THE IMPACT OF TOXIC CHEMICALS ON NEURODEVELOPMENT: A TURN TOWARDS PREVENTION

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Abstract

Exposure to toxic chemicals can adversely impact children's neurodevelopment. Yet, remarkably few resources are dedicated to preventing these adverse effects. We developed a developmental neurotoxicological knowledge translation (KT) tool, the *PRevention of Toxic Chemicals in the Environment for Children Tool* (*PRoTECT*), and evaluated the efficacy of a KT video, *Little Things Matter: The Impact of Toxins on the Developing Brain*.

In study one, *PRoTECT* was refined via focus groups and implemented with 190 participants of childbearing age for development via exploratory factor analysis. We found evidence for a four-factor model, of which 16 of the 18 items had adequate loadings > 0.40 on a derived factor.

In study two, we evaluated responses of 15,594 international participants to validate *PRoTECT*'s conceptual dimensionality and general response patterns across various demographic characteristics. Seventeen items fit into a three-factor model with factors, or subscales, representing (1) preferences to lower exposure and increase prevention, (2) knowledge of the regulation of toxic chemicals by government and industry, and (3) knowledge of developmental neurotoxicology. Scores on subscales 1 and 3 tended to be higher among participants from India, participants with higher education, and parents and pregnant women, indicating stronger preferences to lower exposure and increase prevention and greater knowledge of developmental neurotoxicology, whereas scores on subscale 2 tended to be higher among participants from the United States, indicating less trust in government and industry.

In study three, a randomized controlled trial was conducted, whereby participants were assigned to either watch the KT video (experimental group) or serve in the control group. Scores on *PRoTECT* and other behavioural items were examined at baseline and six-week follow-up. At baseline, participants in the experimental group showed greater changes in scores on *PRoTECT* and a greater intent to reduce exposure than the control group, but the differences were much smaller at six-week follow up; no meaningful changes in behaviour were noted.

This dissertation addresses KT gaps in developmental neurotoxicology. While we wait for legislation to reduce exposure to toxic chemicals, we must find ways to effectively communicate these risks with the hope of advocating for stricter regulations.

Keywords: developmental neurotoxicology, brain development, prevention, scale development, knowledge translation

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List of Abbreviations

Abbreviation	Meaning
ACOG	American College of Obstetricians and Gynecologists
ADHD	Attention-Deficit/Hyperactivity Disorder
ASD	Autism Spectrum Disorder
AUD	Australian Dollar
BPA	Bisphenol A
CAD	Canadian Dollar
CBT	Cognitive Behavioural Therapy
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CNS	Central Nervous System
CO	Carbon Monoxide
COVID-19	Coronavirus Disease of 2019
CVI	Content Validity Index
EDC	Endocrine-Disrupting Chemical
EFA	Exploratory Factor Analysis
EHL	Environmental Health Literacy
FIGO	International Federation of Gynecology and Obstetrics
GBP	British Pound
HBBF	Healthy Babies Bright Futures
HCP	Health-Care Provider
IQ	Intelligence Quotient
KT	Knowledge Translation

LD	Learning Disability
LTM	Little Things Matter
NDD	Neurodevelopmental Disorder
OB/GYN	Obstetrician-Gynecologist
OPP	Organophosphate Pesticide
PBDE	Polybrominated Diphenyl Ether
PCB	Polychlorinated Biphenyl
PEHE	Prenatal Environmental Health Education
PEHSU	Pediatric Environmental Health Specialty Unit
PRoTECT	Prevention of Toxic Chemicals in the Environment for Children Tool
RCT	Randomized Controlled Trial
REB	Research Ethics Board
RMSEA	Root Mean Squared Error of Approximation
RMSR	Root Mean Squared Residual
RS	Indian Rupee
SD	Standard Deviation
SRMR	Standardized Root Mean Squared Residual
TENDR	Targeting Environmental Neuro-Developmental Risks
TLI	Tucker-Lewis Index
U.K.	United Kingdom
U.S.	United States
USD	United States Dollar
UNICEF	United Nations Children’s Fund

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Chapter 1: Introduction

Developing children are often more heavily exposed to toxic chemicals than adults (Lanphear, 2015). Pregnant women and young children are exposed to toxic chemicals in various ways, including inhalation of pollutants, personal-use products, and food and water consumption. Over a dozen industrial chemicals have been classified as developmental toxic chemicals, such as lead, mercury, polychlorinated biphenyls (PCBs), arsenic, solvents, and other pesticides (Grandjean & Landrigan, 2006). Project TENDR (Targeting Environmental Neuro-Developmental Risks) identified toxic chemicals that have been consistently shown through epidemiological and animal research to be associated with adverse neurodevelopmental outcomes. These include lead, mercury, pesticides, organophosphate pesticides (OPPs), air pollution chemicals, polybrominated diphenyl ethers (PBDEs), and PCBs (Bennett et al., 2016). Unfortunately, exposure to toxic chemicals does not occur in isolation; the fetus and developing child, especially those who live in industrial communities with heavy traffic, are exposed to toxic chemical cocktails, or a mixture of toxic chemicals.

Exposure to toxic chemicals may cause adverse effects in developing children, including physical abnormalities, such as low birthweight, as well as cognitive and behavioural dysfunctions, such as diminished intelligence quotient (IQ) and increased risk of neurodevelopmental disorders (Grandjean & Landrigan, 2014). The prenatal and early-life periods have been identified as being more vulnerable to the adverse consequences of toxic chemicals than other developmental periods (Lanphear, 2015; Rauh & Margolis, 2016). First, the fetus and young child are exposed to higher concentrations of toxic chemicals per pound of body weight compared to older children and adults. In addition to their faster metabolic rate, fetuses and young children experience rapid growth, especially in the central nervous system (CNS).

These developmental processes are accompanied by specific periods of plasticity and vulnerability. Not only are growing cells more vulnerable to toxic chemicals, but plasticity makes organs, including the brain, particularly sensitive to chemical influences. Moreover, the immature brain is especially vulnerable to stress hormones and toxic chemicals because the blood-brain barrier, which protects the brain from unwanted chemicals, is not fully formed; thus, the developing brain is more permeable to toxic chemicals than the mature brain. Further, developing children have immature metabolic pathways and are missing certain enzymes that metabolize and excrete toxic chemicals, making it more difficult to rid the body of toxicity.

Toxic Chemicals and the Developing Brain

The mechanisms by which specific toxic chemicals affect the developing brain are well established, allowing scientists to identify which developmental periods are the most susceptible to which toxic chemicals (Lanphear, 2015). Toxic chemicals, such as mercury, can cause cell death and alter cell migration and proliferation; because these processes occur rapidly during fetal development, mercury likely has its greatest effect *in utero* (Rice & Barone, 2000). Toxic chemicals such as lead disrupt neurotransmission, synaptogenesis, and synaptic trimming, which are all crucial during early childhood. Of all the toxic chemicals, lead has been suggested to pose the most serious threat to young children, in part because of its impact on multiple neurodevelopmental processes (Schneider et al., 2003). It has become increasingly apparent that the prenatal and early postnatal periods, specifically the first two and a half years of life, are the most critical periods to interruption by exposure to toxic chemicals (Black et al., 2017).

Toxic chemicals pose an insidious threat to children, leaving them at a greater risk for many neurodevelopmental disorders (NDDs), including learning disabilities (LDs), attention-deficit/hyperactivity disorder (ADHD), and autism spectrum disorder (ASD) – all of which are on the rise and are thought to have an underlying environmental component contributing to their etiology (Rauh & Margolis, 2016). Many toxic chemicals, such as lead, have been shown to have no safe level (Lanphear, 2015). Because the developing brain is particularly vulnerable to toxic chemicals, low doses of toxic chemicals that might not have an adverse effect on adults could interfere with neurodevelopment in critical periods of brain development. Therefore, early identification and recognition of potential neurodevelopmental toxic chemicals is crucial to protect children from harm posed by environmental toxic chemicals. Much of the contributing research on children's environmental health has come from prospective birth cohort studies examining the relationship between exposure to environmental toxic chemicals in early life and childhood health outcomes. However, there is very limited research on early-life prevention of exposures or ways to reduce chronic exposure.

Reducing Exposure to Toxic Chemicals in Development

Investigators have begun to study how to reduce children and pregnant women's exposure to toxic chemicals. Most of these studies were RCTs to test whether interventions can reduce exposure to specific chemicals, such as lead, phthalates, and pesticides. There are various types of interventions aimed at reducing exposures, including educational interventions, experimental interventions on individual levels, and experimental interventions on community levels (Barrett et al., 2015; Dewailly et al., 2012; Fagan et al., 2020). Educational interventions focus on transmitting knowledge to individuals on the potential harms of toxic chemicals and include ways to reduce or eliminate exposures and sources. Experimental interventions include the modification of a source of exposure via water filtration, removal of sources, changes to diet, or implementation of air filters.

Many of the intervention studies focus on experimental interventions (e.g., changing a diet source or water supply) instead of educational interventions. Further, studies that have looked at educational interventions for lead found no differences in blood lead levels after an educational intervention (Pfadenhauer et al., 2016). In addition to the lack of evidence showing that educational interventions are effective in reducing exposure, there is also very limited information about what the public knows regarding the risk of toxic chemicals.

Perceptions of Exposure to Toxic Chemicals by the Public, Parents, and Pregnant Women

In 2015 and 2018, Healthy Babies Bright Futures (HBBF) conducted a survey of over 1000 adult participants to examine their knowledge and behaviours related to toxic chemicals (Healthy Babies Bright Futures, 2018). Although traditional news coverage linking developmental health impacts with toxic chemicals doubled between 2015 to 2018, fewer participants in 2018 reported having read anything recently about toxic chemicals found in everyday household items (from 50% *yes* in 2015 to 44% *yes* in 2018). However, after administering message testing about toxic chemicals, more participants indicated that they considered toxic chemicals serious in their home and environment (from 55% pre-messaging to 66% post-messaging). Message testing included content like, “studies show that more than 90% of American women of childbearing age have toxic chemicals in their bodies that will increase the risk of brain damage and loss of intelligence in their babies.” The survey also found that between 55% and 65% of participants would act to reduce their family’s exposure to toxic chemicals by avoiding buying products with toxic chemicals and conducting online research to find out more information. Based on their findings, the HBBF survey provided eight strategic takeaways to support future knowledge translation, including being solution-focused, using trusted spokespeople (i.e., doctors and scientists), and use of quality content.

The literature since 2009 reveals scant findings on pregnant women and parents' perceptions of toxic chemicals. One recent study from the U.S. assessed parental concern about environmental toxic chemical exposures, as well as the relationship between their concern and their children's urinary concentrations of chemicals (Pell et al., 2017). They found that parental concern about environmental toxic chemicals was associated with lower childhood urinary concentrations of some of these chemicals after controlling for relevant covariates, indicating that parental concern could be an important factor in reducing children's exposure to some chemicals.

A recent study interviewed 300 French pregnant women on their perceptions of the risk of endocrine-disrupting chemicals (EDCs) during pregnancy (Rouillon et al., 2018). Participants endorsed an intermediate risk perception of EDCs and a perceived susceptibility of risk (i.e., that they were susceptible to harms of EDCs). Older age, higher level of knowledge via labeling of consumer products, and extent of exposure to information from media sources increased perceived risk. Chen and colleagues (2014) evaluated pregnant women's perceptions of healthy behaviours during pregnancy and found that there are two major gaps when women evaluate the risk of EDCs during pregnancy. These gaps were (1) not knowing that adverse effects during fetal development can have long-term implications on their children's future health and (2) emphasis on personal experience and anecdotal evidence during decision-making rather than evidence-based risk. Recently, a qualitative study conducted in Ireland regarding the public's awareness and risk perceptions of EDCs found that overall awareness of EDCs was low (Kelly et al., 2020). It was concluded that future research should use quantitative methods and larger samples to determine the public's knowledge of toxic chemicals as well as to develop effective risk communication strategies.

Perceptions of Exposure to Toxic Chemicals by Health-Care Providers

In the past decade or so, several studies have examined health-care professionals' (HCPs) knowledge, beliefs, and practices towards environmental toxic chemical exposures. According to Trasande and colleagues (2006), 301 pediatricians in New York State completed a survey assessing their level of knowledge for common environmental exposures and their opinions about the need for additional resources for children's environmental health. About 20% of participants reported having had any training in environmental history-taking. While participants generally indicated that they consider environmental exposures important, they also reported little belief that they could have control over environmental health risks. Only 9% knew about resources for children's environmental health, like the Pediatric Environmental Health Specialty Unit (PEHSU).

Stotland and colleagues (2014) surveyed over 2000 obstetrician-gynecologists (OB/GYNs) in the U.S. to assess attitudes, beliefs, and practices related to environmental health. While 80% of participants agreed that environmental health history was important, only 20% routinely counseled women about common environmental exposures, such as phthalates, bisphenol A (BPA), and pesticides, during pregnancy. Reasons for not counseling on environmental health included lacking adequate knowledge, uncertainty about environmental health data, inability to take action to reduce exposures, and limited resources.

Studies conducted in Europe found similar results as those conducted in the U.S., despite different political, health, and cultural spheres. Marie and colleagues assessed French HCPs' perceptions of environmental risks for pregnant women (Marie, Lémery, Vendittelli, & Sauvant-Rochat, 2016). They reported that fewer than 12% of HCPs surveyed their patients about exposure to chemicals or advised them to reduce possible exposure. Most HCPs said they lacked information and training about toxic chemicals. A study in France of perinatal HCPs found similar results (Sunyach et al., 2018); participants cited fear of the patient's reaction and lack of reliable solutions as the key reasons they did not discuss environmental chemicals. A more recent French study found that most (85%) prenatal HCPs felt they were not sufficiently informed about the risks of endocrine disruptors during pregnancy and responded that they provided no information regarding these risks to their patients (Marguillier et al., 2020). Encouragingly, almost 90% of participants answered that they wanted more information about the risk of endocrine disruptors in pregnancy.

Taken together, these studies suggest the need for better education and training of HCPs to equip them to address risks related to toxic chemicals during pregnancy, including a mechanism to keep them informed of new developments in this evolving science. In 2015, the International Federation of Gynecology and Obstetrics (FIGO) urged HCPs, especially those in pre- and perinatal health, to make environmental health a part of routine healthcare (Di Renzo et al., 2015). Yet, despite this important warning, little has changed in primary healthcare settings, as shown by the survey results conducted after this time.

Although there have been several calls for increased environmental health education in the healthcare setting (Haruty et al., 2016; Sathyanarayana et al., 2012), it is still unknown whether the information has reached pregnant women and parents. Grason and Misra reported that they could not identify any peer-reviewed articles on pregnant women's knowledge and behaviours related to environmental toxic chemicals and childbearing (Grason & Misra, 2009). This article highlighted several strategies that could address the knowledge gap on toxic chemicals during pregnancy. Some of these strategies included enhancement of news media, product labeling, and promotion of HCP counseling for women and parents.

Rationale

We have learned a lot over the past two decades as the field of developmental neurotoxicology has evolved. Specifically, low levels of toxic chemicals, originally thought to be innocuous, can be toxic to the developing brain. Recognition of the impact of toxic chemicals on brain development can help prevent NDDs by reducing widespread exposure to chemicals. The problem is that people may not understand the risks, or how to manage their family's exposure, which reduces the likelihood of implementing changes to lower exposure and advocating for a safer environment. Compounding this problem is the chemical industry, which has a huge influence over the public as it continues to lobby that low-level exposure to toxic chemicals is safe.

What Do Parents Know?

While parents can play a major role in preventing their children's exposure to toxic chemicals, there is limited empirical evidence about parents' knowledge of the impact of toxic chemicals on neurodevelopmental outcomes or whether knowledge dissemination techniques are successful at changing behaviours. With the absence of information on parents' perceptions, it is unknown whether and how clinicians and researchers can effectively target parents and impact their behaviour. If parents are unaware of risks, they are unlikely to attempt to reduce their children's exposure to toxic chemicals. While there are many papers calling for action by scientists on their duty to warn and prevent against developmental effects of toxic chemicals (Di Renzo et al., 2015; Marguillier et al., 2020), there are very few studies illustrating parents' perceptions and knowledge of the risks associated with exposure to toxic chemicals on children's neurodevelopment.

What Do Parents Prefer?

Little is known about parental preferences for resources going towards prevention of NDDs. While a substantial proportion of disease can be attributed to toxic chemicals, very little research and funding goes towards prevention. For example, one in four cases of childhood leukemia is attributed to toxic chemicals such as pesticides, solvents, and air pollution (Whitehead, et al., 2016). Yet, only 4% of American health dollars is devoted to public health or prevention and only 1% of the National Cancer Institute's budget for research in childhood cancer is devoted to prevention. Therefore, understanding parental preference for more money and resources going towards prevention of NDDs could accelerate the allocation of resources by presenting the information to relevant stakeholders.

Does Knowledge Translation Work?

It is also unknown whether KT tools are effective at influencing parents' behaviours. While there are several advocacy groups whose mission is to translate knowledge on developmental toxicity and ways to reduce exposures, it is unknown whether these tools are effective at enacting change. The HBBF survey was able to show that participants' concerns increased after the messaging but was unable to show whether participants changed their behaviours or attitudes.

It is likely futile to wait for regulatory policies on the widespread commercial use of toxic chemicals to change. In the meantime, the most effective change can come from educating families and parents on how to make safer choices for their children's health. Parents' knowledge empowerment may also accelerate the development of regulations by influencing parents' preferences and advocacy. Indeed, this development may be one of the most important outcomes of KT to parents.

Dissertation Aims

The first aim of this dissertation was to develop a questionnaire that assesses the public's knowledge and preferences towards toxic chemicals and children's brain development, as well as preferences towards prevention of NDDs (Green et al., 2022).

The second aim of this dissertation was to conduct a large, international survey using the newly designed questionnaire to examine what people know regarding toxic chemicals, attitudes towards prevention, barriers to making changes to reduce exposures, and other relevant information related to children's environmental health and neurodevelopment.

The third aim of this dissertation was to examine the efficacy of a KT tool for influencing people's knowledge, intentions, and behaviours. Current interventions targeting people of childbearing age consist of KT tools to educate about toxic chemicals and recommend ways to reduce exposure. Often, people turn to social media for information regarding health and development (Chen et al., 2014). We investigated whether a commonly used KT tool (the *Little Things Matter: The Impact of Toxins on the Developing Brain* video found in Appendix D) is effective at educating and instilling behavioural change. While there are several advocacy groups whose mission is to translate knowledge about the effects of toxic chemicals on development and ways to reduce exposures, it is unknown whether these tools are effective at enacting change.

With the absence of information on parents' and prospective parents' knowledge on the influence of exposure to toxic chemicals on children's brain development, it is unknown whether and how clinicians and researchers can effectively educate parents on risks and impact parents' exposure-reducing behaviours. Waiting for policy change regarding regulation of the commercial use of toxic chemicals can be futile. In the meantime, effective change can come from educating families and parents and advising them on how to make safer choices for their children's health.

Chapter 2: Development and Validation of the Prevention of Toxic Chemicals in the Environment for Children Tool: A Questionnaire for Examining the Community's Knowledge of and Preferences Toward Toxic Chemicals and Children's Brain Development

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Development and Validation of the Prevention of Toxic Chemicals in the Environment for Children Tool: A Questionnaire for Examining the Community's Knowledge of and Preferences Toward Toxic Chemicals and Children's Brain Development

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Early-life exposures to toxic chemicals can adversely impact brain development. Understanding people's knowledge of the impact of toxic chemicals on brain development is critical to reduce widespread exposure to chemicals. Yet it is unknown what people know about risks of toxic chemicals and how to reduce exposures. We developed and validated the questionnaire, *PRevention of Toxic chemicals in the Environment for Children Tool (PRoTECT),* to examine people's knowledge and attitudes about the influence of toxic chemicals on child development. We used best practices for developing and validating scales. First, we drafted items to assess knowledge of the impact of toxic chemicals on brain development, levels of concern regarding exposures, and preferences for prevention of neurodevelopmental disorders. Second, we received feedback on item clarity from five focus groups consisting of 46 community participants. In addition, 17 experts completed a content validity scale for each item and provided qualitative feedback. We administered the revised 18-item questionnaire to 190 participants of child-bearing age for scale development, and using exploratory factor analysis, we found evidence for a four-factor model of *PRoTECT*, RMSR = 0.05, of which 16 of the 18 items had adequate content validity with loadings >0.40 on a derived factor. We discuss future directions and applications of *PRoTECT*.

Keywords: children's environmental health, prevention, toxic chemicals, brain development, scale development

INTRODUCTION

Toxic chemicals are an insidious threat to children. Toxic chemicals elevate the risk for neurodevelopmental disorders, including learning disabilities, attention deficit hyperactivity disorder (ADHD), and autism spectrum disorder (ASD) (1). The developing brain is particularly vulnerable to toxic chemicals, even at low doses that might not have an adverse effect on adults.

Therefore, early identification and recognition by the public of potential sources of exposure to toxic chemicals are crucial to protect children. An extensive number of studies have examined the impact of early life environmental exposures on brain-based disorders, but few have examined ways to prevent or of reduce exposure. Further, little is known about what the public knows about the impact of toxic chemicals on child development, or how to educate practitioners and parents to recognize toxic chemicals and protect children.

Over the last two decades, scientists and physicians have called for increased education on children's environmental health in the healthcare setting (2–5). In 2021, the American College of Obstetricians and Gynecologists (ACOG) called for obstetrician-gynecologists and other prental health providers to become more knowledgeable about the impact of toxic chemicals on prenatal health to conduct an environmental health history, provide information on risks, and refer their patients to experts when indicated (6).

Education of parents and pregnant women has received less attention than healthcare providers, even though mothers are eager for information about pregnancy and early childhood (7). In 2009, Grason and Misra were unable to identify any peer-reviewed articles on women's knowledge about toxic chemicals in pregnancy, and highlighted strategies to address the knowledge gap on toxic chemicals during pregnancy, including enhancement of news media, product labeling, and promotion of health-care provider counseling for women and parents (8). Despite this, Crighton et al. found that a large proportion of mothers felt inadequately educated on environmental health risks, and many did not perceive exposure to toxic chemicals in the indoor environment to be of high concern (9). Yet, Laferriere et al. found that mothers who were concerned about environmental health risks were more than twice as likely to engage in protective behaviors to reduce exposures, such as opting for organic foods or switching to safer household products, suggesting that parental concern may play a role in behavior modification (10).

In fact, several studies have shown that educating parents about the impacts of toxic chemicals on children's health can influence their behaviors. One recent American study found that greater parental concern about toxic chemicals was associated with lower urinary concentrations of phthalates and phenols in children's urine (11). Another American study showed that expectant mothers' exposure to media coverage about the impact of pesticides, arsenic, and bisphenol A on children's health was associated with self-reported intent to reduce exposure to toxic chemicals, especially during pregnancy (12). Subsequent studies stressed the role of mass media in providing environmental health information to new and expectant mothers. Specifically, encountering online media articles on prenatal and child health was strongly associated with increased perceptions of personal accountability for choices that optimize environmental health (13). Similarly, Barbir et al. found that respondents' willingness to reduce plastic consumption was associated with their access to information (14). Furthermore, Crighton et al. indicated that mothers were willing to change their behaviors and reduce exposures when they were educated about the risks and actions to take (9). Taken together, these findings suggest that awareness and education of the impacts of toxic chemicals are key for reducing exposures to toxic chemicals.

Acknowledging the impact of toxic chemicals on brain development may help prevent neurodevelopmental disorders by encouraging the public to find ways to reduce widespread exposure to chemicals and advocate for stricter regulations to prevent chemicals from entering the environment. While advocations for regulatory policies on the widespread commercial use of toxic chemicals continues, families can be educated on how to make safer choices for their children's health. Yet, it is unknown what people know about the risks of toxic chemicals, and with the absence of information on their knowledge, it is unknown how clinicians and researchers can better support parents. While people may not understand the risks, or how to manage exposures, information disseminated by the chemical industry about the safety of their products further undermines public awareness of the scientific evidence of developmental health risks associated with toxic chemicals. Lastly, documenting parents' preferences for prevention of neurodevelopmental disorders may also accelerate the development of regulations and enhance parental advocacy.

We designed and validated the *PRevention of Toxic chemicals in the Environment for Children Tool (PRoTECT)* to assess parents' knowledge about toxic chemicals and brain development. We also wanted to assess their level of concern about toxic chemicals and preferences for the prevention of neurodevelopmental disorders.

METHODS

We developed and validated *PRoTECT* using best practices for developing and validating scales (15). The development and validation of the survey involved three phases: (1) item development, (2) scale development, and (3) scale evaluation. Our study received ethical approval from the York University ethical review board.

Item Development

Domain and Item Generation

The questionnaire's domains were developed and defined based on the authors' (RG, BL, EP, CT) collective expertise in children's environmental health, collaboration with stakeholders and funders, and a literature review to identify areas that were lacking in the field. We identified three domains of interest: (1) knowledge of developmental neurotoxicity, (2) level of concern about exposure to toxic chemicals, and (3) preferences for the prevention of neurodevelopmental disorders.

To define the domains of interest and generate items, we conducted a scoping review using the following key terms: "toxic chemicals" OR "toxi*" OR "chemicals" OR "environment*" AND "neurodevelopment" OR "ADHD" OR "autism" OR "cogniti*" OR "behav*" AND "attitude" OR "knowledge" OR "preference". After identifying key papers on this subject, we used the references from the papers to identify additional relevant articles. The scoping review only identified nine empirical studies on parents' and pregnant women's knowledge and attitudes of children's environmental health. Thus, we extended our search to include healthcare providers' knowledge of developmental neurotoxicity.

The first domain, knowledge of developmental neurotoxicity, was defined as knowledge of the relation between toxic chemicals and neurodevelopmental outcomes. Specifically, this domain included knowledge of the impact of *low levels* of toxic chemicals on brain development, the ubiquity of toxic chemical exposure present in the environment and everyday products, children's and fetuses' unique vulnerability to toxic chemicals, and the government's oversight and regulation of toxic chemicals. The second domain, level of concern, was defined as people's perceptions of the risks associated with exposure to toxic chemicals, including where they are found, whom they trust to provide information on toxic chemicals, and whether reducing exposure is important. The final domain, attitudes toward prevention, included people's preferences toward prevention relative to treatment of neurodevelopmental disorders, their knowledge of the government's expenditures to prevent neurodevelopmental disorders, their preferences, if any, for the government to prioritize funding into prevention, and their understanding of the prevention paradox (i.e., more children would benefit by preventing neurodevelopmental disorders than from treating disorders once they occur).

No validated scales have examined parental knowledge of developmental neurotoxicity and preferences for prevention, so we used the articles obtained in the scoping review to develop phrasing and rating scales. For example, we looked at terms that refer to "toxic chemicals" and found that studies have used "environmental exposures" (5), "environmental toxicants" (16), "chemical molecules" (17), or "endocrine-disrupting chemicals" (18). Some studies assessed answers qualitatively through thematic analysis (17, 18) and others used Likert scales (5, 16, 19).

Content Validity

Using previous studies, we generated items with a goal of five items per domain for a total of 15 items. Our group revised the items four times prior to external review. Our final compilation included 19 items. We chose to use a five-point Likert-type response scale, ranging from 1 *(strongly agree)* to 5 *(strongly disagree)* based on previous research of health-related knowledge surveys (5, 16, 19).

We assessed content validity by having experts evaluate the questionnaire items and using focus groups of the target population. We contacted 20 international experts in epidemiology, psychology, environmental health advocacy, neurodevelopment, and public education to assess the content validity of questionnaire items and provide feedback using a Google Survey platform. Each expert was asked to rate the content relevance of each item using a four-point response scale [i.e., 1 (*not relevant*), 2 (*unable to assess relevance without revision*), 3 (*relevant but needs minor revision*), and 4 (*very relevant and succinct*)]. Following each item, experts were asked to provide general qualitative feedback on the item and specific qualitative feedback about how it was worded. At the end of the questionnaire, experts provided their general impressions on key words used throughout the survey, as well as whether any content was missing or any item should be removed.

We conducted three rounds of expert reviews with 17 of the 20 experts (85% response rate). Following each round of expert review, we executed content analysis to determine the proportion of agreement among the experts. We calculated a content validity index (CVI) for each item based on the proportion of experts who rated the item as content valid (rating of three or four). After the final expert review, we calculated a CVI for the entire instrument based on the proportion of questionnaire items that received a content valid rating.

While the expert reviews were underway, we conducted five focus groups across North America, with a total of 35 participants (69% female, age range: 18–45), to assess the clarity and relevance of questionnaire items. Participants were recruited through social media postings (Facebook, Instagram, Twitter) and email. All focus groups were held on the video conferencing platform, Zoom, for ∼1 h. Four focus groups were conducted with both parent and non-parent participants to assess item accessibility and comprehensibility. The fifth focus group was conducted with parents only, to assess emotional reactions to the survey items. All participants consented to be a part of the focus groups and received a $25 gift certificate for their involvement in the study.

The focus groups were conducted as semi-structured cognitive interviews to assess item interpretation and facilitate open discussion. After reading each questionnaire item, participants were asked open-ended questions including "how would you phrase this item in your own words?", "is there anything in this statement that you would change?" and "do you have any reactions when reading this item?". We also asked questions specifically tailored to each item with a similar open-ended format based on comments and suggestions from the expert reviews.

The focus groups were transcribed and coded to collect qualitative and quantitative data. One research assistant conducted the interview (SR), two research assistants transcribed and coded all focus groups (CG, JJ), and the lead author observed all groups and prepared the questions and guided the discussion using the chat function (RG). The research assistants transcribed the groups independently and collated their transcripts following the final focus group. Qualitative information was collected using the collated transcript to assess descriptive judgment and participants' emotional responses to items. We created a coding matrix to collect quantitative information and to determine the number of verbal and non-verbal cues indicating agreement or dissent with questions (20, 21).

After three rounds of expert reviews and five focus groups, we compiled the responses to inform new items on *PRoTECT* which was presented to our internal team for dialogue and feedback (described in more detail in results).

Scale Development

Sampling and Survey Administration

We used the next version of *PRoTECT* to collect data for a preliminary exploratory factor analysis. We recruited participants through social media postings (Facebook, Instagram, and Twitter) and offered them a $5 gift card once they completed the survey. *PRoTECT* was administered *via* Qualtrics, an online survey platform. Following consent, participants were presented with a brief demographic questionnaire, followed by a general introduction to *PRoTECT*, and then the questionnaire items. The items were presented such that a participant could only view one item at a time and could not return to previous items. All responses were timed to ensure participants' responses were valid (i.e., they spent sufficient time filling out the questionnaire).

Scale Evaluation

Statistical Analyses

The items' five-point Likert-type response scale suggests that a traditional linear factor analysis model may not be appropriate for the resulting ordered, categorical data; accordingly, we fit exploratory factor analysis (EFA) models to the polychoric correlations among items using unweighted least squares estimation [see (22)] and fit a linear EFA model using Pearson product-moment correlations as a sensitivity analysis. Prior to estimating EFA models, we examined the polychoric and product-moment associations among items. We used a scree plot, parallel analysis, and root mean square residual (RMSR) statistics to identify the optimal number of factors for the EFA model [see (22)].

RESULTS

Results From Expert Review

Quantitative Results

The first round of expert review consisted of six experts in epidemiology, psychology, children's environment health advocacy, and medicine. In the first round, 17 of 18 items had excellent content validity ratings (CVI $\geq$ 0.83). The second round consisted of six additional experts and 17 of 19 items (one item was added based on results from the first round) had excellent content validity ratings (CVI $\geq$ 0.83). Two items were dropped in the second round based on low ratings. In the third and final round of expert review, four experts participated, and 13 of 17 items had excellent content validity ratings (CVI = 1.00). The CVI of the total questionnaire in round three was 0.76 (see **Table 1** for the CVI scores for each item in each round). Items that did not receive an adequate CVI were reworded, reordered, or deleted in accordance with experts' qualitative feedback and recommendations from focus group participants.

Qualitative Results

In addition to providing a rating between 1 and 4, experts provided qualitative feedback for each item and their general impressions at the end of the questionnaire. We aggregated the individual comments for each item, and if two or more experts made a similar comment, we addressed that comment and restructured the item. For example, many experts felt that an item (i.e., see item 5 on rounds 1 and 2) could elicit blame in parents, suggesting that "[we] need to be very careful not to infer 'blame' in this type of query" and to "take care not to induce potentially unproductive feelings of guilt in parents". Therefore, the item was restructured to reduce its potential to incite guilt in parents (i.e., see item 5 on round 3). In other examples, experts rephrased items in their own words to reduce jargon or added words to make the item more specific. For example, an expert suggested adding the word "effective" before regulations (see item 4 on round 3).

The experts' general impressions revealed several themes. First, experts reported that certain terms (i.e., "toxic chemicals" or "learning and behavioral conditions") needed to be defined at the beginning of the questionnaire. For example, one expert wrote, "I would try to use as widely accessible terminology as possible. I think that may mean having a few lead-in comments that help to define terms that are going to be used in subsequent questions". Another theme that emerged was whether some items may be leading to get an "agree" response. One expert wrote, "wonder if some questions may be leading" and another wrote, "seems like it is loaded to get an 'agree' response". Thirdly, experts reported that many items had "too many clauses" in it or "lots of nuances" that would make it difficult for a parent to understand. Lastly, experts expressed support for our project and shared that it is "so great that this is being done!!!".

We also asked experts if any content was missing. If two or more experts suggested the same item, we considered adding it to the survey. This process led to a new item asking about genetics vs. environmental exposures in determining health outcomes. For example, one expert suggested "do respondents perceive developmental disorders as random or pre-determined (e.g., genetic)?". Two experts suggested adding items on "pesticides" and "labeling like natural vs. organic". Experts also suggested adding what parents are "already using to minimize chemical exposure or what strategies they currently think are helpful" as well as "what entity respondents trust to be effective at ensuring the safety of their food, consumer products, etc". Still, most experts did not feel any content was missing. One expert wrote "one can always think of other questions, but I think the survey hits the right mark and is a good length".

Results From the Focus Groups

The purpose of the focus groups was to understand participant's grasp of phrases or terminology of the items, as well as their preference. For each item, we coded focus group transcripts to indicate participant agreement, dissent, and significant statements suggesting either agreement or dissent (**Supplementary Table 1**). For example, when asked whether participants preferred the use of "toxic chemicals" in Item 1 instead of "environmental chemicals", 11 participants indicated assent, five dissent, one provided a significant statement indicating agreement, one provided a significant statement indicating dissent, four indicated no preference, and seven did not respond. The questionnaire items were then edited to reflect participant feedback.

Participants provided qualitative feedback for each item and their general impressions. Many themes overlapped with the expert reviews. For example, participants shared that some of the items elicited blame or guilt. In reference to item 5 referenced above, one participant mentioned "this felt like a moment of blame", and another said, "[there is] something triggering in this question for me as a parent". Participants also indicated that certain wording was too technical. For example, with respect to

TABLE 1 | The number of experts with a content valid rating and the calculation of CVI for each item.

Item	Round 1		Round 2		Round 3	
	Number of experts	CVI	Number of experts	CVI	Number of experts	CVI
1. Toxic chemicals in our day-to-day lives, like air pollution or lead in drinking water, can increase a child's risk of developing ADHD or autism	6	1.00	6	1.00	4	1.00
2. The amount of resources that my government invests to prevent learning and behavioral conditions in children is about equal to the amount it invests to treat these conditions	6	1.00	5	0.83	3*	0.75
3. My government should devote more resources to make sure that consumer products do not contain toxic chemicals that are unsafe for children.	5	0.83	6	1.00	4*	1.00
4. Of all the things my government does to keep children healthy, reducing children's exposure to toxic chemicals should be a priority.	5	0.83	5	0.83	N/A	N/A
5. There are things parents can do during pregnancy and early childhood to reduce their child's risk of developing a learning or behavioral condition, like ADHD or autism.	6	1.00	5	0.83	N/A	N/A
6. The levels of toxic chemicals commonly found in food, consumer products, and drinking water are too low to interfere with children's brain development.	6	1.00	5	0.83	3*	0.75
7. Most governments spend 95% or more of their budgets to treat disease and disabilities. Governments should devote more of their budget to prevent these conditions	5	0.83	6	1.00	4*	1.00
8. I trust scientists' recommendations about how to reduce exposure to toxic chemicals	4	0.67	4	0.67	4*	1.00
9. Children are more likely to be harmed by toxic chemicals than adults, especially before they are born.	6	1.00	6	1.00	4*	1.00
10. I trust companies to make products that don't contain harmful chemicals.	6	1.00	6	1.00	4*	1.00
11. If I knew how to reduce children's exposure to toxic chemicals, I would do it.	6	1.00	4	0.67	4*	1.00
12. The number of children who would benefit from regulating toxic chemicals linked to learning and behavioral conditions is greater than the number of children who benefit from treating these conditions.	6	1.00	5	0.83	3*	0.75
13. I want to learn more about how to reduce children's exposure to toxic chemicals.	6	1.00	6	1.00	4	1.00
14. Toxic chemicals are found in everyday products, including foods, cleaning products, and personal care products.	6	1.00	6	1.00	N/A	N/A
15. All parents have equal opportunities to protect their children from toxic chemicals, regardless of income level, race or where they live	6	1.00	5	0.83	3*	0.75
16. My government has regulations to make sure that personal care products, furnishings, and food do not contain harmful levels of toxic chemicals.	6	1.00	6	1.00	3*	0.75
17. If toxic chemicals were a threat to my family's health, my pediatrician, obstetrician, or general practitioner would have told me about it.	6	1.00	6	1.00	4*	1.00
18. Research shows that most pregnant women have toxic chemicals in their blood	5	0.83	6	1.00	4*	1.00
19. Toxic chemicals that pregnant women are exposed to can increase the risk of their child having a learning or behavioral condition after they are born.	N/A	N/A	5	0.83	4*	1.00
20. I try to purchase products that do not contain toxic chemicals that may be harmful to my family	N/A	N/A	N/A	N/A	4	1.00

Indicates that the wording of the item was changed in subsequent rounds to reflect changes posed by expert and focus group participants. See **Supplementary Table 2 for more information on this.*

item 12 on rounds 1 and 2 (i.e., trying to explain the prevention paradox), one participant "was wondering if we could break it down because I had some trouble understanding", another mentioned that "people who aren't involved in science may be confused", and a third participant said "it took me a few times and I'm not sure if I even understand it right". Participants also expressed that they wanted the items to be specific and not too vague. For example, in reference to item two (rounds 1 and 2), one participant asked, "can we be more specific what 'more resources' means", and another said "resources is very broad…could be almost anything". When asked whom people would trust to get this information in item eight (rounds 1 and 2), participants expressed that they would want the information coming from scientists who study the topic. For example, one participant said, "I would overall trust a health professional or scientist in a specific field". In some instances, participants suggested rewriting the item altogether. One participant said, "I would suggest rewording the whole thing".

Participants said that they wanted key definitions before terms that would be used several times (i.e., "toxic chemicals" and "developmental conditions"). For instance, participants asked "can we add in brackets what these learning and behavioral conditions might be" and "I'd like to know a bit more about what the toxic chemicals are". Thus, we added key definitions to the beginning of the measure (**Figure 1**). Similar to the expert review, participants shared the overall importance of the survey,

PROTECT

PRevention **O**f **T**oxic chemicals in the **E**nvironment for **C**hildren **T**ool

PROTECT is a survey to find out what parents and people of childbearing age know about toxic chemicals and developmental conditions in children. Toxic chemicals, like lead, pesticides and phthalates, can be found in our homes, air, and water, and can be harmful to our health. Developmental conditions include learning disabilities, attention deficit/hyperactivity disorder (ADHD), and autism spectrum disorder (autism), among other developmental conditions.

We are asking you to rate each item on a scale from "Strongly Agree" to "Strongly Disagree". If you come to an item that you are unsure of the answer, please give your best guess and do not skip any items.

	1 – Strongly Agree	2 – Somewhat Agree	3 – Neither Agree nor Disagree	4 – Somewhat Disagree	5 – Strongly Disagree
1. Toxic chemicals in our day-to-day lives, like air pollution or lead in drinking water, can increase a child's risk of developing conditions like ADHD or autism.	1	2	3	4	5
2. Most governments spend about the same amount to **prevent** developmental conditions as they spend to **treat** these conditions.	1	2	3	4	5
3. All parents have equal opportunities to protect their children from toxic chemicals like pesticides or heavy metals, regardless of income level, race and ethnicity, or where they live.	1	2	3	4	5
4. My government has effective regulations to ensure that food and personal care products do not contain harmful levels of toxic chemicals.	1	2	3	4	5

FIGURE 1 | Final version of PRoTECT.

and emphasized that this work is "…so important to research and get more data", that it is a "really important topic", and that it "…doesn't veer away from what the objective is… clear and succinct". Some participants said they hadn't heard a lot on this topic.

Overall, qualitative results revealed good content validity ("I would describe it as a survey about toxic chemicals and child health and development"), and the Likert-type response was understood ("the nature of the questionnaire is to agree or disagree… I know that it's not a statement, it's asking for your opinion").

Item Reduction

Items underwent several rounds of revision based on expert and focus review. One item (item 4 on rounds 1 and 2) was removed due to poor ratings from both experts and focus group participants. The version of *PRoTECT* administered to participants consisted of 18 items and included a brief introduction to define key terms (**Supplementary Figure 1**).

Results From EFA

A total of 235 participants were recruited and began the *PRoTECT* questionnaire. Of those, 190 (81%) completed the questionnaire [55% female, mean (SD) age = 26.32 (5.40)], providing a ratio of over 10 participants per item.

The strength of the inter-item polychoric correlations ranged from approximately zero ($r = 0.02$) to $r = 0.65$. To determine the optimal number of factors to explain the pattern of inter-item correlations, we first plotted the eigenvalues of the correlation matrix with a scree plot, which suggested that four factors account for the pattern of inter-item correlations (i.e., there is a noticeable decrease after the fourth eigenvalue, after which the remaining eigenvalues level off more steadily).

A parallel analysis using 100 iterations also suggested four factors. The RMSR for the 4-factor model (i.e., RMSR = 0.05) was substantially better than the RMSR from the 3-factor model (RMSR = 0.08) or 2-factor model (RMSR = 0.10). Therefore, we present the results from the four-factor model with an oblimin rotation of the factor pattern matrix (**Table 2**). Importantly, 16 out of 18 items had factor loadings above 0.40 on one of the four factors. Item 18 had factor loadings of 0.35 on two factors. Item 11 did not have a substantial loading on any factor. Correlations among factors are shown in **Table 3**.

Sensitivity Analysis

A four-factor model fitted to the inter-item product moment correlations also had an adequately low RMSR statistic = 0.04, and the oblimin-rotated factor pattern led to similar conclusions about how each item related to each of the four factors.

TABLE 2 | Factor loadings of the four-factor model.

	Factor 1	Factor 2	Factor 3	Factor 4
Item 1	−0.03	0.24	**0.76**	−0.26
Item 2	0.08	0.20	−0.06	**0.55**
Item 3	0.03	0.30	−0.06	**0.66**
Item 4	0.03	**0.67**	0.01	0.01
Item 5	−0.02	−0.14	**0.88**	0.04
Item 6	0.32	0.08	**0.43**	0.17
Item 7	−0.12	**0.62**	0.05	0.14
Item 8	0.21	−0.07	**0.57**	0.24
Item 9	**0.71**	0.00	0.09	0.11
Item 10	**0.61**	−0.23	0.08	0.22
Item 11	0.19	−0.07	0.05	−0.06
Item 12	0.10	**0.66**	−0.05	0.21
Item 13	**0.40**	0.08	0.21	−0.05
Item 14	**0.47**	−0.11	0.09	0.11
Item 15	**0.76**	0.05	0.05	0.01
Item 16	**0.82**	0.09	−0.09	−0.08
Item 17	**0.57**	−0.09	−0.09	−0.31
Item 18	0.35	0.35	0.08	−0.41

Values in bold denote loadings >0.40.

TABLE 3 | Factor correlations.

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	-	0.15	0.30	0.06
Factor 2		-	0.04	0.08
Factor 3			-	−0.06
Factor 4				-

DISCUSSION

This study developed and described *PRoTECT*, a questionnaire assessing knowledge about toxic chemicals and neurodevelopment, level of concern, and preferences for prevention of neurodevelopmental disorders. The participants, including potential and current parents, said that the questionnaire was important and contained information that they do not hear about in their day-to-day lives. Similarly, expert reviewers indicated that this kind of research needed to be done and asked to be contacted with the results.

Feedback from several rounds of expert and participants generated a questionnaire consisting of 18 items. Considering this is the first questionnaire to measure knowledge and preferences surrounding toxic chemicals and brain development, we used factor analysis to provide meaning to the pattern of inter-item correlations and apply conceptual labels to the four factors described below.

Factor 1, which represented desire or intention to reduce exposure to toxic chemicals, included items such as "If I knew how to reduce children's exposure to toxic chemicals, I would try to do it" and "I want to learn more about how to reduce children's exposure to toxic chemicals". Factor 2 represented trust in authority sources about exposure to toxic chemicals, and included items such as "My government has effective regulations to ensure that food and personal care products do not contain harmful levels of toxic chemicals" and "If toxic chemicals were a threat to my family's health, my pediatrician, doctor, or health care provider would have told me about it". Factor 3 represented knowledge about developmental neurotoxicity (i.e., the relationship between toxic chemicals and development), and included items such as "Toxic chemicals in our day-to-day lives, like air pollution or lead in drinking water, can increase a child's risk of developing conditions like ADHD or autism" and "Reducing exposure to toxic chemicals during pregnancy and in early childhood can help lower a child's risk of developing a condition like ADHD or autism". Lastly, Factor 4 represented knowledge about toxic chemicals and society, and included items such as "Most governments invest about the same amount to **prevent** developmental conditions as they spend to **treat** these conditions" and "All parents have equal opportunities to protect their children from toxic chemicals like pesticides or heavy metals, regardless of income level, race and ethnicity, or where they live" (**Supplementary Table 3**).

Since item 18 ("I am worried that my family may be exposed to toxic chemicals") had a loading that was <0.40 and could be tapping more into emotional feelings ("worried") as opposed to knowledge or attitudes, we removed it from the questionnaire.

Item 11 ("toxic chemicals are generally more harmful to babies and children than they are to adults"), a knowledge-based item that we felt was important to retain, did not have a substantial factor loading on any factor, indicating that it is not strongly influenced by any of the four constructs represented by the factors. Theoretically, it should be related to factor 3 (knowledge of developmental neurotoxicity); however, it could be phrased such that the item was not understood. For example, participants may have disagreed with the item if they thought it suggested that babies and children have more opportunity to be exposed to toxic chemicals, as opposed to its intended meaning of greater susceptibility to the adverse impacts of toxic chemicals. Considering that this item had been revised multiple times following focus groups and expert reviews, it could be that it is not self-explanatory. Therefore, to avoid confusion about opportunity for exposure between children and adults, we changed item 11 to: *"Exposure to toxic chemicals is particularly harmful to babies and children."* The final version of *PRoTECT* can be found in **Figure 1**.

The highest inter-factor correlation was between factors 3 and 4 ($r = 0.30$), suggesting that people who knew more about developmental neurotoxicity were also more likely to want to reduce their exposure to toxic chemicals.

Applications

PRoTECT can be used by researchers and clinicians to evaluate knowledge of toxic chemicals and neurodevelopment, as well as parents' and expectant parents' intentions to reduce their exposure to toxic chemicals and preferences toward prevention. Further, it can be used by researchers and children's environmental health advocates to assess understanding and urgency of the risks that toxic chemicals may pose, and to track knowledge and preferences over time.

Our intention is that *PRoTECT* will be used to inform and advance policy measures to reduce early-life exposures to toxic chemicals and, by extension, curb rising rates of neurodevelopmental disorders among children. In addition to limited research on the public's knowledge about the relationship between toxic chemicals and development, surprisingly little is known about people's preferences for healthcare resources going toward prevention of neurodevelopmental disorders, which is something we aimed to assess in the current study. Currently, little research and funding is geared to prevention of disease and disability. For example, one in four cases of childhood leukemia is attributed to toxic chemicals such as pesticides, solvents, and air pollution (23). Yet, only 4% of American health dollars are devoted to prevention of childhood cancers (24). Similarly, only 1% of the National Cancer Institute's budget for research in childhood cancer is devoted to prevention (24). While preference for prevention was not identified as a factor in our factor analysis, if we find that responses on *PRoTECT* reveal that parents prefer more funding go toward prevention of neurodevelopmental disorders, health sector stakeholders and decision makers can be informed of this preference. Parents can accelerate change by showing their preferences, as has been seen in other public health interventions, such as childhood vaccinations and water disaster in Flint, Michigan (25, 26). Knowledge of parental preference for more money and healthcare resources going toward prevention of neurodevelopmental disorders could accelerate change by presenting the information to political stakeholders.

Future Directions

We are currently administering *PRoTECT* to a sample of 10,000 participants across five countries. We are conducting a nested, randomized-control trial (RCT) with inclusion of a knowledge translation tool in which half of the respondents will watch a video on the impact of toxic chemicals on brain development. The large sample will provide opportunities for further psychometric evaluation of *PRoTECT* and investigate whether the four-factor model of *PRoTECT* remains across a larger sample and more diverse group. A six-week follow-up survey will be conducted to assess differences in responses to *PRoTECT* after exposure to the video or its material, and whether any intent to change behaviors persist or increase after completing the questionnaire.

While we await stronger legislation to reduce toxic exposures among pregnant women and children, it is important to find ways to effectively communicate these risks with parents and caregivers. Thus, *PRoTECT* represents a potentially useful tool for assessing knowledge as it pertains to toxic chemicals found in the environment and their impact of children's development. In turn, parents' understanding of the impact of toxic chemicals on children's development may accelerate the promulgation of protective policies and regulations.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available upon request by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by York University Ethical Review Board. The patients/participants provided their electronic informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

RG, BL, EP, and CT: study conception and design. RG, CG, SR, and JJ: data collection. RG, BL, CG, and DF: analysis and interpretation of results. RG and CG: draft manuscript preparation. RG, BL, EP, CG, DF, and CT: manuscript review. All authors reviewed the results and approved the final version of the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.863071/full#supplementary-material

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Supplemental Tables

Supplemental Table 1. *Coding matrix reflecting the number of verbal and non-verbal cues indicating agreement or dissent with items.*

Question	Consensus
Item 1 Do you prefer: Toxic chemicals (disagree is prefer environmental chemicals)	A=11 D= 5 SE = 1 SD = 1 NU = 4 NR = 7
Item 2 Do you prefer: to prevent learning and behavioural conditions (disagree is “in preventing learning and behavioural conditions”)	NU = 3 NR = 4 * only asked in Focus group 1 (April 26) with 7 total participants
Item 2 Would you like examples in brackets included in the item	A = 16 NR = 13
Item 2 Would you prefer “learning and behavioural conditions”? (disagree is ADHD, autism, neurodevelopmental disorders)	D = 9 SD = 5 NR = 15
Item 3 Do you prefer “devote”? (disagree is invest)	A = 9 D = 5 NU = 2 NR = 13
Item 4 Should we remove first part of the item?	A = 12 SE = 1 D = 3 NR = 13
Item 4: If we remove the first part of the item is it leading to get an agree answer?	A = 6 NR = 23
Item 5 Do you prefer “actions”? (disagree is “things”)	A = 8 NU = 3 NR = 18
Item 5 Should we phrase this item in the negative?	A = 5 NR = 1 * only asked in Focus group 4 with 6 total participants
Item 5 Can ADHD and autism be paired once with “learning and behavioural conditions”?	A = 10 D = 3 NR = 16

Item 6 Do you prefer "interfere"? (disagree is prefer "impact)	D = 9 NU = 3 NR = 17
Item 6 Do you understand what the term "development" means?	A = 11 NR = 18
Item 7 Do you prefer the term "budgets"? (disagree = funds/resources)	A = 7 NU = 1 NR = 21
Item 8 Do you prefer the term "scientists"? (disagree = researchers)	A = 16 D = 5 NU = 1 NR = 7
Item 8 Do you prefer the term "scientists"? (disagree = more specific type of scientist)	A = 10 D = 17 SD = 1 NR = 1
Item 9 Do you prefer "before they are born"? (disagree = prenatal/gestation/in utero)	A = 2 D = 3 NR = 24
Item 6/9 Do you know when the brain develops?	D = 8 NR = 21
Item 10 Is this clear?	A = 9 NR = 20
Item 11 Do you prefer "exposure to"? (disagree = more specific)	A = 15 D = 2 NR = 12
Item 11 Do you know what "exposure to" means?	A = 6 D = 2 NU = 2 NR =19
Item 12 Do you understand what this item is saying?	A = 2 D =7 NR = 20
Item 12 Do you prefer "regulating" (disagree = reducing/reductions to)	A = 1 D = 7 SD = 1 NR = 20
Item 12 Do you prefer 12 B? (disagree = 12 A)	A = 16 NU = 1 NR = 12
Item 13 Do you prefer "want to learn more"? (disagree = "am interested in learning more")	A = 5 D = 1 SE = 1 NU = 4 NR = 18
Item 14 Is the item clear?	A = 13

	NR = 16
Item 15 Do you prefer "regardless"? (disagree = "no matter their)	A = 3 NR = 4 * only asked in Focus group 1 with 7 total participants
Item 15 Do you prefer "race"? (disagree = "ethnicity")	A = 2 D = 1 NU = 4 NR = 22
Item 15 Do you prefer "opportunities" (disagree = "abilities")	D = 4 NR = 25
Item 15 Do you prefer the item worded in the negative?	A = 4 NU = 1 NR = 1 * only asked in Focus group 4 with 6 total participants
Item 16 Do you like "regulations"?	A = 5 SE = 2 NR = 22
Item 17 Do you prefer "general practitioner"? (disagree = physician/doctor/family doctor)	A = 1 D = 17 * one participant disagreed with all terms NR = 10
Item 18 Do you prefer "research"? (disagree = "studies")	A = 7 D = 6 NR = 16
Item 18 Do you prefer "blood"? (disagree = bodies)	A = 4 D = 2 SD = 1 N = 1 NR = 21
Item 19 Is "after they are born" implied in the item?	A = 6 NR = 23

Abbreviations: A = Indicated agreement (i.e., verbal or nonverbal), D = Indicated dissent (i.e., verbal or nonverbal), SE = Provided significant statement or example suggesting agreement, SD = Provided significant statement or example suggesting dissent, NR = Did not response, NU = Indicated no preference

Supplemental Table 2. *Items in Each Round*

Item	Round 1	Round 2	Round 3

1.	Toxic chemicals in our day-to-day lives, like air pollution or lead in drinking water, can increase a child's risk of developing ADHD or autism	Toxic chemicals in our day-to-day lives, like air pollution or lead in drinking water, can increase a child's risk of developing ADHD or autism	Toxic chemicals in our day-to-day lives, like air pollution or lead in drinking water, can increase a child's risk of developing ADHD or autism
2.	The amount of resources that my government invests to prevent learning and behavioral conditions in children is about equal to the amount it invests to treat these conditions	The amount of resources that my government invests to prevent learning and behavioral conditions in children is about equal to the amount it invests to treat these conditions	Most governments invest about the same amount to prevent conditions like ADHD and autism as they spend to treat these conditions
3.	My government should devote more resources to make sure that consumer products do not contain toxic chemicals that are unsafe for children.	My government should devote more resources to make sure that consumer products do not contain toxic chemicals that are unsafe for children.	My government should strengthen their policies and programs to make sure that consumer products do not contain harmful levels of toxic chemicals.
4.	Of all the things my government does to keep children healthy, reducing children's exposure to toxic chemicals should be a priority.	Of all the things my government does to keep children healthy, reducing children's exposure to toxic chemicals should be a priority.	N/A
5.	There are things parents can do during pregnancy and early childhood to reduce their child's risk of developing a learning or behavioural condition, like ADHD or autism.	There are things parents can do during pregnancy and early childhood to reduce their child's risk of developing a learning or behavioural condition, like ADHD or autism.	N/A
6.	The levels of toxic chemicals commonly found in food, consumer products, and drinking water are too low to interfere with children's brain development.	The levels of toxic chemicals commonly found in food, consumer products, and drinking water are too low to interfere with children's brain development.	My government has effective regulations to ensure that food and personal care products do not contain harmful levels of toxic chemicals.

7.	Most governments spend 95% or more of their budgets to treat disease and disabilities. Governments should devote more of their budget to prevent these conditions	Most governments spend 95% or more of their budgets to treat disease and disabilities. Governments should devote more of their budget to prevent these conditions	Most governments spend most of their health budget to manage and treat medical conditions, including conditions like ADHD or autism. I think governments should devote more resources to find ways to prevent children from developing these condition
8.	I trust scientists' recommendations about how to reduce exposure to toxic chemicals	I trust scientists' recommendations about how to reduce exposure to toxic chemicals	Of all the sources of information about health impacts from toxic chemicals, I would trust information coming from the scientists who study them.
9.	Children are more likely to be harmed by toxic chemicals than adults, especially before they are born.	Children are more likely to be harmed by toxic chemicals than adults, especially before they are born.	Toxic chemicals are more harmful to babies and children than they are to adults.
10.	I trust companies to make products that don't contain harmful chemicals.	I trust companies to make products that don't contain harmful chemicals.	I trust most companies to make products that don’t contain harmful levels of toxic chemicals.
11.	If I knew how to reduce children's exposure to toxic chemicals, I would do it.	If I knew how to reduce children's exposure to toxic chemicals, I would do it.	If I knew how to reduce children’s exposure to toxic chemicals, I would try to do it.
12.	The number of children who would benefit from regulating toxic chemicals linked to learning and behavioural conditions is greater than the number of children who benefit from treating these conditions.	The number of children who would benefit from regulating toxic chemicals linked to learning and behavioural conditions is greater than the number of children who benefit from treating these conditions.	More children would benefit by reducing toxic chemicals linked with conditions like ADHD and autism than the number of children who benefit from treatment of these conditions
13.	I want to learn more about how to reduce children's exposure to toxic chemicals.	I want to learn more about how to reduce children's exposure to toxic chemicals.	I want to learn more about how to reduce children's exposure to toxic chemicals.

14.	Toxic chemicals are found in everyday products, including foods, cleaning products, and personal care products.	Toxic chemicals are found in everyday products, including foods, cleaning products, and personal care products.	N/A
15.	All parents have equal opportunities to protect their children from toxic chemicals, regardless of income level, race or where they live	All parents have equal opportunities to protect their children from toxic chemicals, regardless of income level, race or where they live	All parents have equal opportunities to protect their children from toxic chemicals like pesticides or heavy metals, regardless of income level, race and ethnicity, or where they live.
16.	My government has regulations to make sure that personal care products, furnishings, and food do not contain harmful levels of toxic chemicals.	My government has regulations to make sure that personal care products, furnishings, and food do not contain harmful levels of toxic chemicals.	My government has effective regulations to ensure that food and personal care products do not contain harmful levels of toxic chemicals
17.	If toxic chemicals were a threat to my family's health, my pediatrician, obstetrician, or general practitioner would have told me about it.	If toxic chemicals were a threat to my family's health, my pediatrician, obstetrician, or general practitioner would have told me about it.	If toxic chemicals were a threat to my family's health, my pediatrician, doctor, or health care provider would have told me about it.
18.	Research shows that most pregnant women have toxic chemicals in their blood	Research shows that most pregnant women have toxic chemicals in their blood	Toxic chemicals can be detected in the blood of most pregnant women.
19.	N/A	Toxic chemicals that pregnant women are exposed to can increase the risk of their child having a learning or behavioural condition after they are born.	Toxic chemicals found in pregnant women can increase their child's risk of having a learning or behavioural condition.
20.	N/A	N/A	I try to purchase products that do not contain toxic chemicals that may be harmful to my family

Supplemental Table 3. *Items clustered by factor.*

Factor 1: Desire to reduce exposure to toxic chemicals
Of all the sources of information about health impacts from toxic chemicals, I trust information coming from scientists who study them.

More children would benefit by regulating and reducing toxic chemicals to ***prevent*** *developmental conditions than the number of children who benefit from* ***treatment*** *of these conditions.*
Toxic chemicals can be detected in the blood of most pregnant women.
My government should strengthen their policies and programs to make sure that consumer products do not contain toxic chemicals that are harmful to children.
If I knew how to reduce children's exposure to toxic chemicals, I would try to do it.
I try to purchase products that do not contain toxic chemicals that may be harmful to my family.
*I am worried that my family may be exposed to toxic chemicals.**
I want to learn more about how to reduce children's exposure to toxic chemicals.
Factor 2: Trust in sources of toxic chemicals
My government has effective regulations to ensure that food and personal care products do not contain harmful levels of toxic chemicals.
If toxic chemicals were a threat to my family's health, my pediatrician, doctor, or health care provider would have told me about it.
*I am worried that my family may be exposed to toxic chemicals.**
Factor 3: Knowledge of developmental toxicity
Toxic chemicals in our day-to-day lives, like air pollution or lead in drinking water, can increase a child's risk of developing conditions like ADHD or autism.
Reducing exposure to toxic chemicals during pregnancy and in early childhood can help lower a child's risk of developing a condition like ADHD or autism.
When it comes to addressing developmental conditions affecting children, most governments spend the majority of the health budget on management and treatment of these conditions. I think governments should spend more of their budget to find ways to prevent children from developing these conditions.
Exposure to toxic chemicals during pregnancy can increase a child's risk of having a developmental condition.
Factor 4: Knowledge of government and society about toxic chemicals and exposure
Most governments invest about the same amount to ***prevent*** *developmental conditions as they spend to* ***treat*** *these conditions.*

All parents have equal opportunities to protect their children from toxic chemicals like pesticides or heavy metals, regardless of income level, race and ethnicity, or where they live.

**Equal loading onto two factors.* **No loading: *"Toxic chemicals are generally more harmful to babies and children than they are to adults."*

Supplemental Figures

Supplemental Figure 1. *PRoTECT Version used for EFA*

PROTECT

PRevention **O**f **T**oxic chemicals in the **E**nvironment for **C**hildren **T**ool

PROTECT is a survey to find out what parents and people of childbearing age know about toxic chemicals and developmental conditions in children. Toxic chemicals, like lead, pesticides and phthalates, can be found in our homes, air, and water, and can be harmful to our health. Developmental conditions include learning disabilities, attention deficit/hyperactivity disorder (ADHD), and autism spectrum disorder (autism), among other developmental conditions.

We are asking you to rate each item on a scale from "Strongly Agree" to "Strongly Disagree". If you come to an item that you are unsure of the answer, please give your best guess and do not skip any items.

	1 – Strongly Agree	2 – Somewhat Agree	3 – Neither Agree nor Disagree	4 – Somewhat Disagree	5 – Strongly Disagree
1. Toxic chemicals in our day-to-day lives, like air pollution or lead in drinking water, can increase a child’s risk of developing conditions like ADHD or autism.	**1**	**2**	**3**	**4**	**5**
2. Most governments invest about the same amount to **prevent** developmental conditions as they spend to **treat** these conditions.	**1**	**2**	**3**	**4**	**5**
3. All parents have equal opportunities to protect their children from toxic chemicals like pesticides or heavy metals, regardless of income level, race and ethnicity, or where they live.	**1**	**2**	**3**	**4**	**5**
4. My government has effective regulations to ensure that food and personal care products do not contain harmful levels of toxic chemicals.	**1**	**2**	**3**	**4**	**5**

5. Reducing exposure to toxic chemicals during pregnancy and in early childhood can help lower a child's risk of developing a condition like ADHD or autism.	1	2	3	4	5
6. When it comes to addressing developmental conditions affecting children, most governments spend the majority of the health budget on management and treatment of these conditions. I think governments should spend more of their budget to find ways to prevent children from developing these conditions.	1	2	3	4	5
7. If toxic chemicals were a threat to my family's health, my pediatrician, doctor, or health care provider would have told me about it.	1	2	3	4	5
	1 – Strongly Agree	2 – Somewhat Agree	3 – Neither Agree nor Disagree	4 – Somewhat Disagree	5 – Strongly Disagree
8. Exposure to toxic chemicals during pregnancy can increase a child's risk of having a developmental condition	1	2	3	4	5
9. I want to learn more about how to reduce children's exposure to toxic chemicals.	1	2	3	4	5
10. Of all the sources of information about health impacts from toxic chemicals, I trust information coming from scientists who study them.	1	2	3	4	5
11. Toxic chemicals are generally more harmful to babies and children than they are to adults.	1	2	3	4	5
12. I trust that most companies make products that don't contain harmful levels of toxic chemicals.	1	2	3	4	5
13. More children would benefit by regulating and reducing toxic chemicals to **prevent** developmental conditions than the number of children who benefit from **treatment** of these conditions.	1	2	3	4	5
14. Toxic chemicals can be detected in the blood of most pregnant women.	1	2	3	4	5
15. My government should strengthen their policies and programs to make sure that consumer products do not contain toxic chemicals that are harmful to children.	1	2	3	4	5
16. If I knew how to reduce children's exposure to toxic chemicals, I would try to do it.	1	2	3	4	5

17. I try to purchase products that do not contain toxic chemicals that may be harmful to my family.	**1**	**2**	**3**	**4**	**5**
18. I am worried that my family may be exposed to toxic chemicals.	**1**	**2**	**3**	**4**	**5**

Chapter 3: Validation of *PRoTECT* and Examination of Response Distribution

Recognizing that relevant information on environmental health for families had not been reaching parents (Barbir et al., 2021; Grason & Misra, 2009; Mello & Hovick, 2016), our team developed and began to validate a questionnaire, *PRoTECT*, to examine the public's knowledge and concerns about toxic chemicals in the environment and children's brain development, as well as their preferences towards prevention of neurodevelopmental disorders (Green et al., 2022). Understanding knowledge and concerns is the first step in identifying whether and how healthcare providers and researchers can help the public make informed decisions about their exposure to toxic chemicals. If parents are aware of risks, they may be more likely to make changes toward reducing their children's exposure to toxic chemicals (Gray, 2018).

While there are many papers calling for action by scientists on their duty to warn and prevent against developmental neurotoxicity (Di Renzo et al., 2015; Marguillier et al., 2020), limited studies have examined whether this information reaches parents and families (Green et al., 2022) and what they know and prefer when it comes to managing toxic chemicals for children's health. Moreover, few studies have evaluated the public's knowledge and awareness about the impact of toxic chemicals on NDDs (Rosas et al., 2014). Some studies have looked at the public's knowledge of environmental health more broadly, and found that the public does not have a strong understanding of how the environment can impact human health (Gray, 2018). Gray's systematic review of 31 studies examining environmental health literacy (EHL) suggested that knowledge of environmental health related to sources of exposure and how to reduce exposures, is lacking, highlighting the importance of individual- and community-based EHL efforts.

In recent years, researchers have assessed the validity of EHL tools that explore a broad range of environmental health issues (Dixon, Hendrickson, Ercolano, Quackenbush, & Dixon, 2009; Gray, 2018; Gray et al., 2021; Lichtveld et al., 2019; Ratnapradipa, Middleton, Wodika, Brown, & Preihs, 2015). Although their assessment methods differ from one another, these researchers use factor analysis, interviews, expert reviews, and focus groups to develop or refine these instruments. A few of these tools are validated (Dixon et al., 2009; Lichtveld et al., 2019; Ratnapradipa et al., 2015), but none have explored EHL in relation to neurotoxicity in children and pregnancy. For example, Dixon et al. (2009) validated the Environmental Health Engagement Profile (EHEP) instrument, which investigates engagement (i.e., knowledge, attitudes, and behaviours) with environmental health issues across five subscales. These include the Pollution Sensitivity Scale, Pollution-Causes-Illness Scale, Pollution Acceptance Scale, Community Environment Action Scale, and Personal Environment Action Scale. Similarly, Ratnapradipa et al. (2015) refined and began to validate a Delphi environmental health survey investigating EHL in eleven core areas, including air, water, radiation, food safety, emergency preparedness, healthy housing, infectious disease and vector control, toxicology, injury prevention, waste and sanitation, and weather and climate change. More recently, Lichtveld et al. (2019) validated an instrument that investigates EHL for air, food, water, and general environmental health subscales, whereas Gray et al. (2021) developed a process-focused EHL instrument focusing on the contamination of well water with toxic metals. Ultimately, we hope that *PRoTECT* can be used to assess EHL of developmental neurotoxicity in children and pregnancy.

The aim of the present study was to further validate the *PRoTECT* measure by (1) evaluating the dimensional structure of *PRoTECT* using a large, international sample and (2) examine distributions of responses and subscale scores representing the dimensional structure of *PRoTECT* across the sample and various demographic characteristics.

Methods

Study Design

We recruited 15,594 participants aged 18 to 45 years from Canada, the U.S., the United Kingdom (U.K.), India, and Australia via CloudResearch's Prime Panels®, an online platform commonly used for behavioural research (Chandler et al., 2019). Prime Panels recruits online survey participants to ensure that eligibility criteria and data quality standards are met through CloudResearch's high quality control system, SENTRY® (https://www.cloudresearch.com/products/sentry-data-quality-validation/). In our study, SENTRY® prevented approximately 50% of total participant traffic from accessing *PRoTECT* due to inattentiveness, reCAPTCHA fails, and similar problems. Furthermore, our convenience sample was demographically stratified via Prime Panels based on soft census gender (49% male and 51% female for all countries) and age quotas (18 to 22 years: 15 to 24%; 23 to 35 years: 45 to 51%; and 36 to 45 years: 25 to 39% based on country). U.S. participants were also demographically stratified based on soft census race quotas (American Indian/Alaska Native: 1.0%; Asian: 6.0%; Black: 18.0%; Hispanic: 17.5%; Native Hawaiian: 0.2%; White: 53.3%; and Other: 2.0%). This demographic stratification was implemented to aggregate an international sample from market research panels and obtain high quality data as well as to ensure an adequate sample of people identifying as Black. Eligible participants anonymously completed our study through an online survey platform, Qualtrics (https://qualtrics.com/) and received a small monetary incentive for completion (amount determined by CloudResearch ahead of time).

Data collection occurred in October 2021. Participants completed a brief demographic questionnaire, as well as *PRoTECT.* The study was approved by York University's research ethics board (REB).

Description of PRoTECT

PRoTECT consists of items with a five-point Likert-type response scale ranging from *strongly agree* to *strongly disagree*. One item of *PRoTECT* was provided per screen to ensure that participants answered each item before moving on to the next item. Each item response is given a score from 1 to 5, with higher scores indicating greater levels of knowledge towards developmental neurotoxicity or stronger preferences for prevention and government regulation. On the *PRoTECT* questionnaire shown in Appendix A, an asterisk indicates a reverse coded item, such that *strongly disagree* would be coded as a 5 and *strongly agree* would be coded as a 1.

We previously identified four factors underlying 16 *PRoTECT* item responses using EFA conducted as part of a pilot phase using a smaller sample (N = 190). Each factor represented a separate conceptual construct, which included (1) desire or intention to reduce exposure to toxic chemicals, (2) trust in authority sources about exposure to toxic chemicals, (3) knowledge of developmental neurotoxicity, and (4) knowledge about toxic chemicals and society, including regulatory bodies (Green et al., 2022).

Statistical Analyses

To further evaluate the factor structure of *PRoTECT*, we first split the dataset into an exploratory dataset by randomly selecting 75% of the original sample. This dataset was used for EFAs and fitting preliminary confirmatory factor analysis (CFA) models, while the remaining 25% of the original sample, a confirmatory dataset, was used to fit a final CFA model specified according to results from the EFA (for a description of the distinction between EFA and CFA models, see Flora & Flake, 2017). EFA models were estimated using the psych package in R (Revelle, 2023), whereas CFA models were estimated using the lavaan package (Rosseel, 2012). We fitted models using linear (product-moment) and polychoric correlations among item responses and estimates were very similar; therefore, we report results from product-moment correlations because the parameter estimates are easier to interpret, and fit indices are more well-developed.

To evaluate the overall fit of an EFA or CFA model to the data, we used descriptive fit indexes including the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), the standardized root mean squared residual (SRMR), and the root mean squared error of approximation (RMSEA). Higher values for the CFI and TLI are more desirable (e.g., .90 or higher), whereas lower values for SRMR and RMSEA (.08 or lower) indicate a good model-data fit (Hu & Bentler, 1999).

Demographic variables of interest included country, race/ethnicity, gender, age, education, pregnancy status, parental status, and whether participants had a child with an NDD (i.e., “Are there identified developmental conditions (such as, ADHD, Autism, Learning Disability, Intellectual Disability) with any of your children?”). Given our sample of over 15,000, we did not perform significance testing because very small, trivial effects can be statistically significant with this sample size. We examined mean scores on subscales constructed to represent the factors from the EFA and CFA across various demographic groups. We also examined the frequency of responses across the Likert-type item responses according to demographic factors.

Results

Demographic Characteristics

In total, 15,594 participants completed the demographic questions and *PRoTECT*; their demographic characteristics are shown in Table 1. Although participants could endorse several ethnic identities, we collapsed them into four groups: White, Black, South Asian, and Other.

Table 1. *Demographic characteristics of participants at baseline*

Gender (*n* (%))	
Female	8129 (52.13)
Male	7285 (46.72)
Non-Binary	128 (0.82)
Country (*n* (%))	
Canada	2829 (18.14)
Australia	2675 (17.15)
India	3186 (20.43)
United Kingdom	2784 (17.85)
United States	4120 (26.42)
Ethnic Groups (*n* (%))	
White	7994 (51.26)
Black	1038 (6.66)
South Asian	3052 (19.57)
Other	3510 (22.51)
Location (*n* (%))	
Major City	5636 (36.14)
Suburban Edges	4643 (29.77)
Major Town	1671 (10.72)
Small Town	3060 (19.62)
Remote	436 (2.80)

Mean (SD) age (years)	31.97 (8.15)
Level of Education (*n* (%))	
High school or less	3737 (23.96)
Some college or university, no degree/diploma	2546 (16.33)
Bachelor's degree or diploma	6328 (40.58)
Master's, doctorate, or professional degree	2786 (17.87)
Employment (*n* (%))	
Full-time	8012 (51.38)
Part-time	2322 (14.89)
Other (Retired, Student, Self-Employed, Unemployed, Unknown, prefer not to disclose)	4819 (30.90)
Political Leaning*	
Mean (SD), Median	4.95 (2.48), 5
Total Household Income (CAD) (*n* (%))	
$0-$49,999	1011 (38.63)
$50,000 - $74,999	529 (20.21)
$75,000 - $99,999	454 (17.35)
$100,000 or more	623 (23.81)
Total Household Income (AUD) (*n* (%))	
$0-$53,999	772 (31.91)
$54,000 - $80,999	441 (18.23)
$81,000 - $109,999	414 (17.11)
$110,000 or above	792 (32.74)
Total Household Income (RS) (*n* (%))	
₹0-₹499,999	1233 (40.73)
₹500,000 - ₹749,999	472 (15.59)

₹750,000 - ₹999,999	426 (14.07)
₹1,000,000 or above	896 (29.60)
Total Household Income (GBP) (*n* (%))	
£0-£28,999	1066 (40.68)
£29,000 - £42,999	595 (22.71)
£43,000 - £56,999	397 (15.15)
£57,000 or above	562 (21.45)
Total Household Income (USD) (*n* (%))	
$0-$39,999	1397 (32.19)
$40,000 - $59,999	794 (18.30)
$60,000 - $79,999	661 (15.23)
$80,000 or above	1487 (34.27)
Parental Questions	
Marital Status (*n* (%))	
Single	8280 (51.27)
Married / Common Law	6608 (44.06)
Separated / Divorced or Widowed	706 (4.67)
Children (*n* (%))	
Yes, I have children	6737 (43.20)
No, I don’t have children	8857 (56.80)
Pregnancy Status (*n* (%))	
Pregnant	755 (11.27)
Non-pregnant	5943 (88.73)
Endorsed Developmental Conditions (Participants’ Children) (*n* (%))	
No	5271 (78.24)
Yes	1169 (17.35)

I don't know	235 (3.49)
Identified Developmental Conditions (Participants) (*n* (%))	
No	5736 (85.33)
Yes	833 (12.39)
I don't know	153 (2.28)

*Question: *In politics, people sometimes talk about the 'left' and the 'right'. On a scale where '0' means left and '10' means right, where would you place yourself on the scale?*

Factor Analyses

We estimated two-, three-, and four-factor EFA models with the exploratory data. While the four-factor model had the best parsimony-adjusted fit statistics (according to the TLI and RMSEA), there were no items whose strongest loading was on the fourth factor. A three-factor model also fit this dataset well, but only two items (items one and five) had their strongest loading on the third factor.

Next, we estimated a two-factor CFA model with the exploratory data; this model was inspired by the three-factor EFA model, such that one factor was defined by the items with high loadings on the first EFA factor and the other factor defined by items with high loadings on the second EFA factor, leaving out items one and five. This model fit the exploratory data reasonably well (i.e., CFI = .90, TLI = .88, RMSEA = .067, SRMR = .059). A three-factor CFA model inspired by the three-factor EFA model with items one and five forming their own factor (the third factor) also fit reasonably well (i.e., CFI = .88, TLI = .86, RMSEA = .072, SRMR = .061). Importantly, although factors one and three were moderately correlated (r = .59), their correlation was not strong enough to imply that items one and five should load on the first factor instead of forming a third factor.

When we examined the conceptual content of the individual items forming the three factors, we identified similar themes as Green et al. (2022), with (1) factor one defined by items describing preferences to lower exposure and concern regarding exposure, (2) factor two defined by items describing knowledge of the regulation of toxic chemicals by government and industry, and (3) factor three defined by items describing knowledge of developmental neurotoxicity. Finally, we fit the final three-factor CFA model to the held-out, confirmatory dataset. Although the EFA analyses suggested a separate factor for items 1 and 5, (knowledge of developmental neurotoxicity), we estimated a model in which other items that also described knowledge of developmental neurotoxicity (items 8 and 14) were indicators of factor three (instead of items 8 and 14 being an indicator of factor one, preferences to lower exposure and increase prevention efforts) using the confirmatory dataset, and found that the overall model fit was very similar to the previous three-factor CFA model (i.e., CFI = .87 , TLI = .84 , RMSEA = .076 , SRMR = .062). Because this model had better interpretability, we retained it for subsequent analyses. The items on the three factors, (1) preferences to lower exposure and increase prevention efforts, (2) knowledge of the regulation of toxic chemicals by government and industry, and (3) knowledge of developmental neurotoxicity, as well as their factor loading estimates, are shown in Table 2.

Table 2. *Confirmatory factor analysis for PRoTECT*

	Item Text	Factor loading Estimate	Standard Error
Factor 1*: Preferences to lower exposure and increase prevention efforts*			
Item 6	When it comes to addressing developmental conditions affecting children, most governments spend the majority of the health budget on management and treatment of these conditions. I think governments should spend more of their budget to find ways to prevent children from developing these conditions.	0.514	0.008
Item 9	I want to learn more about how to reduce children's exposure to toxic chemicals.	0.610	0.008

Item 10	Of all the sources of information about health impacts from toxic chemicals, I trust information coming from scientists who study them.	0.448	0.008
Item 11	Exposure to toxic chemicals is particularly harmful to babies and children.	0.538	0.008
Item 13	More children would benefit by regulating and reducing toxic chemicals to **prevent** developmental conditions than the number of children who benefit from **treatment** of these conditions.	0.511	0.007
Item 15	My government should strengthen their policies and programs to make sure that consumer products do not contain toxic chemicals that are harmful to children.	0.564	0.007
Item 16	If I knew how to reduce children's exposure to toxic chemicals, I would try to do it.	0.581	0.008
Item 17	I try to purchase products that do not contain toxic chemicals that may be harmful to my family.	0.543	0.008
Factor 2: *Knowledge of regulations of toxic chemicals by government and industry*			
Item 2	Most governments spend about the same amount to **prevent** developmental conditions as they spend to **treat** these conditions.	0.862	0.010
Item 3	All parents have equal opportunities to protect their children from toxic chemicals like pesticides or heavy metals, regardless of income level, race and ethnicity, or where they live.	0.990	0.011
Item 4	My government has effective regulations to ensure that food and personal care products do not contain harmful levels of toxic chemicals.	0.679	0.010
Item 7	If toxic chemicals were a threat to my family's health, my pediatrician, doctor, or health care provider would have told me about it.	0.692	0.010
Item 12	I trust that most companies make products that don't contain harmful levels of toxic chemicals.	0.768	0.011
Factor 3: *Knowledge of developmental neurotoxicity*			
Item 1	Toxic chemicals in our day-to-day lives, like air pollution or lead in drinking water, can increase a child's risk of developing conditions like ADHD or autism.	0.737	0.012
Item 5	Reducing exposure to toxic chemicals during pregnancy and in early childhood can help lower a child's risk of developing a condition like ADHD or autism.	0.751	0.010
Item 8	Exposure to toxic chemicals during pregnancy can increase a child's risk of having a developmental condition.	0.596	0.009

Item 14	Toxic chemicals can be detected in the blood of most pregnant women.	0.387	0.008

Table 3 gives the percentages of each item response as well as the means and standard deviations (SDs) of the item scores. Subscales were created by averaging the item scores across the items loading on each factor. Items in subscale one (preferences to reduce exposure and increase prevention) were modestly to strongly correlated with each other (i.e., $r = .28$ to .51), items in subscale two (attitudes towards regulatory sources of chemicals) were moderately to strongly correlated (i.e., $r = .34$ to .52), and items in subscale three (knowledge of developmental neurotoxicity) were modestly to strongly correlated (i.e., $r = .26$ to .59). These subscales had sufficient reliability estimates with omega coefficients (McDonald, 1999) of 0.84, 0.77 and 0.74 for subscales one, two, and three, respectively. Subscale one (preferences to lower exposure and increase prevention) was strongly correlated with subscale three (knowledge of developmental neurotoxicity), $r = .59$. In contrast, subscale one was weakly correlated with subscale two (attitudes towards regulations of chemicals by industry and government), $r = -.11$. Subscale two was modestly negatively associated with subscale three, $r = -.25$.

Overall, participants tended to endorse the highest scores on preferences to reduce exposures and increase prevention efforts (subscale one) compared to the other two subscales with a mean(SD) of 4.21(0.59). Participants also tended to endorse high scores about knowledge of toxic chemicals and developmental neurotoxicity (subscale three), albeit less than for subscale one, indicating awareness around the impact of toxic chemicals on neurodevelopment M(SD) = 3.90(0.72). In contrast, relative to subscales one and three, participants tended to endorse lower scores on the regulations of toxic chemicals by government and industry (subscale two), with a mean(SD) of 2.83(0.91), indicating more neutral attitudes (i.e., or unsure) that industry and government are doing enough to regulate toxic chemicals.

Table 3. *Percentage and mean(SD) for responses on each item of PRoTECT*

Item	Item Text	M(SD)	Strongly disagree (1)	Disagree	Neither agree nor disagree	Agree	Strongly agree (5)
Subscale one: *Preferences to lower exposure and increase prevention*		4.21(0.59)					
Item 6	When it comes to addressing developmental conditions affecting children, most governments spend the majority of the health budget on management and treatment of these conditions. I think governments should spend more of their budget to find ways to prevent children from developing these conditions.	4.02(0.99)	2.40	4.76	19.33	35.87	37.64
Item 9	I want to learn more about how to reduce children's exposure to toxic chemicals.	4.06(0.99)	2.33	4.64	18.74	33.41	40.88
Item 10	Of all the sources of information about health impacts from toxic chemicals, I trust information coming from scientists who study them.	4.20(0.88)	1.08	3.07	14.99	36.52	44.34
Item 11	Exposure to toxic chemicals is particularly harmful to babies and children.	4.41(0.83)	0.72	2.28	10.90	27.46	58.64
Item 13	More children would benefit by regulating and reducing toxic chemicals to **prevent** developmental conditions than the number of children who benefit from **treatment** of these conditions.	4.10(0.88)	0.98	2.50	20.63	37.28	38.61
Item 15	My government should strengthen their policies and programs to make sure that consumer products do not contain toxic chemicals that are harmful to children.	4.35(0.83)	0.93	1.65	12.90	30.61	53.91
Item 16	If I knew how to reduce children's exposure to toxic chemicals, I would try to do it.	4.39(0.84)	0.81	2.17	12.15	26.82	58.05
Item 17	I try to purchase products that do not contain toxic chemicals that may be harmful to my family.	4.17(0.92)	1.15	3.66	17.54	32.47	45.18

Item	Item Text	M(SD)	Strongly agree (1)	Agree	Neither agree nor disagree	Disagree	Strongly disagree (5)

Subscale two: *Attitudes towards regulations of toxic chemicals by government and industry**		2.83(0.91)					
Item 2	Most governments spend about the same amount to **prevent** developmental conditions as they spend to **treat** these conditions.	3.05(1.23)	11.9	23.68	25.52	25.08	13.83
Item 3	All parents have equal opportunities to protect their children from toxic chemicals like pesticides or heavy metals, regardless of income level, race and ethnicity, or where they live.	2.99(1.51)	23.94	19.37	13.46	20.39	22.83
Item 4	My government has effective regulations to ensure that food and personal care products do not contain harmful levels of toxic chemicals.	2.63(1.15)	15.63	36.69	24.14	16.08	7.46
Item 7	If toxic chemicals were a threat to my family's health, my pediatrician, doctor, or health care provider would have told me about it.	2.60(1.17)	20.10	30.06	25.80	17.86	6.17
Item 12	I trust that most companies make products that don't contain harmful levels of toxic chemicals.	2.87(1.24)	14.63	28.30	23.42	22.28	11.37
Item	Item Text	M(SD)	Strongly disagree (1)	Disagree	Neither agree nor disagree	Agree	Strongly agree (5)
Subscale three: *Knowledge of developmental neurotoxicity*		3.90(0.72)					
Item 1	Toxic chemicals in our day-to-day lives, like air pollution or lead in drinking water, can increase a child's risk of developing conditions like ADHD or autism.	3.83(1.14)	5.19	7.68	20.49	32.04	34.61
Item 5	Reducing exposure to toxic chemicals during pregnancy and in early childhood can help lower a child's risk of developing a condition like ADHD or autism.	3.96(1.00)	2.69	4.90	21.85	35.06	35.50
Item 8	Exposure to toxic chemicals during pregnancy can increase a child's risk of having a developmental condition.	4.25(0.86)	0.95	2.42	14.89	34.64	47.10
Item 14	Toxic chemicals can be detected in the blood of most pregnant women.	3.57(0.89)	1.31	6.76	42.58	32.57	16.78

Differences in Subscale Responses by Demographic Factors

Subscale One: Preferences Towards Lower Exposure to Toxic Chemicals and for Prevention. Participants from India endorsed higher scores (more likely to agree or strongly agree) on subscale one compared to participants from other countries, with a mean(SD) of 4.49(0.51) in relation to the U.S. (4.24(0.57)), Canada (4.13(0.61)), Australia (4.12(0.60)), and the U.K. (4.03(0.58)). This subscale difference was most strongly determined by item 9, such that 67.7% of Indian participants strongly agreed that they wanted to learn more about how to reduce children's exposure to toxic chemicals, compared to 38.8% of participants from the U.S., 35.9% of Canadian participants, 32.3% of Australian participants, and 28.2% of participants from the U.K.

We also observed that higher levels of education were associated with higher scores on subscale one, with the mean(SD) for participants with master's, doctorate, or professional degrees of 4.36(0.57) in comparison to those who completed a bachelor's degree or diploma (4.26(0.56)), some college or university (4.16(0.58)), and high school or less (4.06(0.63)). Specifically, 47.4% of participants with the highest education (master's, doctorate, or professional degrees) strongly agreed with the 'prevention paradox' (that more children would benefit by regulating and reducing toxic chemicals to prevent developmental conditions than the number of children who benefit from treatment of these conditions; item 13) compared with 39.6% of participants with a bachelor's degree or diploma, 34.3% of participants with some college or university, and 32.9% of participants with a high school degree or less.

Lastly, there was a very slight difference based on parental status, such that parents had a higher mean(SD) score of 4.27(0.57) compared to non-parents' score of 4.17(0.60). We observed no substantial differences in mean scores based on gender, pregnancy status, age, or having a child with an NDD. More details on distributions across demographic factors can be found in Table 4 and Supplemental Table 1.

Subscale Two: Attitudes Towards Regulation of Toxic Chemicals by Government and Industry. For subscale two, participants from the U.S. had the highest scores with a mean(SD) of 3.26(0.88), indicating they have less trust in industry's regulations of toxic chemicals and do not believe that government is doing enough to regulate chemicals, compared to participants from other countries (Canada: 2.88(0.87), the U.K.: 2.81(0.79), Australia: 2.70(0.79), India: 2.30(0.87)). Specifically, there were large differences across an item asking about social justice, such that 38.1% of participants from the U.S. strongly disagreed that all parents have equal opportunities to protect their children from toxic chemicals (item 3), compared to 24% of Canadian participants, 19% of participants from the U.K., 17.8% of Australian participants, and 9.2% of Indian participants.

We found slight age differences such that mean(SD) scores tended to be higher among older participants (r = .09). Females also tended to have slightly higher scores (2.92(0.91)) than males (2.72(0.90)). We observed modest differences based on parental and pregnancy status, such that non-parents (2.90(0.89)) and non-pregnant women (2.79(0.92)) had higher mean scores (less trust in industry's regulations of toxic chemicals) than parents (2.74(0.93)) and pregnant women (2.36(0.91)). More details on distributions across demographic factors can be found in Table 4 and Supplemental Table 1.

Subscale Three: Knowledge of Developmental Neurotoxicity. We also observed differences in knowledge of developmental neurotoxicity by country. These were consistent with subscale one, such that participants from India had higher scores than participants from other countries, with a mean(SD) of 4.35(0.55), in comparison to 3.93(0.68) for the U.S., 3.81(0.71) for Canada, 3.72(0.72) for Australia, and 3.61(0.70) for the U.K. In particular, 65% of participants from India strongly agreed that gestational exposures to toxic chemicals can increase a child's risk of having a developmental condition (item 8), compared with 52.3% of participants from the U.S., 43.8% of participants from Canada, 37.9% of participants from Australia, and 30.9% of participants from the U.K.

As noted with subscale one, mean scores also increased with higher levels of education. Specifically, participants with the highest level of education had greater knowledge of developmental neurotoxicity than those with the lower levels of education, with the mean(SD) for participants with master's, doctorate, or professional degrees of 4.11(0.68) in comparison to those who completed a bachelor's degree or diploma (3.93(0.69)), some college or university (3.82(0.73)), and high school or less (3.76(0.73)). For example, 46.3% of participants with the highest education level strongly agreed that reducing exposure to toxic chemicals during pregnancy and in early childhood can help lower a child's risk of developing a condition like ADHD or ASD (item 5) compared to 36.3% of participants with a bachelor's degree or diploma, 31.7% of participants with some college or university, and 28.4% of participants with a high school degree or less.

In contrast to subscale two, males (4.00(0.67)) had slightly higher mean(SD) scores than females (3.82(0.74)) indicating greater knowledge of toxic chemicals and developmental neurotoxicity; furthermore, pregnant women (4.07(0.68)) had slightly higher scores compared to non-pregnant women (3.91(0.72)). More details on distributions across demographic factors can be found in Table 4 and Supplemental Table 1.

Table 4. *Responses on PRoTECT subscales by demographic characteristics*

	M(SD)

Demographic Factor	Subscale one: *Preferences to lower exposure and increase prevention*	Subscale two: *Attitudes Towards Regulations of Toxic Chemicals*	Subscale three: *Knowledge of Developmental Neurotoxicity*
Gender			
Female	4.21 (0.58)	2.92 (0.91)	3.82 (0.74)
Male	4.21 (0.60)	2.72 (0.90)	4.00 (0.67)
Non-Binary	4.07 (0.66)	3.32 (0.91)	3.47 (0.86)
Country			
Canada	4.13 (0.61)	2.88 (0.87)	3.81 (0.71)
Australia	4.12 (0.60)	2.70 (0.79)	3.72 (0.72)
India	4.49 (0.51)	2.30 (0.87)	4.35 (0.55)
United Kingdom	4.03 (0.58)	2.81 (0.79)	3.61 (0.70)
United States	4.24 (0.57)	3.26 (0.88)	3.93 (0.68)
Ethnic Groups			
White	4.12 (0.58)	3.02 (0.86)	3.72 (0.72)
Black	4.25 (0.58)	2.95 (0.93)	4.02 (0.67)
South Asian	4.47 (0.5)	2.37 (0.88)	4.32 (0.56)
Other	4.18 (0.63)	2.76 (0.90)	3.92 (0.7)
Age (Years)			
18-24 years	4.14 (0.63)	2.68 (0.85)	3.85 (0.75)
25-32 years	4.24 (0.57)	2.81 (0.92)	3.92 (0.72)
35-39 years	4.23 (0.59)	2.92 (0.92)	3.92 (0.69)
40+ years	4.19 (0.59)	2.87 (0.92)	3.88 (0.71)
Level of Education			
High school or less	4.06 (0.63)	2.75 (0.83)	3.76 (0.73)
Some college or university, no degree/diploma	4.16 (0.58)	3.00 (0.87)	3.82 (0.73)

Bachelor's degree or diploma	4.26 (0.56)	2.90 (0.91)	3.93 (0.69)
Master's, doctorate or professional degree	4.36 (0.57)	2.65 (1.00)	4.11 (0.68)
Children			
Yes, I have children	4.27 (0.57)	2.74 (0.93)	3.93 (0.72)
No, I don't have children	4.17 (0.6)	2.90 (0.89)	3.88 (0.72)
Pregnancy Status (No (%))			
Pregnant	4.25 (0.6)	2.36 (0.91)	4.07 (0.68)
Non-pregnant	4.28 (0.57)	2.79 (0.92)	3.91 (0.72)
Identified Developmental Conditions (Participants' Children)			
No	4.29 (0.57)	2.68 (0.92)	3.98 (0.69)
Yes	4.21 (0.58)	2.94 (0.93)	3.75 (0.80)

Discussion

Little is known about the public's knowledge about how toxic chemicals affect brain development or about their concern over their exposure to toxic chemicals and their preference for prevention of NDDs. Using a large international sample, we administered *PRoTECT* to identify patterns of knowledge, preferences, and intentions related to developmental neurotoxicology.

Factor analyses were used to determine a three-factor model that adequately explains the associations among individual *PRoTECT* item responses. The content domains of the items comprising the three factors had very similar themes as the original model described in Green et al. (2022), which had factors representing (1) preferences to reduce exposure to toxic chemicals and increase prevention efforts, (2) trust in authority sources about exposure to toxic chemicals, (3) knowledge of developmental neurotoxicity, and (4) knowledge about toxic chemicals and society. In the current analyses, factors two and four from Green et al. (2022) were combined to form factor two. The content domains corresponding to the resulting three factors included: (1) preferences to lower exposure and levels of concern regarding exposure, (2) knowledge of the regulation of toxic chemicals by government and industry, and (3) knowledge of developmental neurotoxicity. In the current study, subscale scores were created by averaging scores for the items loading on each of these factors.

Overall, participants had high mean scores on subscale one, assessing preferences towards lowering exposures and increasing prevention efforts, and subscale three, assessing knowledge of developmental neurotoxicity. These subscales were strongly correlated, suggesting that participants who knew more about the impact of toxic chemicals on children's health were also more likely to want to invest in prevention and reduce their exposures.

When asked whether toxic chemicals in our environment can impact brain development, most participants indicated that they can. Although few studies have specifically evaluated the public's knowledge and awareness about the impact of toxic chemicals on NDDs (Rosas et al., 2014), some studies have looked at the public's knowledge of environmental health more broadly and found that the public does not have a strong understanding of *how* the environment can impact human health (Gray, 2018). In a survey of over 800 people using the *Short Assessment of Environmental Health Literacy* questionnaire (Rohlman, Kile, & Irvin, 2022), 99% of respondents had low EHL compared to only 10% of respondents with low general health literacy. Similarly, a systematic review of 31 studies examining EHL found that participants' environmental health knowledge was mixed, with some participants being able to connect environmental exposures with negative health outcomes but unable to describe environmental health definitions or strategies that can be used to reduce exposures (Gray, 2018).

We also found that, on average, participants had less awareness related to government and industry regulations of toxic chemicals and tended to endorse the sentiment that all parents have equal opportunities to protect their children from toxic chemicals (subscale two). In addition, subscale two was negatively correlated with knowledge of developmental neurotoxicity (subscale three), suggesting that participants who knew more about the impacts of toxic chemicals on health also believed that their government and industry were doing enough to monitor exposures. Moreover, despite 84% of people endorsing a wish for government to do more to regulate toxic chemicals, more than half of the participants believed that their governments were doing enough to ensure that harmful levels of toxic chemicals were not being released into the environment. These results suggest that educating the public on the frequent failures of industry to monitor chemicals and lack of governmental regulatory surveillance is an important area of KT. Such public awareness could empower people to advocate for stricter regulations of chemicals and limitations of regulatory agencies.

Across the items on *PRoTECT*, there were some notable differences among demographic variables. Participants in India had higher mean scores on knowledge of developmental neurotoxicity and stronger preferences to reduce exposure to toxic chemicals than those in Australia, Canada, the U.K., and the U.S. This result may indicate that people in India feel that toxic chemicals in their environment pose a greater threat to their children’s health relative to Western participants. It could also be that there is more public health awareness around the impact of toxic chemicals in India than in other countries. Furthermore, U.S. participants were more likely to distrust industry and government and recognize that parents do not have equal opportunities to protect their children compared with participants in other countries. This result could reflect the changes in U.S. public trust in science and the increasing political polarization over the past few years during the COVID-19 pandemic (Agley, 2020).

Additionally, participants with higher levels of education displayed higher mean scores on knowledge and attitudes towards prevention, suggesting either that they are more familiar with the potential harms posed by toxic chemicals and wish to reduce their exposures, or that they demonstrate a stronger reasoning ability on the items. Scores also tended to be higher with older participants, though not consistently. Gender differences were inconsistent across subscales.

We did not observe many meaningful differences among parents, pregnant women, or people with a child who has an NDD. We did observe lower mean scores among pregnant women and parents on subscale two, suggesting that they may have more trust in industry and government to monitor exposures compared to people who are not pregnant or parents. It could be that parents place more hope and trust in authority to make sure that their kids are not exposed to harmful chemicals or that industry may be more likely to label baby or child products as “chemical-free” or “green” compared to more general products.

Surprisingly, parents with a child with an NDD had lower mean scores across subscales. This result suggests that these parents may not be aware of the connection between toxic chemicals and their children’s conditions. This finding is consistent with the medical system placing a low emphasis on environmental contributors to disease and prevention more broadly (Crighton et al., 2016; Di Renzo et al., 2015; Lanphear, 2015).

While this study investigated differences by certain demographics (age, ethnicity, gender, education, country, parental/pregnancy status, and child with neurodevelopmental disorder), future studies should examine differences according to income, political identification, area of residence (e.g., urban vs. rural), marital status, employment, and number of children. Future studies may also explicitly measure prior knowledge of environmental health and toxic chemicals, which may influence response patterns on *PRoTECT*.

This study had limitations in addition to its strengths. We used CloudResearch's Prime Panels to recruit participants for our internet-based study. This convenience sample may be less representative than samples recruited through traditional means. In our study, participants' must have had access to the internet and thus it is possible that they may be more informed about children's environmental health than the general population. Future research may investigate this topic using a variety of data sources. Yet, by using Prime Panels, we were able to recruit a large, international pool of participants across five countries to elucidate knowledge about the impact of toxic chemicals on neurodevelopment, concerns about exposure, and preferences for prevention.

We hope results of this study will help inform policy makers, HCPs, clinicians, and parents. In our study, participants who knew more about the impact of toxic chemicals on brain development also tended to indicate stronger preferences to reduce their family's exposure and to increase spending on prevention of NDDs. Knowledge and awareness may influence third parties, like companies, to promote the desired behaviour (Rhein & Schmid, 2020). Similarly, it may lead to activism and lobbying of government to create change. Greater knowledge can be used to stimulate greater awareness and advocacy towards stricter regulations. We can place efforts into raising more awareness on the problems posed by toxic chemicals and advocate that turning towards prevention is an important way to promote health. We found that most participants (over 75%) want their government to find ways to spend more of their budget to prevent children from developing NDDs and want their government to strengthen their regulations to make sure consumer products do not contain toxic chemicals. When is it time we listen to their voices?

Supplemental Table 1. *Responses to PRoTECT items by demographic characteristics*

Item	Item Description	Demographic Variable		Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
		Subscale one: *Preferences to lower exposure/concern regarding exposure*						
Item 6	When it comes to addressing developmental conditions affecting children, most governments spend the majority of the health budget on management and treatment of these conditions. I think governments shoul d spend more of their budget to find ways to prevent children from developing these conditions.	Gender						
			Female	200 (2.5%)	399 (5.1%)	1563 (19.8%)	2854 (36.1%)	2884 (36.5%)
			Male	142 (2%)	319 (4.5%)	1279 (18.1%)	2597 (36.7%)	2731 (38.6%)
			Non-Binary	8 (8%)	3 (3%)	22 (22%)	40 (40%)	27 (27%)
		Country						
			Canada	74 (2.7%)	115 (4.2%)	625 (22.8%)	1048 (38.2%)	884 (32.2%)
			Australia	60 (2.3%)	133 (5.2%)	575 (22.4%)	1024 (39.8%)	780 (30.32%)
			India	40 (1.3%)	98 (3.3%)	282 (9.5%)	892 (30%)	1660 (55.9%)
			United Kingdom	75 (2.7%)	169 (6.2%)	692 (25.2%)	1117 (40.7%)	693 (25.2%)
			United States	102 (2.5%)	208 (5.1%)	702 (17.4%)	1415 (34.7%)	1651 (40.5%)
		Pregnancy Status						
			Yes	10 (1.4%)	37 (5%)	129 (17.5%)	258 (35.1%)	302 (41%)
			No	133 (2.3%)	304 (5.2%)	1010 (17.4%)	2116 (36.4%)	2258 (38.8%)
		Child ND						
			Yes	89 (1.7%)	256 (4.9%)	882 (17.1%)	1885 (36.5%)	2053 (39.8%)
			No	46 (2.3%)	69 (5.2%)	211 (17.4%)	402 (36.4%)	424 (38.8%)
			I don’t know	7 (3.2%)	11 (5%)	48 (21.8%)	80 (36.4%)	74 (33.6%)
		Parental Status						
			Yes	143 (2.2%)	341 (5.2%)	1150 (17.4%)	2382 (36.1%)	2577 (39.1%)
			No	208 (2.4%)	382 (4.5%)	1726 (20.3%)	3114 (36.5%)	3091 (36.3%)
		Levels of Education						
			High school or less	123 (3.4%)	193 (5.4%)	905 (25.1%)	1276 (35.4%)	1106 (30.7%)

			Some college or university, no degree/ diploma	58 (2.3%)	140 (5.6%)	538 (21.5%)	891 (35.7%)	872 (34.9%)
			Bachelor's degree or diploma	118 (1.9%)	276 (4.5%)	1040 (16.9%)	2333 (37.8%)	2404 (38.9%)
			Master's, doctorate or professional degree	46 (1.7%)	111 (4.11%)	343 (12.7%)	959 (35.5%)	1241 (45.9%)
		Age	18-24 years	91 (2.8%)	149 (4.75)	674 (21.1%)	1132 (35.4%)	1152 (36%)
			25-32 years	114 (2.4%)	244 (5.1%)	845 (17.6%)	1767 (36.9%)	1813 (37.9%)
			33-39 years	87 (2.1%)	207 (5%)	776 (18.8%)	1468 (35.5%)	1593 (38.6%)
			40+ years	59 (1.9%)	123 (4.1%)	581 (19.4%)	1129 (37.6%)	1110 (36.9%)
Item 9	I want to learn more about how to reduce children's exposure to toxic chemicals.	Gender						
			Female	163 (2.1%)	312 (3.9%)	1462 (18.5%)	2703 (34.2%)	3260 (41.3%)
			Male	173 (2.4%)	372 (5.3%)	1296 (18.3%)	2340 (33.1%)	2887 (40.8%)
			Non-Binary	5 (4.1%)	10 (8.3%)	25 (20.8%)	39 (32.5%)	41 (34.2%)
		Country						
			Canada	47 (1.7%)	138 (5%)	614 (22.4%)	959 (34.9%)	988 (35.9%)
			Australia	64 (2.5%)	129 (5%)	586 (22.8%)	961 (37.4%)	832 (32.3%)
			India	14 (0.5%)	38 (1.3%)	199 (6.7%)	709 (23.9%)	2012 (67.7%)
			United Kingdom	76 (2.8%)	162 (5.9%)	604 (22%)	1130 (41.2%)	774 (28.2%)
			United States	142 (3.5%)	231 (5.6%)	790 (19.3%)	1331 (32.6%)	1584 (38.8%)
		Pregnancy Status						
			Yes	9 (1.2%)	25 (3.4%)	94 (12.7%)	242 (32.8%)	366 (49.6%)
			No	71 (1.2%)	176 (3%)	902 (15.5%)	1999 (34.3%)	2673 (45.9%)
		Child ND						
			Yes	60 (1.2%)	159 (3.4%)	738 (12.8%)	1749 (32.9%)	2459 (49.7%)
			No	18 (1.6%)	41 (3.6%)	218 (18.9%)	408 (35.4%)	467 (40.5%)

			I don’t know	2 (0.9%)	1 (0.5%)	39 (17.7%)	69 (31.4%)	109 (49.5%)
		Parental Status						
			Yes	81 (1.2%)	203 (3.1%)	1000 (15.2%)	2248 (34.1%)	3061 (46.4%)
			No	262 (3.1%)	495 (5.8%)	1793 (21%)	2842 (33.4%)	3129 (36.7%)
		Levels of Education						
			High school or less	104 (2.9%)	181 (5%)	918 (25.5%)	1220 (33.9%)	1180 (32.8%)
			Some college or university, no degree/ diploma	65 (2.6%)	138 (5.5%)	523 (21%)	862 (34.5%)	911 (36.5%)
			Bachelor's degree or diploma	125 (2%)	282 (4.6%)	952 (15.4%)	2200 (35.7%)	2612 (42.3%)
			Master's, doctorate or professional degree	43 (1.6%)	86 (3.2%)	352 (13%)	772 (28.6%)	1447 (53.6%)
		Age						
			18-24 years	71 (2.2%)	153 (4.8%)	564 (17.6%)	1103 (34.5%)	1307 (40.1%)
			25-32 years	83 (1.7%)	185 (3.9%)	799 (16.7%)	1597 (33.4%)	2119 (44.3%)
			33-39 years	99 (2.4%)	194 (4.7%)	790 (19.1%)	1360 (32.9%)	1688 (40.9%)
			40+ years	90 (2.9%)	166 (5.5%)	640 (21.3%)	1030 (34.3%)	1076 (35.8%)
Item 10	Of all the sources of information about health impacts from toxic chemicals, I trust information coming from scientists who study them.	Gender						
			Female	92 (1.2%)	238 (3%)	1240 (15.7%)	2975 (37.7%)	3355 (42.5%)
			Male	57 (0.8%)	223 (3.2%)	967 (13.7%)	2545 (36%)	3276 (46.3%)
			Non-Binary	2 (1.7%)	4 (3.3%)	22 (18.3%)	26 (21.7%)	66 (55%)
		Country						
			Canada	33 (1.2%)	81 (2.9%)	491 (17.9%)	1045 (38.1%)	1096 (39.9%)
			Australia	22 (0.9%)	79 (3.1%)	441 (17.1%)	1015 (39.5%)	1015 (39.5%)
			India	12 (0.4%)	34 (1.1%)	215 (7.2%)	857 (28.8%)	1854 (62.4%)
			United Kingdom	25 (0.9%)	102 (3.7%)	543 (19.8%)	1160 (42.2%)	916 (33.4%)

			United States	62 (1.5%)	172 (4.2%)	544 (13.3%)	1479 (36.3%)	1821 (44.7%)
		Pregnancy Status						
			Yes	7 (0.95%)	21 (2.9%)	122 (16.6%)	247 (33.6%)	339 (46.1%)
			No	58 (0.99%)	197 (3.4%)	827 (14.2%)	2261 (38.8%)	2478 (42.6%)
		Child ND						
			Yes	52 (1%)	157 (3%)	713 (13.8%)	1956 (37.9%)	2287 (44.3%)
			No	13 (1.1%)	54 (4.7%)	194 (16.8%)	450 (39.1%)	441 (38.3%)
			I don't know	0 (0%)	6 (2.7%)	46 (20.9%)	81 (36.8%)	87 (39.5%)
		Parental Status						
			Yes	65 (0.98%)	218 (3.3%)	957 (14.5%)	2515 (38.1%)	2838 (43%)
			No	89 (1%)	250 (2.9%)	1277 (15%)	3041 (35.7%)	3864 (45.3%)
		Levels of Education						
			High school or less	58 (1.6%)	162 (4.5%)	776 (21.5%)	1336 (37.1%)	1271 (35.3%)
			Some college or university, no degree/ diploma	35 (1.4%)	86 (3.4%)	414 (16.6%)	977 (39.1%)	987 (39.5%)
			Bachelor's degree or diploma	42 (0.7%)	176 (2.8%)	749 (12.1%)	2341 (37.9%)	2863 (46.4%)
			Master's, doctorate or professional degree	16 (0.6%)	40 (1.5%)	257 (9.5%)	858 (31.8%)	1529 (56.6%)
		Age						
			18-24 years	34 (1.1%)	101 (3.2%)	461 (14.4%)	1106 (34.6%)	1496 (46.8%)
			25-32 years	41 (0.9%)	133 (2.8%)	688 (14.4%)	1671 (34.9%)	2250 (47%)
			33-39 years	45 (1.1%)	129 (3.1%)	593 (14.4%)	1575 (38.1%)	1789 (43.3%)
			40+ years	34 (1.1%)	105 (3.5%)	492 (16.4%)	1204 (40.1%)	1167 (38.9%)
Item 11	Exposure to toxic chemicals is particularly harmful to babies and children.	Gender						
			Female	44 (0.6%)	135 (1.7%)	866 (10.9%)	2265 (28.7%)	4590 (58.1%)
			Male	59 (0.8%)	195 (2.8%)	735 (10.4%)	1899 (26.9%)	4180 (59.1%)

	Non-Binary	1 (0.8%)	7 (5.8%)	10 (8.3%)	31 (25.8%)	71 (59.2%)
Country						
	Canada	30 (1.1%)	61 (2.2%)	352 (12.8%)	757 (27.6%)	1546 (56.3%)
	Australia	17 (0.7%)	69 (2.7%)	336 (13.1%)	759 (29.5%)	1391 (54.1%)
	India	22 (0.7%)	81 (2.7%)	196 (6.6%)	708 (23.8%)	1965 (66.1%)
	United Kingdom	16 (0.6%)	67 (2.4%)	416 (15.1%)	1039 (37.8%)	1208 (44%)
	United States	19 (0.5%)	62 (1.5%)	319 (7.8%)	937 (23%)	2741 (67.2%)
Pregnancy Status						
	Yes	6 (0.8%)	22 (3%)	80 (10.9%)	226 (30.1%)	402 (54.6%)
	No	34 (0.6%)	95 (1.6%)	558 (9.6%)	1611 (27.7%)	3523 (60.5%)
Child ND						
	Yes	33 (0.6%)	88 (1.7%)	485 (9.4%)	1441 (27.9%)	3118 (60.4%)
	No	6 (0.5%)	23 (2%)	127 (11%)	329 (28.6%)	667 (57.9%)
	I don’t know	1 (0.5%)	5 (2.3%)	23 (10.5%)	62 (28.2%)	129 (58.6%)
Parental Status						
	Yes	40 (0.6%)	119 (1.8%)	640 (9.7%)	1847 (28%)	3947 (59.9%)
	No	64 (0.8%)	221 (2.6%)	979 (11.5%)	2353 (27.6%)	4904 (57.6%)
Levels of Education						
	High school or less	40 (1.1%)	98 (2.7%)	564 (15.7%)	997 (27.7%)	1904 (52.8%)
	Some college or university, no degree/ diploma	16 (0.6%)	58 (2.3%)	267 (10.7%)	661 (26.5%)	1497 (59.9%)
	Bachelor's degree or diploma	26 (0.4%)	107 (1.7%)	540 (8.8%)	1799 (29.2%)	3699 (60%)

			Master's, doctorate or professional degree	19 (0.7%)	69 (2.6%)	210 (7.8%)	711 (26.3%)	1691 (62.6%)
		Age						
			18-24 years	39 (1.2%)	128 (4%)	423 (13.2%)	837 (26.2%)	1771 (55.4%)
			25-32 years	29 (0.6%)	101 (2.1%)	469 (9.8%)	1308 (27.3%)	2876 (60.1%)
			33-39 years	21 (0.5%)	68 (1.6%)	408 (9.9%)	1176 (28.5%)	2458 (59.5%)
			40+ years	15 (0.5%)	43 (1.4%)	319 (10.6%)	879 (29.3%)	1746 (58.2%)
Item 13	More children would benefit by regulating and reducing toxic chemicals to **prevent** development al conditions than the number of children who benefit from **treatment** of these conditions.	Gender						
			Female	71 (0.9%)	196 (2.5%)	1766 (22.4%)	2962 (37.5%)	2905 (36.8%)
			Male	65 (0.9%)	168 (2.4%)	1270 (18%)	2695 (38.1%)	2870 (40.6%)
			Non-Binary	7 (5.8%)	6 (5%)	36 (30%)	35 (29.2%)	36 (30%)
		Country						
			Canada	31 (1.1%)	68 (2.5%)	649 (23.6%)	1044 (38%)	954 (34.7%)
			Australia	34 (1.3%)	69 (2.7%)	591 (23%)	1047 (40.7%)	831 (32.3%)
			India	17 (0.6%)	35 (1.2%)	344 (11.6%)	1019 (34.3%)	1557 (52.4%)
			United Kingdom	30 (1.1%)	72 (2.6%)	677 (24.7%)	1168 (42.5%)	799 (29.1%)
			United States	32 (0.8%)	127 (3.1%)	824 (20.2%)	1420 (34.8%)	1675 (41.1%)
		Pregnancy Status						
			Yes	7 (0.9%)	17 (2.3%)	111 (15.1%)	294 (39.9%)	307 (41.7%)
			No	37 (0.6%)	125 (2.1%)	1145 (19.7%)	2181 (37.5%)	2333 (40.1%)
		Child ND						
			Yes	24 (0.5%)	100 (1.9%)	940 (18.2%)	1967 (38.1%)	2134 (41.3%)
			No	19 (1.6%)	35 (3%)	248 (21.5%)	434 (37.7%)	416 (36.1%)
			I don’t know	1 (0.5%)	5 (2.3%)	61 (27.7%)	76 (34.5%)	77 (35%)
		Parental Status						
			Yes	45 (0.7%)	142 (2.2%)	1264 (19.2%)	2489 (37.8%)	45 (40.2%)

			No	99 (1.2%)	229 (2.7%)	1821 (21.4%)	3209 (37.7%)	99 (37.1%)
		Levels of Education						
			High school or less	49 (1.4%)	93 (2.6%)	979 (27.2%)	1297 (36%)	1185 (32.9%)
			Some college or university, no degree/ diploma	28 (1.1%)	87 (3.5%)	581 (23.2%)	945 (37.8%)	858 (34.3%)
			Bachelor's degree or diploma	44 (0.7%)	120 (1.9%)	1089 (17.6%)	2473 (40.1)	2445 (39.6%)
			Master's, doctorate or professional degree	17 (0.6%)	64 (2.4%)	389 (14.4%)	950 (35.2%)	1280 (47.4%)
		Age						
			18-24 years	63 (2%)	104 (3.3%)	738 (23.1%)	1173 (36.7%)	1120 (35%)
			25-32 years	39 (0.8%)	117 (2.4%)	917 (19.2%)	1834 (38.3%)	1876 (39.2%)
			33-39 years	26 (0.6%)	94 (2.3%)	834 (20.2%)	1530 (37%)	1647 (39.9%)
			40+ years	16 (0.5%)	56 (1.9%)	596 (19.9%)	1161 (38.7%)	1173 (39.1%)
Item 15	My government should strengthen their policies and programs to make sure that consumer products do not contain toxic chemicals that are harmful to children.	Gender						
			Female	55 (0.7%)	109 (1.4%)	983 (12.4%)	2421 (30.6%)	4332 (54.8%)
			Male	65 (0.9%)	126 (1.8%)	902 (12.8%)	2220 (31.4%)	3755 (53.1%)
			Non-Binary	1 (0.8%)	5 (4.2%)	18 (15%)	26 (21.7%)	70 (58.3%)
		Country						
			Canada	31 (1.1%)	52 (1.9%)	431 (15.7%)	903 (32.9%)	1329 (48.4%)
			Australia	11 (0.4%)	39 (1.5%)	401 (15.6%)	915 (35.6%)	1206 (46.9%)
			India	23 (0.8%)	41 (1.4%)	203 (6.8%)	664 (22.3%)	2041 (68.7%)
			United Kingdom	19 (0.7%)	39 (1.42%)	441 (16.1%)	1029 (37.5%)	1218 (44.4%)
			United States	37 (0.9%)	71 (1.7%)	438 (10.7%)	1163 (28.5%)	2369 (58.1%)
		Pregnancy Status						
			Yes	6	17 (2.3%)	87 (11.8%)	244 (33.2%)	382 (51.9%)

				(0.8%)				
			No	27 (0.5%)	88 (1.5%)	656 (11.3%)	1811 (31.1%)	3239 (55.6%)
		Child ND						
			Yes	23 (0.4%)	86 (1.7%)	578 (11.2%)	1629 (31.5%)	2849 (55.2%)
			No	9 (0.8%)	16 (1.4%)	136 (11.8%)	364 (31.6%)	627 (54.4%)
			I don't know	1 (0.5%)	3 (1.4%)	28 (12.7%)	56 (25.5%)	132 (60%)
		Parental Status						
			Yes	33 (0.5%)	106 (1.6%)	749 (11.4%)	2064 (31.3%)	3641 (55.2%)
			No	88 (1%)	136 (1.6%)	1165 (13.7%)	2610 (30.6%)	4522 (53.1%)
		Levels of Education						
			High school or less	32 (0.9%)	66 (1.8%)	636 (17.7%)	1123 (31.2%)	1746 (48.5%)
			Some college or university, no degree/ diploma	25 (1%)	41 (1.6%)	318 (12.7%)	792 (31.7%)	1323 (52.9%)
			Bachelor's degree or diploma	43 (0.7%)	80 (1.3%)	667 (10.8%)	1975 (32%)	3406 (55.2%)
			Master's, doctorate or professional degree	14 (0.5%)	51 (1.9%)	254 (9.4%)	753 (27.9%)	1628 (60.3%)
		Age						
			18-24 years	38 (1.2%)	79 (2.5%)	487 (15.2%)	933 (29.2%)	1661 (51.9%)
			25-32 years	35 (0.7%)	70 (1.5%)	581 (12.1%)	1518 (31.7%)	2579 (53.9%)
			33-39 years	27 (0.7%)	57 (1.4%)	478 (11.6%)	1298 (31.4%)	2271 (55%)
			40+ years	21 (0.7%)	36 (1.2%)	368 (12.3%)	925 (30.8%)	1652 (55%)
Item 16	If I knew how to reduce children's exposure to toxic chemicals, I would try to do it.	Gender						
			Female	47 (0.6%)	134 (1.7%)	883 (11.2%)	2111 (26.7%)	4725 (59.8%)
			Male	62 (0.9%)	185 (2.6%)	896 (12.7%)	1924 (27.2%)	4001 (56.6%)
			Non-Binary	0 (0%)	2 (1.7%)	18 (15%)	28 (23.3%)	72 (60%)
		Country						
			Canada	25	51 (1.9%)	419 (15.3%)	796 (29%)	1455 (53%)

		(0.9%)				
	Australia	18 (0.7%)	55 (21.3%)	388 (15.1%)	735 (28.6%)	1376 (53.5%)
	India	15 (0.5%)	51 (1.7%)	205 (6.9%)	620 (20.9%)	2081 (70%)
	United Kingdom	28 (1%)	82 (3%)	413 (15%)	927 (33.8%)	1296 (47.2%)
	United States	23 (0.6%)	84 (2.1%)	379 (9.3%)	994 (24.4%)	2598 (63.7%)
Pregnancy Status						
	Yes	5 (0.7%)	25 (3.4%)	91 (12.4%)	201 (27.3%)	414 (56.3%)
	No	24 (0.4%)	84 (1.4%)	528 (9.1%)	1462 (25.1%)	3723 (64%)
Child ND						
	Yes	21 (0.4%)	77 (1.5%)	487 (9.4%)	1307 (25.3%)	3273 (63.4%)
	No	7 (0.6%)	26 (2.3%)	111 (9.6%)	301 (26.1%)	707 (61.4%)
	I don’t know	1 (0.5%)	3 (1.4%)	20 (9.1%)	50 (22.7%)	146 (66.4%)
Parental Status						
	Yes	29 (0.4%)	111 (1.7%)	623 (9.4%)	1669 (25.3%)	4161 (63.1%)
	No	80 (0.9%)	212 (2.5%)	1181 (13.9%)	2403 (28.2%)	4645 (54.5%)
Levels of Education						
	High school or less	33 (0.9%)	98 (2.7%)	617 (17.1%)	980 (27.2%)	1875 (52%)
	Some college or university, no degree/ diploma	15 (0.6%)	47 (1.9%)	304 (12.2%)	700 (28%)	1433 (57.3%)
	Bachelor's degree or diploma	39 (0.6%)	112 (1.8%)	592 (9.6%)	1738 (28.2%)	3690 (59.8%)
	Master's, doctorate or professional degree	16 (0.6%)	57 (2.1%)	253 (9.4%)	623 (23.1%)	1751 (64.9%)
Age						
	18-24 years	32 (1%)	112 (3.5%)	480 (15%)	879 (27.5%)	1695 (53%)
	25-32 years	28 (0.6%)	91 (1.9%)	520 (10.9%)	1296 (27.1%)	2848 (59.5%)
	33-39 years	25	69 (1.7%)	459 (11.1%)	1082 (26.2%)	2496 (60.4%)

				(0.6%)				
			40+ years	24 (0.8%)	51 (1.7%)	345 (11.5%)	815 (27.1%)	1767 (58.9%)
Item 17	I try to purchase products that do not contain toxic chemicals that may be harmful to my family.	Gender						
			Female	66 (0.8%)	262 (3.3%)	1352 (17.1%)	2637 (33.4%)	3583 (45.4%)
			Male	97 (1.4%)	267 (3.8%)	1243 (17.6%)	2257 (31.9%)	3204 (45.3%)
			Non-Binary	3 (2.5%)	7 (5.8%)	25 (20.8%)	42 (35%)	43 (35.8%)
		Country						
			Canada	35 (1.3%)	109 (4%)	548 (20%)	941 (34.3%)	1113 (40.5%)
			Australia	19 (0.7%)	77 (3%)	532 (20.7%)	862 (33.5%)	1082 (42.1%)
			India	29 (0.9%)	42 (1.4%)	226 (7.6%)	772 (25.9%)	1903 (64%)
			United Kingdom	42 (1.5%)	147 (5.4%)	661 (24.1%)	999 (36.4%)	897 (32.7%)
			United States	41 (1%)	163 (4%)	664 (16.3%)	1369 (33.6%)	1841 (45.1%)
		Pregnancy Status						
			Yes	8 (1.1%)	23 (3.1%)	101 (13.7%)	233 (31.7%)	371 (50.4%)
			No	43 (0.7%)	148 (2.5%)	886 (15.2%)	1866 (32.1%)	2878 (49.4%)
		Child ND						
			Yes	37 (0.7%)	140 (2.7%)	762 (14.8%)	1621 (31.4%)	2605 (50.4%)
			No	11 (1%)	24 (2.1%)	185 (16.1%)	410 (35.6%)	522 (45.3%)
			I don’t know	2 (0.9%)	5 (2.3%)	38 (17.3%)	61 (27.7%)	114 (51.8%)
		Parental Status						
			Yes	51 (0.8%)	174 (2.6%)	995 (15.1%)	2105 (31.9%)	3268 (49.6%)
			No	115 (1.3%)	364 (4.3%)	1636 (19.2%)	2838 (33.3%)	3568 (41.9%)
		Levels of Education						
			High school or less	52 (1.4%)	139 (3.9%)	866 (24%)	1125 (31.2%)	1421 (39.4%)
			Some college or university, no degree/ diploma	28 (1.1%)	116 (4.6%)	459 (18.4%)	846 (33.9%)	1050 (42%)

Item	Item Text	Demographic Variable		Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
			Bachelor's degree or diploma	54 (0.9%)	209 (3.4%)	924 (15%)	2097 (34%)	2887 (46.8%)
			Master's, doctorate or professional degree	26 (1%)	69 (2.6%)	336 (12.4%)	849 (31.4%)	1420 (52.6%)
		Age						
			18-24 years	53 (1.7%)	155 (4.8%)	601 (18.8%)	992 (31%)	1397 (43.7%)
			25-32 years	38 (0.8%)	172 (3.6%)	775 (16.2%)	1595 (33.3%)	2203 (46.1%)
			33-39 years	37 (0.9%)	131 (3.2%)	70 (17.1%)	1364 (33%)	1893 (45.8%)
			40+ years	38 (1.3%)	80 (2.7%)	549 (18.3%)	992 (33%)	1343 (44.7%)

Item	Item Text	Demographic Variable		Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Subscale two: *Knowledge of regulations of toxic chemicals by government and industry**								
Item 2	Most governments spend about the same amount to **prevent** developmental conditions as they spend to **treat** these conditions.	Gender						
			Female	1170 (14.8%)	2210 (28%)	2016 (25.5%)	1705 (21.6%)	799 (10.1%)
			Male	860 (12.2%)	1582 (22.4%)	1774 (25.1%)	1881 (26.6%)	971 (13.7%)
			Non-Binary	35 (29.2%)	25 (20.8%)	35 (29.2%)	16 (13.3%)	9 (7.5%)
		Country						
			Canada	374 (13.6%)	651 (23.7%)	808 (29.4%)	609 (22.2%)	304 (11.1%)
			Australia	262 (10.2%)	633 (24.6%)	761 (29.6%)	657 (25.5%)	259 (10.1%)
			India	149 (5%)	472 (15.9%)	493 (16.6%)	1114 (37.5%)	744 (25%)
			United Kingdom	301 (11%)	721 (26.3%)	903 (32.9%)	607 (22.1%)	214 (7.8%)
			United States	980 (24%)	1342 (32.9%)	878 (21.5%)	618 (15.2%)	260 (6.4%)
		Pregnancy Status						
			Yes	53 (7.2%)	119 (16.2%)	152 (20.7%)	235 (31.9%)	177 (24%)
			No	790 (13.6%)	1482 (24.5%)	1502 (25.8%)	1369 (23.5%)	678 (11.6%)
		Child ND						
			Yes	585 (11.3%)	1224 (23.7%)	1297 (25.1%)	1338 (25.9%)	721 (13.9%)
			No	219 (19%)	302 (26.2%)	289 (25.1%)	226 (19.6%)	116 (10.1%)
			I don’t know	32 (14.5%)	67 (30.5%)	67 (25.6%)	38 (23.4%)	16 (10.7%)
		Parental Status						
			Yes	844 (12.8%)	1605 (24.3%)	1665 (25.3%)	1614 (24.5%)	865 (13.1%)
			No	1222 (14.3%)	2214 (25.9%)	2178 (25.6%)	1991 (23.4%)	916 (10.7%)

		Levels of Education						
			High school or less	372 (10.3%)	778 (21.6%)	1197 (33.2%)	881 (24.5%)	375 (10.4%)
			Some college or university, no degree/ diploma	401 (16%)	712 (28.5%)	669 (26.8%)	502 (20.1%)	215 (8.6%)
			Bachelor's degree or diploma	930 (15.1%)	1730 (28%)	1448 (23.5%)	1407 (22.8%)	656 (10.6%)
			Master's, doctorate or professional degree	353 (13.1%)	589 (21.8%)	471 (17.4%)	776 (28.7%)	511 (18.9%)
		Age						
			18-24 years	298 (9.3%)	711 (22.2%)	780 (24.4%)	978 (30.6%)	431 (13.5%)
			25-32 years	659 (13.8%)	1198 (25%)	1129 (23.6%)	1157 (24.2%)	640 (13.4%)
			33-39 years	645 (!5.6%)	1129 (27.3%)	1048 (25.4%)	870 (21.1%)	439 (10.6%)
			40+ years	464 (!5.5%)	781 (26%)	886 (29.5%)	600 (20%)	271 (9%)
Item 3	All parents have equal opportunities to protect their children from toxic chemicals like pesticides or heavy metals, regardless of income level, race and ethnicity, or where they live.	Gender						
			Female	1957 (24.7%)	1723 (21.8%)	1038 (13.1%)	1427 (18.1%)	1755 (22.2%)
			Male	1445 (20.4%)	1350 (19.1%)	950 (13.4%)	1486 (21%)	1837 (25.9%)
			Non-Binary	61 (50.8%)	14 (11.7%)	11 (9.2%)	20 (!6.7%)	14 (11.7%)
		Country						
			Canada	660 (24%)	578 (21%)	437 (15.9%)	513 (18.7%)	558 (20.3%)
			Australia	458 (17.8%)	533 (20.7%)	418 (16.3%)	594 (23.1%)	569 (22.1%)
			India	274 (9.2%)	381 (12.8%)	253 (8.5%)	634 (21.3%)	1430 (48.1%)
			United Kingdom	521 (19%)	621 (22.6%)	450 (16.4%)	629 (22.9%)	525 (19.1%)
			United States	1555 (38.1%)	978 (24%)	444 (10.9%)	572 (14%)	529 (13%)
		Pregnancy Status						
			Yes	67 (9.1%)	83 (11.3%)	101 (13.7%)	208 (28.3%)	277 (37.6%)
			No	1180 (20.3%)	1243 (21.4%)	708 (12.2%)	1180 (20.3%)	1510 (25.9%)
		Child ND						
			Yes	916 (17.7%)	1017 (19.7%)	625 (12.1%)	1110 (21.5%)	1497 (29%)
			No	270 (23.4%)	254 (22%)	151 (13.1%)	224 (19.4%)	253

								(22%)
			I don’t know	56 (25.5%)	45 (20.5%)	32 (14.5%)	44 (20%)	43 (19.5%)
		Parental Status						
			Yes	1250 (18.9%)	1328 (20.1%)	814 (12.3%)	1394 (21.1%)	1807 (27.4%)
			No	2218 (26%)	1763 (20.7%)	1188 (13.9%)	1548 (18.2%)	1804 (21.2%)
		Levels of Education						
			High school or less	625 (17.3%)	679 (18.8%)	688 (19.1%)	796 (22.1%)	815 (22.6%)
			Some college or university, no degree/ diploma	675 (27%)	578 (23.1%)	341 (13.6%)	426 (17%)	479 (19.2%)
			Bachelor's degree or diploma	1580 (25.6%)	1361 (22.1%)	672 (10.9%)	1185 (19.2%)	1373 (22.2%)
			Master's, doctorate or professional degree	573 (21.2%)	463 (17.1%)	260 (9.6%)	508 (18.8%)	896 (33.2%)
		Age						
			18-24 years	643 (20.1%)	601 (18.8%)	466 (14.6%)	643 (20.1%)	845 (26.4%)
			25-32 years	1124 (23.5%)	941 (19.7%)	588 (12.3%)	953 (19.9%)	1177 (24.6%)
			33-39 years	1020 (24.7%)	884 (21.4%)	518 (12.5%)	775 (18.8%)	934 (22.6%)
			40+ years	681 (22.7%)	665 (22.2%)	430 (14.3%)	571 (19%)	655 (21.8%)
Item 4	My government has effective regulations to ensure that food and personal care products do not contain harmful levels of toxic chemicals.	Gender						
			Female	635 (8%)	1352 (17.1%)	1992 (25.2%)	2816 (35.6%)	1105 (14%)
			Male	445 (6.3%)	1042 (14.7%)	1606 (22.7%)	2739 (38.8%)	1236 (17.5%)
			Non-Binary	17 (14.2%)	28 (23.3%)	30 (25%)	30 (25%)	15 (12.5%)
		Country						
			Canada	149 (5.4%)	397 (14.5%)	748 (27.2%)	1057 (38.5%)	395 (14.4%)
			Australia	73 (2.8%)	251 (9.8%)	706 (27.4%)	1069 (41.5%)	473 (18.4%)
			India	230 (7.7%)	469 (15.8%)	562 (18.9%)	975 (32.8)	736 (24.8%)
			United Kingdom	121 (4.4%)	352 (12.8%)	751 (27.3%)	113 (41.4%)	384 (14%)
			United States	525 (12.9%)	961 (23.6%)	870 (21.3%)	1353 (33.2%)	369 (9%)
		Pregnancy Status						
			Yes	28	95 (12.9%)	168 (22.8%)	239 (32.5%)	206

				(3.8%)				(28%)
			No	416 (7.1%)	887 (15.2%)	1348 (23.2%)	2213 (38%)	957 (16.4%)
		Child ND						
			Yes	338 (6.5%)	741 (14.3%)	1191 (23.1%)	1936 (37.5%)	959 (18.6%)
			No	85 (7.4%)	205 (17.8%)	263 (22.8%)	432 (37.5%)	167 (14.5%)
			I don’t know	21 (9.5%)	28 (12.7%)	59 (26.8%)	79 (35.9%)	33 (15%)
		Parental Status						
			Yes	445 (6.7%)	985 (14.9%)	1525 (23.1%)	2464 (37.4%)	1174 (17.8%)
			No	653 (7.7%)	1445 (16.9%)	2112 (24.7%)	3128 (36.7%)	1183 (13.8%)
		Levels of Education						
			High school or less	213 (5.9%)	452 (12.5%)	1071 (29.7%)	1295 (35.9%)	572 (15.9%)
			Some college or university, no degree/ diploma	216 (8.6%)	423 (16.9%)	617 (24.7%)	913 (36.5%)	330 (13.2%)
			Bachelor's degree or diploma	465 (7.5%)	1095 (17.7%)	1350 (21.9%)	2390 (38.7%)	871 (14.1%)
			Master's, doctorate or professional degree	196 (7.3%)	449 (16.6%)	543 (20.1%)	957 (35.4%)	555 (20.6%)
		Age						
			18-24 years	218 (6.8%)	491 (15.4%)	817 (25.5%)	1153 (36.1%)	519 (16.2%)
			25-32 years	381 (7.9%)	800 (16.7%)	1118 (23.4%)	1739 (36.4%)	745 (15.6%)
			33-39 years	297 (7.2%)	662 (16%)	991 (23.9%)	1540 (37.3%)	641 (15.5%)
			40+ years	202 (6.7%)	477 (15.9%)	711 (23.7%)	1160 (38.6%)	452 (15.1%)
Item 7	If toxic chemicals were a threat to my family’s health, my pediatrician, doctor, or health care provider would have told me about it.	Gender						
			Female	533 (6.7%)	1622 (20.5%)	2064 (26.1%)	2275 (28.8%)	1406 (17.8%)
			Male	387 (5.5%)	1057 (15%)	1757 (24.9%)	2246 (31.8%)	1621 (22.9%)
			Non-Binary	14 (11.7%)	27 (22.5%)	34 (28.3%)	29 (24.2%)	16 (13.3%)
		Country						
			Canada	198 (7.2%)	516 (18.8%)	770 (28%)	774 (28.2%)	488 (17.8%)
			Australia	121 (4.7%)	408 (15.9%)	700 (27.2%)	859 (33.4%)	484 (18.8%)
			India	39 (1.3%)	212 (7.1%)	521 (17.5%)	1046 (35.2%)	1154 (38.8%)
			United Kingdom	188 (6.8%)	593 (21.6%)	782 (28.5%)	817 (29.8%)	366 (13.3%)

			United States	389 (9.5%)	982 (24.1%)	1092 (26.8%)	1063 (26.1%)	552 (13.5%)
		Pregnancy Status						
			Yes	18 (2.4%)	89 (12.1%)	154 (21%)	242 (32.9%)	233 (31.7%)
			No	363 (6.2%)	994 (17.1%)	1408 (24.2%)	1815 (31.2%)	1241 (21.3%)
		Child ND						
			Yes	260 (5%)	809 (15.7%)	1208 (23.4%)	1657 (32.1%)	1231 (23.8%)
			No	102 (8.9%)	220 (19.1%)	289 (25.1%)	333 (28.9%)	208 (18.1%)
			I don't know	18 (8.2%)	43 (19.5%)	62 (28.2%)	60 (27.3%)	37 (16.8%)
		Parental Status						
			Yes	384 (5.8%)	1085 (16.5%)	1571 (23.8%)	2064 (31.3%)	1489 (22.6%)
			No	551 (6.5%)	1626 (19.1%)	2294 (26.9%)	2495 (29.3%)	1555 (18.2%)
		Levels of Education						
			High school or less	224 (6.2%)	574 (15.9%)	1048 (29.1%)	1066 (29.6%)	691 (19.2%)
			Some college or university, no degree/ diploma	214 (8.6%)	545 (21.8%)	633 (25.3%)	723 (28.9%)	384 (15.4%)
			Bachelor's degree or diploma	391 (6.3%)	1181 (19.1%)	1575 (25.5%)	1860 (30.1%)	1164 (18.9%)
			Master's, doctorate or professional degree	100 (3.7%)	399 (14.8%)	555 (20.6%)	873 (32.3%)	773 (28.6%)
		Age						
			18-24 years	133 (4.2%)	443 (13.9%)	817 (25.5%)	1038 (32.5%)	767 (24%)
			25-32 years	283 (5.9%)	832 (17.4%)	1175 (24.6%)	1481 (31%)	1012 (21.2%)
			33-39 years	288 (6.9%)	804 (19.5%)	1050 (25.4%)	1221 (29.6%)	768 (18.6%)
			40+ years	231 (7.7%)	632 (21.1%)	823 (27.4%)	819 (27.3%)	497 (16.6%)
Item 12	I trust that most companies make products that don't contain harmful levels of toxic chemicals.	Gender						
			Female	928 (11.7%)	1867 (23.6%)	1866 (23.6%)	2202 (27.9%)	1037 (13.1%)
			Male	748 (10.6%)	1488 (21.1%)	1608 (22.8%)	2052 (29%)	1172 (16.7%)
			Non-Binary	25 (20.8%)	31 (25.8%)	27 (22.5%)	28 (23.3%)	9 (7.55)
		Country						
			Canada	317 (11.5%)	623 (22.7%)	722 (26.3%)	757 (27.6%)	327 (11.9%)

Item	Item Text	Demographic Variable		Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
			Australia	183 (7.1%)	507 (19.7%)	691 (26.9%)	792 (30.8%)	399 (15.5%)
			India	244 (8.2%)	553 (18.6%)	589 (19.8%)	853 (28.7%)	733 (24.7%)
			United Kingdom	180 (6.6%)	496 (18.1%)	694 (25.3%)	971 (35.4%)	405 (14.7%)
			United States	780 (19.1%)	1211 (29.7%)	815 (20%)	916 (22.5%)	356 (8.7)
		PregnancyStatus						
			Yes	42 (5.7%)	125 (17%)	149 (20.2%)	212 (28.8%)	208 (28.2%)
			No	627 (10.8%)	1225 (21%)	1333 (22.9%)	1741 (29.9%)	895 (15.4%)
		Child ND						
			Yes	487 (9.4%)	1063 (20.6%)	1147 (22.2%)	1573 (30.5%)	895 (17.3%)
			No	148 (12.8%)	234 (20.3%)	279 (24.2%)	324 (28.1%)	167 (14.5%)
			I don’t know	30 (13.6%)	48 (21.8%)	54 (24.5%)	56 (25.5%)	32 (14.5%)
		Parental Status						
			Yes	670 (10.2%)	1358 (20.6%)	1493 (22.6%)	1963 (29.8%)	1109 (16.8%)
			No	1034 (12.1%)	2032 (23.8%)	2018 (23.7%)	2326 (27.3%)	1111 (13%)
		Levels of Education						
			High school or less	326 (9%)	676 (18.8%)	949 (26.3%)	1098 (30.5%)	554 (15.4%)
			Some college or university, no degree/ diploma	327 (13.1%)	597 (23.9%)	593 (23.7%)	703 (28.1%)	279 (11.2%)
			Bachelor's degree or diploma	746 (12.1%)	1523 (24.7%)	1357 (22%)	1716 (27.8%)	829 (13.4%)
			Master's, doctorate or professional degree	296 (11%)	582 (21.6%)	559 (20.7%)	739 (27.4%)	524 (19.4%)
		Age						
			18-24 years	296 (9.3%)	670 (20.9%)	736 (23%)	936 (29.3%)	560 (17.5%)
			25-32 years	563 (11.8%)	1054 (22%)	1063 (22.2%)	1360 (28.4%)	743 (15.5%)
			33-39 years	480 (11.6%)	991 (23.9%)	956 (23.1%)	1138 (27.5%)	566 (13.7%)
			40+ years	365 (12.2%)	675 (22.5%)	756 (25.2%)	855 (28.5%)	351 (11.7%)

Subscale three: *Knowledge of developmental neurotoxicity*								
Item 1	Toxic chemicals in our day-to-day lives, like air pollution or lead in drinking water, can increase a child's risk of developing conditions like ADHD or autism.	Gender						
			Female	526 (6.7%)	757 (9.6%)	1863 (23.6%)	2427 (30.7%)	2327 (29.5%)
			Male	247 (3.5%)	411 (5.8%)	1184 (16.8%)	2394 (33.9%)	2832 (40.1%)
			Non-Binary	21 (17.5%)	12 (10%)	27 (22.5%)	38 (31.7%)	22 (18.3%)
		Country						
			Canada	160 (5.8%)	205 (7.5%)	696 (25.3%)	927 (33.8%)	758 (27.6%)
			Australia	214 (8.3%)	236 (9.2%)	687 (26.7%)	833 (32.4%)	602 (23.4%)
			India	28 (0.9%)	21 (0.7%)	144 (4.8%)	705 (23.7%)	2074 (69.8%)
			United Kingdom	193 (7%)	367 (13.4%)	784 (28.6%)	927 (33.8%)	475 (17.3%)
			United States	202 (5%)	352 (8.6%)	770 (18.9%)	1475 (36.2%)	1279 (31.4%)
		Pregnancy Status						
			Yes	23 (3.1%)	28 (3.8%)	105 (14.3%)	254 (34.5%)	326 (44.3%)
			No	276 (4.7%)	485 (8.3%)	1245 (21.4%)	1882 (32.3%)	1933 (33.2%)
		Child ND						
			Yes	191 (3.7%)	386 (7.5%)	1018 (19.7%)	1692 (32.8%)	1878 (36.4%)
			No	96 (8.3%)	112 (9.7%)	263 (22.8%)	364 (31.6%)	317 (27.5%)
			I don't know	10 (4.5%)	14 (6.4%)	61 (27.7%)	73 (33.2%)	62 (28.2%)
		Parental Status						
			Yes	299 (4.5%)	514 (7.8%)	1355 (20.6%)	2149 (32.6%)	2276 (34.5%)
			No	498 (5.8%)	667 (7.8%)	1726 (20.3%)	2718 (31.9%)	2912 (34.2%)
		Levels of Education						
			High school or less	230 (6.4%)	292 (8.1%)	970 (26.9%)	1126 (31.3%)	985 (27.3%)
			Some college or university, no degree/ diploma	161 (6.4%)	233 (9.3%)	570 (22.8%)	808 (32.3%)	727 (29.1%)
			Bachelor's degree or diploma	301 (4.8%)	501 (8.1%)	1176 (19.1%)	2068 (33.5%)	2125 (34.4%)
			Master's, doctorate or professional degree	92 (3.4%)	150 (5.5%)	324 (12%)	830 (30.7%)	1304 (48.3%)

		Age						
			18-24 years	245 (7.7%)	250 (7.8%)	603 (18.9%)	894 (27.9%)	1206 (37.7%)
			25-32 years	273 (5.7%)	399 (8.3%)	863 (18%)	1530 (32%)	1718 (35.9%)
			33-39 years	173 (4.2%)	320 (7.7%)	884 (21.4%)	1394 (33.7%)	1360 (32.9%)
			40+ years	106 (3.5%)	212 (7.1%)	731 (24.4%)	1049 (34.9%)	904 (30.1%)
Item 5	Reducing exposure to toxic chemicals during pregnancy and in early childhood can help lower a child’s risk of developing a condition like ADHD or autism.	Gender						
			Female	267 (3.4%)	476 (6%)	1951 (24.7%)	2749 (34.8%)	2457 (31.1%)
			Male	123 (1.7%)	257 (3.6%)	1320 (18.7%)	2517 (35.6%)	2851 (40.3%)
			Non-Binary	15 (12.5%)	14 (11.7%)	25 (20.8%)	35 (29.2%)	31 (25.8%)
		Country						
			Canada	88 (3.2%)	139 (5.1%)	695 (25.3%)	982 (35.8%)	842 (30.7%)
			Australia	97 (3.8%)	163 (6.3%)	680 (26.4%)	941 (36.6%)	691 (26.9%)
			India	21 (0.7%)	39 (1.3%)	267 (9%)	885 (29.8%)	1760 (59.2%)
			United Kingdom	104 (3.8%)	223 (8.1%)	854 (31.1%)	1020 (37.1%)	545 (19.8%)
			United States	96 (2.4%)	187 (4.6%)	807 (19.8%)	1481 (36.3%)	1507 (36.9%)
		Pregnancy Status						
			Yes	14 (1.9%)	29 (3.9%)	145 (19.7%)	247 (33.6%)	301 (40.9%)
			No	134 (2.3%)	280 (4.8%)	1252 (21.5%)	2061 (35.4%)	2094 (36%)
		Child ND						
			Yes	72 (1.4%)	221 (4.3%)	1025 (19.8%)	1834 (35.5%)	2013 (39%)
			No	69 (6%)	75 (6.5%)	294 (25.5%)	395 (34.3%)	319 (27.7%)
			I don’t know	7 (3.2%)	11 (5%)	71 (32.3%)	67 (30.5%)	64 (29.1%)
		Parental Status						
			Yes	125 (3.9%)	201 (6.3%)	684 (21.4%)	1036 (32.4%)	1152 (36%)
			No	149 (3.1%)	247 (5.2%)	969 (20.3%)	1675 (35%)	1743 (36.4%)
		Levels of Education						
			High school or less	126 (3.5%)	207 (5.7%)	1016 (28.2%)	1232 (34.2%)	1022 (28.4%)

			Some college or university, no degree/ diploma	91 (3.6%)	148 (5.9%)	586 (23.4%)	883 (35.3%)	791 (31.7%)
			Bachelor's degree or diploma	141 (2.3%)	298 (4.8%)	1231 (19.9%)	2263 (36.7%)	2238 (36.3%)
			Master's, doctorate or professional degree	39 (1.4%)	88 (3.3%)	425 (15.7%)	897 (33.2%)	1251 (46.3%)
		Age						
			18-24 years	125 (3.9%)	201 (6.3%)	684 (21.4%)	1036 (32.4%)	1152 (36%)
			25-32 years	149 (3.1%)	247 (5.2%)	969 (20.3%)	1675 (35%)	1743 (36.4%)
			33-39 years	85 (2.1%)	189 (4.6%)	933 (22.6%)	1461 (35.4%)	1463 (35.4%)
			40+ years	47 (1.6%)	114 (3.8%)	717 (23.9%)	1137 (37.9%)	987 (32.9%)
Item 8	Exposure to toxic chemicals during pregnancy can increase a child's risk of having a developmental condition.	Gender						
			Female	87 (1.1%)	189 (2.4%)	1234 (15.6%)	2908 (36.8%)	3482 (44.1%)
			Male	51 (0.7%)	171 (2.4%)	961 (13.6%)	2326 (32.9%)	3559 (50.4%)
			Non-Binary	4 (3.3%)	9 (7.5%)	21 (17.5%)	40 (33.3%)	46 (38.3%)
		Country						
			Canada	26 (0.9%)	64 (2.3%)	496 (18.1%)	956 (34.8%)	1204 (43.8%)
			Australia	35 (1.4%)	87 (3.4%)	484 (18.8%)	992 (38.6%)	974 (37.9%)
			India	18 (0.6%)	46 (1.5%)	194 (6.5%)	782 (26.3%)	1932 (65%)
			United Kingdom	39 (1.4%)	90 (3.3%)	619 (22.5%)	1149 (41.8%)	849 (30.9%)
			United States	26 (0.6%)	82 (2%)	434 (10.6%)	1402 (34.4%)	2134 (52.3%)
		Pregnancy Status						
			Yes	9 (1.2%)	19 (2.6%)	91 (12.4%)	256 (34.8%)	361 (49%)
			No	47 (0.8%)	144 (2.5%)	836 (14.4%)	2106 (36.2%)	2688 (46.2%)
		Child ND						
			Yes	31 (0.6%)	116 (2.2%)	677 (13.1%)	1839 (35.6%)	2502 (48.4%)
			No	22 (1.9%)	42 (3.6%)	200 (17.4%)	430 (37.3%)	458 (39.8%)
			I don't know	3	4	47 (21.4%)	81 (36.8%)	85 (38.6%)

				(1.4%)	(1.8%)			
		Parental Status						
			Yes	57 (0.9%)	163 (2.5%)	934 (14.2%)	2368 (35.9%)	3071 (46.6%)
			No	87 (1%)	206 (2.4%)	1293 (15.2%)	2913 (34.2%)	4022 (47.2%)
		Levels of Education						
			High school or less	51 (1.4%)	104 (2.9%)	746 (20.7%)	1300 (36.1%)	1402 (38.9%)
			Some college or university, no degree/ diploma	23 (0.9%)	73 (2.9%)	393 (15.7%)	882 (35.3%)	1128 (45.1%)
			Bachelor's degree or diploma	41 (0.7%)	136 (2.2%)	764 (12.4%)	2194 (35.6%)	3036 (49.2%)
			Master's, doctorate or professional degree	24 (0.9%)	45 (1.7%)	279 (10.3%)	875 (32.4%)	1477 (54.7%)
		Age						
			18-24 years	51 (1.6%)	114 (3.6%)	524 (16.4%)	1042 (32.6%)	1467 (45.9%)
			25-32 years	43 (0.9%)	125 (2.6%)	642 (13.4%)	1625 (34%)	2348 (49.1%)
			33-39 years	34 (0.8%)	80 (1.9%)	592 (14.3%)	1505 (36.4%)	1920 (46.5%)
			40+ years	16 (0.5%)	50 (1.7%)	469 (15.6%)	1109 (36.9%)	1358 (45.2%)
Item 14	Toxic chemicals can be detected in the blood of most pregnant women.	Gender						
			Female	95 (1.2%)	562 (7.1%)	3427 (43.4%)	2593 (32.8%)	1223 (15.5%)
			Male	99 (1.4%)	445 (6.3%)	2932 (41.5%)	2306 (32.6%)	1286 (18.2%)
			Non-Binary	1 (0.8%)	15 (12.5%)	54 (45%)	32 (26.7%)	18 (15%)
		Country						
			Canada	42 (1.5%)	169 (6.2%)	1267 (46.1%)	877 (31.9%)	391 (14.2%)
			Australia	40 (1.6%)	164 (6.4%)	1194 (46.4%)	815 (31.7%)	359 (13.9%)
			India	26 (0.9%)	141 (4.7%)	897 (30.2%)	1078 (36.3%)	830 (27.9%)
			United Kingdom	27 (1%)	212 (7.7%)	1323 (48.2%)	857 (31.2%)	327 (11.9%)
			United States	61 (1.5%)	341 (8.4%)	1743 (42.7%)	1311 (32.1%)	622 (15.3%)
		Pregnancy Status						
			Yes	11	34 (4.6%)	238 (32.3%)	258 (35.1%)	195 (26.5%)

		(1.5%)				
	No	80 (1.4%)	403 (6.9%)	2337 (40.1%)	1932 (33.2%)	1069 (18.4%)
Child ND						
	Yes	55 (1.1%)	336 (6.5%)	2005 (38.8%)	1741 (33.7%)	1028 (19.9%)
	No	30 (2.6%)	86 (7.5%)	478 (41.5%)	373 (32.4%)	185 (16.1%)
	I don't know	5 (2.3%)	14 (6.4%)	88 (40%)	73 (33.2%)	40 (18.2%)
Parental Status						
	Yes	91 (1.4%)	439 (6.7%)	2592 (39.3%)	2202 (33.4%)	1269 (19.2%)
	No	105 (1.2%)	588 (6.9%)	3832 (45%)	2736 (32.1%)	1260 (14.8%)
Levels of Education						
	High school or less	46 (1.3%)	246 (6.8%)	1676 (46.5%)	1072 (29.8%)	563 (15.6%)
	Some college or university, no degree/ diploma	36 (1.4%)	179 (7.2%)	1124 (45%)	779 (31.2%)	381 (15.2%)
	Bachelor's degree or diploma	67 (1.1%)	427 (6.9%)	2651 (43%)	2087 (33.8%)	939 (15.2%)
	Master's, doctorate or professional degree	39 (1.4%)	170 (6.3%)	920 (34.1%)	953 (35.3%)	618 (22.9%)
Age						
	18-24 years	56 (1.8%)	242 (7.6%)	1360 (42.5%)	1059 (33.1%)	481 (15%)
	25-32 years	55 (1.2%)	338 (7.1%)	1965 (41.1%)	1568 (32.8%)	857 (17.9%)
	33-39 years	55 (1.3%)	286 (6.9%)	1758 (42.6%)	1344 (32.5%)	688 (16.7%)
	40+ years	30 (0.9%)	161 (5.4%)	1341 (44.7%)	967 (32.2%)	503 (16.8%)

Chapter 4: A Large, International Randomized Controlled Trial Investigating Developmental Neurotoxicological Literacy and Translating Children's Environmental Health with the Public

Over the past 30 years, the prevalence of neurodevelopmental disorders (NDDs) like ADHD and ASD has increased from 13% to 18% (Zablotsky et al., 2019). This rising rate indicates a need to identify modifiable risk factors and policies to protect children. Toxic chemicals, like lead and pesticides, increase the risk of NDDs (Lanphear, 2015), but legislation to prohibit widespread exposure to toxic chemicals and emissions of pollutants is lacking. Legislation is critical to protect children but delays in legislative action continue to put children at risk. Increasing community awareness and education about the impact of toxic chemicals on brain development may accelerate the adoption of legislation to protect children from toxic chemicals (Gray, 2018).

Little is known about KT tools to educate the public about the risks of toxic chemicals on brain development. In 2018, Healthy Brains and Bright Futures (HBBF) administered a survey to over 1000 adults to examine their knowledge of toxic chemicals and whether targeted messaging about risks posed by toxic chemicals impacted their attitudes (Healthy Brains Bright Futures, 2018). They found that after sending messages about toxic chemicals, such as "*studies show that more than 90% of American women of childbearing age have toxic chemicals in their bodies at a level that will increase the risk of brain damage and loss of intelligence in their babies*," more respondents indicated that they considered toxic chemicals serious in their home and environment (from 55% pre-messaging to 66% post-messaging). While the HBBF survey showed that respondents had concerns, it did not examine whether respondents changed their behaviours to reduce exposure.

It is largely unknown whether KT tools may effectively protect children by influencing behaviours that reduce exposure to toxic chemicals. Two studies conducted interventions with families to investigate attitudes and behaviours about residential hazards, such as carbon monoxide (CO), drinking water contaminants, lead, mold, radon, and pest control (Butterfield et al., 2011; Mankikar et al., 2016). After administering EHL interventions (i.e., education provided by public health nurses as an RCT (Butterfield et al., 2011) and home visitors via the Healthy Homes program (Mankikar et al., 2016)), studies found that participants' knowledge and awareness of environmental health hazards, self-efficacy in relation to environmental health, and adoption of environmental health precautions improved. However, these studies consisted of smaller sample sizes (i.e., N=150 to 235), were only city- or state-wide, and did not specifically assess knowledge of the impact of chemicals on neurodevelopment or the public's preferences for prevention of NDDs.

Until regulations to reduce or control the widespread commercial use of toxic chemicals are promulgated, we can educate families and parents and advise them on how to make safer choices for their children's health. Increasing parents' knowledge about toxic chemicals may accelerate the development of regulations by influencing parents' preferences and advocacy (Shorvon & Berg, 2008). Indeed, inspiring advocacy among citizens by increasing awareness may be one of the most important outcomes of KT to parents.

We aimed to assess the efficacy of a KT video, *Little Things Matter: The Impact of Toxins on the Developing Brain,* created by Little Things Matter (LTM). LTM is a non-profit organization with a mission to enhance public understanding of how health is linked with the environment and elevate efforts to prevent disease by providing recommendations to reduce exposure to environmental toxic chemicals. LTM creates videos and social media posts about recent science associated with environmental health to relay scientific information to the public in a way that is accessible and actionable. In 2014, LTM released the video, *Little Things Matter: The Impact of Toxins on the Developing Brain*, to show how low-level exposure to toxic chemicals has a substantial impact on population health. This video also describes how too little has been done to protect children from ubiquitous, but insidious, toxic chemicals and concludes with list of actions to reduce exposures to toxic chemicals. The aim of this video, which has been viewed over 140,000 times since its release, was to educate the public about the impact of toxic chemicals on children's development and highlight the power of prevention for managing chronic health conditions. The link to this video is provided in Appendix D.

The aim of this present study was to conduct a randomized controlled trial (RCT) to examine the efficacy of the LTM video for instilling knowledge, changing preferences, and impacting intent and behaviour as they pertain to reducing exposure to toxic chemicals (a) immediately after watching the video and (b) after a six-week interval.

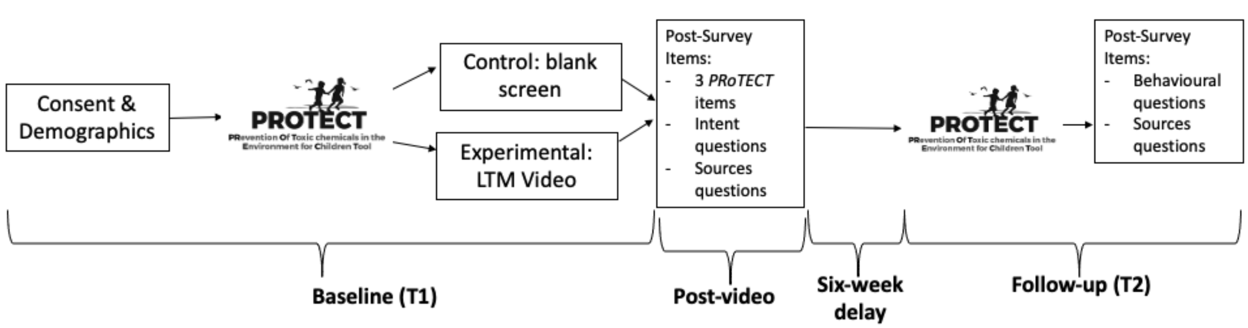
Methods

As with the previous study, we recruited 15,594 participants aged 18 to 45 years from Canada, the United States (U.S.), the United Kingdom (U.K.), India, and Australia via CloudResearch's Prime Panels®, an online platform commonly used for behavioural research (Chandler et al., 2019). Eligible participants anonymously completed our study through an online survey platform, Qualtrics (https://qualtrics.com/), and received a small monetary incentive for completion (amount determined by CloudResearch ahead of time).

The survey was completed in October 2021. Participants completed a brief demographic questionnaire as well as the 17-item *Prevention of Toxic chemicals in the Environment for Children Tool* found in Appendix A *(PRoTECT;* Green et al., 2022*).* We showed one item per screen to ensure that participants answered each item before moving on to the next item. The study was approved by York University's research ethics board (REB).

Following the administration of *PRoTECT*, we used an RCT design to examine the efficacy of a KT video (Appendix D) for instilling knowledge, impacting preferences, and changing behaviours to reduce exposure to toxic chemicals (Figure 1). We randomly assigned half of the respondents (the experimental group) to watch the *Little Things Matter: The Impact of Toxins on the Developing Brain* video. We oversampled participants for the experimental group by 25% in case there was dropout during the 7-minute video. The control group saw a blank screen in between baseline and post-survey items and clicked next page to advance. All participants completed post-survey items, including three items from *PRoTECT* (one from each subscale) and items about their intention to change behaviours across their household items, food, and personal care products, to reduce exposure to toxic chemicals. After a six-week delay, *PRoTECT* and the post-survey items were re-administered to a subset of participants. We contacted all participants to complete the follow-up; however, retention rates are low among CloudResearch recruitment. This attrition is consistent with online survey data collection sites, whereby only approximately 15 to 20% of participants are typically retained after the first study is complete.

Figure 1. *Study timeline*



Tools

We previously identified three factors underlying responses to the individual *PRoTECT* items using factor analysis. Each factor represented a separate construct related to the content domains of PROTECT; we labeled these factors: (1) preferences to lower exposure and increase prevention efforts, (2) knowledge of the regulation of toxic chemicals by government and industry, and (3) knowledge of developmental neurotoxicity. A subscale score can be calculated to represent each factor by averaging the numerical scores of each item in a given factor. As such, we used the three subscale scores on *PRoTECT* as outcome measures in this study. Full development and validation details of *PRoTECT* can be found in Chapter 3.

PRoTECT consists of 17 items with five-point Likert-type response scales ranging from *strongly disagree* to *strongly agree*. Accordingly, we assigned a score for each item from 1 to 5, with higher scores indicating stronger preferences for prevention and government regulation (subscale one) or greater levels of knowledge about developmental neurotoxicity (subscale three). On the *PRoTECT* tool shown in Appendix A, an asterisk indicates a reverse-coded item, such that *strongly disagree* would be coded as a 5 and *strongly agree* would be coded as a 1. Therefore, higher scores indicate increased knowledge of regulations related to toxic chemicals by government and industry (subscale two).

Knowledge Translation Tool (Little Things Matter: The Impact of Toxins on Brain Development). The *Little Things Matter: The Impact of Toxins on the Developing Brain* video is 7 minutes in length and illustrates how low-level exposures to toxic chemicals can result in substantial population level intellectual deficits, as well as behavioural problems. The video illustrates how subtle shifts in the intellectual abilities of individual children have a big impact on the number of children in a population that are challenged or gifted. The video was created by experts in the field, as well as consultants, and included focus groups with stakeholders to provide feedback and guidance on delivery and content. This video concludes with a list of ways to reduce exposures to toxic chemicals. The scientific evidence that was used to inform the video's content can be found in Lanphear, 2015. The video was assessed by consultants and creators in multiple stages, with several reviews from community members and advocacy groups.

To confirm and assess participants' attention throughout the video, participants were asked a multiple-choice question asking what the video was about, with the following response options: A) related to the history of the chemical industry, B) impact of toxic chemicals on brain development (*correct answer*), C) growth of the U.S. population over the past 20 years, or D) trends in intellectual quotient (IQ) scores over time. Respondents who did not answer correctly were instructed to exit the survey.

Post-Survey Items. Post-survey items were developed by coauthors of the current paper, who are experts in children's environmental health (BL, EP, CT, RG), in consultation with the team at Prenatal Environmental Health Education (PEHE), whose goal is to improve the understanding of factors that promote and inhibit the update of prenatal environmental health preventive care activities across Canada. Our goals were to examine potential barriers to reduce exposure and identify where people can learn more about environmental health.

First, we asked participants to complete three items from *PRoTECT*, one from each of the original content domains (i.e., preferences for prevention, knowledge of government regulation, and developmental neurotoxicity), to determine how the video impacted their responses across these three items immediately after viewing the video (items 2, 5, 15 from *PRoTECT*, Appendix 1). Next, we asked participants five questions about whether they intended to modify their behaviours over the next month. Items included questions such as, "In the next month, how likely are you to make any changes to reduce toxic chemicals in your household?", with each having a five-point Likert-type response scale ranging from *very likely* to *very unlikely*. In addition, participants completed a checklist of potential barriers that would make it difficult for participants to reduce their exposure, including cost, convenience, and not knowing how. See Appendix B for the full list of questions presented.

After six weeks, participants were asked additional questions. These questions included whether within the last six-weeks, they had seen or heard anything about toxic chemicals and health, whether they spoke about the topic (or plan to speak about it) with their healthcare provider (HCP), whether they had trouble determining if a product was non-toxic, and how concerned they were that they might be exposed to toxic chemicals in day-to-day life (see Appendix C).

Statistical Analyses

To determine how viewing the LTM video influenced knowledge and preferences related to exposure to toxic chemicals, we compared pre-video baseline mean responses with six-week follow-up mean responses on the *PRoTECT* subscales by group status (i.e., experimental group or control group). Likewise, to determine whether the LTM video influenced intent or behavioural change, we compared mean responses on the intent to change and changes in behaviour by group status. The proportion of participants endorsing each barrier to reducing exposures to toxic chemicals was compared across groups. Precise estimates were evaluated using means (i.e., effect sizes) as compared to significance testing due to the very large sample. We also stratified the sample by key demographic groups to see if mean changes differed by sample characteristic. We used stratification rather than interaction terms due to its better interpretability and large sample size within demographic groups.

In supplemental analyses, we aggregated responses based on higher scores (i.e., score of 4 or 5 on the Likert scale) comparing pre- versus post-agreement of scores across each group, as well as whether there were differences in responses across demographic factors.

Results

Baseline

In total, 15,594 participants completed the study; 58.1% (*n*=9064) in the experimental group and 41.9% (*n*=6530) in the control group. Of the experimental group participants, 75.3% (*n*=6827) watched the video (i.e., did not exit study mid-video), and only 4.1% (*n*=281) failed the attention check. Participants who failed the attention check were instructed to leave the study without completing the post-survey items, leaving 72.2% (*n*=6546) participants in the experimental group for post-survey items.

Table 1. *Demographic characteristics of participants at baseline*

	Baseline	
	Control Group	Experimental Group
n	6530	9064
Gender (frequency (%))		
Female	3268 (50.05)	4861 (53.63)
Male	3202 (49.03)	4083 (45.05)
Non-Binary	45 (0.69)	83 (0.91)
Country (frequency (%))		
Canada	1100 (16.85)	1729 (19.08)
Australia	1081 (16.55)	1594 (17.59)
India	1294 (19.82)	1892 (20.87)
United Kingdom	1154 (17.67)	1630 (17.98)
United States	1901 (29.11)	2219 (24.48)

Ethnic Groups (frequency (%))		
White	3416 (52.30)	4578 (50.51)
Black	481 (7.37)	557 (6.15)
South Asian	1231 (18.85)	1821 (20.09)
Other	1402 (21.27)	2108 (23.26)
Location (frequency (%))		
Major City	2342 (35.87)	3294 (36.34)
Suburban Edges	1982 (30.35)	2661 (29.36)
Major Town	667 (10.21)	1004 (11.08)
Small Town	1303 (19.95)	1757 (19.38)
Remote	176 (2.70)	260 (2.87)
Mean (SD) years of age	32.22 (8.24)	31.65 (8.16)
Level of Education (frequency (%))		
High school or less	1612 (24.69)	2125 (23.44)
Some college or university, no degree/diploma	1085 (16.62)	1461 (16.12)
Bachelor's degree or diploma	2643 (40.48)	3685 (40.66)
Master's, doctorate or professional degree	1115 (17.08)	1671 (18.43)
Employment (frequency (%))		
Full-time	3416 (52.31)	4596 (50.71)
Part-time	945 (14.47)	1377 (15.19)
Other (Retired, Student, Self-Employed, Unemployed, Unknown, prefer not to disclose)	1970 (30.17)	2849 (31.43)
Political Leaning*		
Mean (SD), Median	5.04 (2.44), 5	4.94 (2.47), 5
Total Household Income (CAD) (frequency (%))		

$0-$49,999	404 (36.73)	607 (35.11)
$50,000 - $74,999	203 (18.45)	326 (18.85)
$75,000 - $99,999	167 (15.18)	287 (16.6)
$100,000 or more	244 (22.18)	379 (21.92)
Total Household Income (AUD) (frequency (%))		
$0-$53,999	280 (25.9)	492 (30.86)
$54,000 - $80,999	186 (17.21)	255 (15.9)
$81,000 - $109,999	187 (17.3)	227 (14.24)
$110,000 or above	344 (31.81)	448 (28.1)
Total Household Income (RS) (frequency (%))		
₹0-₹499,999	536 (41.42)	697 (36.84)
₹500,000 - ₹749,999	173 (13.37)	299 (15.8)
₹750,000 - ₹999,999	175 (13.52)	251 (13.27)
₹1,000,000 or above	354 (27.35)	542 (28.65)
Total Household Income (GBP) (frequency (%))		
£0-£28,999	439 (38.03)	627 (38.46)
£29,000 - £42,999	246 (21.32)	349 (21.41)
£43,000 - £56,999	169 (14.64)	228 (13.99)
£57,000 or above	227 (19.67)	335 (20.54)
Total Household Income (USD) (frequency (%))		
$0-$39,999	633 (33.29)	764 (34.42)
$40,000 - $59,999	342 (17.99)	452 (20.37)
$60,000 - $79,999	302 (15.89)	359 (16.17)
$80,000 or above	709 (37.27)	778 (35.05)

Parental Questions		
Marital Status (frequency (%))		
Single	3348 (51.27)	4932 (54.41)
Married / Common Law	2877 (44.06)	3731 (41.16)
Separated / Divorced or Widowed	305 (4.67)	401 (4.42)
Children (frequency (%))		
Yes, I have children	2941 (45.04)	3796 (41.88)
No, I don't have children	3589 (54.96)	5268 (58.12)
Pregnancy Status (frequency (%))		
Pregnant	350 (11.98)	405 (10.73)
Non-pregnant	2572 (88.02)	3371 (89.27)
Identified Developmental Conditions (Participants' Children) (frequency (%))		
No	2303 (78.65)	2968 (78.64)
Yes	504 (17.21)	665 (17.62)
I don't know	108 (3.69)	127 (3.37)
Identified Developmental Conditions (Participants) (frequency (%))		
No	2502 (85.28)	3234 (85.37)
Yes	363 (12.37)	470 (12.41)
I don't know	69 (2.35)	84 (2.22)

* Question: *In politics, people sometimes talk about the 'left' and the 'right'. On a scale where '0' means left and '10' means right, where would you place yourself on the scale?*

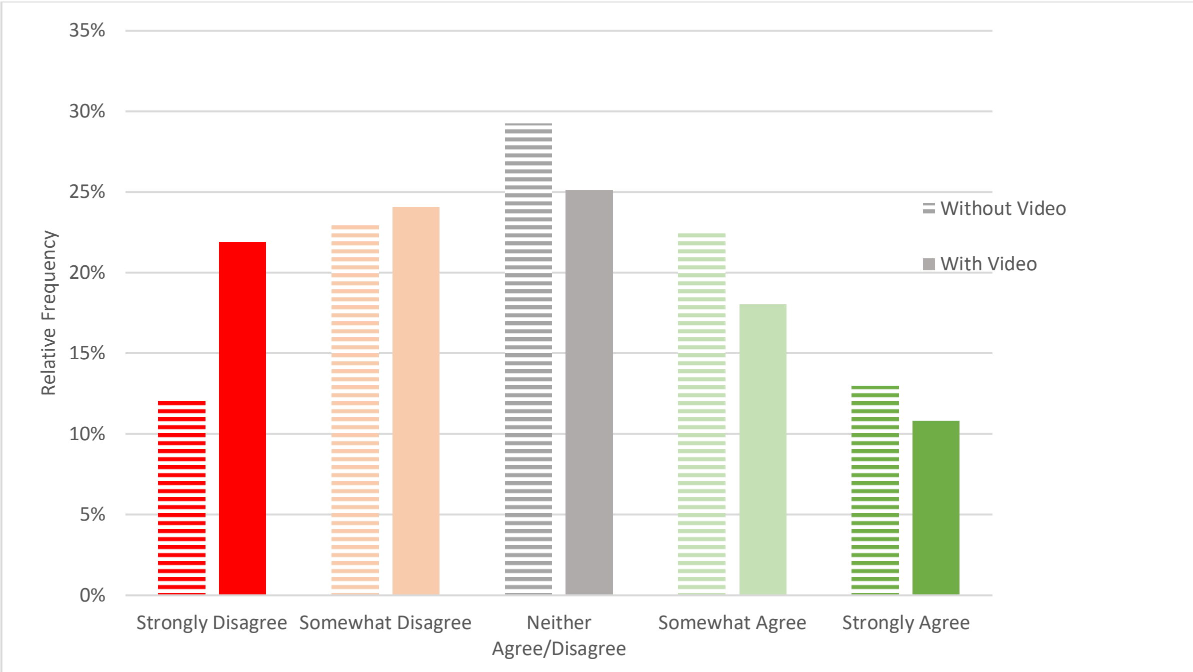
Immediately after watching the video (experimental group) or observing a blank screen (control group), participants were re-surveyed on three items from *PRoTECT* about the impact of toxic chemicals on brain development (item 5), attitudes towards government's investment in prevention (item 2), and preferences for more governmental spending in prevention (item 15).

The pre-post differences on these items were much larger for the experimental group than the control group (Table 2, Figure 2).

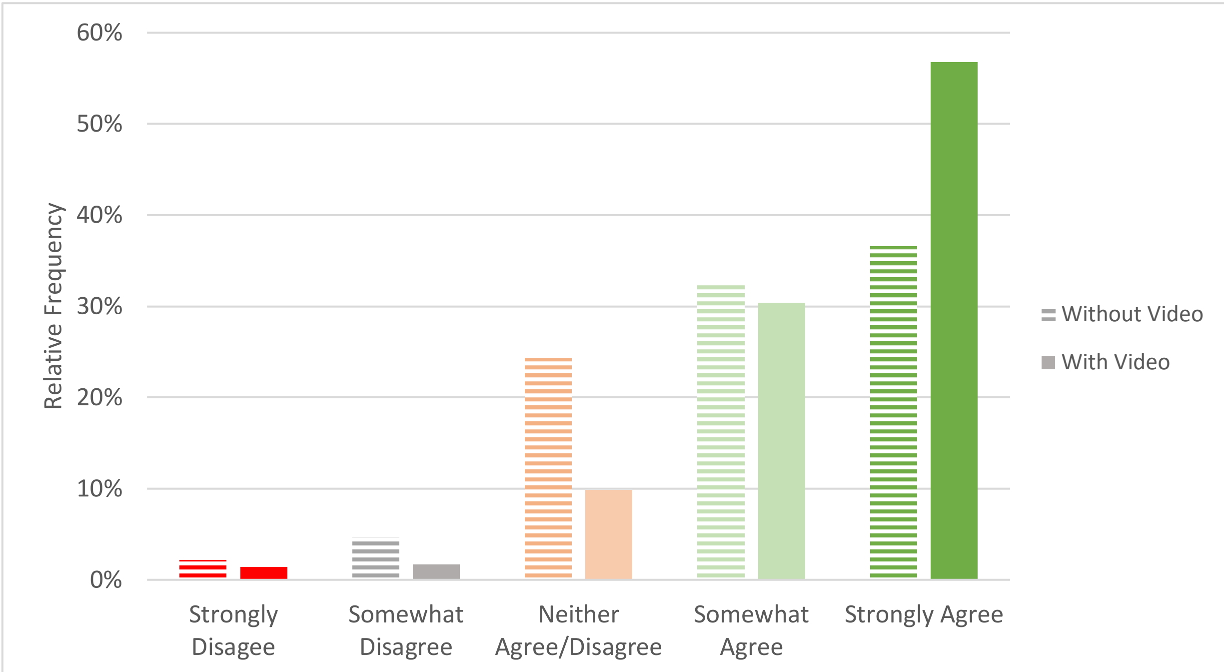
Table 2. *Mean scores on items 2, 5, and 15 pre- and post-video by group status*

	Control Group			Experimental Group		
	Pre M (SD)	Post M (SD)	Mean Difference	Pre M (SD)	Post M (SD)	Mean Difference
Item 2	3.03 (1.23)	2.99 (1.21)	-0.04	3.07 (1.23)	3.28 (1.29)	0.21
Item 5	3.95 (1.01)	3.92 (0.97)	-0.03	3.96 (1.00)	4.40 (0.84)	0.44
Item 15	4.34 (0.84)	4.27 (0.86)	-0.07	4.36 (0.83)	4.52 (0.76)	0.16

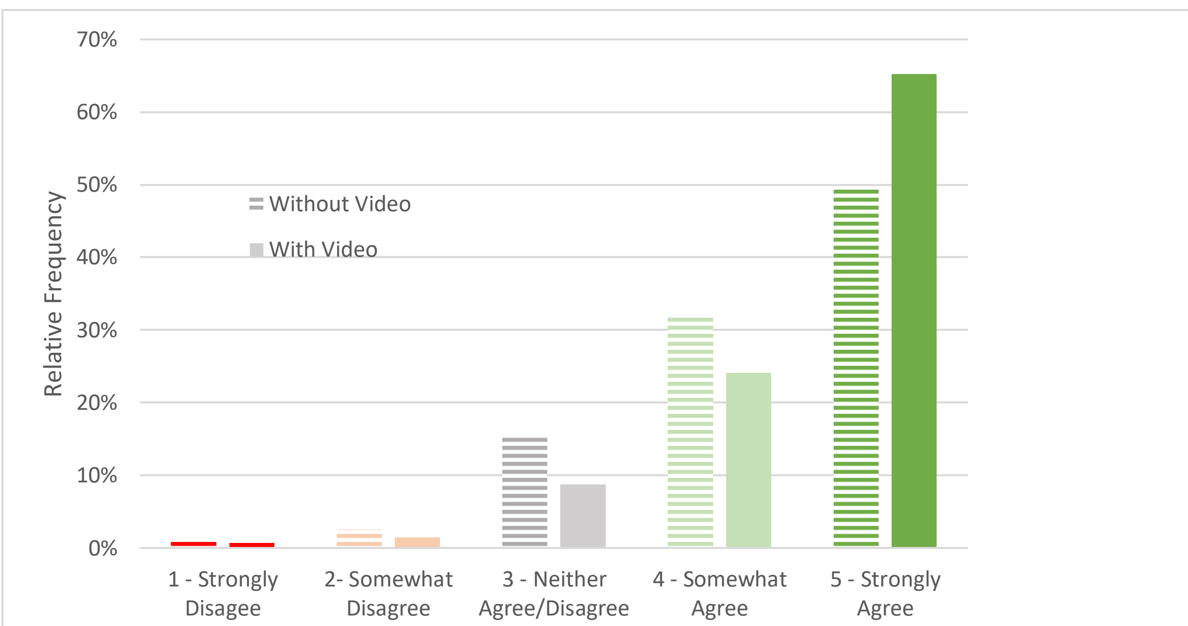
Figure 2. *Differences on responses to selected PRoTECT items by group at baseline following intervention*



Item 2: Most governments spend about the same amount to prevent developmental conditions as they spend to treat these conditions.



Item 5: Reducing exposure to toxic chemicals during pregnancy and in early childhood can lower a child's risk of developing a condition like ADHD or autism.



Item 15: My government should strengthen their policies and programs to make sure that consumer products do not contain toxic chemicals that are harmful to children.

Impact of Video on Knowledge and Intent to Reduce Exposures. Following the three *PRoTECT* items, participants were asked additional questions about their intentions to reduce their exposure to toxic chemicals. Participants in the experimental group were more likely to report confidence in their ability to explain the role of toxic chemicals on brain development based on their consistently higher proportion of *likely* and *very likely* endorsements (Table 3). However, there was almost no group difference in the responses to items about intent to change food purchases or consumption or to change use of personal-care products.

Table 3. *Baseline differences by group status in intentions to reduce exposure to toxic chemicals over the next month*

Questions	Control group	Experimental group
Would you feel comfortable explaining to a friend that toxic chemicals can impact brain development?	Mean (SD): 3.69 (1.14) Likely: 32.9% Very likely: 28.5%	Mean (SD): 3.98 (1.01) Likely: 39.8% Very likely: 35.1%
How likely are you to make any changes to reduce toxic chemicals in your household?	Mean (SD): 3.78 (1.34) Likely: 36.6% Very likely: 34.2%	Mean (SD): 3.90 (1.38) Likely: 34.7% Very likely: 41.0%
How likely are you to make any changes to the foods you buy or eat to reduce your exposure to toxic chemicals?	Mean (SD): 3.75 (1.38) Likely: 35.3% Very likely: 34.6%	Mean (SD): 3.76 (1.49) Likely: 32.9% Very likely: 39.0%

How likely are you to make any changes in your use of personal-care products to reduce your exposure to toxic chemicals?	Mean (SD): 3.77 (1.37) Likely: 35.7 Very likely: 34.9	Mean (SD): 3.78 (1.47) Likely: 32.9 Very likely: 39.3

Participants' endorsement of barriers to reduce exposures to toxic chemicals differed by group assignment (Table 4). Only 13.8% of participants in the experimental group reported that they did not know how to reduce toxic chemicals compared with 23.8% of participants in the control group. However, in both groups more than 20% of participants endorsed barriers regarding the cost of non-toxic products and not knowing where to purchase non-toxic products. In contrast, fewer than 5% of participants across both groups reported that they did not believe that reducing toxic chemicals would make a difference to their health. There were no substantial group differences for the other barriers.

Table 4. *Barriers to reduce exposure to toxic chemicals by group status at baseline immediately following intervention*

Barriers endorsed by the participant	Control group (%) N=9703	Experimental group (%) N=9784
I don't know how to reduce toxic chemicals	23.80	13.77
Non-toxic products and food cost too much	20.96	26.06
It is not convenient to shop in stores where less toxic items are available	15.06	17.06

I don’t know where to purchase non-toxic items or food	20.47	20.81
I don’t believe it makes a difference to my health/my family’s health	4.13	3.22
I don’t have support from my partner or other family member	2.99	3.84
I don’t have time	4.46	4.80
Other	0.88	1.15
None of the above apply to my situation	7.26	9.28

Note. Participants could check off as many barriers as applied.

Six-Week Follow-Up

Demographic characteristics of the participants who completed the six-week follow-up are in Table 5. Overall, demographic characteristics were similar to the sample at baseline. There were slight differences at follow-up, such that there was a higher percentage of U.S. participants, a higher average level of education, a higher income in Australia, and a lower income in the U.S. There were also more participants from the U.S. in the experimental group than the control group; thus, we present results collapsed and by country (Table 5).

Table 5. *Demographic characteristics of participants at six-week follow up*

	Six-week follow-up	
	Control Group	Experimental Group
n	2206	2636
Gender (frequency (%))		
Female	1097 (49.73)	1364 (51.75)
Male	1092 (49.50)	1246 (47.27)

Non-Binary	12 (0.54)	20 (0.76)
Country (frequency (%))		
Canada	187 (8.48)	198 (7.51)
Australia	250 (11.33)	227 (8.61)
India	541 (24.52)	474 (17.98)
United Kingdom	277 (12.56)	252 (9.56)
United States	951 (43.11)	1485 (56.34)
Ethnicity (frequency (%))		
White	1118 (50.68)	1361 (51.63)
Black	187 (8.48)	253 (9.60)
South Asian	478 (21.67)	473 (17.94)
Other	379 (17.18)	510 (19.35)
Location (frequency (%))		
Major City	781 (35.40)	885 (33.57)
Suburban Edges	714 (32.37)	829 (31.45)
Major Town	242 (10.97)	305 (11.57)
Small Town	399 (18.09)	524 (19.88)
Remote	53 (2.40)	73 (2.77)
Age in years (M, SD)	33.48 (8.16)	33.36 (7.47)
Level of Education (frequency (%))		
High school or less	369 (16.73)	388 (14.72)
Some college or university, no degree/diploma	344 (15.59)	453 (17.19)
Bachelor’s degree or diploma	1035 (46.92)	1270 (48.18)
Master’s, doctorate, or professional degree	440 (19.95)	516 (19.58)
Employment (frequency (%))		
Full-time	1223 (55.44)	1498 (56.83)

Part-time	288 (13.06)	309 (11.72)
Other (i.e., retired, student, self-employed, unemployed)	680 (30.83)	810 (30.73)
Politics		
Mean (SD), Median	4.93 (2.64), 5	4.58 (2.65), 5
Total Household Income (CAD) (frequency (%))		
$0 - $49,999	70 (37.43)	51 (25.76)
$50,000 - $74,999	36 (19.25)	49 (24.75)
$75,000 - $99,999	30 (16.04)	39 (19.70)
$100,000 or above	43 (23.0)	49 (24.74)
Total Household Income (AUD) (frequency (%))		
$0 - $53,999	59 (23.60)	60 (26.43)
$54,000 - $80,999	49 (19.60)	52 (22.91)
$81,000 - $109,999	44 (17.60)	33 (14.54)
$110,000 or above	85 (34.0)	63 (27.75)
Total Household Income (RS) (frequency (%))		
₹0 - ₹499,999	228 (42.14)	160 (33.76)
₹500,000 - ₹749,999	79 (14.60)	81 (17.09)
₹750,000 - ₹999,999	77 (14.23)	72 (15.19)
₹1,000,000 or above	139 (25.69)	146 (30.80)
Total Household Income (GBP) (frequency (%))		
£0 - £28,999	96 (36.66)	109 (43.25)
£29,000 - £42,999	63 (22.74)	56 (22.22)
£43,000 - £56,999	47 (16.97)	29 (11.51)
£57,000 or above	51 (18.41)	46 (18.25)

Total Household Income (USD) (frequency (%))		
Less than or equal to $39,999	295 (31.02)	441 (29.70)
$40,000 - $59,999	168 (17.67)	302 (20.34)
$60,000 - $79,999	147 (15.46)	257 (17.31)
$80,000 or above	322 (33.86)	455 (30.64)
Parental Questions		
Marital Status (frequency (%))		
Single	1103 (50)	1351 (51.25)
Married / Common Law	1007 (46.65)	1146 (43.47)
Separated / Divorced or Widowed	96 (4.25)	139 (5.27)
Children (frequency (%))		
Yes, I have children	1014 (45.97)	1149 (43.59)
No, I don’t have children	1192 (54.03)	1487 (56.41)
Pregnancy Status (frequency (%))		
Pregnant	122 (12.12)	97 (8.46)
Non-pregnant	885 (87.88)	1049 (91.54)
Identified Developmental Conditions (Participants’ Children) (frequency (%))		
No	819 (81.57)	910 (80.32)
Yes	152 (15.14)	193 (17.03)
I don’t know	26 (2.59)	26 (2.29)
Other	7 (0.70)	4 (0.35)
Identified Developmental Conditions (Participants) (frequency (%))		
No	892 (88.67)	1009 (88.51)
Yes	94 (9.34)	115 (10.09)
I don’t know	20 (1.99)	16 (1.40)

Pre-Post Response Changes on PRoTECT Items by Group Status and Country. Mean differences on subscale scores by group status are shown in Table 6. Means increased from baseline to follow-up in both groups. In the control group, the mean(SD) scores were 4.21(0.60) for subscale one (preferences to lower exposure and increase prevention), 2.82(0.91) for subscale two (attitudes towards regulations of toxic chemicals), and 3.91(0.72) for subscale three (knowledge of developmental neurotoxicity). In the experimental group, the mean(SD) scores were 4.21(0.59) for subscale one, 2.84(0.91) for subscale two, and 3.90(0.72) for subscale three. The mean change over time by group was greatest for subscale two (control group = 0.11 and experimental group = 0.31), in comparison to subscale one (control group = 0.06 and experimental group = 0.10) and subscale three (control group = 0.12 and experimental group = 0.21), indicating greater differences in attitudes towards regulations of toxic chemicals (subscale two) in comparison to preferences to lower exposure and increase prevention (subscale one) as well as knowledge of developmental neurotoxicity (subscale three).

Regarding subscale two, 10% or more of participants in the experimental group endorsed greater agreement from baseline to follow up that (1) governments do not spend the same to prevent conditions as they do to treat (item 2), (2) parents do not have equal opportunities to protect their children (item 3), (3) the government does not have effective regulations to limit levels of toxic chemicals (item 4), and (4) they do not trust companies to ensure that they are not including harmful levels of toxic chemicals in their products (item 12), (Supplemental Table 1). By contrast, participants in the control group had changes between 0 and 8% on these items.

On subscale one, experimental group participants had between 5 and 9.99% higher percentage of agreeing at follow-up as compared to baseline, compared to less than 5% changes for control participants on the following items: (1) governments should spend more money to prevent developmental conditions in children (item 6), (2) babies and children are among those who are particularly harmed by exposure to toxic chemicals (item 11), (3) prevention of developmental conditions in children is more beneficial than treatment (item 13), and (4) government policies and programs should be strengthened to ensure that children's exposure to toxic chemicals is limited (item 15; Supplemental Table 1). The remaining items in subscale one did not have notable group differences.

Regarding subscale three, compared with the control group, participants in the experimental group reported having a greater increase in their knowledge of developmental neurotoxicity. The experimental group participants were more likely to give responses with 5 to10% higher agreement compared to baseline for the items indicating that (1) reducing children's exposure to toxic chemicals can help lower their risk of developing a neurodevelopmental condition (item 5), (2) exposure to toxic chemicals during pregnancy can increase children's risk of developing a neurodevelopmental condition (item 8), and (3) that toxic chemicals can be found in blood during pregnancy (item 14).

In supplemental analyses, we identified differences in responses by country (see Supplemental Table 1). Experimental group participants from the U.S. had changes that were, at minimum, an additional 5% greater than those of U.S. control group participants. These findings suggest that participants from the U.S. exhibited a greater difference in response after watching the video than participants from Canada, Australia, the U.K., and India. Considering that 43% of the participants in time 2 were in the U.S., the greatest pre/post differences in responses on *PRoTECT* on most items were due to U.S. participants and not participants from other countries.

Table 6. *Mean subscale scores at baseline and follow-up by group status*

Control Group	Experimental Group

	Baseline M (SD)	6-Week Follow-Up M (SD)	Mean Difference	Baseline M (SD)	6-Week Follow-Up M (SD)	Mean Difference
Subscale one: *Preferences to lower exposure and increase prevention*	4.21 (0.60)	4.27 (0.57)	0.06	4.21 (0.59)	4.31 (0.56)	0.10
Subscale two: *Attitudes towards regulations of toxic chemicals*	2.82 (0.91)	2.93 (0.94)	0.11	2.84 (0.91)	3.15 (0.92)	0.31
Subscale three: *Knowledge of developmental neurotoxicity*	3.91 (0.72)	4.03 (0.69)	0.12	3.90 (0.72)	4.11 (0.67)	0.21

We observed a similar correlation between preferences to lower exposure to toxic chemicals and increase prevention efforts (subscale one) and knowledge of developmental neurotoxicity (subscale three) at follow-up, r = .60, compared with the baseline correlation, r = 0.59. This correlation indicates that people who appreciate the impact of toxic chemicals on brain development are more likely to be concerned and want to find ways to emphasize prevention. By contrast, though consistent with baseline data, correlations among the remaining subscales were weaker at follow-up (i.e., subscales 2 (i.e., attitudes towards regulations of toxic chemicals) and 3: r = -.08; subscales 1 and 2: r = -.02).

Impact of Video on Behavioural Changes. We also examined group differences in the post-survey behavioural change items (Table 7) but did not find meaningful differences by group, suggesting that both groups made changes to reduce their exposures (i.e., high response rate of "some/great extent"), regardless of having watched thew video. In fact, mean scores were slightly higher in the control group.

Table 7. *Differences by group status in reduction of exposure to toxic chemicals at six-week follow up*

To what extent have you…	Control group (%)	Experimental group (%)
… changed your household practices to reduce exposures to toxic chemicals?	Mean (SD): 3.08 (1.48) Some extent: 45.85 A great extent: 13.36	Mean (SD): 3.01 (1.5) Some extent: 50.75 A great extent: 10.10
…made any changes to the foods you buy or eat to reduce your exposure to toxic chemicals?	Mean (SD): 3.17 (1.51) Some extent: 46.27 A great extent: 16.92	Mean (SD): 3.06 (1.56) Some extent: 50.17 A great extent: 14.26
…made any changes in your purchase or use of personal-care products to reduce your exposure to toxic chemicals?	Mean (SD): 2.97 (1.5) Some extent: 38.43 A great extent: 14.72	Mean (SD): 2.82 (1.56) Some extent: 38.18 A great extent: 13.25

In terms of changes made to reduce exposures by demographic factors, we did not observe differences by parental status, but pregnant women were more likely to have reported making more changes in the household than non-pregnant women (16.2 versus 11.8% making some to a great extent) and more changes to food than non-pregnant women (19.8 versus 14.7% making some to a great extent), collapsed across the experimental and control groups.

We observed substantial differences by country. Of the experimental group participants, participants from India reported greater behavioral changes to reduce toxic chemicals than other participants. For example, 22.9% of Indian participants reported having made a great extent of change to household practices to reduce toxic chemicals as opposed to 8.1% of Canadian participants, 6.6% of Australian participants, 4.8% of participants from the U.K. and 5.6% of participants from the U.S. This difference was also observed in the control group, where Indian participants made more changes to household practices; 25.3% of Indian participants made a great extent of change to household practices compared to 8% of Canadian participants, 5.2% of Australian participants, 6.6% of participants from the U.K., and 6.9% of participants from the U.S.

Indian participants also reported more changes to the foods they buy or eat to reduce exposure to toxic chemicals than those in other countries; 32.5% of Indian participants made a great extent of changes to foods as opposed to 11.2% of participants from Canada, 8.2% of participants from Australia, 6.5% of participants from the U.K., and 7.9% of participants from U.S. The same pattern was found for the control group; 33.3% of Indian participants made changes to the foods they buy or eat compared to 10.7% of Canadian participants, 6% of Australian participants, 8.8% of participants from the U.K., and 8.4% of participants from the U.S.

Moreover, we observed the same trend for changes to personal care products by country: 28.8% of Indian participants made a great extent of changes to their purchases in personal care products compared to 10.4% of participants from Canada, 8.6% of participants from Australia, 5.7% of participants from the U.K., and 6.4% of participants from the U.S. This pattern also emerged among participants from the control group: 29% of Indian participants made changes to personal care products as opposed to 10.2% of participants from Canada, 6.4% of participants from Australia, 7.3% of participants from the U.K., and 6.3% of participants from the U.S.

Barriers to Change. In the six-week follow up, barriers followed the same trends as we observed at baseline with many endorsing cost, inconvenience, and not knowing where to shop as substantial barriers towards buying non-toxic products (Table 8). Consistent with the baseline survey, fewer participants in the experimental group reported not knowing how to reduce toxic chemicals (17.0%) than in the control group (26.6%).

Table 8. *Barriers to reduce exposure to toxic chemicals at six-week follow-up*

Examples of barriers	Control group N=1934	Experimental group N=2297
	% reported	
I don't know how to reduce toxic chemicals	26.63	16.98
Non-toxic products and food cost too much	36.35	40.05
It is not convenient to shop in stores where less toxic items are available	24.82	27.47
I don't know where to purchase non-toxic items or food	22.49	20.85
I don't believe it makes a difference to my health/my family's health	4.91	4.27
I don't have support from my partner or other family member	5.38	5.22
I don't have time	9.00	10.27

Note. Participants could endorse as many barriers as applied.

The number of participants who had trouble determining whether a product was non-toxic differed slightly by group status; participants in the experimental group reported less difficulty determining toxicity (52%) than participants in the control group (56%).

Healthcare Provider (HCP) Results

We asked participants whether they plan to speak about toxic chemicals with their HCP. Collapsed across groups (because there were no meaningful differences by group), approximately 32% of participants said that they plan to speak about this issue with their HCP, whereas 15% said that they have already spoken about it with them. We observed differences by country of residence: More Indian participants said they planned to speak to their HCPs (45%) compared to 33.6% of participants from Canada, 32.1% from Australia, 23.7% from the U.K., and 27.9% of participants from the U.S. Similarly, 35% of Indian participants said they have already spoken to their HCPs compared with 10% or less from the remaining four countries. Pregnant participants were also more likely to have spoken to their HCP about toxic chemicals: 33.2% of pregnant women said that they have already spoken to their HCPs compared with 17.8% of non-pregnant women.

We asked participants why they did not plan to speak to their HCP. Participants could endorse as many reasons as applied. Of the 53% of participants who said they do not plan to speak to their HCP about toxic chemicals, approximately 30% said they had more important issues to raise, 30% said they did not have enough knowledge to know what they should ask, 23% said that did not think their HCP would have the information they were looking for, 20% said that they felt their HCP might dismiss their concerns, 17% said they were not sure it was a valid question, and 15% said that they felt they would not have time to talk about it. Only 5% said that they would not have trusted their HCP's advice.

Finally, over 70% of participants in both groups reported that they were "somewhat" to "very concerned" that they or their family may be exposed to toxic chemicals.

Discussion

We tested the efficacy of a video for producing changes in knowledge and behaviours both immediately after its implementation and after a six-week delay. Compared with the control group, the experimental group endorsed a slightly greater likelihood to reduce their exposure to toxic chemicals immediately after watching the video. Compared with the control group, the experimental group also had greater mean score increases across scales measuring knowledge of developmental neurotoxicity, desire for government investment in prevention, and government spending the same to prevent disorders as it does to treat them. This highlights that the video, on average, tended to both educate and change participants' opinions, especially participants from the U.S. The fact that we found the greatest effect of the video among U.S. participants may be attributed to the fact that the video referenced U.S. normative data for IQ testing and referenced U.S. government behaviour. Despite that the greatest *changes* in response patterns observed among U.S. participants, we found very consistent findings in response patterns on *PRoTECT* by country.

In terms of intent to change behaviours to reduce exposures, although the experimental group endorsed higher levels of intent to modify their behaviours, both groups responded with high degrees of being likely or very likely to change their current behaviours to reduce their exposures at follow-up (almost 70%). It could be that the *PRoTECT* questionnaire, in and of itself, serves as an intervention to educate people on the prevalence and risks of toxic chemicals in the environment. This finding could also reflect adjustment bias where participants adjusted their opinions to reflect the information they just received (George et al., 2000). The items on *PRoTECT*, asking about potential harms of toxic chemicals, may be enough to encourage people to think about their current practices and consider making changes to reduce their exposure. Importantly, the subscale assessing knowledge of developmental neurotoxicity was strongly correlated with the subscale assessing preferences for reducing exposure and concerns regarding exposure at both time points. Thus, knowledge is a key driver to awareness of the problems posed by toxic chemicals. People with higher levels of knowledge of developmental neurotoxicity are more likely to want to learn how to reduce their exposures. This association between knowledge and desire to reduce exposures may mean that even quick, relatively simple interventions may be used as knowledge translation to make families aware of risks.

At the six-week follow-up, the experimental group continued to obtain higher scores across all three subscales measuring preferences to reduce exposures to toxic chemicals, attitudes towards regulations of toxic chemicals by government and industry, and knowledge of developmental neurotoxicity. The differences between the experimental and control groups were smaller than the differences observed immediately after the video.

Both groups tended to respond that they made changes in their household to reduce exposures to toxic chemicals. Therefore, we did not see differences by group status in making behavioural changes. Approximately 70% of participants in both groups said that they made changes to reduce exposure to toxic chemicals in their household, food, and personal care products. Furthermore, about 10% of participants across both groups reported that they were already making these choices, whereas 20% reported not making any changes.

When asked specifically about making changes that were suggested in the video itself, between 30 and 40% of respondents in each group said they bought more fresh foods, more organic foods, and avoided canned or processed foods. About 2 to 3% more in the experimental group responded that they checked their home for lead hazards and dusted floors and surfaces than in the control group. Within these changes to household options, about 20% of participants in each group reported that they were already doing most of the above.

Although we found differences on knowledge and attitudes by group immediately after viewing the video, we did not find substantial differences by group after a six-week period with respect to changes in behaviour to reduce exposures to toxic chemicals. This result should not be surprising. In fact, while it is important to understand knowledge and awareness regarding health, it is unclear whether this understanding leads to changes in behaviour. For example, previous studies of environmental concerns and changes to increase environmental sustainability found that awareness does not necessarily lead to changes in behaviours (Grunert, 2011; Ketelsen et al., 2020; Rhein & Schmid, 2020). Knowledge is important but it is not always enough to change behaviour, especially when it comes to health (Arlinghaus & Johnston, 2017; Kelly & Barker, 2016). Some recommendations to improve the likelihood of creating change are to have people hear the information from HCPs instead of reading it in promotional materials (Raynor et al., 2007), to connect the information to desirable health outcomes (Arlinghaus & Johnston, 2017), and to train people on how to make changes related to their exposure to toxic chemicals.

Although we did not find differences in making changes to reduce exposures by group status, we did observe differences across certain demographic groups. Participants in India were more likely to endorse an intent to make changes than participants from other countries. U.S. participants were the least likely to intend to make changes to reduce their exposures across both groups. This difference by country may help explain why we did not observe large changes by group status in follow-up since U.S. participants comprised 43% of the sample at follow-up. At follow-up, however, regardless of experimental group status, pregnant women were more likely than non-pregnant women to make changes to reduce their exposures, suggesting that awareness of toxic chemicals and children's development, whether from a video or questionnaire, was effective at instilling change among pregnant women.

We also found that there were substantial barriers reducing the likelihood of families making change. Previous research on sustainability found that barriers to making change included incomplete information, unwillingness to pay for more sustainable options, lack of alternatives, and lack of motivation to change (Grunert, 2011; Ketelsen et al., 2020; Rhein & Schmid, 2020). In our study, the percentage of participants who reported barriers to reduce exposure to toxic chemicals in the six-week follow up was slightly higher than the percentage at baseline for the barrier of the cost of non-toxic products (baseline: control = 21% and experimental = 26.1%; follow-up: control = 36.4% and experimental = 40.1%) and the inconvenience of shopping for non-toxic products (baseline: control = 15.1% and experimental = 17.1%; follow-up: control = 24.8% and experimental = 27.5%). In both the initial and follow-up survey, fewer participants in the experimental group said they did not know how to reduce their exposure to toxic chemicals than the control group (26.6% versus 17.0% at follow-up and 23.8% versus 13.8% in the immediate), suggesting that the video is effective for instilling knowledge about how to reduce exposures. Lastly, across both groups, 55% of participants endorsed having trouble finding out whether a product is non-toxic, indicating another substantial barrier to behaviour change. Taken together, these findings suggest that KT alone, be it a video or a questionnaire, may be insufficient to evoke behavioural change. Systemic barriers – like cost and difficulties determining how and where to buy non-toxic products – were key barriers.

We found that participants from India were more concerned about toxic chemicals, want stricter government regulations, and were more likely to make changes to reduce exposure than participants from other countries. This finding could be because waste and pollution are more visible in India than other countries (UNICEF, 2020). The threat that toxic chemicals pose on children's health may feel more urgent to those living in India as opposed to a more insidious threat to those living in more Western countries.

About 10% of the participants were not concerned about toxic chemicals and indicated no desire or intent to reduce their exposures to toxic chemicals. When we compared this group of people (*n*=218) to the main sample, this subset was more likely to be from the US (80.3%), white (78%), male (72.4%), lower income (27.5%), single (60.4%), and without children (65.4%) compared with the whole sample (Supplemental Table 2).

Previous studies have examined parents' preferences for the source of information on managing environmental health risks. Mothers reported most often receiving information from the internet, but they preferred to be educated by their prenatal care providers (Laferriere & Crighton, 2017). Approximately 50% of participants in our study indicated that they plan to speak with their HCP or already spoke to them about environmental health risks; participants from India and pregnant women were more likely to respond that they plan to speak with their HCP or have already spoken with them about environmental health risks. Of the participants who answered that they do not plan to consult with their HCP about the impact of toxic chemicals, most commonly indicated reasons were that they had other more important issues they wanted to raise with their HCP (21.7%) or they did not have enough knowledge of what they should ask (21.6%). Only 3.5% of respondents said they would not have trusted their HCP's advice.

Unfortunately, many physicians have not developed the language or skills to effectively communicate the uncertainties and threats of toxic chemicals to their patients (Stotland et al., 2014; Trasande et al., 2006). Medical schools and post-graduate programs provide little or no training in environmental health for physicians. Not surprisingly, most physicians do not know about the scope of the problem, much less what to do to help their patients understand and mitigate risks. Recommendations to address this issue include integrating environmental health into post-secondary education and physician training as well as establishing educational resources within clinics (Crighton et al., 2016). Considering that half of participants either do not have access to HCPs or lack time or resources to address this issue with their HCPs, these remain key future opportunities for KT.

Lastly, 75% of participants expressed concern about being exposed, or a family member being exposed, to toxic chemicals in their daily life. This result is consistent with the HBBF survey that found that 70% of participants, across both groups, were concerned (Healthy Babies Bright Futures, 2018). Taken together, these levels of concern represent an urgent cry for public health protection.

This study had limitations and strengths. We used CloudResearch's Prime Panels® to recruit participants for our internet-based study. This convenience sample may be less representative than a sample recruited through traditional means. In our case, participants must have had access to the internet; thus, it is possible that they may be more informed about children's environmental health than the general population due to the accessibility and amount of information available on the internet. Future research may investigate this topic using a variety of data sources. Yet, by using Prime Panels®, we were able to recruit a large, international pool of participants across five countries. In addition, because we excluded participants who failed the attention check, we likely inflated the benefits of the video by only including participants who understood what the video was about. Out of the 7070 participants who answered the attention check question, approximately 96% passed, showing an overall high-level of understandability by participants and that the video was effective at sustaining people's attention.

Our KT video imparted knowledge, impacted preferences for prevention, and led to a greater desire to reduce exposures to toxic chemicals. However, we did not observe a clear connection between our KT video and behavioural changes. We found evidence that people are concerned about their exposure to toxic chemicals, but systemic barriers inhibit their intent to reduce exposure and change behaviours. Still, knowledge and awareness may influence third parties, like companies, to promote the desired behaviour or to bring to the attention of healthcare providers (Rhein & Schmid, 2020). Similarly, awareness may lead to activism and lobbying of government to create change. Greater knowledge can be used to stimulate greater awareness and advocacy towards stricter regulations.

Supplemental Table 1. *Higher responses on PRoTECT items collapsed across groups and stratified by country, pregnancy status, levels of education, and age*

Item	Item Text	Demographic Variable		Percent of Correct Responses (Strongly Agree) Control group Pre	Control group Post	Control group % Change	Experimental group Pre	Experimental group Post	Experimental group % Change
Factor 1: *Preferences to lower exposure and increase prevention efforts*									
Item 6	When it comes to addressing developmental conditions affecting children, most governments spend the majority of the health budget on management and treatment of these conditions. I think governments should spend more of their budget to find ways to prevent children from developing these conditions.	Collapsed Across Groups		37.35	41.01	3.66	37.85	45.39	7.54*
		Country							
			Canada	13.77	6.12	-7.65 ***	15.83	6.52	-9.31 ***
			Australia	12.87	7.65	-5.22 ***	13.66	7.35	-6.31 ***
			India	28.89	32.46	3.57	29.74	20.81	-8.93 ***
			United Kingdom	11.22	8.2	-3.02	11.8	6.03	-5.77 ***
			United States	33.25	45.57	12.32**	28.98	59.29	30.31**
		Pregnancy Status							
			Yes	11.95	10.54	-1.41	11.76	6.49	-5.27 ***
			No	88.05	89.46	1.41	88.24	93.51	5.27*
		Levels of Education							
			High school or less	20.34	14.33	-6.01 ***	18.86	13.59	-5.27 ***
			Some college or university, no degree/ diploma	15.61	15.44	-0.17	15.68	16.65	0.97
			Bachelor's degree or diploma	42.27	46.53	4.26	43.02	48.38	5.36*
			Master's, doctorate or professional degree	21.77	23.7	1.93	22.45	21.38	-1.07
		Age							
			18-24 years	19.4	13.66	-5.74 ***	21.18	12.47	-8.71 ***
			25-32 years	31.37	31.69	0.32	31.93	31.63	-0.3
			33-39 years	28.77	32.68	3.91	28.1	33.2	5.1*
			40+ years	20.46	21.97	1.51	18.78	22.71	3.93
Item 9	I want to learn more about how to reduce children's	Collapsed Across Groups		39.79	43.33	3.54	41.66	42.01	0.35
		Country							
			Canada	13.69	6.96	-6.73 ***	16.66	6.46	-10.2 ****

	exposure to toxic chemicals.		Australia	12.21	7.69	-4.52	13.69	7.45	-6.24***
			India	32.98	40.33	7.35*	32.74	29.62	-3.12
			United Kingdom	12.07	9.36	-2.71	11.77	6.82	-4.95
			United States	29.05	35.65	6.6*	25.15	49.64	24.49**
		Pregnancy Status							
			Yes	12.49	12.7	0.21	11.68	7.43	-4.25
			No	87.51	87.3	-0.21	88.32	92.57	4.25
		Levels of Education							
			High school or less	20.24	13.03	-7.21***	18.46	13.05	-5.41***
			Some college or university, no degree/ diploma	15.1	13.76	-1.34	14.6	14.04	-0.56
			Bachelor's degree or diploma	42.15	48	5.85*	42.92	47.79	4.87
			Master's, doctorate or professional degree	22.51	25.21	2.7	24.02	25.11	1.09
		Age							
			18-24 years	20.36	15.9	-4.46	21.81	14.18	-7.63***
			25-32 years	34.97	31.91	-3.06	33.3	33.21	-0.09
			33-39 years	26.87	31.6	4.73	28.1	32.23	4.13
			40+ years	17.8	20.58	2.78	16.79	20.38	3.59
Item 10	Of all the sources of information about health impacts from toxic chemicals, I trust information coming from scientists who study them.	Collapsed Across Groups		43.69	45.74	2.05	44.82	47.06	2.24
		Country							
			Canada	14.51	6.21	-8.3***	16.58	6.17	-10.41****
			Australia	14.3	8.97	-5.33***	14.98	7.22	-7.76***
			India	27.6	33.5	5.9*	28.02	23.34	-4.68
			United Kingdom	13.33	8.87	-4.46	12.71	6.5	-6.21***
			United States	30.26	42.46	12.2**	27.71	56.78	29.07**
		Pregnancy Status							
			Yes	12.89	9.95	-2.94	11.63	8.38	-3.25

			No	87.11	90.05	2.94	88.37	91.62	3.25
		Levels of Education							
			High school or less	19.93	13.01	-6.92 ***	18.52	11.41	-7.11 ***
			Some college or university, no degree/ diploma	14.51	14.9	0.39	15	16.16	1.16
			Bachelor's degree or diploma	42.95	48.36	5.41*	43.34	48.63	5.29*
			Master's, doctorate or professional degree	22.62	23.73	1.11	23.14	23.79	0.65
		Age							
			18-24 years	21.32	17.54	-3.78	22.82	13.23	-9.59 ***
			25-32 years	32.32	29.56	-2.76	33.99	33.76	-0.23
			33-39 years	27.56	33.2	5.64*	27.02	32.88	5.86*
			40+ years	18.79	19.7	0.91	16.17	20.13	3.96
Item 11	Exposure to toxic chemicals is particularly harmful to babies and children.	Collapsed Across Groups		59.03	62.94	3.91	58.37	67.51	9.14*
		Country							
			Canada	15.63	6.88	-8.75 ***	17.71	6.49	-11.22 ****
			Australia	15.11	10.03	-5.08 ***	15.5	7.67	-7.83 ***
			India	22.19	26.07	3.88	22.49	17.29	-5.2 ***
			United Kingdom	12.98	9.81	-3.17	12.97	7.11	-5.86 ***
			United States	34.09	47.21	13.12**	31.32	61.44	30.12**
		Pregnancy Status							
			Yes	10.37	10.46	0.09	10.33	7.67	-2.66
			No	89.63	89.54	-0.09	89.67	92.33	2.66
		Levels of Education							
			High school or less	22.56	14.37	-8.19 ***	20.6	12.65	-7.95 ***
			Some college or university, no degree/ diploma	16.91	16.03	-0.88	17.11	16.86	-0.25

			Bachelor's degree or diploma	41.63	48.23	6.6*	42.72	49.52	6.8*
			Master's, doctorate or professional degree	18.9	21.37	2.47	19.57	20.97	1.4
		Age							
			18-24 years	18.76	13.11	-5.65***	20.59	11.58	-9.01***
			25-32 years	31.74	29.87	-1.87	32.63	32.01	-0.62
			33-39 years	28.99	33.95	4.96	27.97	33.63	5.66*
			40+ years	20.51	23.07	2.56	18.81	22.78	3.97
Item 13	More children would benefit by regulating and reducing toxic chemicals to **prevent** developmental conditions than the number of children who benefit from **treatment** of these conditions.	Collapsed Across Groups		39.27	44.02	4.75	38.13	47.14	9.01*
		Country							
			Canada	13.66	6.26	-7.4***	17.15	6.9	-10.25****
			Australia	13.81	9.13	-4.68	13.87	6.82	-7.05***
			India	26.3	30.15	3.85	27.32	21.51	-5.81***
			United Kingdom	13.36	10.05	-3.31	12.77	5.7	-7.07***
			United States	32.88	44.41	11.53**	28.89	59.07	30.18**
		Pregnancy Status							
			Yes	11.97	11.97	0	11.54	6.77	-4.77
			No	88.03	88.03	0	88.46	93.23	4.77
		Levels of Education							
			High school or less	20.92	14.99	-5.93***	19.91	12.88	-7.03***
			Some college or university, no degree/ diploma	15.03	15.62	0.59	14.74	16.59	1.85
			Bachelor's degree or diploma	43.05	45.71	2.66	41.99	47.99	6*
			Master's, doctorate or professional degree	20.99	23.68	2.69	23.35	22.54	-0.81
		Age							
			18-24 years	18.51	13.54	-4.97	19.85	12.84	-7.01***
			25-32 years	31.6	29.85	-1.75	32.37	31.14	-1.23

			33-39 years	28.14	33.13	4.99	28.92	32.74	3.82
			40+ years	21.75	23.49	1.74	18.87	23.27	4.4
Item 15	My government should strengthen their policies and programs to make sure that consumer products do not contain toxic chemicals that are harmful to children.	Collapsed Across Groups		53.32	56.52	3.20	54.34	60.58	6.24*
		Country							
			Canada	14.37	6.97	-7.4***	16.66	7.13	-9.53***
			Australia	13.95	10.01	-3.94	14.68	8.19	-6.49***
			India	24.37	29.86	5.49*	25.48	20.44	-5.04***
			United Kingdom	14.28	9.93	-4.35	14.23	6.56	-7.67***
			United States	33.04	43.23	10.19**	28.95	57.69	28.74**
		Pregnancy Status							
			Yes	11.3	10.39	-0.91	10	6.4	-3.6
			No	88.7	89.61	0.91	90	93.6	3.6
		Levels of Education							
			High school or less	22.42	15.5	-6.92***	20.55	14.06	-6.49***
			Some college or university, no degree/ diploma	16.73	15.74	-0.99	16.17	16.89	0.72
			Bachelor's degree or diploma	41.83	47.3	5.47*	42.42	48.15	5.73*
			Master's, doctorate or professional degree	19.02	21.47	2.45	20.87	20.9	0.03
		Age							
			18-24 years	18.7	14.41	-4.29	21.24	12.94	-8.3***
			25-32 years	30.95	29.7	-1.25	31.85	30.81	-1.04
			33-39 years	29.09	33.23	4.14	27.71	33.06	5.35*
			40+ years	21.26	22.66	1.4	19.2	23.19	3.99
Item 16	If I knew how to reduce children's exposure to toxic chemicals, I would try to do it.	Collapsed Across Groups		58.18	59.89	1.71	57.95	62.69	4.74
		Country							
			Canada	14.9	6.8	-8.1***	16.75	6.53	-10.22****
			Australia	14.8	9.75	-5.05***	15.4	7.85	-7.55***
			India	23.05	27.82	4.77	24.34	20	-4.34

			United Kingdom	14.31	10.2	-4.11	13.86	6.95	-6.91***
			United States	32.93	45.43	12.5**	29.65	58.67	29.02**
		Pregnancy Status							
			Yes	10.19	10.57	0.38	9.76	7.65	-2.11
			No	89.81	89.43	-0.38	90.24	92.35	2.11
		Levels of Education							
			High school or less	22.25	14.84	-7.41***	20.47	13.05	-7.42***
			Some college or university, no degree/ diploma	16.22	16.44	0.22	16.62	16.87	0.25
			Bachelor's degree or diploma	42.04	47.87	5.83*	42.46	49.15	6.69*
			Master's, doctorate or professional degree	19.48	20.85	1.37	20.45	20.93	0.48
		Age							
			18-24 years	17.86	13.23	-4.63	20.03	11.9	-8.13***
			25-32 years	31.84	30.91	-0.93	32.48	32.21	-0.27
			33-39 years	28.83	33.26	4.43	28.71	33.11	4.4
			40+ years	21.47	22.6	1.13	18.79	22.78	3.99
Item 17	I try to purchase products that do not contain toxic chemicals that may be harmful to my family.	Collapsed Across Groups		45.29	44.42	-0.87	45.09	46.74	1.65
		Country							
			Canada	14.33	7.35	-6.98***	16.75	7.31	-9.44***
			Australia	14.99	9.18	-5.81***	15.58	8.52	-7.06***
			India	27.03	33.27	6.24*	28.62	22.32	-6.3***
			United Kingdom	13.12	8.98	-4.14	12.09	5.68	-6.41***
			United States	30.53	41.22	10.69**	26.96	56.17	29.21**
		Pregnancy Status							
			Yes	11.4	11.39	-0.01	11.12	7.93	-3.19
			No	88.6	88.61	0.01	88.88	92.07	3.19
		Levels of Education							

			High school or less	22.03	14.59	-7.44***	19.98	13.46	-6.52***
			Some college or university, no degree/ diploma	15.62	15.93	0.31	15.48	14.76	-0.72
			Bachelor's degree or diploma	43.33	46.66	3.33	42.12	48.69	6.57*
			Master's, doctorate or professional degree	19.02	22.82	3.8	22.43	23.08	0.65
		Age							
			18-24 years	18.85	14.9	-3.95	21.39	11.36	-10.03****
			25-32 years	32.2	30.2	-2	31.79	33.04	1.25
			33-39 years	28.66	33.37	4.71	27.93	33.44	5.51*
			40+ years	20.29	21.53	1.24	18.89	22.16	3.27

Item	Item Text	Demographic Variable		Percent of Correct Responses (Disagree and Strongly Disagree combined)					
				Control group			Experimental group		
				Pre	Post	% Change	Pre	Post	% Change
Factor 2: *Attitudes towards regulations of toxic chemicals by government and industry*									
Item 2	Most governments spend about the same amount to **prevent** developmental conditions as they spend to **treat** these conditions.	Collapsed Across Groups		38.36	46.96	8.60*	39.32	53.96	14.64**
		Country							
			Canada	16.55	5.86	-10.69****	16.85	4.94	-11.91****
			Australia	14.68	10.96	-3.72	14.96	6.38	-8.58***
			India	9.46	11.34	1.88	10.99	9.06	-1.93
			United Kingdom	17.09	12	-5.09***	15.9	7.48	-8.42***
			United States	42.22	59.83	17.61**	41.31	72.13	30.82**
		Pregnancy Status							
			Yes	7.16	6.44	-0.72	7.11	6.77	-0.34
			No	92.84	55.15	-37.69****	92.89	93.23	0.34
		Levels of Education							
			High school or less	19.83	14.58	-5.25***	18.96	12.04	-6.92***
			Some college or university, no degree/ diploma	18.76	16.76	-2	19.53	20.23	0.7

			Bachelor's degree or diploma	45.67	49.34	3.67	44.99	49.14	4.15
			Master's, doctorate or professional degree	15.74	19.32	3.58	16.52	18.58	2.06
		Age							
			18-24 years	15.56	10.49	-5.07***	17.76	11.12	-6.64***
			25-32 years	30.59	29.58	-1.01	31.4	31.3	-0.1
			33-39 years	30.82	36.39	5.57*	31.16	35.07	3.91
			40+ years	23.04	23.53	0.49	19.68	22.51	2.83
Item 3	All parents have equal opportunities to protect their children from toxic chemicals like pesticides or heavy metals, regardless of income level, race and ethnicity, or where they live.	Collapsed Across Groups		42.60	49.80	7.20*	43.69	56.43	12.74**
		Country							
			Canada	17.16	5.99	-11.17****	18.93	5.92	-13.01****
			Australia	14.68	9.92	-4.76	14.53	5.86	-8.67***
			India	9.01	11.8	2.79	10.58	9.61	-0.97
			United Kingdom	17.19	11.89	-5.3***	15.94	7.24	-8.7***
			United States	41.95	60.41	18.46**	40.02	71.36	31.34**
		Pregnancy Status							
			Yes	6.12	6.26	0.14	5.75	5.84	0.09
			No	93.88	53.65	-40.23****	94.25	94.16	-0.09
		Levels of Education							
			High school or less	20.13	14.59	-5.54***	19.33	13.2	-6.13***
			Some college or university, no degree/ diploma	19.13	17.19	-1.94	19.43	19.47	0.04
			Bachelor's degree or diploma	45.17	48.52	3.35	44.92	48.91	3.99
			Master's, doctorate or professional degree	15.57	19.7	4.13	16.32	18.42	2.1
		Age							
			18-24 years	17.64	11.89	-5.75***	19.1	12.24	-6.86***
			25-32 years	30.67	29.13	-1.54	31.58	31.67	0.09

		33-39 years	29.54	36.55	7.01*	30.22	34.23	4.01
		40+ years	22.15	22.43	0.28	19.1	21.86	2.76
Item 4	My government has effective regulations to ensure that food and personal care products do not contain harmful levels of toxic chemicals.	Collapsed Across Groups	23.83	28.20	4.37	23.33	34.16	10.83**
		Country						
		Canada	14.03	4.11	-9.92***	15.5	5.12	-10.38****
		Australia	7.51	5.85	-1.66	9.98	4.36	-5.62***
		India	17.54	19.43	1.89	20.88	17.1	-3.78
		United Kingdom	12.68	8.69	-3.99	12.76	3.81	-8.95***
		United States	48.25	61.93	13.68**	40.88	69.61	28.73**
		Pregnancy Status						
		Yes	9.42	10.91	1.49	8.21	7.63	-0.58
		No	90.58	93.45	2.87	91.79	92.37	0.58
		Levels of Education						
		High school or less	19.54	14.72	-4.82	18.36	11.61	-6.75***
		Some college or university, no degree/ diploma	18.92	13.61	-5.31***	17.81	17.96	0.15
		Bachelor's degree or diploma	43.8	48.73	4.93	45.11	49.95	4.84
		Master's, doctorate or professional degree	17.74	22.94	5.2*	18.72	20.48	1.76
		Age						
		18-24 years	18.95	12.8	-6.15***	20.37	13.83	-6.54***
		25-32 years	32.68	29.7	-2.98	33.14	31.7	-1.44
		33-39 years	27.75	36.02	8.27*	27.85	32.57	4.72
		40+ years	20.62	21.48	0.86	18.64	21.9	3.26
Item 7	If toxic chemicals were a threat to my family's health, my pediatrician, doctor, or health care provider would have	Collapsed Across Groups	24.17	25.12	0.95	23.93	28.87	4.94
		Country						
		Canada	18.56	8.23	-10.33****	19.13	6.78	-12.35****
		Australia	13.27	11.27	-2	14.85	6.52	-8.33***
		India	6.09	7.69	1. 6	7.4	6.13	-1.27

	told me about it.		United Kingdom	21.73	15.56	-6.17 ***	19.48	9.52	-9.96 ***
			United States	40.35	57.25	16.9**	39.14	71.06	31.92**
		Pregnancy Status							
			Yes	8.8	11.45	2.65	6.72	6.37	-0.35
			No	91.2	98.09	6.89*	93.28	93.63	0.35
		Levels of Education							
			High school or less	23.24	17.06	-6.18 ***	20.93	14.1	-6.83 ***
			Some college or university, no degree/ diploma	20.92	16.16	-4.76	20.89	18.15	-2.74
			Bachelor's degree or diploma	43.12	52.42	9.3*	43.22	53.39	10.17**
			Master's, doctorate or professional degree	12.72	14.36	1.64	14.96	14.36	-0.6
		Age							
			18-24 years	15.28	9.3	-5.98 ***	15.92	10.17	-5.75 ***
			25-32 years	30.19	29.52	-0.67	30	33.64	3.64
			33-39 years	30.55	37.57	7.02*	30.81	31.03	0.22
			40+ years	23.98	23.61	-0.37	23.27	25.16	1.89
Item 12	I trust that most companies make products that don't contain harmful levels of toxic chemicals.	Collapsed Across Groups		32.93	37.89	4.96	34.17	45.78	11.61**
		Country							
			Canada	17.67	5.48	-12.19 ****	18.03	7.02	-11.01 ****
			Australia	12.91	7.74	-5.17 ***	13.27	6.11	-7.16 ***
			India	13.99	17.5	3.51	16.78	14.04	-2.74
			United Kingdom	11.88	9.64	-2.24	13.15	6.19	-6.96 ***
			United States	43.54	59.64	16.1**	38.76	66.64	27.88**
		Pregnancy Status							
			Yes	8.56	8.13	-0.43	8.35	7.71	-0.64
			No	91.44	69.65	-21.79 ***	91.65	92.29	0.64
		Levels of Education							

			High school or less	20.59	13.96	-6.63***	19.02	12.33	-6.69***
			Some college or university, no degree/ diploma	18.65	16.23	-2.42	18.11	18.71	0.6
			Bachelor's degree or diploma	44.1	49.52	5.42*	45.04	49.42	4.38
			Master's, doctorate or professional degree	16.67	20.29	3.62	17.83	19.54	1.71
		Age							
			18-24 years	17.98	10.36	-7.62***	19.6	12.55	-7.05***
			25-32 years	30.76	31.43	0.67	31.81	32.2	0.39
			33-39 years	29.51	35.12	5.61*	28.96	33.2	4.24
			40+ years	21.75	23.1	1.35	19.63	22.05	2.42

Item	Item Text	Demographic Variable		Percent of Correct Responses (Strongly Agree)					
				Control group			Experimental group		
				Pre	Post	% Change	Pre	Post	% Change
Factor 3: *Knowledge of developmental neurotoxicity*									
Item 1	Toxic chemicals in our day-to-day lives, like air pollution or lead in drinking water, can increase a child's risk of developing conditions like ADHD or autism.	Collapsed Across Groups		34.89	40.67	5.78*	34.40	43.89	9.49*
		Country							
			Canada	11.37	5.42	-5.95***	15.79	8.21	-7.58***
			Australia	10.49	5.97	-4.52	11.7	6.29	-5.41***
			India	39.05	42.95	3.9	40.67	29.92	-10.75****
			United Kingdom	8.78	7.05	-1.73	8.71	4.95	-3.76
			United States	30.31	38.61	8.3*	23.12	50.63	27.51**
		Pregnancy Status							
			Yes	14.2	12.91	-1.29	14.45	7.65	-6.8***
			No	85.8	87.09	1.29	85.55	92.35	6.8*s
		Levels of Education							
			High school or less	20.3	13.09	-7.21***	18.53	12.53	-6***
			Some college or university, no degree/ diploma	14.76	15.95	1.19	14.08	15.48	1.4

			Bachelor's degree or diploma	40.78	45.32	4.54	41.73	48.19	6.46*
			Master's, doctorate or professional degree	24.15	25.63	1.48	25.66	23.8	-1.86
		Age							
			18-24 years	21.61	17.25	-4.36	24.69	14.25	-10.44 ****
			25-32 years	33.86	32.21	-1.65	32.05	31.77	-0.28
			33-39 years	25.96	28.52	2.56	26.88	32.44	5.56*
			40+ years	18.56	22.02	3.46	16.38	21.54	5.16*
Item 5	Reducing exposure to toxic chemicals during pregnancy and in early childhood can help lower a child’s risk of developing a condition like ADHD or autism.	Collapsed Across Groups		35.40	39.99	4.59	35.57	43.35	9.78*
		Country							
			Canada	13.43	7.15	-6.28 ***	16.31	6.43	-9.88 ***
			Australia	11.94	7.37	-4.57	12.84	6.84	-6 ***
			India	32.59	37.09	4.5	33.3	22.57	-10.73 ****
			United Kingdom	8.87	6.26	-2.61	10.2	5.19	-5.01 ***
			United States	33.17	42.12	8.95*	27.35	58.98	31.63**
		Pregnancy Status							
			Yes	11.8	10.12	-1.68	13.11	8.23	-4.88
			No	88.2	89.88	1.68	86.89	91.77	4.88
		Levels of Education							
			High school or less	20.28	13.57	-6.71 ***	18.46	13.25	-5.21 ***
			Some college or university, no degree/ diploma	15.13	14.93	-0.2	14.69	16.31	1.62
			Bachelor's degree or diploma	42.04	46.49	4.45	42.67	50.17	7.5*
			Master's, doctorate or professional degree	22.55	25	2.45	24.18	20.28	-3.9
		Age							
			18-24 years	19.57	13.97	-5.6 ***	22.8	12.52	-10.28 ****
			25-32 years	32.59	31.62	-0.97	32.29	31.88	-0.41

			33-39 years	28.32	32.29	3.97	27.47	34.02	6.55*
			40+ years	19.53	22.12	2.59	17.44	21.58	4.14
Item 8	Exposure to toxic chemicals during pregnancy can increase a child's risk of having a developmental condition.	Collapsed Across Groups		47.11	48.78	1.67	47.10	55.41	8.31*
		Country							
			Canada	14.91	7.47	-7.44***	17.18	7.01	-10.17****
			Australia	13.44	8.03	-5.41***	13.23	7.35	-5.88***
			India	26.95	31.83	4.88	27.85	21.29	-6.56***
			United Kingdom	10.85	7.75	-3.1	11.62	5.24	-6.38***
			United States	33.85	44.93	11.08**	30.12	59.12	29**
		Pregnancy Status							
			Yes	11.42	9.24	-2.18	12.08	7.72	-4.36
			No	88.58	90.76	2.18	87.92	92.28	4.36
		Levels of Education							
			High school or less	20.69	14.73	-5.96***	19.12	12.92	-6.2***
			Some college or university, no degree/ diploma	16.62	14.82	-1.8	15.64	16.61	0.97
			Bachelor's degree or diploma	42.71	47.62	4.91	43.45	49.01	5.56*
			Master's, doctorate or professional degree	19.97	22.83	2.86	21.79	21.46	-0.33
		Age							
			18-24 years	19.69	14.11	-5.58***	21.26	12.11	-9.15***
			25-32 years	32.51	32.01	-0.5	33.06	32.52	-0.54
			33-39 years	27.51	31.37	3.86	27.71	33.2	5.49*
			40+ years	20.29	22.51	2.22	17.97	22.18	4.21
Item 14	Toxic chemicals can be detected in the blood of most pregnant women.	Collapsed Across Groups		17.48	18.99	1.51	16.27	21.61	5.34*
		Country							
			Canada	12.79	7.86	-4.93	16.6	8.58	-8.02***
			Australia	12.19	7.86	-4.33	14.95	6.83	-8.12***
			India	31.67	37.62	5.95*	33.79	22.24	-11.55****

	United Kingdom	12.62	9.76	-2.86	12.12	6.13	-5.99***
	United States	30.74	36.9	6.16*	22.53	56.22	33.69**
Pregnancy Status							
	Yes	15.06	10.53	-4.53	15.42	6.09	-9.33***
	No	84.94	89.47	4.53	84.58	93.91	9.33*
Levels of Education							
	High school or less	24.1	12.08	-12.02****	21.44	12.3	-9.14***
	Some college or university, no degree/ diploma	16.38	17.87	1.49	14.7	18.45	3.75
	Bachelor's degree or diploma	36.54	45.17	8.63*	38.08	46.05	7.97*
	Master's, doctorate or professional degree	22.98	24.88	1.9	25.78	23.2	-2.58
Age							
	18-24 years	17.7	16.9	-0.8	20.03	10.16	-9.87***
	25-32 years	35.48	26.43	-9.05***	32.02	34.15	2.13
	33-39 years	27.77	32.38	4.61	27.4	31.87	4.47
	40+ years	19.05	24.29	5.24*	20.55	23.82	3.27

** difference of 5 to 9.99 percent*
*** difference of 10 percent or more*
**** difference of -5 to -9.99 percent*
***** difference of -10 percent or more*

Supplemental Table 2. *Demographic characteristics of 'non-responders' compared to general population*

	Baseline (included all who completed demographics)			
	'Non-responders'		Whole sample	
	Control Group	Experimental Group	Control Group	Experimental Group
n	91	127	6887	9447

Gender (No (%))				
Female	29 (31.87)	34 (26.77)	3469 (50.37)	5086 (53.84)
Male	61 (67.03)	92 (72.44)	3352 (48.67)	4233 (44.81)
Non-Binary	1 (1.10)	1 (0.79)	48 (0.70)	88 (0.93)
Country (No (%))				
Canada	5 (5.49)	8 (6.30)	1124 (16.32)	1755 (18.58)
Australia	12 (13.19)	5 (3.94)	1086 (15.77)	1631 (17.26)
India	1 (1.10)	0 (0.0)	1331 (19.33)	1949 (20.63)
United Kingdom	10 (10.99)	12 (9.45)	1167 (16.94)	1647 (17.43)
United States	63 (69.23)	102 (80.31)	2179 (31.64)	2465 (26.09)
Ethnic Groups (No (%))				
White	75 (82.42)	99 (77.95)	3592 (52.16)	4757 (50.35)
Black	5 (5.49)	10 (7.87)	540 (7.84)	613 (6.49)
South Asian	1 (1.10)	2 (1.57)	1260 (18.30)	1867 (19.76)
Other				
Location (No (%))				
Major City	17 (18.68)	31 (24.41)	2448 (35.55)	3401 (36.00)
Suburban Edges	33 (36.26)	37 (29.13)	2100 (30.49)	2801 (29.65)
Major Town	18 (19.78)	14 (11.02)	708 (10.28)	1048 (11.09)
Small Town	19 (20.88)	38 (29.92)	1382 (20.07)	1843 (19.51)
Remote	4 (4.40)	6 (4.72)	183 (2.66)	262 (2.77)
Mean (SD) age (years)	35. 15 (8.43)	34.22 (7.43)	32.26 (8.18)	31.70 (8.12)
Level of Education (No (%))				
High school or less	17 (18.68)	24 (18.90)	1678 (24.36)	2188 (23.16)
Some college or university, no degree/diploma	18 (19.78)	28 (22.05)	1159 (16.83)	1535 (16.25)
Bachelor's degree or diploma	49 (53.85)	61 (48.03)	2796 (40.60)	3865 (40.91)
Master's, doctorate or	7 (7.69)	14 (11.02)	1177 (17.09)	1729 (18.30)

professional degree				
Employment (No (%))				
Full-time	49 (53.85)	72 (56.69)	3608 (52.39)	4813 (50.95)
Part-time	6 (6.59)	6 (4.72)	990 (14.37)	1427 (15.11)
Other	36 (39.56)	49 (38.58)	2289 (33.24)	3207 (33.95)
Politics				
Mean (SD), Median	4.70 (2.56)	4.40 (2.98)	5.00 (2.47)	4.91 (2.48)
Total Household Income (CAD) (No (%))				
$0-$49,999	3 (3.30)	2 (1.57)	415 (6.03)	618 (6.54)
$50,000 - $74,999	0 (0.0)	1 (0.79)	209 (3.03)	327 (3.46)
$75,000 - $99,999	1 (1.10)	3 (2.36)	168 (2.44)	287 (3.04)
$100,000 or more	87 (95.60)	121 (95.28)	6095 (88.50)	8215 (86.96)
Total Household Income (AUD) (No (%))				
$0-$53,999	1 (1.10)	0 (0.0)	283 (4.11)	509 (5.39)
$54,000 - $80,999	5 (5.49)	1 (0.79)	186 (2.70)	261 (2.76)
$81,000 - $109,999	2 (2.20)	1 (0.79)	188 (2.73)	231 (2.45)
$110,000 or above	83 (91.21)	125 (98.43)	6230 (90.46)	8446 (89.40)
Total Household Income (RS) (No (%))				
₹0-₹499,999	0 (0.0)	0 (0.0)	553 (8.03)	729 (7.72)
₹500,000 - ₹749,999	0 (0.0)	0 (0.0)	176 (2.56)	305 (3.23)
₹750,000 - ₹999,999	0 (0.0)	0 (0.0)	179 (2.60)	257 (2.72)
₹1,000,000 or above	1 (100.0)	0 (0)	5979 (86.82)	8156 (86.33)
Total Household Income (GBP) (No (%))				
£0-£28,999	4 (4.40)	4 (3.15)	445 (6.46)	639 (6.76)

£29,000 - £42,999	3 (3.30)	2 (1.57)	246 (3.57)	351 (3.72)
£43,000 - £56,999	2 (2.20)	3 (2.36)	171 (2.48)	228 (2.41)
£57,000 or above	82 (90.11)	118 (92.91)	6025 (87.48)	8229 (87.11)
Total Household Income (USD) (No (%))				
$0-$39,999	25 (27.47)	40 (31.50)	725 (10.53)	827 (8.75)
$40,000 - $59,999	11 (12.09)	15 (11.81)	400 (5.81)	492 (5.21)
$60,000 - $79,999	11 (12.09)	18 (14.17)	342 (4.97)	399 (4.22)
$80,000 or above	44 (48.35)	54 (42.52)	5420 (78.70)	7729 (81.81)
Parental Questions				
Marital Status (No (%))				
Single	55 (60.44)	77 (60.63)	3527 (51.21)	5134 (54.35)
Married/Common Law	28 (30.77)	40 (31.50)	3031 (44.01)	3884 (41.11)
Separated/Divorced/ Widowed	8 (8.79)	10 (7.87)	329 (4.78)	429 (4.54)
Children (No (%))				
Yes, I have children	27 (29.67)	44 (34.65)	3110 (45.16)	3961 (41.93)
No, I don't have children	64 (70.33)	83 (65.35)	3777 (54.84)	5486 (58.07)
Pregnancy Status (No (%))				
Pregnant	1 (3.70)	5 (11.36)	373 (12.09)	418 (10.63)
Non-pregnant	26 (96.30)	39 (88.64)	2711 (87.91)	3515 (89.37)
Identified Developmental Conditions (Participants' Children) (No (%))				
No	25 (92.59)	42 (95.45)	2398 (77.96)	3076 (78.57)
Yes	2 (7.41)	2 (4.55)	545 (17.72)	694 (17.73)
I don't know	0 (0.0)	0 (0.0)	117 (3.80)	131 (3.35)
Identified Developmental Conditions (Participants) (No (%))				

No	26 (96.30)	42 (95.45)	2619 (84.95)	3359 (85.43)
Yes	1 (3.70)	2 (4.55)	390 (12.65)	487 (12.39)
I don’t know	0 (0.0)	0 (0.0)	74 (2.40)	86 (2.19)

Chapter 5: General Discussion

Summary

We developed and evaluated a children's environmental health knowledge translation tool, known as the *PRevention of Toxic Chemicals in the Environment for Children Tool* (*PRoTECT*), which assesses knowledge of developmental neurotoxicity, attitudes towards regulations of toxic chemicals, and attitudes towards the lowering of exposures to toxic chemicals and investing in the prevention of neurodevelopmental disorders; *PRoTECT* consists of 17 items with five-point Likert-type response scales ranging from *strongly agree* to *strongly disagree*. In study one, *PRoTECT* was developed with scientific and child advocacy experts and refined via focus groups. *PRoTECT* was then implemented with 190 participants of childbearing age (18 to 45 years) for an initial examination of its dimensionality via EFA. Study two included 15,594 participants of childbearing age from five countries (Canada, U.S., U.K., India, and Australia) to evaluate *PRoTECT's* conceptual dimensionality and general response patterns across various demographic characteristics. The content domains found utilizing factor analyses were (1) preferences to lower exposure and increasing prevention, (2) knowledge of the regulation of toxic chemicals by government and industry, and (3) knowledge of developmental neurotoxicity, indicating that three subscale scores can be calculated from the *PRoTECT* item scores to represent these conceptual factors. In study three, a randomized controlled trial (RCT) was used to evaluate the efficacy of a video, *Little Things Matter: Impact of Toxic Chemicals on the Developing Brain*, with respect to providing knowledge of developmental neurotoxicity using *PRoTECT*, and perhaps lead to behavioural changes to reduce exposures to toxic chemicals, at baseline, as well as at 6-weeks' post-intervention. Participants were randomly assigned to either watch the knowledge dissemination tool (experimental group) or serve in the control group.

Immediately post-video, participants in the experimental group showed greater changes in scores on *PRoTECT* and a greater intent to reduce exposure than the control group, especially those from the U.S., those who were higher educated, and those who were in their thirties. There were modest group differences in readiness to change at post-video, but the differences were much smaller at the six-week follow up. All participants reported significant barriers to reduce exposure to toxic chemicals, including not knowing how or where to purchase products, cost, and convenience.

Findings in Context: Relationship Between Knowledge and Behaviour

Toxic chemicals in the environment are a problem. When it comes to children, we have learned that, unfortunately, *Little Things Matter*; small doses of a chemical, once considered innocuous, can in fact be harmful for the developing brain. We found that people who were more knowledgeable about the impacts of toxic chemicals on children's development were also more likely to want to learn more about how to reduce their exposures and want to invest more money into prevention of disorders caused by toxic chemicals. Knowledge translation, then, may be a way to ignite change by inspiring people to learn more and perhaps, in turn, advocate for change.

However, despite having more knowledge, we observed that a smaller percentage (approximately 50% to 60%) reported actually making changes to reduce exposures in the follow-up period compared to their original intent at baseline (approximately 60% to 75%). Further, although the video illustrated how people could make changes to reduce their exposures, approximately the same percentage (50% to 60%) of participants in the control and experimental group reported making changes. While scores on *PRoTECT* increased over time, across both groups, demonstrating more knowledge on toxic chemicals and child development, more changes were not observed. What happened?

Assuming that education-based interventions or providing individuals with information will promote behavioural change disregards the broader context of social, economic, political, and environmental circumstances (Kelly & Barker, 2016) as well as personal factors such as motivation. In addition, education-based interventions are mostly ineffective in preventing disease on a population-wide scale (Vallis, 2022). For example, population-wide public health interventions, such as bans on second-hand cigarette smoke, led to greater reduction in cigarette use than education alone (Blaakman et al., 2015), underscoring the importance of population-wide strategies in controlling health behaviours. Education on health impacts may not always lead to behavioural changes. A randomized control trial (RCT) in Sweden randomly assigned students to complete an educational program on smoking and found that although students completing the program had greater knowledge on heart and lung function and heart-healthy behaviors, there were no differences in behavioural changes among students in the experimental versus control groups (Lindberg, Ståhle, & Rydén, 2006). Similar results were noted with a tobacco prevention program, initiated by the Department of Education in Saudi Arabia, whereby students did not change their behaviours after completing the program, but did increase their knowledge and awareness of the negative effects of smoking (Al Agili & Salihu, 2020). These findings further demonstrate that education-based interventions may be ineffective in promoting behavioral change and underscore the urgent need for population-wide strategies to reduce the availability of toxic substances, especially in youth.

Within the context of environmental health, studies examining environmental concerns and behavioural changes related to increasing environmental sustainability found that awareness does not necessarily lead to changes in health-related behaviours (Grunert, 2011; Ketelsen et al., 2020; Rhein & Schmid, 2020). This has been observed in the context of adopting a healthier diet

(Yeh et al., 2008), preventing childhood injuries (Gittelman et al., 2014), and implementing strategies towards disease prevention (Kelly & Barker, 2016). Clearly, as a society, population-wide strategies are needed to protect children because educational strategies to induce individual behavioural change will not necessarily solve the problem. We cannot blame individuals for systemic problems; instead, we need societal or systemic changes that make it easier to stay healthy and harder to get sick.

Role of Psychologists in Healthcare Settings

While healthcare providers are trained to be experts in health, and are comfortable making recommendations and providing education, neither are highly effective in helping people overcome barriers to make changes (Vallis et al., 2018). However, psychologists can participate by supporting healthcare providers in conveying effective ways for people to make health-related behavioural changes. Psychologists understand that change-based relationships work in the context of collaboration with people, motivational communication, and nonjudgmental curiosity, empathy, and support. Psychologists are often trained using cognitive and behavioural principles to induce change. A systematic review of cognitive behavioural therapy (CBT) in any condition, population, or context found consistent evidence for the general benefit of CBT – even outside of traditional uses (Fordham et al., 2021). In this way, psychologists, and more specifically, health psychologists, have a unique role to play in medicine by helping people make changes to promote healthy behaviour. For example, lifestyle changes can lower comorbidities for patients with diabetes, yet less than 30% of Americans with diabetes receive diet or exercise counseling (Shah, 2019). To meet that need, psychologists can help train frontline, patient-facing healthcare providers on effective behavioural change counseling to instill preventative health behaviours and advocate for education on more behavioural change counselling in healthcare provider training (Vallis et al., 2018). Consequently, making these changes can reduce likelihood of comorbidities in disease. While psychologists, in conjunction with public health scientists, have a role to play in promoting behavioural changes on a population-wide scale and reducing comorbidities in disease, it is also important to work on ways to *prevent* diseases to begin with.

Shifting the Narrative to Prevention

During the COVID-19 pandemic, questions about health have appeared in mainstream media in a new way (Leung, 2023). Why do some children get very sick and others do not when exposed to the same virus? Which children are at the greatest risk? What happens when healthcare dollars go towards treating the very sick during a pandemic and some children cannot be seen by their primary care doctor or access hospital services? Is there anything that individuals can do to prevent themselves or their children from becoming very sick? This may be one of the most important times to shift the narrative to prevention. Too often, we are forced to react once we are already sick, especially for children. Yet, we could engage in proactive strategies to reduce the likelihood of getting sick to begin with.

There are two types of strategies to curb disease, the clinical strategy and the population strategy. Most of the healthcare budget goes towards the clinical strategy, leaving only 5% dedicated to the population strategy, which looks for risk factors that lead to disease (Whitehead, et al., 2016). This inconsistency is paradoxical because most death and disability occurs among people who have low to moderate risk of developing the disease. This situation is called the prevention paradox and it can be illustrated in the case of obesity and diabetes-type 2. People who are very obese are at a higher risk of developing diabetes. Among the Canadian population, 4% are very obese and they have a 33% chance of developing diabetes, resulting in 12% of new cases of diabetes emerging from this group (Manuel et al., 2010). However, if we only focused on this high-risk group, we would miss 88% of new cases of diabetes. When we do not focus on the population, we fail to reach the majority of people who will develop a disease.

We found that participants in our study understood the prevention paradox, or the seemingly contradictory situation where most cases of a disease come from a population at low or moderate risk of that disease, and only a minority of cases come from the high-risk population. Almost 80% of respondents endorsed that they agree that more children would benefit from regulating toxic chemicals that would *prevent* neurodevelopmental disorders compared to the number of children who would benefit from *treatment* of these conditions. Why are we not doing more to prevent the disorder from occurring? We need to invest more in population-based strategies that will benefit all children.

There are other problems with clinical strategies. They may inadvertently make the person feel blamed for getting sick to begin with. While creating this questionnaire and meeting with families, we found that parents too often feel responsible about needing to control their families' exposures and feel blamed that they may have caused their child to have a neurodevelopmental disorder. One parent said: "*This makes me sad it's almost like a blame game; you lived in the city it's caused autism in your child. We're trying to find out if my son has autism currently and some of the questions our Dr asked sound like they're going to blame you for it."* Yet, the onus falls on government and industry to regulate what they put into products, ensure children are breathing clean air, and limit widespread exposure to toxic chemicals. We were mindful to design our items on *PRoTECT* in a way that does not elicit blame from parents and instead turns the focus on industry and government. We were not surprised when we saw that close to 80% of respondents agreed that their government should spend more of their budget to find ways to prevent children from neurodevelopmental disorders. This sentiment was endorsed more often by participants who had children than those without children.

Despite people wanting their governments to do more to prevent the onset of new cases of neurodevelopmental disorders, little research and funding is dedicated to prevention of disease and disability. For example, one in four cases of childhood leukemia is attributed to toxic chemicals such as pesticides, solvents, and air pollution (Whitehead et al., 2016). Yet, only 4% of American health dollars are devoted to prevention of childhood cancers (Zachek et al., 2015). Similarly, only 1% of the National Cancer Institute's budget for research in childhood cancer is devoted to prevention (Zachek et al., 2015).

Clinical Perspective

As a clinical psychologist, this research is relevant to my work with families. For example, parents having their children diagnosed with neurodevelopmental conditions such as ADHD, Learning Disabilities, or ASD typically ask *why*? The next question they often ask is *was there something we could have done differently*? Often, parents also wonder *now that this has happened, is there something we can do to prevent my younger child from developing it*? Too rarely is prevention discussed within a clinical perspective. In the current study, we heard from our participants, and louder from our parent participants, that we must devote more resources to identify and control the ubiquity of harmful toxic chemicals in the environment. It is time to give prevention a chance.

Unfortunately, history shows that change does not always occur until parents demand it. Many public health victories, like the declines in lung cancer and lead poisoning, and the near elimination of polio, were due largely to population strategies to control environmental agents, such as toxic chemicals, tobacco smoke, and microbes (Tulchinsky & Varavikova, 2014). For example, Mackenbach and Garssen showed that 78% of reductions in disease from 1970 to 2010 in the Netherlands were due to population-based strategies (i.e., smoking bans); only 22% were from clinical care strategies (Mackenbach & Garssen, 2010). Historically, parents have accelerated change by showing and advocating for their preferences, as has been seen in other public health interventions, such as childhood vaccinations and the water disaster in Flint, Michigan (Krings, Kornberg, & Lane, 2018; Shorvon & Berg, 2008).

While parents' advocacy to create change is empowering and hopeful, relying on parents to accelerate reform is problematic because most parents are unaware of how the government and industry may be failing to protect us until it is too late. In fact, we found that over half of participants agreed that industry and government *are* doing enough to regulate the release of toxic chemicals into the environment. However, we may be able to educate on the shortfalls by government as seen in the current study. After watching the *Little Things Matter* video, the greatest increases in scores were on items asking about regulations of toxic chemicals and government investment in prevention. Participants who watched the video were more aware of the *lack* of regulations made by industry, going from 23% disagreeing that their government had effective regulations to monitor harmful levels of toxic chemicals to 34% disagreeing. The same was observed in terms of the flawed healthcare system of spending too much on treatment and not enough in prevention. We also found a robust parental preference for more money and healthcare resources going toward prevention of neurodevelopmental disorders among those who watched the video. Even if changes are not made immediately, knowledge translation on government and industry's role can get people thinking about this issue in a way that they may not have before.

Future Directions

Parents' understanding of the impact of toxic chemicals on children's development may accelerate the promulgation of protective policies and regulations. While we await stronger legislation to reduce toxic exposures among pregnant women and children, it is important to continue to find ways to effectively communicate these risks with parents and caregivers without inciting blame and guilt. Thus, *PRoTECT* represents a potentially useful tool for assessing knowledge as it pertains to toxic chemicals found in the environment and their impact on children's neurodevelopment. In addition to examining patterns of knowledge, preferences, and concern, *PRoTECT* in and of itself may serve as a type of intervention to educate people on the risks of toxic chemicals and prompt them to begin to look for more information. In fact, we found differences in the *control group* by time such that people endorsed more knowledge, concern, and preferences for prevention at the six-week follow-up compared to baseline. Similarly, we found that 60% of participants in the control group made between one and three changes to reduce their exposures to toxic chemicals, 55% looked for more information on the subject, and about a third had a conversation with someone about this subject (i.e., 36% with family or partner, 33% with friends or colleagues). Considering these findings, we suggest that *PRoTECT* can both be used as an examination tool and as a knowledge awareness tool.

In addition to its use with the public and parents, *PRoTECT* can continue to be used by researchers and clinicians to evaluate trends of knowledge of toxic chemicals and neurodevelopment, parents' and expectant parents' intentions to reduce their exposure to toxic chemicals and preferences towards prevention amongst certain demographic groups, including across countries. It may also be used further among clinicians, especially those working in patient-facing pediatric and obstetrics facilities, to gauge their understanding of risk and awareness about current governmental regulatory practices. Taken together, our intention is that

PRoTECT will be used to inform and advance policy measures to reduce early-life exposures to toxic chemicals and, by extension, curb rising rates of neurodevelopmental disorders among children.

Over the next few years, our team hopes to use the information from this study to implement knowledge translation tools across various avenues. We have a large social media presence (@littlethingsmtr) across Facebook, Instagram, and Twitter. Our goal is to develop poll-like content to ask our followers about their concerns regarding their family's exposures to toxic chemicals, their preferences for their government to invest more in prevention, or barriers to making changes to reduce exposures. This study is just the beginning of an ongoing conversation about children's environmental health research *with* the public. We will use social media to get more information from the public to inform our next study. We will listen to what parents say about how they want to access information and from whom they would like to learn. We will continue to learn from the public on what content they would like to see and how to improve our messaging.

In conclusion, the skyrocketing rates of neurodevelopmental disorders are an urgent problem. While there is much research devoted to interventions for children with NDDs, little goes towards prevention. One way to prevent new cases of NDDs is to reduce risk factors, such as exposures to toxic chemicals. We developed a questionnaire to assess the public's knowledge and preferences as it pertains to lowering exposures to toxic chemicals in the environment. We found great interest in learning more and reducing exposures. Yet, education alone is not sufficient. In order to protect the next generation of children, while it is not enough to educate the public about the risks pose by toxic chemicals, we hope that greater awareness will lead to greater advocacy, and in turn, stricter regulations of toxic chemicals.

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Appendices

Appendix A: Final PRevention Of Toxic chemicals in the Environment for Children Tool (PRoTECT)

PROTECT

PRevention Of Toxic chemicals in the Environment for Children Tool

PROTECT is a survey to find out what parents and people of childbearing age know about toxic chemicals and developmental conditions in children. Toxic chemicals, like lead, pesticides and phthalates, can be found in our homes, air, and water, and can be harmful to our health. Developmental conditions include learning disabilities, attention deficit/hyperactivity disorder (ADHD), and autism spectrum disorder (autism), among other developmental conditions.

We are asking you to rate each item on a scale from "Strongly Agree" to "Strongly Disagree". If you come to an item that you are unsure of the answer, please give your best guess and do not skip any items.

	1 – Strongly Agree	2 – Somewhat Agree	3 – Neither Agree nor Disagree	4 – Somewhat Disagree	5 – Strongly Disagree
1. Toxic chemicals in our day-to-day lives, like air pollution or lead in drinking water, can increase a child's risk of developing conditions like ADHD or autism.	**1**	**2**	**3**	**4**	**5**
2. Most governments spend about the same amount to **prevent** developmental conditions as they spend to **treat** these conditions.	**1**	**2**	**3**	**4**	**5**
3. All parents have equal opportunities to protect their children from toxic chemicals like pesticides or heavy metals, regardless of income level, race and ethnicity, or where they live.	**1**	**2**	**3**	**4**	**5**
4. My government has effective regulations to ensure that food and personal care products do not contain harmful levels of toxic chemicals.	**1**	**2**	**3**	**4**	**5**

5. Reducing exposure to toxic chemicals during pregnancy and in early childhood can help lower a child's risk of developing a condition like ADHD or autism.	**1**	**2**	**3**	**4**	**5**
6. When it comes to addressing developmental conditions affecting children, most governments spend the majority of the health budget on management and treatment of these conditions. I think governments should spend more of their budget to find ways to prevent children from developing these conditions.	**1**	**2**	**3**	**4**	**5**
7. If toxic chemicals were a threat to my family's health, my pediatrician, doctor, or health care provider would have told me about it.	**1**	**2**	**3**	**4**	**5**
	1 – Strongly Agree	2 – Somewhat Agree	3 – Neither Agree nor Disagree	4 – Somewhat Disagree	5 – Strongly Disagree
8. Exposure to toxic chemicals during pregnancy can increase a child's risk of having a developmental condition	**1**	**2**	**3**	**4**	**5**
9. I want to learn more about how to reduce children's exposure to toxic chemicals.	**1**	**2**	**3**	**4**	**5**
10. Of all the sources of information about health impacts from toxic chemicals, I trust information coming from scientists who study them.	**1**	**2**	**3**	**4**	**5**
11. Exposure to toxic chemicals is particularly harmful to babies and children.	**1**	**2**	**3**	**4**	**5**
12. I trust that most companies make products that don't contain harmful levels of toxic chemicals.	**1**	**2**	**3**	**4**	**5**
13. More children would benefit by regulating and reducing toxic chemicals to **prevent** developmental conditions than the number of children who benefit from **treatment** of these conditions.	**1**	**2**	**3**	**4**	**5**
14. Toxic chemicals can be detected in the blood of most pregnant women.	**1**	**2**	**3**	**4**	**5**
15. My government should strengthen their policies and programs to make sure that consumer products do not contain toxic chemicals that are harmful to children.	**1**	**2**	**3**	**4**	**5**
16. If I knew how to reduce children's exposure to toxic chemicals, I would try to do it.	**1**	**2**	**3**	**4**	**5**

17. I try to purchase products that do not contain toxic chemicals that may be harmful to my family.	**1**	**2**	**3**	**4**	**5**

Appendix B: Additional Baseline Questions

In the next month, how likely are you to make any changes to reduce toxic chemicals in your household?

- ○ Very likely (5)
- ○ Somewhat likely (4)
- ○ Neither likely nor unlikely (3)
- ○ Somewhat unlikely (2)
- ○ Very unlikely (1)
- ○ Not applicable – I actively avoid/reduce exposures to toxic chemicals in my household (0)

In the next month, how likely are you to make any changes to the foods you buy or eat to reduce your exposure to toxic chemicals?

- ○ Very likely (5)
- ○ Somewhat likely (4)
- ○ Neither likely nor unlikely (3)
- ○ Somewhat unlikely (2)
- ○ Very unlikely (1)
- ○ Not applicable – I am already making food choices to avoid/reduce my exposures to toxic chemicals (0)

In the next month, how likely are you to make any changes in your use of personal-care products to reduce your exposure to toxic chemicals?

- Very likely (5)
- Somewhat likely (4)
- Neither likely nor unlikely (3)
- Somewhat unlikely (2)
- Very unlikely (1)
- Not applicable – I am already making personal-care product choices to avoid/reduce my exposures to toxic chemicals (0)

In the next month, how likely are you to make any changes in your use of plastics to reduce your risk of health effects?

- Very likely (5)
- Somewhat likely (4)
- Neither likely nor unlikely (3)
- Somewhat unlikely (2)
- Very unlikely (1)
- Not applicable - I am already making choices to avoid/reduce my use of plastics (0)

In the next month, how likely are you to look for more information on this subject (i.e., toxic chemicals and developmental conditions)?

- ○ Very likely (5)
- ○ Somewhat likely (4)
- ○ Neither likely nor unlikely (3)
- ○ Somewhat unlikely (2)
- ○ Very unlikely (1)

Select which (if any) would make it hard for you to reduce toxic chemicals in your household:

- ☐ I don't know how to reduce toxic chemicals (1)
- ☐ Non-toxic products and food cost too much (2)
- ☐ It is not convenient to shop in stores where less toxic items are available (3)
- ☐ I don't know where to purchase non-toxic items or food (4)
- ☐ I don't believe it makes a difference to my health / my family's health (5)
- ☐ I don't have support from my partner or other family member (6)
- ☐ I don't have time (7)

- [ ] Other (8) ____

- [ ] None of the above apply to my situation (99)

Appendix C: Additional 6-Week Follow-Up Questions

Have you done any of the following in the past 6-weeks?
(select all that apply)

- ▢ Shifted towards buying more fresh and frozen foods (1)
- ▢ Bought organic food more often (2)
- ▢ Avoided canned or processed foods (3)
- ▢ Stopped using pesticides in and around my home (4)
- ▢ Checked my home for lead hazards (5)
- ▢ Dusted floors and surfaces to help reduce exposures (6)
- ▢ Contacted an elected official about toxic chemicals in the environment and consumer products (7)
- ▢ Not applicable - I was already doing most of the above (8)

To what extent have you changed your household practices to reduce exposures to toxic chemicals (i.e., more frequent dusting, switching to use of baking soda or vinegar for routine cleaning, not using pesticides around the home)?

- ○ A great extent (3 or more changes) (5)
- ○ To some extent (1 or 2 changes) (4)
- ○ Neutral (unsure if I did) (3)
- ○ Somewhat not (don’t think I did) (2)
- ○ Not at all (definitely did not) (1)
- ○ Not applicable – I was already avoiding/reducing exposures to toxic chemicals in my household (0)

To what extent have you made any changes to the foods you buy or eat to reduce your exposure to toxic chemicals (i.e., avoided canned/processed foods, purchased organic foods, when possible)?

- ◯ A great extent (3 or more changes) (5)
- ◯ To some extent (1 or 2 changes) (4)
- ◯ Neutral (unsure if I did) (3)
- ◯ Somewhat not (don’t think I did) (2)
- ◯ Not at all (definitely did not) (1)
- ◯ Not applicable – I was already making food choices to avoid/reduce my exposures to toxic chemicals (0)

To what extent have you made any changes in your purchase or use of personal-care products to reduce your exposure to toxic chemicals?

- ◯ A great extent (3 or more changes) (5)
- ◯ To some extent (1 or 2 changes) (4)
- ◯ Neutral (unsure if I did) (3)
- ◯ Somewhat not (don’t think I did) (2)
- ◯ Not at all (definitely did not) (1)
- ◯ Not applicable – I was already making personal-care products choices to avoid/reduce my exposures to toxic chemicals (0)

To what extent have you made any changes in your purchase or use of plastics to reduce your exposure to chemicals found in plastics?

○ A great extent (3 or more changes) (5)

○ To some extent (1 or 2 changes) (4)

○ Neutral (unsure if I did) (3)

○ Somewhat not (don’t think I did) (2)

○ Not at all (definitely did not) (1)

○ Not applicable – I was already making choices to avoid plastics (0)

If you made changes to any of the above, please rate the extent to which each of the following reasons motivated you to make these changes:

	A great extent (5)	To some extent (4)	Neutral (3)	Somewhat not (2)	Not at all (1)	N/A - I did not make any changes (0)
My health (1)	○	○	○	○	○	○
My family's health (2)	○	○	○	○	○	○
My friends or family have made these changes (3)	○	○	○	○	○	○
I see others making these changes (4)	○	○	○	○	○	○
Sustainability and/or environmental reasons (5)	○	○	○	○	○	○

Which of the following, if any, made it hard for you to reduce toxic chemicals in your household:
(select all that apply)

- ☐ I don't know how to reduce toxic chemicals (1)
- ☐ Non-toxic products and food cost too much (2)
- ☐ It is not convenient to shop in stores where less toxic items are available (3)
- ☐ I don't know where to purchase non-toxic items or food (4)
- ☐ I don't believe it makes a difference to my health / my family's health (5)
- ☐ I don't have support from my partner or other family member (6)
- ☐ I don't have time (7)

- [ ] Other (8)
- [ ] None of the above apply to my situation (99)

To what extent have you tried to gather more information on this subject (i.e., toxic chemicals and developmental conditions in children)?

- ○ A great extent (3 or more searches) (5)
- ○ To some extent (1 or 2 searches) (4)
- ○ Neutral (unsure if I did) (3)
- ○ Somewhat not (don't think I did) (2)
- ○ Not at all (definitely did not) (1)

Where have you looked for more information?
(arrange in order of importance)

______ Friends and relatives (1)

______ Social media (2)

______ Internet searches (websites, blogs) (3)

______ Medical, public health, and scientific journals (4)

______ News (mainstream media; including TV, radio, newspaper) (5)

______ My doctor or other healthcare professional (6)

______ Other (7)

______ Not applicable - I did not look for information (8)

How often have you seen or heard anything about toxic chemicals and their effects on health without having searched for it over the past 6 weeks?

- ○ Very often (3 or more times) (5)

- Somewhat often (1 or 2 times) (4)
- Neutral (3)
- Somewhat not often (don't think so) (2)
- Not at all often (definitely did not) (1)

Have you had a conversation about this subject with any of the following people: (select all that apply)

- Your child (1)
- Your partner and/or other family members (2)
- Friends or colleagues (3)
- Your healthcare provider (4)
- Your child's healthcare provider (5)
- Your child's educator or childcare provider (6)
- Policymaker or elected official (7)
- No (8)
- Not applicable - I don't have such people to have a conversation with (9)

Have you or do you plan to speak about toxic chemicals and developmental conditions in children with your healthcare provider?

- I spoke about this with my healthcare provider (3)
- I plan to speak about this with my healthcare provider when I next see them (2)
- I do not plan on speaking about this with my healthcare provider (1)
- Not applicable - I do not have a healthcare provider (0)

Which of the following, if any, are reasons that you have not or do not intend to talk about toxic chemicals and health with your healthcare provider?

- ☐ I felt they would not have time to talk about it (1)
- ☐ I felt they might dismiss my concerns (2)
- ☐ I was not sure they would have the information I was looking for (3)
- ☐ I would not have trusted their advice (4)
- ☐ I had other more important issues I wanted to raise with them (5)
- ☐ I was not sure it was a valid question or concern (6)
- ☐ I did not have enough knowledge to know what I should be asking (7)
- ☐ Other (please specify): (8) ____________________

Have you had trouble determining whether a product is non-toxic?

- ○ Very much yes (5)
- ○ Somewhat yes (4)
- ○ Neither yes or no (3)
- ○ Somewhat no (2)
- ○ Very much no (1)
- ○ Not applicable - I have not looked for non-toxic products (0)

How concerned are you that you or your family may be exposed to toxic chemicals in your day-to-day life?

- ○ Very concerned (5)
- ○ Somewhat concerned (4)
- ○ Neither concerned or not concerned (3)
- ○ Somewhat not concerned (2)
- ○ Very much not concerned (1)

Appendix D: Little Things Matter: The Impact of Toxins on the Developing Brain Video

To access the KT tool assessed in this dissertation, the *Little Things Matter: The Impact of Toxins on the Developing Brain* video, please visit this link: https://youtu.be/E6KoMAbz1Bw. This link was embedded in the baseline Qualtrics survey with the text, "Please watch this video. You will be asked questions on the video after it has finished."