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The National Pollutant Release Inventory (NPRI) and the Toxics Release Inventory (TRI) data sets used in this report are constantly evolving, as facilities revise previous submissions to correct reporting errors or make other changes. For this reason, Canada and the United States each “lock” their data sets on a specific date and use those locked data sets for annual summary reports. Each year, both countries issue revised databases that cover all reporting years. The CEC follows a similar process. For the purposes of this report, the TRI data set of June 2004 and the NPRI data set of July 2004 were used. The CEC is aware that changes have occurred since this time to both data sets for the reporting year 2002 that are not reflected in this report.

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Toxic Chemicals

and Children's Health in North America

A Call for Efforts to Determine the Sources, Levels of Exposure,
and Risks that Industrial Chemicals Pose to Children's Health



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Preface

There are many factors that interact to influence children's health. We have come to recognize that children interact with their environment differently from adults and that physical, biological and behavioral characteristics of children often make them more vulnerable to environmental contaminants. Thus, a better understanding of the underlying environmental and health factors can lead to an improved quality of life and well-being for our future generations.

To better understand the interaction between health and the environment, the CEC's governing Council adopted the Cooperative Agenda for Children's Health in North America, in 2002. The primary purpose of this initiative has been to foster collaboration and the sharing of expertise across Canada, Mexico, and the United States and to provide policy-makers with the information needed to adequately address the environmental risks to children's health. The present report is the fruit of that collaboration.

Previous trinational cooperation in this area resulted in the publication of *Children's Health and the Environment in North America: A First Report on Available Indicators and Measures* in January 2006, which highlighted progress and identified information gaps concerning the link between health and the environment. Now, as we look at toxic chemicals and the data from the national pollutant release and transfer registers (PRTRs) of Canada and the United States, we again find that further efforts are required and additional tools are needed to better understand the risks to children.

Those familiar with the CEC's annual *Taking Stock* report on North American industrial pollution will notice a few differences in how we have analyzed the data for the present report. For instance, to make the pollution data more meaningful and easier to interpret, we have adopted the parameter known as *toxic equivalency potentials*, or TEPs, for both carcinogenic and non-carcinogenic risks. The report also includes specific recommendations for action to protect children's health from toxic chemicals in our environment.

In order to place chemical pollution into an appropriate context, the report frames children's health in terms of the major factors involved with disease, disability and death. Looking at PRTR information from 2002—our most recent year for matched data—the report analyzes groups of chemicals that are known or suspected to cause cancer, learning and behavioral changes, and neurological or developmental damage. It also examines individual chemicals associated with health effects in children.

It finds that almost half a million tonnes of chemicals *known or suspected to cause cancer* were released and transferred in Canada and the United States in 2002. It also finds that there was a similar amount of releases and transfers of chemicals *recognized to cause developmental and reproductive damage*. In addition, the report looks at *suspected developmental and reproductive toxicants* and *suspected neurological toxicants*. There were over two million tonnes of releases and transfers of chemicals in these categories.

Unfortunately, these amounts are likely underestimates of the actual chemical load because the data do not include all chemicals or all sources. Furthermore, these are annual estimates; each year we are adding to the cumulative load of chemicals released into the environment. Also, chemicals that persist a long time in the environment and travel far from their points of origin may not be covered by the national PRTR databases.

The good news, however, is that the amounts of carcinogens, developmental toxicants and reproductive toxicants and neurological toxicants released and transferred have decreased overall by 7 to 28 percent from 1998 to 2002. Clearly, the national programs and legislation guaranteeing the principles of “community right-to-know” have helped to drive reductions in pollutant releases and transfers, as have the continuing efforts of industry to improve efficiency and incorporate pollution prevention strategies.

I trust this report will be a starting point for government and nongovernmental organizations, industry, and citizens alike to identify steps that can be taken to further reduce releases and transfers of chemicals, especially those of concern to children's health.

William V. Kennedy
Executive Director

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People from all over North America also contributed to the development of this report by providing their comments during the public review period in April–June 2004. Twenty-six submissions were received from industry groups, companies, public interest groups and government who took the time to thoroughly review the draft report and provide the many helpful suggestions and comments that greatly improved the quality of the report. The Consultative Group for the North American PRTR (Pollutant Release and Transfer Register) Project also contributed feedback and ideas that informed the report's development. Additionally, the Secretariat submitted drafts of the report for review and comment by the Parties in late 2005.

A number of CEC Secretariat staff were involved in the development of this report. Erica Phipps, former program manager for the CEC's PRTR and Children's Health and the Environment initiatives, was responsible for guiding the report's development in its early stages. Victor Shantora, former head of Pollutants and Health, and Keith Chanon, current program manager, were instrumental in bringing the report to completion. Marilou Nichols, program assistant, provided indispensable administrative support and Joanne O'Reilly coordinated work on the preparation of the draft text. The CEC's publications staff handled the editing, translation and production of the document in the three languages. Evan Lloyd, director of communications, and Spencer Ferron-Tripp, media and outreach officer, were responsible for the launch of the document.

Executive Summary

Across North America, in every school, playground and home are the eager faces of our children. We do our best to ensure they grow up healthy. Social, biological and environmental factors interact in complex ways to affect their health. In this report, we focus on one of these environmental factors—toxic chemicals—that can affect children's health adversely.

There are many factors that interact to determine the health of children. Biological factors (age, genetics and gender), social factors (income level, culture and behavior), and broad environmental factors (lifestyle factors and exposures to pollutants) have all been documented as playing major roles in determining children's health. While the focus of this report covers the releases of and potential for exposure to certain industrial chemicals, and pollutants in air, water and the ambient environment, it is recognized that any effort to improve the health of children needs to take a broad approach that would include attention to lifestyle factors like diet, exercise and prevention of harmful exposures like tobacco smoke.

Children are uniquely vulnerable to many environmental threats to good health. Compared to adults, children inhale more air, breathe more rapidly, eat more food, and drink more water per kilogram of body weight. They live closer to the floor where some pollutants tend to accumulate, are more likely to ingest contaminated soil and dust, and spend more time outdoors. In addition to these increased pathways of exposure, children's bodies are also more vulnerable. There are periods of vulnerability in fetal development and childhood, when the lungs, brain, and immune, reproductive, and other systems are maturing. Harmful exposures during these critical developmental windows can lead to lifelong alterations in behavior and functional status, disease occurrence and development. Childhood is a critical life phase, through which we all pass; children's health cannot be separated from health in later life stages.

Children in North America

There are several childhood health effects that are of particular concern in North America. These include: cancer, developmental and learning disabilities and behavioral problems, birth defects, preterm birth, intrauterine growth restriction, asthma and other respiratory diseases, infections (respiratory and gastrointestinal) and injuries. In the absence of common reporting methods for diseases across North America, information must be drawn from national surveys in each country. This lack of a common reporting system is one of the common barriers to understanding the links between childhood diseases and their underlying causes (Goldman *et al.* 1999).

Sources of Information

Information about the amounts of chemicals being released from industrial facilities into the environment in North America is available through national pollutant inventories, known as pollutant release and transfer registers (PRTRs). These inventories, which cover specific chemicals and specified industrial sectors, have been developed by a number of countries around the world. Canada's PRTR is called the National Pollutant Release Inventory (NPRI) and the US inventory is called the Toxics Release Inventory (TRI). Mexico is implementing mandatory reporting under its PRTR, the *Registro de Emisiones y Transferencia de Contaminantes* (RETC), which until 2005 has been voluntary.

Every year in Canada and the US, industries that meet certain criteria must report on the amount of chemicals released into the air, land, or water, or injected underground. The amount of chemicals transferred off-site for disposal, treatment and recycling is also reported. This information is collected by regulatory agencies in national governments each year and compiled into annual reports and electronic databases, which are accessible to the general public.

This report analyzes publicly available data from Canada's National Pollutant Release Inventory (NPRI) and the US Toxics Release Inventory (TRI) for the reporting year 2002. At that time, reporting to Mexico's RETC was voluntary. Because of the differences between mandatory and voluntary data, data from Mexico's RETC are not included in this PRTR analysis. This report also matches the chemicals and industrial sectors that are in common between the NPRI and the TRI, thus creating a matched data set that is amenable to analysis. This matched NPRI-TRI data set therefore does not consider data which are unique to one system, such as on-site recycling, reporting from the metal mining sector and some chemicals such as ammonia and hydrogen sulfide.

Analysis of the Releases of Carcinogens, Developmental Toxicants and Neurotoxicants in North America

This report analyzes the chemicals from industry sectors reported to both the US TRI and the Canadian NPRI. Many of these chemicals can fall into the following categories: known carcinogens, known or suspected developmental toxicants and suspected neurotoxicants. An individual chemical may fall into more than one of these categories. Each year, certain industrial facilities must report to these registries on the amounts of the PRTR-listed chemicals released into the air, land, or water or



Children are uniquely vulnerable to many environmental threats to good health. Compared to adults, children inhale more air, breathe more rapidly, eat more food, and drink more water per kilogram of body weight.

injected underground in North America. For this report, releases are reported in metric tonnes (“tonnes”) or in kilograms (“kg”).

Total releases and transfers of these chemicals reported in 2002 to the Canadian and US PRTRs and entered into the respective PRTR datasets, by category, included almost one-half million tonnes each of carcinogens and of recognized developmental and reproductive toxicants, two and one-quarter million tonnes of suspected developmental and reproductive toxicants, and over two and one-half million tonnes of suspected neurotoxicants.

Toxic chemicals arising from two sectors, primary metals and chemical manufacturing, are responsible for a large percentage of total releases. Other sectors, such as manufacturers of rubber and plastics products, are also large emitters of these substances. Other large releases resulted from manufacturers of paper products and of transportation equipment. Three jurisdictions in North America (Texas, Ohio and Indiana) released the largest amounts of carcinogens on the two PRTR lists in 2002. Tennessee, Ontario and Texas released the largest amounts of recognized developmental and reproductive toxicants.

It is very encouraging to observe that the released quantity of known carcinogens has decreased by 26 percent from 1998 to 2002. Similar downward trends were found for developmental/reproductive toxicants, with a decrease in the United States and Canada of 28 percent from 1998 to 2002.

Interpreting PRTR Data

PRTR data provide important insights into the large amounts of chemicals entering our environment each year from industrial releases but they tend to underestimate the actual loads of chemicals into the environment because inventories, by design, collect information on a limited list of chemicals released or transferred, and only from larger industrial facilities.

Significantly, the data do not include emissions from mobile sources, agricultural sources (i.e., pesticide use), small sources, consumer products or natural sources.

PRTR data do not directly provide information on human exposure. The levels of human exposure to most of the chemicals and the relationship between human exposure levels and PRTR pollutant emissions are unknown. **Since the health risk posed by these chemicals depends on the amount of exposure or dose, as well as toxicity, it is not possible to estimate risks from PRTR data alone or the levels of risks to the health of**

children, or adults, from these releases. Moreover, toxicity is a complex process that is highly dependent on such factors as the nature of the toxic effect, the potency of a substance and the timing of exposure in regard to “windows of susceptibility.”

Despite these limitations, PRTR data are useful tools for developing strategies for the protection of children from potentially harmful chemicals. The reporting of releases of chemicals with the potential for reproductive, developmental, neurological or cancer toxicity to children can lead to further investigations such as monitoring for such chemicals in the air, water, soil and food in such communities, and biomonitoring of people to directly assess exposures to such chemicals. It can focus efforts around prevention of exposures from activities such as spills during transport, manufacture, and use of such chemicals. It can empower communities with information that allows them to participate in decisions about industrial activities in their communities. Finally, such data permit evaluation of efforts to reduce pollutants and waste generation by various industrial sectors.

Many Actions Are Underway to Reduce Chemical Loadings to the Environment

At multiple levels of government, in many industrial sectors and in many communities, there have been concerted efforts to reduce releases of chemicals into the environment and also to reduce children’s exposure to toxic chemicals. The development of “green” industrial technologies and other forms of pollution prevention, new emission standards, the voluntary reduction of releases from companies, the requirement to report releases and transfers and community improvement programs have all helped to reduce releases. PRTR data reflect the emission reductions seen over the years in many chemicals. Well-tested processes exist to allow a continued reduction of releases. PRTRs are also valuable tools to provide the public with information relevant to their community, and to leverage industry to track and reduce their releases of chemicals.

Future Actions Are Needed

Important progress has been made in the past decades to recognize, prevent and reduce children’s exposure to toxic chemicals, but more action is needed on the following fronts:

- *Monitor and reduce releases of toxic chemicals to the environment:* Specifically, we need to consider

children's health in the interpretation of PRTR data and establishment of priorities for emission reductions. We can develop methodologies to put such release data into the broader context of children's exposures. PRTR reporting in North America can be expanded to give a fuller picture, and harmonized to increase the information available on a North American basis. Governments and the Commission for Environmental Cooperation (CEC) should consider adopting a method such as the toxicity exposure potency factors used in this report, to give a clearer picture of hazard potential from releases. In so doing, data gaps in regard to hazard and exposure need to be filled. An effort should also be initiated to develop a North American approach to reporting information about pesticides, including their sales, use, concentrations, poisonings, exposure, and releases.

- *Monitor and reduce exposures to toxic chemicals:* Specifically, trilateral biomonitoring and other exposure monitoring activities under the CEC's North American Regional Action Plan (NARAP) on environmental monitoring and assessment should continue, particularly for exposures relevant to children's health. The US government should continue and expand its human biomonitoring efforts. Where excessive exposures are

found, action should be taken to protect health, especially the health of children.

- *Track childhood diseases that may be related to the environment:* Across North America, efforts should be made to expand and harmonize efforts to track diseases that are possibly related to the environment and to exchange information about linkages between the environment and children's health.
- *Improve scientific knowledge:* The major gaps in our knowledge about the risks associated with exposure to toxic chemicals need to be filled and further study is needed to quantify the extent to which early-life exposure to environmental contaminants contributes to the leading causes of illness, hospitalization and death during childhood and delayed health effects later in life. In addition, governments in North America need to increase research efforts as well as efforts to provide expert assessments of children's health hazards. Finally, trinational cooperation on a longitudinal study of children's health would provide a wealth of relevant information.
- *Increase awareness of the role of toxic chemicals in children's health:* As new knowledge is acquired, efforts to prevent releases and exposures to chemicals can focus on opportunities to protect the health of children.

Introduction

Almost 120 million children live in North America. Many of them face economic, social and environmental challenges every day. More children than ever need daily medication to control asthma. Others struggle to control aggressive outbursts and understand difficult learning concepts. Too many, particularly in poorer areas, suffer from gastrointestinal disease. Children who live with parents or others who smoke at home are exposed whenever a smoker lights up another cigarette. Many factors are affecting the health of these children.

One of the goals of this report is to focus on one of these factors: chemical releases into the environment from industrial activities. Chemical industrial releases are one important part of the puzzle but do not give a full picture of risk since chemicals from industry are only one type of pollutant. Human exposure levels to these chemicals, and other sources of pollution, are beyond the scope of this report.

This report also aims to foster increased trilateral action to prevent and reduce children's exposure to harmful chemicals. Its focus is an analysis of available data on one category of pollutant, toxic chemicals from data obtained from the national pollutant release and transfer registers (PRTRs) in North America,¹ and emphasizes the reporting of chemical carcinogens, developmental toxicants and neurotoxicants. Although at this stage

the data are available only for the United States and Canada, this report discusses in specific terms the potential impacts of these substances on the health of children in North America. It also describes the limits of what we know about these impacts based on present data. With its cross-border analysis of selected PRTR data, it provides a unique North American perspective as a basis for trilateral action.

Children's Health Overview

Health has been defined broadly as "a complete state of physical, mental and social well being" (WHO 1948), and more recently as "a positive concept emphasizing social and personal resources, as well as physical capacity" (WHO 1997).

Although the focus of this report is on chemicals released from industrial facilities and our state of knowledge about the potential impact of such substances on children's health, it is important to frame issues of environmental risk within the broader context of the health of children. Children's health is the net result of a complex interaction of social, biological and environmental factors (see **Figure I-1**). Social factors such as income level, educational attainment, family customs and behavior have been documented to play a major role in determining children's health. Biological factors such as age, genetics and gender all affect health. Environmental factors, such as diet, exposure to second-hand smoke, alcohol consumption, infectious agents, drugs and pharmaceuticals, injury hazards, and exposures to environmental pollutants such as radiation and chemicals contribute to disease and death in children (NRC and IOM 2004).

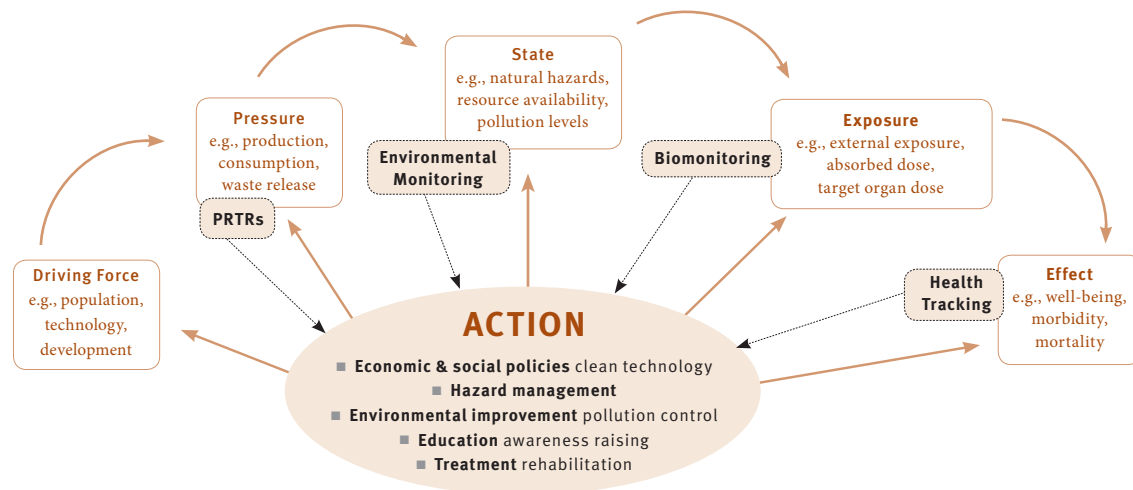
The WHO DPSEE (Driving Force, Pressure, State, Exposure, Effect and Action) model (**Figure I-2**) is a useful framework for understanding the continuum, from drivers of environmental change (such as population and technology), to pressures (such as production, consumption and waste releases), to changes in environmental state (such as pollution levels), to exposure (external, internal and target organ doses), to effects on health. Government, the private sector and individuals can take action to positively effect environmental outcomes at all of these levels. Likewise, information can be used to provide feedback at all levels. Reports of chemical releases shed light on one of the initial links in this chain, namely, activities that

Figure I-1. Children's Health is the Net Result of Many Interacting Factors



1. The Canadian National Pollutant Release Inventory (NPRI) and the US Toxics Release Inventory (TRI). Data from Mexico's *Registro de Emisiones y Transferencia de Contaminantes* (RETC) are not yet available.

Figure I-2: Indicators of Environmental Health at Multiple Levels



Source: WHO. DPSEEA model.

potentially create more pressure on the environment via the generation and release or transfer of wastes, specifically industrial activities within certain sectors such as manufacturing, mining, energy production, and waste disposal. However, such reports do not provide direct information about “downstream” effects. As shown in **Figure I-2**, other indicator systems are necessary to understand the state of the environment (e.g., environmental monitoring systems); exposures to human populations (e.g., human biomonitoring programs) and the state of health and well-being (e.g., tracking of mortality, diseases and measures of well being). Health effects also occur on a continuum and are related to dose and toxicity, as well as to timing of exposure; PRTR data do not inform us directly about these relationships. However, PRTR data are valuable for managing potential hazards at the facility and community levels.

Children Are Uniquely Vulnerable to Many Chemicals

Children are not small adults. Because of their unique physiology and developmental and behavioral characteristics, they are often more vulnerable to toxic chemicals. Such differences need to be taken into account when considering the potential impacts of environmental exposures (Daston *et al.* 2004). Compared to adults, children inhale more air, drink more fluids and eat more food per kilogram of body weight. Because of these differences, children often (but not always) have more intense exposure to chemical contaminants than adults (Miller *et al.* 2002).

Children also inhabit and interact with their environment differently. They live closer to the floor, where pollutants tend to accumulate, they are more likely to ingest or inhale particulates in contaminated soil and dust, and they spend more time outdoors. Because of these behavioral differences, children can have greater exposure to chemicals than adults (Goldman 1998).

In addition, because children’s bodies are in dynamic states of growth and development, they can be more sensitive to chemicals than adults. A child’s ability to break down and eliminate pollutants is poorly developed at birth, because the liver and kidneys are still developing. This means that at various stages of development, children may be more or less capable of breaking down, excreting, activating endogenous enzymes or inactivating toxic substances (Ginsberg *et al.* 2004, Hattis *et al.* 2003). Because children are at the beginning of their lives, effects with a long latency period may manifest themselves much later in life. These differences in children’s size, behavior and development mean that they may be more susceptible to environmental contaminants like toxic chemicals, and that research is needed in order to identify and prevent such hazards (Landrigan 1998).

Children Have “Windows of Vulnerability”

Because children are rapidly growing and developing, there are time periods, or so called “windows of vulnerability,” from gestation through adolescence where systems are particularly sensitive to damage. Any harmful exposure during these critical developmental windows can lead to lifelong alterations in behavior, disease, growth and development. The periods surrounding conception and during pregnancy, just after birth and during infancy, have long been recognized as critical windows for exposure to many contaminants but are receiving increased attention in recent years as we learn more about early human development. Currently, scientists are studying the sensitivity of the fetus to toxic chemicals and are increasingly recognizing the fetal stage as one of the most vulnerable developmental windows. For example, exposure to small amounts of chemicals during critical days of fetal development can change the architecture of the brain. This poses a new challenge: to identify when during a child’s development the exposure to chemicals has taken place (Selevan *et al.* 2000).

Why a North American Report on Toxic Chemicals and Children's Health?

This report reflects the three governments' commitment to work together as partners through the Commission for Environmental Cooperation (CEC).

The preparation of this report by the Secretariat of the CEC was authorized under Council Resolution 02-06 "Cooperative Agenda for Children's Health and the Environment in North America."

The report builds upon work of the CEC and the member states in:

- Analyzing chemicals reported to pollutant release and transfer registers in North America (*Taking Stock* reports);
- Coordinating trilateral efforts to monitor and reduce contaminants through the Sound Management of Chemicals (SMOC) initiative;
- Documenting the ability of some contaminants to travel long distances (*Continental Pollutant Pathways* [CEC 1997]);
- Presenting linkages between children's health and the environment (*Making the Environment Healthier for Our Kids: An Overview of Environmental Challenges to the Health of North America's Children* [CEC 2002]);
- Developing indicators of environmental effects on children's health in North America;
- Publishing the report *Health Impacts of Air Pollution on Morbidity and Mortality Among Children of Ciudad Juárez, Chihuahua, Mexico* (CEC 2003); and
- Publishing an inventory of North American power plant air emissions (CEC 2004).

Pollutant Release and Transfer Registers (PRTs)— A Source of Information on Chemicals from Industrial Activities

PRTs are important sources of information about the amount of chemicals being released into the environment from industrial facilities. Every year across North America, select industries report on the amount of chemicals released into the air, land, and water and injected underground. The amount of chemicals transferred off-site for disposal, treatment and recycling must be reported also. This information is collected by national governments each year and compiled into annual reports and electronic databases. This report analyses the matched data² reported to the Canadian National Pollutant Release Inventory (NPRI) and the US Toxics Release Inventory (TRI). The Mexican inventory, the *Registro de Emisiones y Transferencia de Contaminantes* (RETC), remains under development and data from Mexican facilities are not yet publicly available.

Environmental hazards come in a variety of forms, including: biologic agents (e.g., molds), radiation (e.g., ionizing, sunlight); air pollutants in smog, like nitrogen oxides, sulfur dioxides, particulate matter and ozone; greenhouse gases; and toxic

chemicals and pesticides in water, land and food and other consumer products. PRT data provide information on one category of pollutants: toxic chemicals released to the environment from industrial activities.

Methods and Scope of This Report

Building on methodologies developed for the CEC's annual *Taking Stock* report series, this report analyzes, from a children's health perspective, publicly available PRT data.

It focuses generally on children up to the age of 18 years, depending on the data available. Exposure to chemicals prior to birth can also be important to a child's future development, and so is discussed in this report.

The report is arranged in the following way:

- **Chapter 1** describes the demographics and major causes of death, illness and disability for children in North America.
- **Chapter 2** describes the sources, pathways and health effects of chemicals.
- **Chapter 3** analyzes industrial pollutant release and transfer data for carcinogens, developmental toxicants and neurotoxicants, and other chemicals of concern to children's health.
- **Chapter 4** describes examples of current programs to prevent and reduce children's exposure to chemicals and provides an overview of recommendations for actions to reduce releases of and prevent exposure to toxic chemicals.
- A **Resources** section lists governmental agencies and other organizations which can provide further information.
- **References** for the entire report are to be found following the main body of the report. The reader is encouraged to explore these and other documents for understanding of particular issues in greater depth.
- **Appendixes** offer source data and supplementary information.
- **Tables** referred to in sections 1 and 3 follow the Appendixes.

This report focuses on selected chemicals and presents some forward-looking recommendations for action. It is not a report on risks, but rather information and analysis of the sources of some chemical industrial releases reported by the PRTs of Canada and the United States.

2. A "matched" data set includes only those chemicals and those industrial sectors common to both systems. Thus, data on chemicals reported to one system but not the other are not included. Similarly, data from industrial sectors required to report to one system, but not the other, are not included.