mind at any time.

- Call the principal investigator, Thomas Burke at 410-614-4587 if you have questions or complaints about being in this study.
- If you have any questions about your rights as a research participant, or if you think you have not been treated fairly, you may call the Johns Hopkins School of Public Health Institutional Review Board (IRB) at 410-955-3193, or 1-888-262-3242.

Permission to Proceed

- Is it ok to proceed with the interview?

Appendix H: Key Stakeholder Semi-structured Interview Guide

Background Information

Could you briefly describe your organization's mission and your role?

Has your organization communicated a public position concerning risks to the public on BPA? If so, how would you describe that position?

Communication on BPA
How would you describe your organization's strategies in communicating to the public and policy makers about BPA?

Does your organization have goals with regard to policy interventions related to BPA?

What means of communication does your organization use to disseminate information about BPA (i.e. websites, press releases, submitting testimony, social media, news media, etc.)?

What are your main messages about BPA risks? Have these main messages changed over time?

Is there a document or reference that provides the best summary of your organization's position and work on BPA?

Scientific Evidence
How would you describe the state of the scientific evidence on BPA and human health?

How does your organization use scientific information in crafting public communications about BPA?

What sources of scientific information or critical studies do you reference?

What sources does your organization rely on for trustworthy scientific information?

Challenges/Effective Risk Communication

How would you describe the challenges of communicating to public about BPA?

How do you define effective risk communication?

Why do you think BPA has gotten a lot of public attention?

How would you describe your organization's effectiveness in communicating about BPA?

How do you think the federal government did with regard to their risk communication about BPA?

How do you think industry groups did with regard to their risk communication about BPA?

How do you think environmental and health organizations did with regard to their risk communication about BPA?

What advice would you give to public health professionals communicating about health risks?

Stakeholders

Do you work with other groups to communicate or advocate about BPA?

Who else do you recommend I talk to about communicating about BPA risks?

Appendix I: Interview Codebook

Mnemonic code	*Full description of code*
Government	Identifies respondents from a government agency.
Industry	Identifies respondents from an industry trade association or a consultancy.
NGO	Identifies respondents from a health, environment or consumer-focused non-government organization.
Media	Identifies respondents from the news media.
Researcher	Identifies respondents who are involved in research and/or communication about BPA.
Great quote	Particularly great or well-phrased quote from interview.
Main Messages	Answer to question about main messages about BPA risk/ also public position about BPA. Code entire answer to this question and other times discussion of main messages comes up, as relevant. For example "Our bottom line on BPA is…"
Public Attention	Answer to question as to why BPA has received public attention. Code entire answer to this question and other times discussion of public attention comes up, as relevant.
Comm Challenges	Answer to question about why communicating about BPA is challenging. Code entire answer to this question and other times communication challenges come up, as relevant.
PH Advice	Answer to question about advice to public health professionals. Code entire answer to this question and other times public health advice comes up, as relevant.
Defining Effective Risk Comm	Answer to question about how would they define effective risk communication. Code entire answer to this question and other times effective risk communication comes up, as relevant.
Comm Strategies	Answer to question about the respondent' communication strategies. Code entire answer to this question and other times communication strategies come up, as relevant.
Lessons Learned	Answer to question about lessons we can learn from this case. Code entire answer to this question and other times this issue comes up, as relevant.
Research challenges	Discussion of challenges or complexities of BPA research. Examples include discussion of research methodologies (GLP, endocrinology/academic research, etc), assessing exposure, lack of human studies, etc.
Conflicting methodologies	Discussion of methodologies to study BPA and various approaches that may be at odds. Specifically addresses good laboratory practices (GLP), a toxicology approach and/or endocrinology, hormone, academic focused studies. May discuss the differences between different approaches and merits or

	problems with either.
Literature-strong	In discussion of state of the science, mention of BPA literature as strong. Respondent indicates the BPA literature as relatively strong, clear, compelling, or building-- in either direction toward indicating safety or indicating risk.
Literature-complex	In discussion of state of the science, mention of BPA literature as complex or confusing. For example, respondent indicates the BPA literature as complicated, confusing, hard to understand, or uncertain, in either direction toward indicating safety or indicating risk.
Objectivity	Discussion of bias or objectivity in regard to the science on BPA. Examples include discussion of the science and objectivity, such as industry studies not objective, the discussion of academics' objectivity not objective, government objectivity, the existence or lack thereof of objective parties, etc.
Gov eval	General discussion about government's efforts regarding BPA. Discussion of government's actions or evaluation of their actions and/or communications regarding BPA.
Gov positive	Positive comments regarding the government's efforts in general or communication. Positive discussion of government actions or communications, such as stating effectiveness, good research, good communication, even if respondent does not agree with government.
Gov negative	Negative comments regarding the government's efforts in general or communication. Negative discussion of government actions or communications, such as stating ineffectiveness, bad research, bad communication, even if respondent does not agree with government.
Gov role	Discussion of the government's role or the government's incentives or goals, for example, the government's role in research or communication about BPA.
Industry eval	General discussion about industry's efforts regarding BPA, for example, industry's actions or evaluation of their actions and/or communications regarding BPA.
Industry positive	Positive comments regarding the industry's efforts in general or communication, such as stating effectiveness, good research, good communication, etc., even if respondent does not agree with industry.

Industry negative	Negative comments regarding the industry's efforts in general or communication, such as stating ineffectiveness, bad research, bad communication, even if respondent does not agree with industry.
Industry role	Discussion of the industry's role or the industry's incentives or goals regarding BPA, role of industry in defending their product, etc.
NGO eval	General discussion about NGO's efforts regarding BPA or evaluation of their actions and/or communications regarding BPA.
NGO positive	Positive comments regarding the NGO's efforts in general or communication, such as stating effectiveness, good research, good communication, etc., even if respondent does not agree with NGOs.
NGO negative	Negative comments regarding NGO efforts in general or communication, such as stating effectiveness, bad research, bad communication, etc., even if respondent does not agree with NGOs.
NGO role	Discussion of NGO role or NGO incentives or goals, for example NGO role/mission, incentives to raise money, etc.
Researcher eval	General discussion about researcher efforts regarding BPA or evaluation of their actions and/or communications regarding BPA.
Researcher positive	Positive comments regarding researcher efforts in general or communication, such as stating effectiveness, good research, good communication, etc., even if respondent does not agree with researchers.
Researcher negative	Negative comments regarding researcher efforts in general or communication, such as stating ineffectiveness, bad research, bad communication, even if respondent does not agree with researchers.
Researcher role	Discussion of researcher's role or researchers incentives or goals, or researcher's role in studying or communication about BPA, discussion of objectivity, etc.
Media eval	General discussion about media's efforts regarding BPA or evaluation of their actions and/or communications regarding BPA.
Media positive	Positive comments regarding media efforts in general or communication, such as stating effectiveness, fair reporting, etc., even if respondent does not agree with news media.
Media negative	Negative comments regarding media efforts in general or communication, such as stating ineffectiveness, bias, bad reporting, etc., even if respondent does not agree with news media.

Media role	Discussion of media role or the industry's incentives/goals, such as incentives, objectivity, etc.
Self evaluation	Answer to question about how their organization did with regard to BPA communication.
Scientific literacy	Discussion of scientific literacy or understanding of science in the public and in the media or public risk perception. May refer to high or low science literacy.
Translating science	Discussion of explaining or translating science. May refer to ease or difficulty of putting science in understandable terms, or researchers speaking in technical language.
Misinformation	Discussion of challenges of misinformation, misleading information or counteracting misinformation, bad science, and unclear or misleading information among any stakeholder groups.
Sensationalizing	Discussion of difficulty communicating in light of sensationalized information, for example--- findings of safety aren't as interesting, or it's scary, advocacy vs science, special interests, role of incentives in sensationalizing.
Simple	Discussion of ease of communication, i.e. it's not that difficult or challenging to communicate about BPA.
Poster Child	Discussion of BPA as a poster child, representing endocrine disruption or other environmental contaminations, i.e. description of BPA as an example chemical.
Other	Captures discussion of other interesting aspects of the risk communication challenges, other interesting risk communication challenges not expressly identified, such as characterizing good vs. evil dynamic.
Tone of the debate	Discussion of whether the tone or tenor of the debate on BPA is unusual or polarized (or not).

Curriculum Vitae

Patricia L. Truant, MPH, CPH
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Baltimore, MD 21224
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EDUCATION

PhD — Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
Health Policy and Management, October 2014
Dissertation title: *A Case Study of Bisphenol A (BPA) Risk Communication: Government Agencies, Interest Groups and the Media*

MPH — Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
Concentration in Global Environmental Sustainability, May 2009

BA — University of Maryland, College Park, MD
Journalism, December 2005

PROFESSIONAL EXPERIENCE

Johns Hopkins Center for a Livable Future
Research Assistant, 2011-Present, 2008-2009

- Managed design and data analysis of nationally representative survey on food waste knowledge, behavior and attitudes.
- Lead-authored the food environment chapter in the first U.S. food systems textbook, *Introduction to the US Food System: Public Health, Environment, Equity* (anticipated: Fall 2014); edited 17 remaining textbook chapters.
- Authored and edited sections of the CLF report, *Industrial Food Animal Production in America: Examining the Impact of the Pew Commission's Priority Recommendations*, released in October 2013.
- Translated scholarly articles to press releases and blog posts on current environmental health issues including antibiotic-resistant organisms, biofuels and concentrated animal feeding operations.
- Synthesized research and compiled data on local food production and nutrition interventions for Baltimore Food Policy Task Force Report and Baltimore Office of Sustainability's urban agriculture initiative.

Johns Hopkins Office of Public Health Practice and Training
Research Assistant, 2010-2013

- Managed team of four in the development of environmental health curriculum on air quality, water quality and the built environment for the Maryland Department of Health and Mental Hygiene. Oversaw program budget, developed partnerships with environmental health

community leaders and educators. Supervised videographer in the filming and editing of video lessons for distribution throughout the state.
- Developed, implemented, and analyzed an 800-person community health survey as part of a health and environmental study in Spring Valley, Washington D.C. Communicated findings through community presentations and a final project report.
- Led interviews with community members and public health experts as part of an oral history research project on cancer cluster investigations. Worked with team in Frederick, MD to provide insights and recommendations to public health practitioners, local government and the community. Wrote and edited content for a website with video interviews, Johns Hopkins School of Public Health Magazine article, and an *American Journal of Public Health* article.

U.S. Environmental Protection Agency, Office of Research and Development
ASPPH Public Health Fellow, 2009-2010

- Conducted research and presented findings to EPA, Department of Agriculture, and Department of Energy leadership and staff on the environmental, safety and health effects of biofuels use.
- Developed and managed the selection process for a Request for Proposals on interdisciplinary biofuels research for several million dollars in research grants to EPA laboratories.
- Collaborated with an EPA team to produce "Biofuels and the Environment: First Triennial Report to Congress" and wrote section on environmental and health impacts of biofuels throughout the supply chain.
- Represented EPA on interagency panels overseeing the implementation and evaluation of federally mandated biofuels programs.

Center for Science in the Public Interest
Communications Coordinator, 2006-2008

- Authored and distributed news releases on food issues ranging from school nutrition policies and trans fat legislation to foodborne disease outbreaks.
- Researched the cost-effectiveness of 100-calorie snack packs and distributed findings to the news media, which culminated in a segment on ABC's Good Morning America.
- Conducted targeted media outreach and secured news coverage from top television and newspaper outlets including *The New York Times*, *The Washington Post*, NBC News, CBS News, and others.
- Managed the organization's website, including writing and updating content.
- Planned and executed special events such as expert Congressional testimonies and press conferences with staff members and high-profile guest speakers.

Temple University Office of Communications
Staff writer, 2006

- Covered university news and events for university-run newspaper, the *Temple Times* and the Temple alumni magazine.
- Wrote feature profiles highlighting outstanding professors, staff and students.
- Participated on university-wide development and student orientation committees.

The Buffalo News Washington Bureau
Research Assistant, 2005

- Conducted research and data analysis for two Washington, D.C.-based reporters.
- Attended press briefings on military base closings at the Pentagon and covered events including the 2005 Presidential Inauguration and the 2005 State of the Union Address.

American Public Health Association
Communications Intern, 2005

- Wrote articles on public health issues including postpartum depression and multi-drug resistant tuberculosis for APHA's newspaper, *The Nation's Health*.
- Covered news events at U.S. Department of Health and Human Services and other agencies.
- In 2007-2009, attended APHA's annual meetings in Washington, D.C., San Diego and Philadelphia as part of APHA's blog team covering the event.

TEACHING EXPERIENCE

Served as a teaching assistant in the Department of Health Policy and Management at Johns Hopkins Bloomberg School of Public Health from Fall 2010 to Summer 2014 (courses listed below). Responsibilities included guest lecturing, collaborating with faculty on course development, developing grading rubrics, supervising class activities, managing other staff, organizing and distributing course materials, answering student questions, serving as primary liaison to students about course requirements and deadlines, and course grading.

Course Name *(* Indicates Lead TA)*	**Course credits**	**Number of academic terms served as TA**	**Approx. number of students per term**
Introduction to the Risk Sciences and Public Policy*	4	6	80
Public Health Practice*	4	6	70
Health Advocacy	3	2	80
Tools of Public Health Practice and Decision Making*	1-3	3	250
Current Issues in Public Health	1	8	60

Role of Government in Health Policy	3	1	20
Public Health Applications for Student Experience (PHASE) Internship Course*	1-3	6	10

HONORS AND AWARDS

2010-2014 Center for a Livable Future- Lerner Fellowship
Johns Hopkins Bloomberg School of Public Health

2009 Reed Frost Scholarship
Johns Hopkins Bloomberg School of Public Health

2005 President's Scholarship and Archibald Scholarship
University of Maryland, College Park

2004 University Honors Program Citation
University of Maryland, College Park

PUBLICATIONS AND PRESENTATIONS

Journal Articles

Simpson, BW; **Truant, PL**; Resnick BA (2014). Stop and Listen to the People: An Enhanced Approach to Cancer Cluster Investigations. *American Journal of Public Health, 104 (7),* 1204-1208.

Textbook chapters

Truant, PL; Neff, RA (Forthcoming 2014). The Food Environment. In Roni A. Neff (Ed.), *Introduction to the U.S. Food System: Public health, environment, equity.* San Francisco, CA: Jossey Bass.

Reports and Non-Peer Reviewed Articles

Kim, BF; Laestadius, LI; Lawrence, RS; Martin, RP; McKenzie, SE; Nachman, KE; Smith, TJS; **Truant, PL** (2013)**.** *Industrial Food Animal Production in America: Examining the Impact of the Pew Commission's Priority Recommendations.* Johns Hopkins Center for a Livable Future. Baltimore, MD.

Fox, M; Resnick, B; Nachman, K; **Truant, P**; McGinty, M; Le, Jennifer; Burke, T. (2013). *Follow-Up On Spring Valley Health Study.* Johns Hopkins Office of Public Health Practice and Training. Baltimore, MD.

Simpson, B; Resnick B; **Truant P** (2013). It would break your heart: science vs. experience in a cancer cluster investigation. *Johns Hopkins Public Health Magazine*. Baltimore, MD.

Professional Presentations

Truant, PL (2013, November). Environmental Health Tracking Programs in Middle and High School Curricula: Lessons from Maryland. *Annual meeting of the American Public Health Association.* Lecture conducted from Boston, MA..

Truant, PL (2013, February). 8th Grade Curriculum Development on Environmental Health Topics: Using Technology and Tracking Programs. *Annual meeting of the Maryland*

Association of Environmental and Outdoor Educators. Lecture conducted from Ocean City, MD.

Truant, PL (2012, August). Arsenic and Pharmaceuticals in Poultry Feather Meal: Recent Research and Implications. *2012 Indiana CAFO Watch Conference sponsored by the Socially Responsible Agriculture Project*. Lecture conducted from Chesterfield, IN.

Truant, PL (2012, July). Spring Valley: Analyzing Community Health. Johns Hopkins Environmental and Community Assessments. *Annual meeting of the Chemical Stockpile Emergency Preparedness Program*. Lecture conducted from Pueblo, CO.

PROFESSIONAL MEMBERSHIPS AND CERTIFICATIONS

2013 Certification in Public Health (CPH) from the National Board of Public Health Examiners

2012-2014 Member, American Public Health Association

2013-2014 Member, Society for Risk Analysis

2011 Certificate in Risk Sciences and Public Policy, Johns Hopkins Bloomberg School of Public Health

OTHER UNIVERSITY SERVICE

2013-2014 Served as student representative on Johns Hopkins Bloomberg School of Public Health Plagiarism Task Force

2012-2013 Fellowship Journal Club Coordinator
Johns Hopkins Center for a Livable Future
Johns Hopkins Bloomberg School of Public Health

2011-2012 Public Health Practice Committee Student Representative
Department of Health Policy and Management
Johns Hopkins Bloomberg School of Public Health