Attitudes and Actions towards Toxic Chemicals: An Environmental Health and Risk Perception Survey of Massachusetts Childcare Providers

Ryan M. Bouldin
Helen Meldrum
Danielle Blanch-Hartigan
Department of Natural and Applied Sciences and Bentley Health Thought Leadership Network, Bentley University

Jordan McCormick
School of Public Health, University of California, Berkeley

Vanessa Coloma
Department of Natural and Applied Sciences, Bentley University

Citation: Bouldin, R. M., Meldrum, H., Blanch-Hartigan, D., McCormick, J., & Coloma, V. (2020). Attitudes and actions towards toxic chemicals: An environmental health and risk perception survey of Massachusetts childcare providers. *Children, Youth and Environments, 30*(2), 147-164. Retrieved from http://www.jstor.org/action/showPublication?journalCode=chilyoutenvi

Abstract
Over half of all children in the United States aged 3-5 spend time in preschool settings and are exposed to a disproportionately high level of toxic chemicals compared to other age groups. Long hours at childcare facilities can be a source of exposure to hazardous chemicals in household and children's products. We surveyed 638 childcare providers in Massachusetts to assess their perception of toxic chemicals in their facilities to determine whether exposure concerns influenced their product purchasing behaviors and actions to reduce children's exposure. Childcare providers reported low levels of worry about children's exposure to toxic chemicals, but considered themselves able to make well-informed, healthy purchasing decisions. The strongest predictor of whether a provider was willing to seek safer products was a strong belief that exposure to chemicals is harmful to children. Results suggest that interventions designed to educate childcare providers of chemicals' potential harm to children may be most successful in provoking safe purchasing behavior. Interventions that highlight low-cost solutions that are free of harmful chemicals are likely to provide the highest benefit.

Keywords: childcare, toxic chemicals, flame retardants, risk perception, environmental health

Introduction

As of 2019, approximately 88 percent of 5-year olds, 69 percent of 4-year olds and 40 percent of 3-year olds attend preschool in the U.S. (Snyder, De Brey, & Dillow, 2019). Over the last four decades, enrollment in half-day kindergarten and nursery school has varied, but an average of 3.4 million children participate. Full-day enrollment numbers have increased steadily from approximately 1.5 million in 1980 to about 5 million in 2018. Today, greater than 50 percent of children in the U.S. attend full-day childcare for eight hours or more each day (McFarland et al., 2019). Therefore, naturally occurring (e.g., lead) and synthetic (e.g., flame retardants) chemicals present in childcare facilities represent an important source of chemical exposure for children's developing bodies.

According to the 2016 Targeting Environmental Neuro-Developmental Risks (TENDR) Consensus Statement, children in the United States face widespread exposure to toxic and endocrine-disrupting chemicals (Bennett et al., 2016). Exposure to harmful chemicals, like flame retardants, can occur in homes, childcare facilities, and from the natural environment. While blood serum sampling reveals that U.S. residents exhibit significantly higher concentrations of polybrominated diphenyl ethers (PBDE) flame retardants compared to global residents (Guvenius, Aronsson, Ekman-Ordeberg, Bergman, & Norén, 2003) children bear the highest body burdens, showing greater concentrations than infants or adults (Butt et al., 2016; Hoffman, Webster, Sjodin, & Stapleton, 2017; Toms et al., 2009). As a result of their exposure, children are at greater risk to numerous negative health impacts from flame retardants, including impaired neurological development (Eskenazi et al., 2013) and cancer (National Research Council, 2000).

State regulations, such as those of California, have been enacted to protect children and have demonstrated some success towards lowering the use of flame retardants in children's products (Bureau of Electronic and Appliance Repair, 2013). However, due to their persistent characteristics (de Wit, 2002), flame retardant exposure is still common in childcare facilities. Furthermore, many childcare providers continue to use and purchase products containing flame retardants and other toxic chemicals (Stubbings et al., 2018). A California study demonstrated that 51 percent of the 40 childcare facilities examined in the state exceeded the "no significant risk" level for flame retardant concentrations in indoor air (Bradman et al., 2014). High concentrations of flame retardants are found in polyurethane foam products common in childcare settings, including nap mats or changing pads, produced prior to 2015. A 2011 study by Stapleton and colleagues found flame retardants present in 80 of 101 baby products tested (Stapleton et al., 2011). Studies have also shown a strong association between children's exposure to flame retardants and dust present in indoor environments (Stapleton, Eagle, Sjödin, & Webster, 2012; Stapleton, Misenheimer, Hoffman, & Webster, 2014).

Reducing childhood exposure to harmful chemicals should involve a targeted effort directed at childcare providers. Childcare workers directly observe many behaviors that make children more vulnerable to environmental toxins, including hand-to-mouth transfers and spending time on the floor. However, because research suggests the average American adult has a very limited understanding of

environmental risks (Cranor, 2017), childcare workers may not perceive these actions as opportunities for exposure to harmful chemicals. Additionally, few studies have directly examined the link between exposure and health outcomes in children (Sugeng, de Cock, Schoonmade, & van de Bor, 2017).

In this study, we sought to identify predictors of childcare providers' knowledge, attitudes, and behaviors surrounding exposure to flame retardants and other toxic chemicals in their facilities. Childcare providers may exhibit similar behaviors to the general public when evaluating risk. It is known that people tend to overvalue their own abilities, even in areas of which they have little direct knowledge (Dunning, 2011). As a result, they are likely to use sensory information, such as something they can see or feel, to determine what they deem safe versus unsafe. This may lead to risk perceptions that are not based on scientific evidence (Brown, 2014), and childcare providers may not always make appropriate choices that minimize exposure to toxic chemicals for the children in their care (Kraus, Malmfors, & Slovic, 1992). Furthermore, childcare providers may not have any environmental science education beyond high school, since many have not completed an undergraduate degree (Phillips, Austin, & Whitebook, 2016). Additionally, Head Start classroom teachers have indicated their self-efficacy is highest for teaching basic literacy skills and significantly lower for science. In part because providers report lacking adequate self-confidence as science educators, childcare workers tutor students in language learning far more often than science (Gerde, Pierce, Lee, & Van Egeren, 2018).

In order to design an intervention that will promote healthier decisions and behaviors by childcare providers, it is important to determine if childcare providers' perceptions of risk of chemical exposure stems from their perceived knowledge of environmental health. If so, do they feel adequately informed to change their behavior (Ferrer & Klein, 2015)? Risk perception includes both worry about chemical exposure (does the provider feel the children in their facility will be exposed to toxic chemicals?) and perceived severity (does the provider believe chemical exposure causes real harm?). Meta-analysis demonstrates that interventions targeting *affective* risk perceptions, such as increasing worry, can be effective at producing preventative behavioral change (Ferrer & Klein, 2015; Hay, McCaul, & Magnan, 2006). However, according to fear appeal theory, just increasing worry may not be enough; increasing perceived behavioral control is also necessary for behavior change (Witte & Allen, 2000). If an intervention is successful at increasing both individuals' risk perception and their perceived behavioral control, those individuals' intentions to change their behavior and their subsequent positive health actions should also increase (Sheeran, Harris, & Epton, 2014).

We surveyed childcare providers to assess their risk perception of toxic chemicals in their facilities to understand whether concerns about exposure to chemicals influenced their purchasing of safer products and taking actions to reduce children's exposure to chemicals. We wanted to understand 1) Do childcare providers feel knowledgeable enough about environmental health issues to make healthy product purchasing decisions? 2) Given the opportunity, would a childcare provider be willing to participate in a program to improve the environmental health of their

facility? The key factors behind these questions are whether providers feel they have behavioral control over their product purchasing decisions and whether they have the behavioral intention to remove toxic chemicals from their facilities.

Methods

Survey Development and Distribution

We distributed an online survey to 4,796 Massachusetts childcare providers whose email addresses were provided by the Massachusetts Department of Early Education and Care. The email list was originally developed for the Market Rate Assessment Survey (Branscome, Giapponi, Cohen, & Corso, 2011). This Market Rate Assessment Survey estimated there were 11,428 childcare facilities in MA; thus, we estimate that our survey was distributed to approximately 42 percent of childcare facilities operating in Massachusetts. Facilities within the survey included those with infants through preschool classes, with approximate age ranges from 6 weeks to 5 years old. Responses were collected over a six-week period between late February and early March 2016.[1]

Research Subjects and Data Quality

We received 753 survey responses; 638 of these were fully completed for a completion rate of 86 percent. Overall response rate was 13.3 percent of the 4,796 solicitations. Approximately half of respondents were home-based care providers (53.9 percent) and cared for less than 10 children (43.8 percent). The survey respondents represent a fairly even distribution of geographic locations across Massachusetts with no region representing more than 18.5 percent and no region representing less than 6.4 percent. Table 1 depicts the demographics of the survey respondents.

Table 1. Characteristics of participating childcare facilities

Type of Childcare Facility	Frequency (N = 747)	Percent (%)
Family Care (home-based)	403	53.9
Group Care (center-based)	318	42.6
Missing	26	3.5
Number of Children		
< 10	327	43.8
10-25	101	13.5
25-50	120	16.1
50-100	98	13.1
>100	60	8
Missing	41	5.5

[1] The University's Institutional Review Board approved study materials and procedures. A full copy of the survey emailed to providers and the complete data set are available at doi:10.13140/RG.2.2.23033.70242

Measures

Perceived Environmental Health

To measure participants' perceived knowledge of environmental health, we asked providers to "Classify [their] knowledge of environmental health issues (such as climate change, exposure to chemical hazards, blood lead levels, etc...)" and "how [they would] describe the environmental health of [their] childcare facility." Response options were: excellent, good, average, fair, and poor.

Risk Perception

A series of questions assessed the degree to which providers worried children were at risk from chemicals in consumer products while in their care. We asked, "How much do you worry about chemicals in childcare items such as highchairs, children's furniture, changing pads, crib mattresses, etc... harming children in your facility?" Response options were: never, hardly ever, occasionally, frequently, and almost always. To further investigate levels of worry about chemicals, we asked providers how concerned they were about six different sets of chemicals in their facilities: parabens, flame retardants, bisphenol-A, formaldehyde, cleaning products, and phthalates. Response options were: chemicals unknown to me, not at all, a little, some, and a lot. Next, we assessed providers' perceptions of the severity of the harm to children's health caused by chemical exposures by asking how much they agreed or disagreed that exposure to certain chemicals could cause: 1. Behavior problems in children, 2. Disruption of endocrine (hormone) function in children, and 3. Cancer in later life. Response options were: strongly disagree, disagree, no opinion/uncertain, agree, and strongly agree. The risk perception questions were modelled after the environmental risk questions used for the second cycle of the fourth administration of the Health Information Trends Survey (HINTS 4 Cycle 2; https://hints.cancer.gov) (Nelson et al., 2004), but adapted for the context of childcare facilities.

Behavioral Control

The behavioral control measure defined the degree to which a provider felt they had sufficient knowledge to inform their purchasing behaviors. Providers were asked, "Do you consider yourself informed enough to make purchasing decisions for healthier and safer products for your facility?" Response options (very informed, usually informed, can't self-assess, somewhat informed, not adequately informed) were recorded, then dichotomized for further analysis as very informed/usually informed and can't self-assess/somewhat informed/not adequately informed.

Behavioral Intention

We measured behavioral intention by asking providers how likely they would be to participate in a project to make their childcare facility healthier and to learn about safer replacements for items containing toxic chemicals. Response options included: extremely unlikely, unlikely, neutral/undecided, likely, extremely likely. Responses were dichotomized as extremely likely/likely and extremely unlikely/unlikely/neutral/undecided for further analysis.

Purchasing Barriers
All providers were asked "What is the biggest barrier for you to purchase safer alternative products for your facility?" Response options included: price, time, lack of knowledge, lack of availability of safer products, and other.

Childcare Facility Characteristics
Providers also reported facility type (family vs. center-based care), number of children at the facility, and geographical area. After pilot discussions with childcare providers who were concerned about confidentiality, no additional demographic information was collected.

Data Analysis
We calculated bivariate (Pearson) correlation coefficients between all variables. Multivariable binary logistic regression models, with variables of perceived knowledge, self-reported facility environmental health, exposure worry, harm severity, and facility type, were used to predict behavioral control and behavior intention of the providers.

Results

Environmental Health Knowledge and Worry
Providers reported high levels of environmental health in their facilities with roughly 74 percent ranking their facility as being in excellent (24.1 percent) or good (50.5 percent) condition. The childcare providers ranked their own environmental health knowledge slightly worse, with over 75 percent reporting having an average (40.5 percent) to good (35.6 percent) understanding of environmental health issues (Table 2). Less than 2 percent of respondents reported having inadequate knowledge or poor environmental health in their facilities.

In general, childcare providers reported low levels of worry about potential chemical exposure in their facility from childcare items such as highchairs, furniture, changing pads, and mattresses; nearly 90 percent expressed never (37.6 percent), hardly ever (31.5 percent), or occasionally (19.9 percent) worrying about chemicals in children's products (Table 2). Only 11 percent of childcare providers frequently or almost always worried about chemicals in childcare products.

Providers' level of worry about specific chemicals/chemical groups was similarly low and exhibited strong internal consistency (Cronbach's alpha of 0.899) across chemicals. Parabens and flame retardants invoked the least amount of concern, as 58.35 percent and 62.19 percent of respondents were either unaware of or had no concerns about them, respectively. Chemicals in cleaning products, Bisphenol-A (BPA), and phthalates had the highest levels of concern among providers with 30.1 percent, 26.3 percent, and 26.2 percent reporting either a lot or some concern, respectively. BPA was the chemical that had the highest level of awareness with only 3.2 percent of providers responding they were unaware of the chemical.[2]

---

[2] All data is available at doi:10.13140/RG.2.2.23033.70242

Table 2. Survey outcomes

Facility Environmental Health	Responses (N = 691)	Percent (%)
Excellent	180	24.1
Good	377	50.5
Average	112	15.0
Fair	16	2.1
Poor	3	0.4
Perceived Environmental Health Knowledge	Responses (N = 699)	Percent (%)
Excellent	78	11.16
Good	251	35.91
Average	282	40.34
Fair	77	11.02
Poor	11	1.57
Product Worry	Responses (N = 640)	Percent (%)
Never	219	34.2
Hardly ever	208	32.5
Occasionally	135	21.1
Frequently	48	7.5
Almost always	30	4.7
Behavioral Control Over Purchasing	Responses (N = 631)	Percent (%)
Yes – very informed	146	23.1
Usually informed	273	43.3
Can't self-assess	57	9.0
Somewhat informed	119	18.9
No – not adequately informed	36	5.7
Behavioral Intention to Participate	Responses (N = 628)	Percent (%)
Extremely unlikely	19	3.0
Unlikely	40	6.4
Neutral / undecided	208	33.1
Likely	233	37.1
Extremely likely	128	20.4

Perceived Severity of Harm from Exposure to Chemicals

Despite low levels of worry about chemicals, the vast majority of providers agree or strongly agree that exposure to chemicals can lead to negative health outcomes (Table 3). Most providers agreed or strongly agreed that exposure to chemicals as a child could cause behavior issues (62 percent), endocrine disruption (55 percent), and cancer later in life (69 percent). Provider responses were internally consistent (Cronbach's alpha = 0.799) across the three exposure outcomes.

Table 3. Providers' perception of the severity of harm caused by exposure to certain chemicals

Responses	Exposure to certain chemicals can….		
	cause behavior problems in children (N = 642)	disrupt endocrine function in children (N = 636)	lead to cancer later in life (N = 629)
Strongly Agree (%)	21.65	17.92	23.69
Agree (%)	39.72	36.95	45.47
No Opinion/Uncertain (%)	34.11	41.82	28.78
Disagree (%)	2.49	2.36	0.95
Strongly Disagree (%)	2.02	0.94	1.11

Behavioral Control and Intention

Childcare providers generally felt very informed (23.1 percent) or usually informed (43.3 percent) about the purchase of safer products in their facilities (Table 2). Only 5.7 percent felt they were not adequately knowledgeable about purchasing safer products. Providers also expressed high levels of behavioral intention as they reported being extremely likely (20.4 percent) or likely (37.1 percent) to participate in a program to learn about safer replacements for items containing toxic chemicals. Only 9.4 percent of the childcare providers surveyed said they would be unlikely or extremely unlikely to participate in such a program.

Predictors of Behavioral Control over Purchasing and Intention to Purchase Safer Products

Environmental health knowledge, facility environmental health, product worry, and perceived severity of harm were all significant predictors of behavioral control over purchasing. Facility type was not predictive of behavioral control. Table 4 presents a summary of the model's results.

Table 4. Multivariable binary logistic regression models results

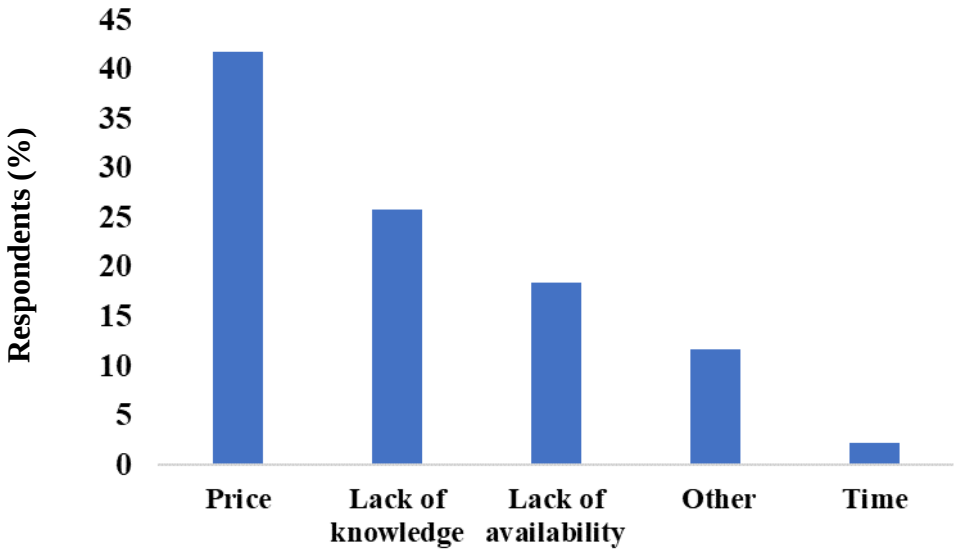
Variables in Behavior Models	Behavioral Control over Purchasing			Behavioral Intention to Participate		
	B	Exp(B)	P	B	Exp(B)	p
Family vs Center-based Care	-0.255	0.775	0.180	0.084	1.087	0.627
Facility Environmental Health	0.648	1.912	0.000	-0.023	0.977	0.853
Perceived Environmental Health Knowledge	0.577	1.781	0.000	0.011	1.011	0.915
Product Worry	-0.183	0.833	0.039	0.104	1.110	0.196
Harm Severity	0.384	1.468	0.007	0.625	1.868	0.000
Behavioral Control over Purchasing	--	--	--	0.086	1.090	0.650

Perceived severity of harm due to chemical exposure was the only predictor of intention to participate in a program to improve childcare facility environmental health. Facility type, environmental health knowledge, facility environmental health, product worry, and behavioral control were not predictive of behavioral intention.

Barriers

Price was viewed as a barrier to purchasing safer products by 42 percent of responding childcare providers (Figure 1). Lack of knowledge and the unavailability of safer products were also reported as barriers by more than 20 percent of respondents. Several childcare providers who selected "Other" as a barrier noted that current Massachusetts early education and care regulations restricted their purchasing behavior, particularly around the directed use of bleach for sanitation.

Figure 1. Barriers to purchasing safer alternative products



Discussion

Understanding the predictive factors of childcare providers' purchasing decisions is an important first step in efforts to decrease exposure to toxic chemicals in young children. Results of this survey of Massachusetts childcare providers suggest that their belief that chemical exposure can lead to harmful health outcomes in children predicts childcare providers' intention to take action towards purchasing safer products for their childcare facilities. Targeting affective risk perceptions thus can lead to changes in health-related behaviors (Hay et al., 2006; Sheeran et al., 2014). Learning more about potential chemical exposures in their own classrooms might turn childcare providers into advocates for improving the physical environment of childcare settings. Many states in the U.S. have begun to embrace the goal of transforming early childhood workforce training and qualifications, even if opportunities for advancing skills and knowledge are still limited (Whitebook, McLean, & Austin, 2016). The type of educational intervention we envision could include customized professional development training in applied environmental science.

Our findings demonstrate that worry about exposure from products in their facility was not a significant predictor of childcare providers' behavioral intentions. However, it is not surprising that some providers still have lingering concerns about the endocrine disruptor BPA. A decade ago, children's products containing BPA emerged as and continue to be a major media topic (Brewer Wise, & Ley, 2013; Mello, 2013). Studies have shown that if a topic can be readily recalled in a person's mind, then they assume it must be important (Gilovich, Griffin, & Kahneman, 2002). Experienced childcare providers are likely to recall the news that the United States Food and Drug Administration banned BPA in baby bottles and sippy cups in 2012 and in infant formula containers the next year. What many in the general public do not realize, however, is that BPA is often replaced with less-studied and potentially more toxic chemicals, such as 4,4'-Sulfonyldiphenol, commonly known as BPS. These "regrettable substitutions" are also common in the flame-retardant industry. Research has shown that people are not fully rational in their product purchasing behavior and are influenced by irrelevant factors such as product labelling (Scherer, Maynard, Dolinoy, Fagerlin, Zikmund-Fisher, 2014). This could lead to childcare providers believing that products labelled as BPA-free or as compliant with flame retardant standards are safer choices, when in fact this may not be true.

Nearly 70 percent of providers in our study reported that they do not ever or hardly ever worry about chemical exposure from products in their facilities. This is comparable to nationally representative U.S. data from the 2004 HINTS 4 Cycle 2 Survey which estimated that only 13.4 percent of the U.S. adult population worried a lot about the harmful health effects of chemicals in household items (Nelson et al., 2004). Similarly, childcare providers' low levels of worry over chemicals like flame retardants may indicate that they do not fully understand exposure probability and therefore overall exposure risk. Childcare providers may be unaware that products in their facilities contain harmful chemicals or may lack an understanding of potential toxicity. The low levels of worry also suggest that childcare providers may be overestimating their own environmental health knowledge. Only 2 percent claim to have poor environmental health knowledge, but 10 percent report being unaware of flame retardants. Additionally, if as a peer group, childcare providers do not feel concerned about chemicals or do not experience pressure from a social normative perspective, they may not feel the need to change. Previous analysis of mothers' behaviors have shown that perceived norms are highly correlated with exposure reduction behaviors (Mello & Hovick, 2016).

Despite growing news coverage of the negative health impacts of chemicals like flame retardants (Callahan, Roe & Chicago Tribune Reporters, 2012; Shemkus, 2017), there are not many specific guidelines and regulations available for childcare providers. For example, current Massachusetts Department of Early Education and Care regulations (606 CMR 7.00) on the safety requirements for equipment, materials, and furnishings contains ambiguous language, merely stating items must be flame retardant; it does not note if the standard may be met without flame retardant chemicals (State of Massachusetts, n.d.). Moreover, the prevailing

nationwide flame retardant standard, California's TB-113-2017, exempts many childcare items, including nap mats, changing pads, and play yards from the flame retardant standard all together (Bureau of Electronic and Appliance Repair, 2013). The lack of clear and accessible information from Massachusetts regulations likely lead to confusion.

Our survey results suggest that respondents' perception of the severity of the harm from exposure rather than worry about the likelihood of exposure, may be driving childcare providers' behavior, and impacting their motivation to change it. That is, childcare providers may not fully appreciate the exposure potential associated with chemicals in their facility, or their concept of risk is not motivating them to take action due to several potential barriers. These findings are consistent with other studies examining risk avoidance, and follows a trend known as the "risk perception paradox," which describes inconsistencies between risk perception and risk-avoidant actions (Wachinger, Renn, Begg, & Kuhlicke, 2013).

Our reasoning is in line with Wachinger and colleagues' (2013) reasons why an individual's comprehension of risk does not always lead to appropriate risk-avoidance behaviors: 1) providers may not believe harmful chemicals exist in their childcare products, and therefore perceive no risk from their use; 2) they may not feel purchasing alternative products will lower their risk; or 3) they may feel powerless to change their facilities due to additional factors, such as cost or regulations.

In our survey, childcare providers overwhelmingly expressed an understanding of the severity of harm to children due to exposure to toxic chemicals. They also generally expressed an interest in learning more about how they can shift their purchasing habits to safer products. Given these positive indicators, providers are likely to overcome the risk perception paradox when exposed to an appropriately designed intervention.

Interventions should be specifically designed for two groups of providers: those already willing to take action and those that are initially more hesitant. For the more hesitant group, interventions should be directed specifically toward education about the potential severity of the harm that toxic chemicals pose to children. If behaviors remain consistent with our results, this should motivate more of these providers to action.

For those already willing to act, interventions should focus on raising awareness to the presence of chemicals in childcare facilities and on overcoming potential barriers to purchasing safer alternatives. There is evidence that collaborative campaigns between scientists and citizens are effective in the push for more stringent chemical regulations (Lubitow, 2013; Mello, Bigman, Sanders-Jackson, & Tan, 2016). These educational interventions could present simplified results of the many peer-reviewed studies that identify chemicals in childcare products, while also highlighting known cost-effective, safer alternative products that are currently available in the marketplace.

The providers who purchase on behalf of the childcare facilities must trust the science that identifies the environmental problems and the claims made by the manufacturers. Professional development interventions in this area would do well to target those who may be overwhelmed trying to understand complex information about what is truly a better product (MacDonald & She, 2015). Simply giving providers a list of products to mitigate chemical exposure will not be enough, nor will a simple fear campaign on the dangers of chemical exposure (Witte & Allen, 2000). The goal of any professional development intervention would be to assist childcare providers in devising a comprehensive and actionable strategy that integrates preventive measures and addresses environmental health issues. Furthermore, since providers feel adequately informed to make purchasing decisions, interventions that highlight low-cost products free of harmful chemicals as examples may provide the greatest impact.

Conclusions

Childcare providers in Massachusetts exhibit a risk perception paradox about chemical exposures in their facilities; although they are largely aware of the health risks associated with chemical exposure, very few report high levels of worry about children's exposure to chemicals in their childcare facility. Although childcare providers' perceptions of the severity of harm from chemicals predicted their intention to participate in a risk-reduction program, worry about exposure to chemicals did not. There may be some advantages to our findings. Scholars interested in environmental education have cautioned that being overwhelmed by complexity creates too much anxiety, thereby resulting in problems in making decisions about environmental risks. Any intervention designed to raise awareness in childcare providers will need to be sensitive to this defined ability to process information (Kaplan, 2000).

Because the educational attainment of the childcare workforce may not be higher than the average American, programs for professional development need to be innovative (Gomez, Kagan, & Fox, 2015). Pre-service and in-service professional development programs should provide childcare workers with both content and practice in environmental science (Powell, Diamond, Bojczyk, & Gerde , 2008). Additionally, there should be a thoughtful plan regarding the balance of emotional and logical appeals presented to inspire behavior change (Slovic, Finucane, Peters, & MacGregor, 2004).

Recent results show that interventions targeting the replacement of products that contain toxic chemicals like flame retardants can be successful at lowering children's exposure to those chemicals in childcare settings (Stubbings et al., 2018). Since providers already feel adequately informed to make purchasing decisions, interventions that raise awareness through environmental education and highlight solutions that overcome the cost barrier are likely to provide the highest benefit.

Study Limitations and Future Research

This study was influenced by demographic constraints, due to a regional focus on childcare facilities in Massachusetts. We also acknowledge a selection bias towards

childcare providers that utilize electronic mail. Respondents were overly representative of childcare providers in western Massachusetts (18.5 percent of respondents) compared to the Boston area (6.7 percent of respondents) which may mean this data is more generalizable to childcare providers in more rural and less populated regions. Additionally, the survey design was constrained by an effort to preserve providers' privacy; therefore, we were unable to follow-up with respondents and were unable to collect more demographic details.

Additionally, perceptual and behavioral constructs were measured with single items and may not align with the conceptualization of these variables in various behavior change theories. For example, perceived behavioral control was operationalized in this study as feeling adequately informed to make good purchasing behaviors. We also modelled predictors of perceived behavioral control separately because we were interested in what may influence providers feeling sufficiently knowledgeable. However, in most behavior change theories, perceived behavioral control is modelled as a predictor of intention. We look to expand future studies to a broader, more nationally representative demographic, assess perceptions and behaviors in a more theoretically rigorous way, and to evaluate long-term health and economic outcomes of the behavioral interventions suggested here. For example, an examination of childcare providers' actual knowledge of environmental health issues would build on this research and identify correlations that exist between a provider's actual versus perceived knowledge.

Acknowledgements

This work was funded by the Massachusetts Toxic Use Reduction Agency (Lowell, MA) Community Grants program, Bentley University Summer Research Grant Program, and the Department of Natural and Applied Sciences at Bentley University.

***Ryan M. Bouldin**, Ph.D. is an associate professor of Sustainable Chemistry and Associate Director of the Honors Program at Bentley University. He holds a Ph.D. in Chemical Engineering from the University of Massachusetts Lowell. His research emphasizes the use of Green Chemistry for the development of advanced materials, sustainable polymers, and safer products. He serves as the Chair of the Board of Directors for the Environmental Health Strategy Center in Portland, Maine.*

***Helen Meldrum**, EdD, educator and consultant, is an Associate Professor of Psychology at Bentley University in Waltham, Massachusetts. Prior to joining the Bentley faculty, she was an Associate Professor of Psychology and Communication at the Massachusetts College of Pharmacy and Health Sciences. Helen has also taught in graduate programs at Babson College, the University of Rhode Island and Northeastern University. Her areas of expertise include: interpersonal and group dynamics, psychology of adulthood, mental health services, and communicating about sensitive issues. Professor Meldrum has a particular strength in teaching "teaching skills," having facilitated many professional train-the-trainer programs in the U.S., Canada, Europe and Israel.*

***Danielle Blanch-Hartigan**, Ph.D., MPH is Associate Professor of Health Studies in the Department of Natural and Applied Sciences and Director of the Health Thought Leadership Network at Bentley University in Waltham, MA. She holds a Ph.D. in Psychology from Northeastern University and an MPH from Harvard TH Chan School of Public Health. She completed postdoctoral training as a Cancer Prevention Fellow in the Behavioral Research Program and Office of Cancer Survivorship at the National Cancer Institute. Her interdisciplinary research in psychology and public health aims to improve the patient experience and foster patient-centered care through better communication.*

***Jordan McCormick**, MPH is Planning Chief for the New Hampshire Department of Health and Human Services. She holds degrees from the University of California, Berkeley and Boston College.*

***Vanesa Coloma** is an Operations Associate at BlueWave Solar in Boston, MA. She is a graduate of Bentley University with a Bachelor of Science in Corporate Finance and Accounting and a minor in Earth, Environment, and Global Sustainability.*

References

Bennett, D., Bellinger, D. C., Birnbaum, L. S., Bradman, A., Chen, A., Cory-Slechta, D. A., . . . Witherspoon, N. O. (2016). Project TENDR: Targeting environmental neuro-developmental risks—The TENDR Consensus Statement. *Environmental Health Perspectives, 124*(7), A118-122. https://doi.org/10.1289/EHP358

Bradman, A., Castorina, R., Gaspar, F., Nishioka, M., Colon, M., Weathers, W., . . . McKone, T. E. (2014). Flame retardant exposures in California early childhood education environments. *Chemosphere, 116*, 61-66. https://doi.org/10.1016/j.chemosphere.2014.02.072

Branscome, K., Giapponi, K., Cohen, E., & Corso, C. (2011). *Massachusetts child care market price survey*. http://machildcareresourcesonline.org/wp-content/uploads/2011/06/Massachusetts-Market-Price-Survey-Final-for-Release.pdf

Brewer, P. R., Wise, D., & Ley, B. L. (2013). Chemical controversy: Canadian and US news coverage of the scientific debate about Bisphenol A. *Environmental Communication, 8*, 21-38. https://doi.org/10.1080/17524032.2013.797918

Brown, V. J. (2014). Risk perception: It's personal. *Environmental Health Perspectives, 122*(10), A276-279. https://doi.org/10.1289/ehp.122-A276

Bureau of Electronic and Appliance Repair, Home Furnishings and Thermal Insulation (2013). *Technical bulletin 117-2013: Requirements, test procedure and apparatus for testing the smolder resistance of materials used*

in upholstered furniture. State of California Department of Consumer Affairs. Retrieved from https://bhgs.dca.ca.gov/about_us/tb117_2013.pdf

Butt, C. M., Hoffman, K., Chen, A., Lorenzo, A., Congleton, J., & Stapleton, H. M. (2016). Regional comparison of organophosphate flame retardant (PFR) urinary metabolites and tetrabromobenzoic acid (TBBA) in mother-toddler pairs from California and New Jersey. *Environment International, 94*, 627-634. https://doi.org/10.1016/j.envint.2016.06.029

Callahan, P., Roe, S., & Chicago Tribune Reporters (2012). Tribune watchdog: Playing with fire. *Chicago Tribune*. Retrieved from http://media.apps.chicagotribune.com/flames/index.html

Cranor, C. F. (2017). *Tragic failures: How and why we are harmed by toxic chemicals*. New York: Oxford University Press.

de Wit, C. A. (2002). An overview of brominated flame retardants in the environment. *Chemosphere, 46*(5), 583-624. https://doi.org/10.1016/S0045-6535(01)00225-9

Dunning, D. (2011). The Dunning–Kruger effect: On remaining ignorant of one's own ignorance. In J. M. Olson & M. P. Zanna (Eds.), *Advances in Experimental Social Psychology* (Vol. 44, pp. 247-296). Academic Press.

Eskenazi, B., Chevrier, J., Rauch, S. A., Kogut, K., Harley, K. G., Johnson, C., . . . Bradman, A. (2013). In utero and childhood polybrominated diphenyl ether (PBDE) exposures and neurodevelopment in the CHAMACOS study. *Environmental Health Perspectives, 121*(2), 257-262. https://doi.org/10.1289/ehp.1205597

Ferrer, R. A., & Klein, W. M. P. (2015). Risk perceptions and health behavior. *Current Opinion in Psychology, 5*, 85-89. http://dx.doi.org/10.1016/j.copsyc.2015.03.012

Gerde, H. K., Pierce, S. J., Lee, K. & Van Egeren, L. A. (2018). Early childhood educators' self-efficacy in science, math, and literacy instruction and science practice in the classroom. *Early Education and Development, 29*(1), 70-90. https://doi.org/10.1080/10409289.2017.1360127

Gilovich, T. D., Griffin, D., & Kahneman, D. (2002). *Heuristics and biases: The psychology of intuitive judgment*. New York: Cambridge University Press.

Gomez, R. E., Kagan, S. L., & Fox, E. A. (2015). Professional development of the early childhood education teaching workforce in the United States: An overview. *Professional Development in Education, 41*(2), 169-186. https://doi.org/10.1080/19415257.2014.986820

Guvenius, D. M., Aronsson, A., Ekman-Ordeberg, G., Bergman, A., & Norén, K. (2003). Human prenatal and postnatal exposure to polybrominated diphenyl ethers, polychlorinated biphenyls, polychlorobiphenylols, and pentachlorophenol. *Environmental Health Perspectives, 111*(9), 1235-1241. https://doi.org/10.1289/ehp.5946

Hay, J. L., McCaul, K. D., & Magnan, R. E. (2006). Does worry about breast cancer predict screening behaviors? A meta-analysis of the prospective evidence. *Preventive Medicine, 42*(6), 401-408. http://dx.doi.org/10.1016/j.ypmed.2006.03.002

Hoffman, K., Webster, T. F., Sjodin, A., & Stapleton, H. M. (2017). Toddler's behavior and its impacts on exposure to polybrominated diphenyl ethers. *Journal of Exposure Science & Environmental Epidemiology, 27*(2), 193-197. https://doi.org/10.1038/jes.2016.11

Kaplan, S. (2000). New ways to promote proenvironmental behavior: Human nature and environmentally responsible behavior. *Journal of Social Issues, 56*(3), 491-508. https://doi.org/10.1111/0022-4537.00180

Kraus, N., Malmfors, T., & Slovic, P. (1992). Intuitive toxicology: Expert and lay judgments of chemical risks. *Risk Analysis, 12*(2), 215-232. https://doi.org/10.1111/j.1539-6924.1992.tb00669.x

Lubitow, A. (2013). Collaborative frame construction in social movement campaigns: Bisphenol-A (BPA) and scientist–activist mobilization. *Social Movement Studies, 12*(4), 429-447. https://doi.org/10.1111/j.1539-6924.1992.tb00669.x

MacDonald, E. F., & She, J. (2015). Seven cognitive concepts for successful eco-design. *Journal of Cleaner Production, 92*, 23-36. https://doi.org/10.1016/j.jclepro.2014.12.096

McFarland, J., Hussar, B., Zhang, J., Wang, X., Wang, K., Hein, S., . . . Barmer, A. (2019). *The condition of education 2019*. NCES 2019-144. National Center for Education Statistics.

Mello, S. L. (2013) *Toxic? The nature and effects of mothers' exposure to pediatric environmental health information in the media*. (Doctoral dissertation). Retrieved from https://repository.upenn.edu/edissertations/779/

Mello, S., Bigman, C. A., Sanders-Jackson, A., & Tan, A. S. (2016). Perceived harm of secondhand electronic cigarette vapors and policy support to restrict public vaping: Results from a national survey of US adults. *Nicotine & Tobacco Research, 18*(5), 686-693. https://doi.org/10.1093/ntr/ntv232

Mello, S., & Hovick, S. R. (2016). Predicting behaviors to reduce toxic chemical exposures among new and expectant mothers: The role of distal variables

within the integrative model of behavioral prediction. *Health Education & Behavior, 43*(6), 705-715. https://doi.org/10.1177%2F1090198116637600

National Research Council (2000). *Toxicological risks of selected flame-retardant chemicals*. Washington, D.C.: The National Academies Press.

Nelson, D., Kreps, G., Hesse, B., Croyle, R., Willis, G., Arora, N., . . . Alden, S. (2004). The Health Information National Trends Survey (HINTS): Development, design, and dissemination. *Journal of Health Communication, 9*(5), 443-460. https://doi.org/10.1080/10810730490504233

Phillips, D., Austin, L. J. E., & Whitebook, M. (2016). The early care and education workforce. *The Future of Children, 26*(2), 139-158. https://doi.org/10.1353/foc.2016.0016

Powell, D. R., Diamond, K. E., Bojczyk, K. E., & Gerde, H. K. (2008). Head Start teachers' perspectives on early literacy. *Journal of Literacy Research, 40*(4), 422-460. https://doi.org/10.1080%2F10862960802637612

Scherer, L. D., Maynard, A., Dolinoy, D. C., Fagerlin, A., & Zikmund-Fisher, B. J. (2014). The psychology of "regrettable substitutions": Examining consumer judgements of Bisphenol A and its alternatives. *Health, Risk & Society, 16*(7-8), 649-666. https://doi.org/10.1080/13698575.2014.969687

Sheeran, P., Harris, P. R., & Epton, T. (2014). Does heightening risk appraisals change people's intentions and behavior? A meta-analysis of experimental studies. *Psychological Bulletin, 140*(2), 511-543. https://psycnet.apa.org/doi/10.1037/a0033065

Shemkus, S. (2017, October, 4). Flame retardants could be hazardous to your health. *Boston Globe*. Retrieved from https://www.bostonglobe.com/business/2017/10/04/flame-retardants-could-hazardous-your-health/VNFlCouUtsDRN4SJEYpdxL/story.html

Slovic, P., Finucane, M. L., Peters, E., & MacGregor, D. G. (2004). Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk, and rationality. *Risk Analysis, 24*(2), 311-322. https://doi.org/10.1111/j.0272-4332.2004.00433.x

Snyder, T. D., De Brey, C., & Dillow, S. A. (2019). *Digest of education statistics 2017*. NCES 2018-070. National Center for Education Statistics.

Stapleton, H. M., Eagle, S., Sjödin, A., & Webster, T. F. (2012). Serum PBDEs in a North Carolina toddler cohort: Associations with handwipes, house dust, and socioeconomic variables. *Environmental Health Perspectives, 120*(7), 1049-1054. https://doi.org/10.1289/ehp.1408522

Stapleton, H. M., Klosterhaus, S., Keller, A., Ferguson, P. L., van Bergen, S., Cooper, E., . . . Blum, A. (2011). Identification of flame retardants in polyurethane foam collected from baby products. *Environmental Science & Technology, 45*(12), 5323-5331. https://doi.org/10.1021/es2007462

Stapleton, H. M., Misenheimer, J., Hoffman, K., & Webster, T. F. (2014). Flame retardant associations between children's handwipes and house dust. *Chemosphere, 116*, 54-60. https://doi.org/10.1016/j.chemosphere.2013.12.100

State of Massachusetts (n.d.). *606 CMR 7.00: Standards for the licensure or approval of family child care; small group and school age and large group and school age child care programs*. Retrieved from https://www.mass.gov/files/documents/2017/10/17/606cmr7.pdf

Stubbings, W. A., Schreder, E. D., Thomas, M. B., Romanak, K., Venier, M., & Salamova, A. (2018). Exposure to brominated and organophosphate ester flame retardants in U.S. childcare environments: Effect of removal of flame-retarded nap mats on indoor levels. *Environmental Pollution, 238*, 1056-1068. https://doi.org/10.1016/j.envpol.2018.03.083

Sugeng, E. J., de Cock, M., Schoonmade, L. J., & van de Bor, M. (2017). Toddler exposure to flame retardant chemicals: Magnitude, health concern and potential risk- or protective factors of exposure: Observational studies summarized in a systematic review. *Chemosphere, 184*, 820-831. https://doi.org/10.1016/j.chemosphere.2017.06.041

Toms, L.-M. L., Sjödin, A., Harden, F., Hobson, P., Jones, R., Edenfield, E., & Mueller, J. F. (2009). Serum Polybrominated Diphenyl Ether (PBDE) levels are higher in children (2–5 years of age) than in infants and adults. *Environmental Health Perspectives, 117*(9), 1461-1465. https://doi.org/10.1289/ehp.0900596

Wachinger, G., Renn, O., Begg, C., & Kuhlicke, C. (2013). The risk perception paradox—Implications for governance and communication of natural hazards. *Risk Analysis, 33*(6), 1049-1065. doi:10.1111/j.1539-6924.2012.01942.x

Whitebook, M., McLean, C., & Austin, L. J. E. (2016). *The early childhood workforce index 2016*. Berkeley, CA: Center for the Study of Child Care Employment. Retrieved from http://cscce.berkeley.edu/early-childhood-workforce-index/

Witte, K., & Allen, M. (2000). A meta-analysis of fear appeals: Implications for effective public health campaigns. *Health Education & Behavior, 27*(5), 591–615. https://doi.org/10.1177/109019810002700506