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BRIEF REPORT: Most Pressing Environmental Hazards Affecting Children and Youth and the Connection With Intellectual and Developmental Disability—Results from Canadian High School Student Focus Groups

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Abstract

The causes of much intellectual and developmental disability (IDD), including autism, attention deficit hyperactivity disorder, and cerebral palsy are not well understood. Genetic factors affecting host susceptibility to toxic agents in the environment may be involved. In the present study, the opinions of secondary school students pertaining to environmental health concerns were collected using a semi-structured questionnaire in a series of focus groups. Participants identified quality of food, sanitation and water quality most frequently as factors thought to promote good health. None of the participants mentioned possible connections between environmental toxins and IDDs. Although participants were concerned about the effects of environmental hazards on themselves, their friends and families, they said it was difficult for them to think about effects on an unborn fetus because of their age and life experience. This pilot study suggests that there is a pressing need for promotion of education among teenagers about environmental hazards affecting fetal health and the health of children and youth.

The world-wide prevalence of intellectual and developmental disability (IDD) varies with definition, study design, assessment methods, and across settings and cultures, but is thought to be between 1% and 3% (Scott & Gerbasi, 2005, p. 190). Factors resulting in severe IDD, which affects only about 0.35% of the population, are better understood than those resulting in mild IDD, autism, attention deficit hyperactivity disorder and cerebral palsy. Although many cases of IDD have no identified cause, there are many physical, environmental and social causes of IDD. Accidents resulting in brain injury, preterm delivery, malnutrition, infections, and maternal smoking, use of alcohol, marijuana and/or cocaine are known to cause or contribute to IDD. A number of factors associated with low socioeconomic status (poverty, underhousing, underemployment and undereducation) are related to higher rates of IDDs, though reasons for this association are likely complex (for additional detail see Percy, 2007).

Much effort has been devoted to the identification of genetic factors causing IDDs, but to date there have been relatively

few studies of the involvement of hazardous substances in the environment. One reason for this is that, in most countries, there are no formal programs in place for testing chemicals for developmental neurotoxicity. In addition, high levels of proof are required for toxic substances to be regulated (Grandjean & Landrigan, 2006; Labie, 2007). It is suspected that genetic factors affecting host susceptibility to certain toxic agents in the environment may be involved in some, though not all, cases of IDD for which causes are not known, including autism (DeSoto, 2009; Larsson, Weiss, Janson, Sundell, & Bornehag, in press). The relative importance of factors that cause or contribute to IDD can differ radically from one country to another and among regions in a given country. Even the importance of the social factors could vary from country to country. Furthermore, the relative impact of certain environmental toxins will depend, in part, upon the degree of industrialization and stringency of local environmental standards.

Specific environmental toxins—including lead, methylmercury, arsenic, pesticides, carbon monoxide, radon, polychlorinated biphenyls (PCBs), dioxins, ionizing radiation, flame retardants, and organic solvents (especially toluene)—can affect neurological function and potentially result in IDD (Centers for Disease Control (CDC), 1997; Gilbert & Grant-Webster, 1995; Grandjean & Landrigan, 2006; Mendola, Selevan, Gutter, & Rice, 2002; Miller, 2004; Mott, Fore, Curtis, & Solomon, 1997; **Mushak,** Davis, Crochetti, & Grant, 1989; National Research Council, 1993; Percy, 2007; Wigle, 2003; Wigle et al., 2007). A recent study of publicly available information found that 202 industrial chemicals have the capacity to damage the human brain, and may have harmed the brains of millions of children worldwide (Grandjean & Landrigan, 2006; Labie, 2007). New ones are continually being released (Lloyd-Smith & Sheffield-Brotherton, 2008).

An argument can be made for involvement of environmental toxins in IDD from knowledge of the developing brain and studies of toxic substances in animal models. The developing brain is vulnerable to insult from toxic environmental agents. Different parts of the nervous system develop at different times (e.g., motor control, sensory, intelligence and attention). The different cell types in the brain have different windows of vulnerability with varying sensitivities to environmental agents (Rice & Barone, 2000; Weiss & Landrigan, 2000). Furthermore, exposure to certain chemicals during early development can result in brain injury pre- and post-natally in amounts (if in solid form) or concentrations (if in solution) much lower than those affecting adult brain function. This is because, in relation to their low body weight, children eat, drink, and breathe more than adults. Thus, hazardous substances in the environment affect children more than adults because they are exposed to more of these substances in comparison to their body weight. Other reasons why children are particularly vulnerable to environmental hazards include: behaviour and activity patterns that bring them into contact with toxins (e.g., chewing chips of leaded paint; breaking fever thermometers containing mercury in their mouths); immature metabolic and physiological systems; immature tissues and organs; exposures in utero and post-natally via breast milk and via contaminated toys and clothing; inability to avoid exposures on their own account (Children's Environmental Health Project, 2000; Goldman & Koduru, 2000; Mott et al., 1997; Plunkett, Turnbull, & Rodricks, 1992; Rice & Barone, 2000). For additional information about the roles of genetics and environmental factors in human development and IDDs, see Percy (2007), and Chapters 7, 8, 10 and 14 in Brown & Percy (2007).

In 2006, the authors were inspired by the Centre for Global Research and Education on Environment and Health (CGREEH, 2009) to carry out a survey of high school students to assess their knowledge of environmental hazards affecting the health of fetuses, children and youth. CGREEH is a citizen-created charity with the mission to investigate and acquire unbiased research and knowledge on environmental effects on health. In order to assist CGREEH in identifying the ten most pressing environmental issues affecting the health of Canadian children that urgently need to be addressed, the opinions of secondary school students pertaining to environmental hazards and health concerns were collected using a protocol approved by the University of Toronto, Mississauga, Research Ethics Board.

Methods

Participants

Participants from Grades 10, 11 and 12 were recruited from two secondary schools—Fr. Michael Goetz Secondary School (FMGSS) and The Bishop Strachan School (BSS) in Mississauga and Toronto, Canada, respectively. The former school is public, Catholic, and co-educational. The latter is private, interdenominational and for women only. A total of 48 volunteer students were recruited from the two participating schools. However, due to unforeseen timetable conflicts, only 32 students took part in the focus groups (8 from Grade 10 (4 males, 4 females), 10 from Grade 11 (4 males, 6 females) and 14 from Grade 12 (4 males, 10 females).

Procedures

Information was collected by the first two authors at FMGSS and BSS, respectively, in six semi-structured focus groups (one from each grade at each of the two schools) lasting 40 minutes to one hour. Before the focus groups, participants were encouraged to complete and submit a publicly available online survey prepared by CGREEH about perceived environmental health hazards. The CGREEH online survey was then used to collect information at each focus group. Focus group activities consisted of two parts: a hard copy questionnaire, and a structured group discussion. The questionnaire consisted of eight items from the CGREEH survey to provide focus group profiles (see Table 1). For the first four of the eight items on the questionnaire, participants were asked to provide a ranking on a scale of 1 to 5 with 1 being the lowest, 3 being average and 5 the highest. For items five through eight, response choices were *yes, no,* and *I don't know*. Structured group discussions centred around seven themes used in the online CGREEH survey to collect information about perceived environmental hazards (see Table 2). In these groups, participants volunteered information, and focus group leaders were careful not to provide feedback that might infer "correctness" or "relevance" of their comments. Discussions were recorded using Waveform audio and cassette formats and tapes were transcribed for data analysis.

Data Analysis

Questionnaires. Profiles for responses to items one through eight were obtained by determining the modal score (i.e., the most frequent) for each response (Brown et al., 2003, p. 291; Statistics Canada, 2009). Modal scores were used for two reasons. First, use of modes is an appropriate way of representing categorical data (i.e., that which can be grouped by specific categories) collected in the questionnaires. Second, modal scores yield "typical" as opposed to "average" profiles. Presentation of typical focus group profiles of the focus groups was preferred to "average" profiles because information in focus group discussions was volunteered and not systematically collected from every participant. (Refer to Table 1.)

Focus Group Discussions. Transcriptions of audiotapes were reviewed by the first and the third author. Sub-themes identified by each of the six focus groups from the two schools were entered into a table under each of the seven discussion themes. Sub-themes were listed only if they were identified by two or more focus groups. (Refer to Table 2.)

Follow-Up

After analysis of the data, a literature search was conducted to determine if the issues identified by the students had been ranked by others as high priority.

Results

Focus Group Profiles

Modal scores corresponding to items in the questionnaire are shown in Table 1. In some cases, responses had two modes; these are denoted by two adjacent scores separated by a comma. Ratings that occurred most frequently (modes) for items one through four ranged from 2 (poor) to 4 (very good), and differed slightly among grades. Students ranked the influence of the media on their knowledge about environmental issues (item four) as average (3) or very good (4). Their knowledge of effects of hazards on the health of children and youth (item two) was lower than average.

Responses to items one and three ranged from poor to average or above. The most frequently occurring response (mode) for items five through eight are recorded as yes (Y), or I don't know (IDK). All groups recognized that the physical environment has an effect on health (item five), that children were more likely to be affected than adults by toxic exposures (item seven), and that risks of exposure and harm are greater for children today than for their parents (item eight). However, there was uncertainty about whether participants had encountered issues about environmental health hazards in school (item six).

Group Results

Results from the focus group discussions are shown in Table 2. Items listed under each of the seven themes considered in discussions are listed in order of the frequency with which they were mentioned by the focus groups. Because focus groups were conducted in three grades (10, 11 and 12) from each of the two schools and transcriptions from each focus group were reviewed, the maximum number of times any sub-theme could be independently reported is six. In this study, items identified with the highest frequency were identified by five of the six focus groups; these are denoted with one asterisk in Table 2, and commented upon in this section. Food quality, sanitation quality, and water quality were the most frequently cited of 11 factors thought to promote good

Table 1. Focus group profile as determined from the questionnaire

	Response Rating (Mode)		
	Grade 10 $n = 8$	*Grade 11* $n = 10$	*Grade 12* $n = 14$
1. My general knowledge of environmental health hazards is:	3	3	2,3
2. My knowledge of environmental health hazards with respect to their effect on children and youth is:	2,3	2	2,3
3. I have encountered issues concerning environmental health hazards in school:	3	2,3	3
4. I hear/read about environmental health hazards in the media:	4	3	3
5. The physical environment has an affect on my health:	Y	Y	Y
6. I have been exposed to substances in my environment that potentially affect my health:	Y	IDK	IDK
7. Children and youth have a greater risk of exposure and harm from environmental health hazards than adults:	Y	Y	Y
8. Children and youth today are at greater risk of exposure and harm from environmental health hazards than their parents were when they were children:	Y	Y	Y

Legend: The left hand column lists the items in the questionnaire used to obtain focus group profiles. Numbers in the table body corresponding to items one through four are the modal scores for focus groups of each grade (2, poor; 3, average, 4, very good). For some of the responses there were two modes; these are denoted by two scores, separated by a comma. Letters in the table body corresponding to items four through eight are the modes for the responses from each grade: Y: yes; IDK, I don't know. See Methods section for details about the rating scales.

Table 2. Most pressing environmental hazards affecting children and youth

	Focus Group Responses			Cumulative Response
	Grade 10 $n = 8$	*Grade 11* $n = 10$	*Grade 12* $n = 14$	*All Grades* $n = 32$
1. What aspects of the physical environment have an effect on an individual's health?				
***food quality**	1	2	2	5
*sanitation quality	1	2	2	5
*water quality	1	2	2	5
air quality	1	2	1	4
chemicals in store-bought products	1	1	2	4
alcohol and drug use	0	0	2	2
exposure to bacteria and/or viruses	0	0	2	2
physical injury/violence	1	0	1	2
soil quality	0	1	1	2
2. Do environmental hazards affect adults and children differently? How? Why?				
*children are more susceptible that adults	2	1	2	5
*children have weaker immune systems	2	2	1	5
adults have more knowledge or potential hazards	0	2	2	4
children engage in riskier behaviour	1	1	1	3
3. Does the environment (i.e. food, water, air, soil) you encounter on a daily basis pose any potential hazards to your health?				
*, **air pollution	1	2	2	5
*unhealthy food	1	2	2	5
acid rain	1	1	2	4
contaminated water	0	1	2	3
**exposure to heavy metals (not specified)	0	2	1	3
genetically modified food/hormones in food	0	2	1	3
**second hand smoke	1	1	1	3
**herbicides and pesticides	0	1	2	3
alcohol and drug use	0	1	1	2
chemicals in soil	0	1	1	2
climate	0	2	0	2
close proximity to factories	1	1	0	2
poor hygiene and sanitation in food industry	0	0	2	2
radiation from electronics	0	2	0	2
my environment is relatively safe compared to other parts of the world	2	0	0	2

Table 2. Most pressing environmental hazards affecting children and youth (continued)

	Focus Group Responses			*Cumulative Response*
	Grade 10 $n = 8$	*Grade 11* $n = 10$	*Grade 12* $n = 14$	*All Grades* $n = 32$
4. How has your health or the health of any other youth that you know of been directly affected by environmental hazards?				
*asthma	2	2	1	5
allergies	1	1	2	4
exposure to E. coli in water	0	1	2	3
poor nutrition/obesity	0	2	1	3
adverse reaction to medication/vaccination	0	1	1	2
5. How can you determine whether or not your health is being affected by environmental hazards?				
consult a physician	1	2	1	4
self-assessment of symptoms	1	1	2	4
consult media sources	1	1	1	3
difficult to identify with certainty	1	2	0	3
consult a parent/guardian	1	0	1	2
6. What environmental hazards are affecting Canadian children and youth the most?				
**contaminated water	1	1	1	3
drug/alcohol use	0	1	2	3
poor nutrition/obesity	1	1	1	3
smoking	1	0	2	2
climate change	0	2	0	2
Canadian children and youth are relatively safe	1	1	0	2
chemicals in cosmetics	0	0	2	2
7. What role can individuals, communities, and governments play in both protecting the public and eliminating such environmental hazards?				
*government should create stricter regulations on private industry practices	1	2	2	5
*individuals should take responsibility for their own health	2	1	2	5
government should put more funding toward environment and health education	1	2	1	4

Table 2. Most pressing environmental hazards affecting children and youth (continued)

	Focus Group Responses			Cumulative Response
	Grade 10 $n = 8$	*Grade 11* $n = 10$	*Grade 12* $n = 14$	*All Grades* $n = 32$
government should provide healthy alternatives and subsidize the associated costs	0	2	2	4
individuals should make an effort to educate themselves	2	1	1	4
environment and health issues should be a mandatory part of the school curriculum	0	2	1	3
individuals should pressure private businesses to be more environmentally conscious	1	1	1	3
communities and the government should run advertising campaigns to increase awareness	1	0	1	2
communities should lobby for healthier alternatives	1	1	0	2
government should make businesses properly label the ingredients of their products along with their potential health risks	1	0	1	2
individuals should make use of available government and community resources	0	1	1	2

Legend: The seven themes used to guide the focus group discussions are numbered from 1. to 7. and shaded. Sub-themes identified by individual focus groups are listed under each theme. Numbers in columns two, three and four indicate the number of times a specific sub-theme was identified independently by a focus group. Column five indicates the total number of times each particular sub-theme was identified. Only sub-themes identified by two or more focus groups are listed.

* *Sub-themes identified most frequently by the focus groups (i.e., by five of the six)*

** *Sub-themes identified as among the top five worst threats to children's health by Mott et al. (1997)*

health. Children were thought to be more affected by environmental toxins because they had immature immune systems. Air pollution and poor quality food were the most commonly cited environmental factors encountered on a daily basis affecting health. Asthma was identified most frequently as a consequence of exposure environmental hazards affecting the participants and other youth. Taking responsibility for one's own health and having the government create stricter standards for private industry practices were the most frequently cited of 11 interventions suggested by the groups for promoting awareness of environmental hazards.

Environmental Hazards Prioritized in the Literature

The literature search revealed few peer-reviewed publications prioritizing hazards that are harmful to prenatal and postnatal health. Mott et al. (1997) identified the five worst environmental threats to the health of children as being lead, air pollution, pesticides, environmental tobacco smoke, and drinking water contamination; these are denoted by a double asterisk in Table 2. An inspection of Table 2 shows that all of these threats were identified by the student focus groups, though not necessarily as the most pressing. Ye, Fu and Guidotti (2007) identified lead and mercury and emerging pollutants including phthalates and perfluorinated compounds as affecting children in China. Wigle et al.

(2008) examined the strength of evidence for causal relationships between prenatal and/or early life exposures to environmental chemical contaminants in air, water, soil/house dust and foods (including human breast milk), and various types of consumer products, to fetal, childhood and adult health. Prenatal and early childhood exposures to high dose methyl-mercury, PCBs, polychlorinated dibenzofurans, maternal smoking, dioxins, and outdoor air pollutants all had epidemiological causal effects on prenatal and adverse pregnancy or child health outcomes. A popular newsletter listed the ten most common environmental toxins as: PCBs, pesticides, mould and fungal toxins, phthalates, volatile organic compounds, asbestos, heavy metals, chloroform and chlorine (Mercola, 2005). This newsletter also provided information on how to lessen exposures to environmental toxins.

Discussion

This small study is limited by the facts that only two secondary schools with very different demographics not necessarily representative of Ontario participated, representation from the three different grades was not equal, the male to female ratio varied from one grade to another, and a post-test was not carried out to determine if students' knowledge was enhanced from focus group discussions. Nevertheless, the results suggest that there is a pressing need for promotion of education among teenagers about specific environmental hazards affecting fetal and children's health and the developing brain. To note is that sub-themes identified by the focus groups as hazardous were generally relevant, though mention of specific metal hazards (e.g., lead, mercury, arsenic, aluminum), specific chemical hazards (e.g., phthalates), or specific infectious agents aside from E. coli (e.g., tropical parasites causing anemia, malaria, and other infections) was limited (Bergen, 2008). This may result from the fact that the students were not familiar with the properties of certain substances that might cause them to be harmful and how such properties might cause harm to fetuses, babies and children. Similarly, although poor nutrition was flagged as a hazard, students did not mention specific dietary problems such as protein-energy malnutrition or dietary micro-nutrient deficiencies. Furthermore, although participants were concerned about the effects of environmental hazards on themselves, their friends and families, they said it was difficult for them to think about effects on an unborn fetus because of their age and life experience. None of the students mentioned possible connections between environmental hazards and the occurrence of IDDs. For example, although drinking alcohol was identified as a potential hazard, the issue of maternal drinking resulting in Fetal Alcohol Spectrum Disorder was not mentioned (Percy, 2007; Chapter 12 in Brown & Percy, 2007).

The study corroborates findings from the National Environmental Education and Training Foundation (NEETF, 1994) which showed that only about 32% of individuals had basic awareness of environmental topics and that 83% of children learned more about environmental issues from the media than any other source. Although a review of scientific literature reveals strides have been taken to develop methods for assessing the risks associated with environmental hazards on children in particular (Wong et al., 2003), initiatives to inform young individuals on these matters are necessary future directions (Coyle, 2004; Wojtowicz, 1995; Yilmaz, Boone, & Andersen, 2004). Another research direction of high priority is to focus on factors in the environment to which babies and fetuses are exposed, including pesticides and chemicals in household products, as well as viruses, that potentially might cause IDD including autism (DeSoto, 2009; Hertz-Picciotto & Delwiche, 2009; Tuomisto, 2006). Of importance is that in the newly revised Ontario high school curriculum, the first overall expectation in the Chemistry unit in the grade nine science course is "assess social, environmental, and economic impacts of the use of common elements and compounds, with reference to their physical and chemical properties" and the first specific expectation is "assess usefulness of and/or the hazards associated with common elements or compounds in terms of their physical and chemical properties" (Ontario Ministry of Education, 2008, p. 62). The biggest change in the revised secondary school science curriculum is that societal and environmental aspects come before the science knowledge and skills!

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Glossary

Asbestos—is a mineral fibre. Previously it was used as insulation and is a component of older linoleum tiles. As it ages, fibres are released into the air.

Chlorine—is a naturally occurring chemical element. It is routinely used to disinfect water, and is found in some household cleaners.

Chloroform—is a chemical formerly used as an anesthetic. It forms when chlorine is added to water (e.g., as in swimming pools).

Dioxins—are a class of chemical contaminants formed during combustion processes (e.g., waste incineration, forest fires, and backyard garbage burning), as well as during some industrial processes (e.g., paper pulp bleaching and herbicide manufacturing). They tend to concentrate in soil and sediment, and accumulate in animal fat.

Perfluorinated compounds—chemicals with unique properties to make materials stain and stick resistant. They are very resistant to breakdown and are turning up in unexpected places around the world.

Heavy metals (e.g., lead, mercury, aluminum, arsenic, cadmium)—accumulate in the soft tissues of the body. Heavy metal pollution most commonly arises from purification of metals.

Mould and fungal toxins—multiply in moist environments. These result in allergies in a substantial fraction of the population.

Pesticides—are among the most widely used chemicals in the world, and also among the most dangerous to human health. Many of the commonly used household insecticides are toxic organophosphates. Pesticide residue is common in food.

Phthalates—used to lengthen the life of fragrances and to soften plastic.

Polychlorinated biphenyls (PCBs)—are a type man made organic chemical previously used widely in various industrial processes. These are very resistant to degradation and leak into the environment especially from poorly managed waste sites. PCBs have been banned for decades but are still in use. Humans are exposed through consumption of contaminated foods, particularly meat, fish, and poultry.

Polychlorinated dibenzofurans—are formed as inadvertent by-products in the production and use of polychlorinated biphenyls (PCBs). These are ubiquitous in soil, sediments and air.

Volatile organic compound—are carbon-containing gases and vapors such as gasoline fumes and solvents (but excluding carbon dioxide, carbon monoxide, methane, and chlorofluorocarbons). They are frequently in carpets, paint, cleaning fluids and dry-cleaned clothing.

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