

Children and Chemical Safety

An Inventory of Activities by International and National Organizations and Agencies

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FOREWORD

The Swedish Chemicals Agency (KemI) has been assigned by the Swedish Government to produce an Action plan for a toxic-free everyday environment 2011 – 2014 – protect the children better. Efforts are going on in several areas, both in Sweden, within the EU and internationally and often in cooperation with other authorities, sector organisations and other actors. Reducing chemical risks in the everyday environment is one step towards attaining the Swedish Parliament's environment quality objective A Non-Toxic Environment, which is the objective that KemI is responsible for.

Within the framework of the action plan for a toxic-free everyday environment, KemI compiles facts in KemI's report and PM series. In this way, KemI wishes to present and distribute new and essential knowledge. The publications can be downloaded from the website www.kemikalieinspektionen.se.

In the action plan, there is a particular focus on protecting children and adolescence better as they are often more vulnerable than adults to the effects of chemicals. There are several reasons to focus on children in an environmental health context. The rapid development that starts prenatally and continues throughout childhood and adolescence make the development of key organ systems vulnerable to chemicals and may increase the risk of impaired health throughout life. At the same time, the exposure to xenobiotics is often significantly higher in children as compared with adults due to the fact that children eat, drink and breathe more in relation to body weight. The fact that children cannot independently choose their living environment also gives the society a particular responsibility to create a healthy environment free of harmful chemical substances.

In order to take appropriate measures there is a need for knowledge about children and chemical health risks. This involves both the identification of existing scientific knowledge, but also to describe the knowledge gaps that are important to deal with. A number of national and international agencies and organizations are currently working on similar and related issues. To create an overview of on-going or recently finished projects KemI assigned the Institute of Environmental Medicine to survey projects and activities related to children and chemical safety. The inventory should be focused on international projects and activities related to child and adolescent exposure to chemicals, chemical-related health risks, as well as projects related to current risk assessment methodology and its relevance for children. In this way, undertaken actions will be built on existing knowledge and in collaboration with unnecessary duplication of work avoided.

The Institute of Environmental Medicine is a research institute at Karolinska Institutet with a special mission to cooperate with and assist national authorities and institutions in order to provide a basis for measures to improve the environmental health in the country, and to support

and participate in international efforts related to environmental medicine. The present report was written by Kristin Larsson, MSc toxicology and Associate Professor Mattias Öberg. Valuable comments were given by Associate Professor Marika Berglund and Professor Annika Hanberg. An initial internet search was performed by Karin Ljung Björklund. The project was led by Mattias Öberg.

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The views and recommendations expressed in this report are the author's own and do not reflect necessarily the view of KemI.

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SAMMANFATTNING

Rapporten syftar till att ge en uppdaterad översikt av pågående eller nyligen avslutade projekt och verksamheter som rör barn och kemiska hälsorisker. Redovisade aktiviteter härrör till såväl internationella som nationella organisationer och omfattar forskningsprojekt, handlingsplaner, riskbedömningar, samt utbildning, informationsutbyte och aktiviteter relaterade till information och utbildning. Inventeringen fokuserar på kemikalier i barns vardagsmiljö.

På global nivå berör de identifierade verksamheterna och projekten ett brett spektrum av barnmiljö-hälsofrågor med viss tonvikt på regioner med låg eller medelhög ekonomisk nivå. De globala organisationerna ger också ett substantiellt bidrag genom verksamhet som syftar till harmonisering av metoder för kemikalieriskbedömning. Rapporterade aktiviteter på regional och nationell nivå, främst Europa och USA, är mer inriktade på specifika kemiska faror och utveckling av dokument med direkt inverkan på regional riskhantering.

Foster, spädbarn, barn och ungdomar kan vara särskilt känsliga för kemisk exponering till följd av utvecklingsspecifika stadier, särskilda exponeringsmönster, samt fysiologiska och toxikodynamiska faktorer. Eftersom barn inte aktivt kan välja sin livsmiljö har samhället ett stort ansvar för att skydda barn från ohälsosam exponering för kemikalier. Under senare år har flera handlingsplaner tagits fram globalt, regionalt och nationellt. Den europeiska handlingsplanen för barns miljö och hälsa, utvecklad vid WHO:s regionkontor för Europa samt i den europeiska miljö-och hälsostrategi från EU-kommissionen är av stor betydelse. Enskilda medlemsländer, däribland Sverige, har som en följd av internationella åtaganden tagit fram nationella handlingsplaner.

Med syfte att övervaka tillståndet för barns miljö och hälsa, jämföra regioner, utvärdera effektiviteten av interventioner och hjälpa beslutsfattare att identifiera risker och vidta åtgärder försöker flera organisationer och myndigheter ta fram indikatorer för barns miljö och hälsa. Hittills har dock huvuddelen av dessa indikatorer inriktats mot ett bredare spektrum av miljörisker, medan indikatorer specifikt inriktade på kemiska hälsorisker är få.

I nuvarande metoder för kemisk hälsoriskbedömning finns inga standardiserade metoder för bedömning av kemiska risker hos barn. Olika organisationer och myndigheter har dock utvecklat verktyg för riskbedömningar för barn och flera dokument syftar till att beskriva barns specifika känslighet och exponeringsmönster, samt till att föreslå åldersberoende bedömningsfaktorer och föreslå lämpliga åldersgrupper för riskbedömningar. Det finns ett allmänt behov av ytterligare forskning för att få kunskap om utvecklings-specifik känslighet och hur man kan införliva denna kunskap i riskbedömningar.

Med syfte att undersöka sambandet mellan tidig exponering och utveckling av sjukdomar senare i livet, genomförs ett stort antal kohort-studier runt om i världen. Att jämföra studier med olika försöksupplägg är svårt och enskilda studier är ofta för små för att studera ovanliga sjukdomar. Därför har flera projekt initierats som syftar till att harmonisera metodiken som används i kohort-studier. Dessutom har flera projekt med biologisk monitorering, som mäter halter av kemiska ämnen hos barn utförts.

Baserat på de verksamheter som identifierats i denna rapport kan ett antal allmänna förslag lyftas fram som sannolikt skulle kunna vara användbara i den fortsatta utvecklingen mot en giftfri miljö

med särskild inriktning på skydd av barn. Dessa förslag omfattar åtgärder för forskning och utredningar (*utför och samordna kohortstudier av barn, utvärdera kemikalier i relation till miljön i skola och förskola, stärk forskning med anknytning till barn och kemikalier, fyll kunskapsluckan när det gäller kemisk exponering och hälsorisker i samband med tonåren*), övervakning (*ta fram en nationell förteckning över prioriterade kemikalier, utför barn-specifik hälsorelaterad miljöövervakning och samla in biomonitoring-data på ett strukturerat sätt*), riskbedömning (*utveckla miljö- och hälsoindikatorer för barn, ta fram riktvärden för halter i barn och barns miljö, liksom riskbedömningsmetodik för bedömning av kemiska risker för barn*), planering och samarbete (*fortsätt och fördjupa samarbetet med internationella och nationella inter-sektoriella organisationer samt följ upp och förnya de nationella handlingsplanerna för barns hälsa och miljö*). Därtill föreslås åtgärder för förbättrad information och utbildning.

SUMMARY

The report aims to give an up-to-date overview of ongoing or recently completed projects and activities related to children and chemical safety, initiated by international and national organizations and agencies. The reported activities include research projects, action plans and risk assessment approaches as well as educational, information-sharing and awareness-raising activities. The inventory focuses on chemicals in children's everyday environment.

At a global level, the identified activities relate to a broader spectrum of child environmental health issues of concern in developed as well as in low and middle-income regions. In addition, the global organizations give a valuable contribution with impact on harmonization of risk assessment methodologies. Reported activities at regional and national levels, mostly in Europe and the US, are more focused on specific chemical hazards and development of documents with direct impact on regional risk management.

Foetuses, infants, children and adolescents may be especially susceptible to chemical exposures owing to developmental stage-specific exposure patterns and physiological and toxicodynamic factors. In addition, children cannot actively choose their living environment. Therefore, the society has to take responsibility to protect children from chemical exposures. In recent years, several action plans have been developed at national, regional and global levels. In Europe, the Children's Environment and Health Action Plan for Europe (CEHAPE), initiated by the World Health Organization (WHO)'s Regional Office for Europe, and the EU's European Environmental and Health Strategy are of high importance. In addition, national children's environment and health action plans have been developed by several individual EU member countries.

Aiming to monitor the state of children's environmental health, compare regions, evaluate effectiveness of interventions and help decision-makers to identify risks and plan actions, several organizations and agencies are working on developing children's environmental health indicators. However, these are concerned with a broader range of environmental hazards; indicators exclusively focusing chemical safety and children's health are few.

Despite numerous methodologies for chemical health risk assessment, no standardized guidelines for assessing chemical risks in children exist. However, organizations and agencies have developed tools for risk assessment in children and several documents are currently available aiming to describe children's specific susceptibilities, provide factors for exposure evaluations, propose age-dependent adjustment factors and suggest appropriate age bins for risk assessments. There is a general call for further research to gain knowledge of developmental stage-specific susceptibilities and how to incorporate this new knowledge into risk assessments.

Aiming to investigate the association between early life exposure factors and development of diseases later in life, birth cohort studies are being performed in many countries. However, individual birth cohorts are often too small to study uncommon diseases. Therefore, several projects have been initiated, aiming to harmonize birth cohort methodologies to enable pooling and comparison of data. Furthermore, several biomonitoring projects measuring chemical body burdens in children have been performed and attempts to harmonize biomonitoring studies have been initiated.

Based on the broad variety of relevant activities identified in the present report, a few general suggestions have been made that are likely to be useful in the further development towards a non-toxic environment with a specific focus on protection of children. These suggestions include actions for research and investigations (*to perform and coordinate birth cohort studies, evaluate chemicals in school and day care environments, strengthen research related to children and chemicals, fill the knowledge gap related to adolescence*), monitoring (*to develop a national priority list of chemicals, perform child-specific health-related monitoring activities and collect data in a structured manner*), risk assessment (*to develop children's environmental health indicators, child-specific reference doses and reference concentrations, as well as risk assessment methodologies for assessment of chemical risk for children*), planning and collaboration (*to collaborate with international and national inter-sector organizations, and revise the national action plans for child health and environment*) and actions for information and education.

1. INTRODUCTION

1.1 Child health and the environment

Health is affected to an unknown extent by chemicals in the everyday environment and children may be particularly susceptible to chemical exposures for several reasons. Small children differ from adults in their exposure patterns, as they tend to bite and chew on objects and move closer to the ground where chemicals accumulate in dust and soil. Children also ingest more food, water and breathe more air, compared with adults, in relation to their body size. In addition, children have less knowledge of potentially harmful substances and therefore show less precautionous behaviour. From the time of conception and throughout the child's developmental stages, the organ systems develop at different time points, creating windows of susceptibility at which certain chemical exposures can cause developmental effects. Furthermore, the body's metabolism is not fully developed in foetuses and infants, thus altering the health impact of chemicals. In addition, children are unable to choose their living environment, and therefore the surrounding society has a particular responsibility to create a healthy environment free from harmful chemical substances.

Even before birth, foetuses are exposed to chemicals via the mother and newborn babies have been shown to have hundreds of exogenous chemicals present in their blood. Therefore, assessing maternal exposure to chemicals is crucial when evaluating chemical exposure in children.

Today, there are no standardized guidelines for chemical risk assessment in children and pregnant women. However, in recent years, the knowledge about and interest in developmental stage-specific susceptibilities and how to incorporate this new knowledge in the risk assessment and management of chemicals have increased.

1.2 Purpose, method and delimitations of the inventory

In order to fulfil the national action plan for a non-toxic environment during the period 2011–2014 the Swedish Chemicals Agency identified a need for an inventory of ongoing or recently completed projects and activities related to children and chemical safety, initiated by international and national organizations and agencies. The current inventory report does not include the results from these activities, but rather, delivers a scheme to guide the planning of future initiatives, so that these initiatives can be built on current knowledge. In this way, collaboration with similar initiatives may be enhanced and duplication of efforts can be avoided.

The inventory is based on information accessible on the Internet. Therefore, only projects and programmes presented on the Internet are included. Limitations of an Internet-based approach are that the available detailed information is often limited and information on the current status of projects may be insufficiently updated. No evaluation of the validity of the research projects has been made. The inventory was performed between November 2011 and February 2012 and was mainly limited to actions and initiatives undertaken since the year 2000.

For the inventory, no set definition of “childhood” and the ages involved was provided, since the definition varies between different documents and projects. However, the most common definition of “childhood” is from conception to late adolescence (normally 18 or 21 years of age). Consequently, chemical exposure of women before and during pregnancy is of high concern.

The inventory departs from the organisational structures. However, since the given focus has been chemicals in the everyday environment and chemicals in products the search domain has not been covering specific initiatives related to pharmaceuticals, drug use, smoking etc. For example, chemicals migrating from food containers are considered rather than food additives, and chemicals from furnishing are included rather than outdoor air pollutants. Research activities are included in the inventory as a part of an ongoing field of activity within the international or governmental organizations discussed. Therefore, independent research projects by universities or industries are not included.

In addition to the organizations and agencies presented in this document, the inventory includes other actors whose activities are likely to be important for child environment and health. These organizations and agencies include the European Chemical Agency, the International Chemicals Secretariat, the European Environmental Bureau, the International Council of Chemical Associations, the Swedish Medical Products Agency, the Swedish Plastics and Chemicals Federation, the US Food and Drug Administration, the European Food Safety Authority, the United Nations Economic Commission for Europe and the United Nations Development Programme. However, no information on actions specifically concerning chemical exposure in children was identified and such specific actions are therefore not included in the present report.

2. ACTIVITIES OF GLOBAL INTERGOVERNMENTAL ORGANIZATIONS

The global intergovernmental or supragovernmental organizations are coordinating initiatives on global health matters. The key actors include several organisations within the UN system such as WHO, IARC, IPCS, and UNEP. The main focus for these organisation is directed towards developing low and middle income regions as well as facilitate broad consensus risk assessment documents. In addition, some activities have been identified by organisations such as OECD and G8, which are more directed toward developed countries. In general, many of the activities aim to support policy-makers to plan science based and efficient interventions in order to improve child health and environment. Identified activities are presented in Table 1.

Table 1. Activities related to chemicals and children's health, performed by intergovernmental organizations.

ACTIVITY	TYPE OF ACTION
WORLD HEALTH ORGANIZATION (WHO)	
National Children's Environmental Health Profiles	Risk identification, risk assessment, monitoring progress
Children's Environmental Health Indicators	Risk identification, risk assessment, monitoring progress
Harmonization of birth cohort studies	Harmonization of birth cohort studies
Harmonized training package	Education of health care providers
Children's Environmental Health Units	Education of health care providers and the public, influencing policy-making
Pilot projects (asthma, arsenic, biomonitoring, cohorts)	Biomonitoring, birth cohorts, other research
Healthy Environments for Children Alliance	Advocating, influencing policy-making, information sharing
Plan of Action for Children's Health and Environment (2010-2015)	Action plan
Healthy Environments for Healthy Children: Key Messages for Action	Education of decision-makers and the public
Children in the New Millennium: Environmental Impact on Children	Risk identification, influencing policy-making, recommendations for actions
Childhood Lead Poisoning	Education of health care providers and decision-makers
Children's Exposure to Mercury Compounds	Education of health care providers and decision-makers
Persistent Organic Pollutants - Impact on Children's Health	Education of health care providers
Children's Health and the Environment: A Global Perspective. A Resource Manual for the Health Sector	Education of health care providers
INTERNATIONAL AGENCY FOR RESEARCH ON CANCER (IARC)	
Consortium of agricultural cohorts (AGRICOH)	Cohort consortium
Automated Childhood Cancer Information System	Cancer database
INTERNATIONAL PROGRAM FOR CHEMICAL SAFETY (IPCS)	
Harmonization of Approaches to the Assessment of Risk from Exposure to Chemicals	Risk assessment methodology

Identifying Important Life Stages for Monitoring and Assessing Risks from Exposures to Environmental Contaminants	Risk assessment methodology
Environmental Health Criteria 237	Risk assessment methodology
Environmental Health Criteria 59	Risk assessment methodology
Environmental Health Criteria 30	Risk assessment methodology
UNITED NATIONS (UN)	
A World Fit for Children	Action plan
Plan of Implementation	Action plan
UNITED NATIONS ENVIRONMENTAL PROGRAMME (UNEP)	
Children's Environmental health Project	Risk identification, monitoring of progress, influencing policy-making
Strategic Approach to International Chemicals Management (SAICM)	Framework policy
Global Plan of Action	Action plan
Childhood Pesticide Poisoning	Awareness-raising, action recommendations
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)	
Children's Environmental Health Indicators	Risk identification , risk assessment, monitoring progress
Valuation of Environment-Related Health Impacts, with a Particular Focus on Children	Cost-benefit analysis of children's environmental health
GROUP OF EIGHT (G8)	
Miami Declaration	Action plan

2.1 World Health Organization (WHO)

2.1.1 Children's Environmental Health (CEH) programme

Under the *Children Environmental Health programme*, WHO performs several actions to reduce children's exposure to environmental health risks. The activities concern a broad range of environmental hazards, including unsafe water, food hygiene, indoor and outdoor air pollution, chemical exposure, sanitation and injuries.

Activities in the CEH programme include the development of *children's environmental health indicators*, following a global initiative launched at the World Summit in Sustainable Development (WSSD) in 2002. The main goals are to evaluate the state of children's environmental health, compare different regions, monitor the effectiveness of interventions and help policy-makers to plan actions in order to improve environmental conditions for children (WHO, 2012a).

WHO has developed *National Children's Environmental Health Profiles* for 24 countries in the African and American regions, which are used to rapidly identify and assess environmental risks and the effects on children's health. The profiles aim to facilitate the development of cost-effective strategies and to measure the effectiveness of implemented strategies. The profiles are country-specific and recognize the national state of children's environmental health and the nation's ability to make interventions to reduce various environmental health risks, chemicals included (WHO, 2005a).

Aiming to investigate the impact of environmental exposures on the growing foetus and child, numerous birth cohort studies have been conducted around the world. WHO has observed the difficulty with comparing and pooling existing data from different studies, due to inconsistent study designs. Therefore, WHO is now working towards harmonization of birth cohort studies, by using agreed measurements of e.g. disease outcomes, biomarkers and exposures, when new studies are being designed (WHO, 2011a). Together with The National Children's Study's International Interest Group, WHO developed "*A Guide to Undertaking a Birth Cohort Study: Purposes, Pitfalls and Practicalities*", addressing researchers planning to launch a birth cohort study (Golding et al, 2009).

In order to educate health care professionals in identifying, assessing and managing children's diseases caused by environmental exposures, WHO has developed a harmonized training package. The package consists of more than 30 modules including notes, references, case studies and self-evaluation tools. In addition, introduction courses for one day up to one week are provided. The package covers the specific vulnerability of children as well as health effects of chemical, physical and biological hazards and potential exposure routes. Available training modules concerning chemicals are available in the following categories; lead, mercury, other heavy metals, pesticides, persistent organic pollutants (POPs) and chemicals (WHO, 2011b).

WHO has also set up a number of so called *Children Environmental Health Units* (CEHUs) which perform activities, such as to educate the public about the effects of environmental exposure on children's health, offer education and guidance to health care providers and help governmental agencies to make policies regarding environmental exposures and children's health. CEHUs can either be virtual or physically present in e.g. clinics and research centres. The different CEHUs are encouraged to create networks to exchange experiences and research outcomes (WHO, 2010a). According to the WHO official home page, CEHUs currently exist in the US, Canada, Mexico and Spain and new CEHUs are being introduced in Argentina and Uruguay (WHO, 2012b)

Several *pilot projects* within the WHO CEH programme have been launched, regarding environmental exposures and children's health. These projects are being performed in the following areas; effects of arsenic exposure during pregnancy on children, biomonitoring of persistent toxic substances in children, long-term cohort studies of children in selected developing countries and asthma in children.

2.1.2 Key publications

WHO has publicized several documents related to children's environmental health. The most relevant publications are presented below:

In collaboration, WHO, United Nations Environment Programme (UNEP) and United Nations Children's Fund (UNICEF) published "*Healthy Environments for Healthy Children: Key Messages for Action*" (WHO/UNEP, 2010), aiming to educate decision-makers and caregivers by giving practical examples of how to create safe environments for children. Identified environmental hazards include environmental change, water safety, sanitation, nutrition, growth and development, vectors of disease, air pollution, chemicals, injuries, environmental emergencies, noise and healthy housing. Chemicals mentioned to be of concern to children's health are lead, mercury, pesticides, POPs, household products and indoor air chemicals. This

document is an updated version of “Children in the New Millennium: Environmental Impact on Health” from 2002 (see below).

Several documents aim to implement one of the goals set up by the Bangkok Statement in 2002; “Incorporate children’s environmental health into the training for health care providers and other professionals”. “*Persistent Organic Pollutants- Impact on Child Health*” (WHO, 2010b) provides information to health professionals about the impact of POPs on children’s health. The report includes sections on developmental stage-specific susceptibility to POPs, research needs and prevention methods. In addition, “*Childhood Lead Poisoning*” (WHO, 2010d) and “*Children’s Exposure to Mercury Compounds*” (WHO, 2010e) were developed in order to educate health care professionals and policy-makers about prenatal and childhood lead and mercury exposures and related health effects.

“*Children’s Health and the Environment: A Global Perspective. A Resource Manual for the Health Sector*” (WHO, 2004) describes developmental stage-specific susceptibilities, exposure scenarios, symptoms, treatments and prevention strategies of environmentally caused illnesses. Furthermore, the document identifies various environmental threats and describes case studies of environmental risks in children’s environment. The document presents a wide range of global environmental hazards, with limited focus on chemicals.

“*Children in the New Millennium: Environmental Impact on Health*” (WHO/UNEP/UNICEF, 2002) was developed in collaboration between WHO, UNEP and UNICEF. The document focuses on children’s environmental health in a global perspective, including descriptions of developmental stage-specific susceptibilities and various environmental hazards as well as recommendations for actions. A chapter on chemical pollution is included, in which pesticides, POPs, heavy metals and pollution from cars, industries and waste sites are considered to be of concern for children’s health. The document calls for action from governments and communities, especially in the developing world and Eastern Europe, to manage environmental chemicals in order to protect children’s health. Prompted actions include further research on multiple and synergistic effects of chemicals and specific toxicological effects at different developmental stages, in order to enable development of children-specific safety limits and guidelines.

2.1.3 Conferences, workshops and proceedings

Selected conferences on children’s health and the environment organized by WHO are presented below:

The Third international WHO conference on Children’s Health and the Environment: from Research and Knowledge to Policy and Action, was held in Busan, Republic of Korea, in 2009. During the meeting, the development of a “*Global Plan of Action for Children’s Health and the Environment (2010-2015)*” was initiated (WHO, 2010c). The main goal of the action plan is to protect children’s health by creating a safe and clean environment. The plan presents five target areas for achieving this goal; 1. Data collection and analysis 2. Collaborative research 3. Advocacy 4. Clinical service delivery, and 5. Awareness-raising and education. Recommended actions targeting chemical hazards include to promote periodic biomonitoring of chemicals in human biological samples, to coordinate birth cohorts and to properly manage chemicals in the environment. In order to implement the plan, strong collaborations between intergovernmental, regional, national and Non-Governmental Organizations (NGOs) and governmental agencies are encouraged. Furthermore, at the meeting the “*Busan Pledge for Action*” was established, setting

up further goals and actions to reduce environmental contamination in order to improve children's health (WHO, 2009).

The Second International WHO Conference on Environmental Threats to the Health of Children: Increasing Knowledge and Taking Actions, was held in Buenos Aires, Argentina, in 2005. Children's environmental health, primarily in Central and Latin America, was being discussed. In addition, "*The Buenos Aires Declaration*" was established, committing the participants to take actions in order to protect children from environmental hazards (WHO, 2005b).

The First International WHO Conference on Environmental Threats to Children: Hazards and Vulnerability, was held in Bangkok, Thailand, in 2002. The main focus was children's environmental health in the WHO South East Asia and Western Pacific regions. The participants expressed the need for strengthened international collaboration between scientists in developing and developed countries and for global and regional actions to be taken. At the conference, the "*Bangkok Statement - A pledge to promote children's health*" was developed, in which the conference participants commit themselves to take action in order to promote children's environmental health (WHO, 2002).

In addition to the above conferences, WHO has organized several workshops on children's environmental health. Workshops have been given in the areas of e.g. environmental health training for paediatricians, setting up longitudinal birth cohort studies, and literature research on chemicals and children's health in developing countries.

2.1.4 Healthy Environments for Children Alliance (HECA)

WHO and UNEP are the main coordinators of Healthy Environments for Children Alliance (HECA), which was formed in 2002, following an initiative taken at the WSSD. HECA is a world-wide alliance aiming to improve children's environmental health at home, in school and in the community, by influencing policy- and decision-makers through advocating and information sharing. Furthermore, HECA organizes workshops and gives support to several projects such as the WHO's Children's Environmental Health Profiles (see section 2.1.1). HECA addresses the topic of chemical risks and children's health by encouraging stricter protective laws and more investment in research and development of more a consistent approach for risk assessment and toxicity testing, considering children's unique susceptibilities (HECA, 2011).

2.2 International Agency for Research on Cancer (IARC)

The IARC research section for environment and radiation has the main objective to investigate the relationship between environmental, life-style, occupational and radiation-related factors and cancer in the population (IARC, 2012a). An example of research activities related to childhood exposure is the AGRICOH-project, which is a consortium of agricultural cohorts investigating environmental exposures and development of cancer and other diseases. Approximately one third of the 23 cohort studies included in the project involve children (IARC, 2012b).

In addition, IARC provides the Automated Childhood Cancer Information System (ACCIS), used to detect trends in childhood cancer incidence and mortality in European children. This database can be used as a tool for research on environmental exposures and children's health (IARC, 2012c).

2.3 International Programme on Chemical Safety (IPCS)

IPCS conducts a project named Harmonization of Approaches to the Assessment of Risk from Exposure, aiming to harmonize the basics in global risk assessment and develop guiding documents addressing specific areas of risk assessment (IPCS, 2011a). One of the activities within the project is Identifying Early Life Stages for Characterizing Chemical Exposures, under which IPCS provides tools for assessing risks in children, based on the knowledge of developmental-specific susceptibilities and exposure scenarios. This approach also aims to facilitate collection of data and evaluation of cumulative risk and aggregate analyses. In addition, the document “*Identifying Important Life Stages for Monitoring and Assessing Risks from Exposures to Environmental Contaminants*” presenting a harmonized set of age bins for risk assessments was drafted in 2011, however the final document is yet to be published (IPCS, 2011b).

IPCS has published three Environmental Health Criteria Monographs regarding the methodology of risk assessments in children. These documents are listed below together with a short summary for the most recent monograph.

Environmental Health Criteria 237: Principles for Evaluating Risks in Children Associated with Exposure to Chemicals (IPCS, 2006). The document covers differences in children’s and adults’ susceptibilities to chemicals, as well as developmental stage-specific susceptibilities and outcomes in children. In the document, it is concluded that there are some available assessment tools applicable for children, but further research is needed to enable a consistent risk assessment in children. Chemicals considered to be of highest concern for children’s health are heavy metals, POPs, pesticides and air pollutants.

Environmental Health Criteria 59 : Principles for Evaluating Health Risks from Chemicals during Infancy and Early Childhood (IPCS 1986)

Environmental Health Criteria 30: Principles for Evaluating Health Risks to Progeny Associated with Exposure to Chemicals during Pregnancy (IPCS, 1984)

2.4 United Nations (UN)

UN has developed several goal orientated strategies on children’s health and/or the environment. However, these strategies regard a far wider range of health problems besides chemical exposures. The most relevant are presented below:

The Millennium Development Goals were adopted and signed by 189 world leaders, at the United Nations Millennium Summit Conference held in New York, US, in 2000. The strategy presents eight goals, to be achieved by 2015, for improving the lives of the world’s poorest people. One of these goals specifically regards children’s health, by aiming to reduce the under-five mortality rate by two-thirds (UN, 2000).

At the conference Special Session of the UN General Assembly on Children, held in New York, US, in 2002, the plan “*A World Fit for Children*” was declared. This agenda for the world’s children includes 21 specific goals, covering a broad range of issues regarding children’s health. Chemical hazards are mentioned briefly (UN, 2002a).

The World Summit on Sustainable Development was held in Johannesburg, South Africa, in 2002. The aim of the conference was to develop an action plan for the implementation of the Agenda 21 goals for a sustainable development (agenda 21 was developed at the Earth Summit in

Rio in 1992). In the “*Plan of Implementation*”, actions are recommended in areas such as poverty, consumption and production, natural resources and health. Actions for sound management of chemicals are presented (UN, 2002b).

2.4.1 United Nations Environment Programme (UNEP)

Within UNEP’s work on harmful substances, specific actions are taken in the following areas; chemicals in products, heavy metals, pesticides, POPs and hazardous waste. In 2010, UNEP chemical branch launched the *Children Environmental Health Project*, addressing chemical safety and children’s health in developing countries. The main goals are to identify and evaluate children’s chemical health risks, promote research in developing countries and provide national strategies for reducing chemical risks. In order to reach these goals, a steering committee was established, consisting of representatives from UNEP, WHO, UNICEF, OECD, Ministry of Environment Japan and US Environmental Protection Agency (US EPA). Literature reviews on children’s environmental health during the last 10 years in developing countries of Asia, Latin America, and Africa were performed, accounting for chemical risks, chemical management strategies, research gaps, research strengths and recommendations. Proposed future actions by UNEP include harmonization of cohort studies, promotion of children’s environmental health at international meetings as well as working with capacity building and identifying national needs (UNEP, 2011).

UNEP is also the main coordinator of the *Strategic Approach to International Chemicals Management* (SAICM) which is a global policy framework on chemical safety, established in 2006. The main goal is to improve, by 2020, the way chemicals are used and produced, thus minimizing adverse effects on health and the environment. For implementation of SAICM, a “*Global Plan of Action*” (UNEP, 2005) was developed, which presents 36 possible work areas and suggests actions to be taken, which actors that should take these actions and how the progress should be monitored. One of the work areas concerns children and chemical safety and suggested actions within this area are presented below:

- Develop guidance materials to assist in the preparation of initial national assessments of children’s environmental health and the identification of priority concerns. Develop and implement action plans to address those priority concerns.
- Establish needed infrastructure for research that will reduce uncertainty in risk assessment.
- Develop mechanisms to share and disseminate information that can be used to reduce uncertainty in risk assessment
- Eliminate as a priority any child labour that involves hazardous substances.
- Promote education and training on children’s chemical safety
- Promote the use of comparable indicators of children’s environmental health as part of a national assessment and prioritization process for managing unacceptable risks to children’s health.
- Consider potential enhanced exposures and vulnerabilities of children when setting nationally acceptable levels or criteria related to chemicals.
- Develop broad strategies specifically directed to the health of children and young families.
- Establish needed infrastructure for research into the impact of exposure to chemicals on children and women.

In 2004, UNEP published “*Childhood Pesticide Poisoning – Information for Advocacy and Action*” (UNEP/FAO/WHO, 2004) in collaboration with WHO and the Food and Agricultural Organization (FAO). The report describes child-specific susceptibilities and exposure scenarios of pesticide exposure. In addition, the document recommends actions to be taken on local, national and international levels in order to reduce children’s and women’s pesticide exposures, especially in developing countries. In addition, UNEP collaborates on chemical issues with e.g. WHO, the International Labour Organization (ILO) and UNICEF, and has been involved in the development of documents such as “*Healthy Environments for Healthy Children: Key Messages for Action*” and “*Children in the New Millennium: Environmental Impact on Health*”. UNEP is also one of the organizations behind the IPCS and HECA.

2.5 Organisation for Economic Co-operation and Development (OECD)

The OECD Environmental Directorate (ED) provides data collections, policy analysis and evaluation of country-specific performance in order to assist governments to create cost-efficient environmental policies. The OECD ED has a work area in chemical safety and biosafety, which includes risk assessments. The work undertaken in this area aims to assist member countries to improve chemical safety and make their chemical control policies more efficient. Furthermore, the OECD ED is involved in the development of children’s environmental health indicators.

Addressing the lack of focus on children when evaluating environmental health impacts and the lack of incorporation of children’s health in policy-making, OECD ED initiated the three-year project Valuation of Environment-Related Health Impacts, with a Particular Focus on Children (VERHI), in 2006. The project was funded by the European Commission (EC) Framework Programme for Research and Technological Development 6 (FP6) and was conducted in Italy, Great Britain and the Czech Republic. The study involved both children and adults, thus allowing comparisons of the results. One of the studied aspects was the willingness-to-pay for healthiness in children versus adults (OECD, 2010). The results are available in the report “*Valuation of Environment-Related Health Risks for Children*” (Alberini, 2010). Furthermore, in the area of economic evaluation of children’s environmental health, OECD has published “*Economic Valuation of Environmental Health Risks to Children*” (OECD, 2006) and “*Children’s Environmental Health Indicators: A Survey*” (OECD, 2005).

Currently, OECD is making an inventory of activities related to chemicals and children’s health.

2.6 The Group of Eight (G8)

The G8 is a forum which includes Canada, France, Germany, Italy, Japan, UK, US and Russia. The group holds annual summit meetings concerning a wide range of topics including health, environment, trade, labour, economics and energy.

In 1997, during the G8 Environment Ministers’ Meeting in Miami, the G8 leaders signed the *Miami declaration*, which calls on improved prevention of environmental exposures and proposes actions to be taken in order to protect children’s health. Among other priorities, the declaration calls on harmonized guidelines for risk assessments in children, taking into account children’s specific physiology, exposure patterns and cumulative exposures. Other prioritized areas are children’s exposure to lead and endocrine disrupting chemicals (EDCs) (G8, 1997).

The G8 Environment Ministers’ Meeting, held in Syracuse, Italy, in 2009, included a session on children’s health and the environment. The ministers called on improvement of indicators for

measuring progress of interventions and proposed more epidemiological research in children. Furthermore, it was concluded that the G8, WHO, UNICEF and UNEP have made progress on children's environmental health since the *Miami declaration* was established in 1997 (G8, 2009).

3. ACTIVITIES OF INTERGOVERNMENTAL ORGANIZATIONS IN EUROPE

The coordination of activities related to chemicals and children’s health in Europe is predominately performed by the WHO Regional Office for Europe together with the European commission and European Environment Agency (EEA). Other European organizations and agencies, such as the European Chemical Agency, the European Environmental Bureau, the European Food Safety Authority and the United Nations Economic Commission for Europe do not present activities related to children and chemical safety within the delimitations of the current inventory. Table 2 presents a list of activities, reports and action plans concerning chemicals and children’s health prepared by the intergovernmental organizations in Europe.

Table 2. Activities related to chemicals and children’s health, performed by WHO European regional office, the European commission and the European Environmental Agency.

ACTIVITY	TYPE OF ACTION
WHO REGIONAL OFFICE FOR EUROPE	
Environment and Health Information System	Information sharing, risk assessment, awareness-raising
CEHAPE / National CEHAPs	Action plan
Children’s Environmental Health Indicators for Europe	Risk identification, risk assessment methodology, monitoring progress
EUROPEAN COMMISSION	
The EU Environment and Health Strategy and the European Environment and Health Action Plan 2004-2010	Action plan
6th Environment Action Programme	Action plan
Framework Programme for Research and Technological Development	Research funding
EUROPEAN ENVIRONMENT AGENCY	
Children’s Health and Environment: a Review of Evidence	Risk identification, influencing policy-making

3.1 WHO Regional Office for Europe

At the Fourth Ministerial Conference on Environment and Health held in Budapest, Hungary, in 2004, the *Children’s Environment and Health Action Plan for Europe* (CEHAPE) (WHO Regional Office for Europe, 2004) was adopted by 53 member countries. The plan recognizes environmental hazards effecting children’s health and presents four Regional Priority Goals (RPG) out of which one regards exposure to chemicals, physical agents, biological agents and hazardous working environments. Aiming to reduce child mortality caused by chemical exposures, CEHAPE encourages actions, legislations and regulations to achieve the following priorities:

- Reduce exposure of children and pregnant women to hazardous chemical, physical and biological agents to levels that do not produce harmful effects on children’s health.

- Ensure appropriate information on and/or testing for effects on the health of developing organisms of chemicals, products and technologies before their marketing and release into the environment.
- Ensure the safe collection, storage, transportation, recovery, disposal and destruction of non-hazardous and hazardous waste, with particular attention to toxic waste.
- Monitor in a harmonized way the exposure of children, as well as men and women of reproductive age, to hazardous chemical, physical and biological agents.
- Ensure that the Stockholm Convention on Persistent Organic Pollutants, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal and the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade are applied.

In order to reach the CEHAPE goals, National Children's Environment and Health Action Plans are being developed. In 2005, WHO published "*Children's Health and Environment – Developing Action Plans*" (WHO Regional Office for Europe, 2005), aiming to guide policy-makers to create national action plans. The document presents actions specific for children's environmental health and concrete ways to reduce children's exposure to environmental hazards as well as the tools needed for implementation. The specific nation's choice of actions depends on the regional needs, priorities and abilities to undertake the activities. In addition, a set of children's environmental health indicators for monitoring the progress of the implementation of CEHAPE is presented (for more information see the ENHIS-project below). In the document, environmental chemicals mentioned to be of concern to children's health are lead, mercury, arsenic, pollutions from waste sites and industries, pesticides and other organic chemicals (POPs, polybrominated diphenyl ethers (PBDE), phthalates and Bisphenol A (BPA)) and indoor air pollutants (benzene, formaldehyde and polyaromatic compounds).

The European Environment and Health Committee (EEHC) is a coalition of representatives of European nations and organizations, coordinating the implementation and monitoring the outcomes of WHO's environment and health commitments, such as CEHAPE. At the Fourth Ministerial Conference on Environment and Health, the EEHC was urged to set up a test force consisting of member countries willing to implement national CEHAPs and conduct pilot projects. These projects aimed to develop standardized tools, such as indicators, to be used in the development of national CEHAPs.

In 2009, WHO published "*Improving Children's Health and the Environment - Examples from the WHO European Region*" (WHO Regional Office for Europe, 2009a). The document provides advices in the further development of national CEHAPs, by presenting thirty-three case studies describing experiences from initiatives taken to implement national CEHAPs. Case studies related to chemical exposures are: "Alternative to phthalates in medical equipment for babies" (Austria), "Environmental lead poisoning in children living in the Silesia Province" (Poland) and "Poisonous Persuaders" (the Netherlands) (the latter project aimed to reduce the incidence of accidents related to pharmaceutical and household chemicals, by informing parents about chemical risks).

In 2009, a questionnaire on the progress of national CEHAPs was sent out to the 53 member states in the WHO Europe Region. The main findings from the 46 responding countries were that

30 countries had developed national CEHAPs and 12 countries were in the developing stage. The national CEHAPs are either part of broader environmental action plans or separate action plans. Sweden is one of the countries which have developed a national CEHAP (see section 4.1.4).

As a reconfirmation on the pledge to implement CEHAPE in order to reach the RPGs, the “*Commitment to Act*” (WHO Regional Office for Europe, 2010) was presented on the Fifth Ministerial Conference on Environment and Health, held in Parma, Italy, in 2010. In this document, updated approaches related to environmental chemical hazards include the following five relevant for child health and chemicals:

- We will take advantage of the approach and provisions of relevant international agreements.
- We will contribute to the Strategic Approach to International Chemicals Management (SAICM) and to the development of the global legal instrument on mercury.
- We aim to protect each child from the risks posed by exposure to harmful substances and preparations, focusing on pregnant and breast-feeding women and places where children live, learn and play. We will identify those risks and eliminate them as far as possible, by 2015.
- We will act on the identified risks of exposure to carcinogens, mutagens and reproductive toxicants, including radon, ultraviolet radiation, asbestos and endocrine disruptors, and urge other stakeholders to do the same. In particular, unless we have already done so, we will develop by 2015 national programmes for elimination of asbestos-related diseases in collaboration with WHO and ILO.
- We call for more research into the potentially adverse effects of persistent, endocrine-disrupting and bio-accumulating chemicals and their combination, as well as for the identification of safer alternatives. We also call for an increase of research into the use of nanoparticles in products and nano-materials, and electromagnetic fields, in order to evaluate possible harmful exposures. We will develop and use improved health risk and benefit assessment methods.
- We will pay particular attention to child labour and exploitation as one of the major settings of exposure to relevant risks, and especially to hazardous chemicals and physical stressors.

The *European Environment and Health Information System* (ENHIS) is coordinated by the WHO Regional Office for Europe and funded by the European commission. The system provides summarized indicator-based assessments on children’s health and the environment, including evaluation of the policy relevance. For these assessments, a set of core indicators, addressing the four CEHAPE RPGs, has been developed based on evaluations of current policy needs and data gaps. The indicators which regard chemical exposures in children are presented below, together with references to fact sheets on each indicator:

- “*Persistent Organic Pollutants in Human Milk*” (WHO Regional Office for Europe, 2009b)
- “*Exposures of Children to Chemical Hazards in Food*” (WHO Regional Office for Europe, 2009c) focuses on arsenic, cadmium, lead and mercury.

- “Levels of lead in children’s blood” (WHO Regional Office for Europe, 2009d).

3.2 European Commission (EC)

In 2003, the EC developed *The EU Environment and Health Strategy*, also known as the Science, Children, Awareness, Legal instrument, Evaluation (SCALE) initiative. The overall aims are to reduce the disease burden caused by environmental factors, prevent new environmental health risks and improve the policy-making on environmental health. Until 2011, cycle one of the strategy was implemented, focusing on childhood asthma and allergies, neurodevelopmental disorders, childhood cancer and endocrine disrupting effects. To implement the strategy, the “*European Environment and Health Action Plan 2004-2010*” (EC, 2004) was developed. The plan presents 13 actions aiming to further investigate the associations between health and environmental risks, to support further research to fill knowledge gaps, to review policies and to improve communication. The development of a second action plan for further implementation of the Environmental and Health Strategy has been proposed (HEAL, 2010).

The Directorate General (DG) for Environment is currently striving to accomplish the 6th *Environment Action Programme* (6EAP), which was developed in 2002 (EC, 2002). The 6EAP presents a framework for environmental policies in the EU from 2002 to 2012 and describes strategies to reach the goals defined within the 6EAP. The programme addresses four environmental areas, out of which one is environment and health. Actions on environmental exposures in children are not mentioned per se but research enabling updates on child-specific health standards and exposure limits is encouraged.

Concerning environmental pollutants, the DG for Environment focuses mainly on polychlorinated biphenyls (PCBs) and dioxins, EDCs and pesticides. However, none of the identified activities are specific for children’s health.

Other DGs of the EC, such as the DG for Health and Consumers (DG SANCO) were included in the search for relevant activities. However, no activities with specific focus on chemicals and children’s health were identified.

3.2.1 Framework Programme for Research and Technological Development (FP)

The EC funds research projects mainly through the FPs. The current programme is FP7, running from 2007 to 2013. A list of projects regarding chemicals and children’s health, funded by the FP7, FP6 (2003-2006) and FP5 (1998-2002), is presented in table 3. In summary, a majority of the projects involved birth cohort studies and the most studied health effects were related to the hormonal and reproductive systems.

3.2.2 European Environment Agency (EEA)

In 1994, the European Environment Agency (EEA) was founded as an agency of the EU. The EEA’s mission is to provide information on environmental issues to policy-makers and the public, evaluate the effectiveness of undertaken policies and create a network for environmental information sharing and coordination between member countries.

EEA addresses a number of environmental topic areas, out of which two are; chemicals and environment & health. Activities within the latter area are being undertaken in order to monitor the progress of the EU Environment and Health Strategy. In this work, EEA cooperates with the EC, WHO, other agencies, nations and stakeholders. Performed actions are aiming to improve

assessment methodologies on environmental health, facilitate information access, support ENHIS and evaluate the economic aspect of environment related health issues (EEA, 2011).

In collaboration with WHO Regional Office for Europe, EEA published “*Children’s health and environment: A review of evidence*” in 2002 (Tamburlini, 2002). The report accounts for the main threats, research gaps and policy priorities on children’s health and the environment. The main aim is to assist decision-makers to develop efficient policies and strategies to protect children from environmental threats.

Table 3. Projects related to chemicals and children's health, funded by the EC FP5, FP6 and FP7. Please note that several projects also studied other environmental health risks besides chemical exposures.

FP5			
Project name	Project description	Studied chemicals	Start-finish
INUENDO	The project studied the exposure to environmental pollutants and the impact on fertility and other hormone linked effects in adults and children living in Sweden, Poland, Greenland and Ukraine. The methodology combined interviews with biological analyses, such as measures of semen quality and hormone status. http://www.inuendo.dk/	POPs	2002-2005
ENVIR.REPROD.HEALTH	The aims of the project were to evaluate the status of adult and infant male reproductive health in Europe, understand the association between environmental chemicals and reproductive health, and the mechanisms behind this association. An evaluation of differences in incidence of reproductive disorders between European countries was made. In addition, <i>in vivo</i> and <i>in vitro</i> studies investigating endocrine disruptive mechanisms were performed. http://ec.europa.eu/research/environment/pdf/env_health_projects/chemicals/c-envir.pdf	EDCs	2000-2005
EXPORED – Exposure outcome relationships in male urogenital malformations with special reference to endocrine disrupters	The aim was to investigate the association between the exposure to potential EDCs during pregnancy and male urogenital malformations. The project used existing birth cohort studies from Denmark and Finland. Biological samples were analysed for possible endocrine disrupters and background data, such as hormonal status, was evaluated. In addition, a matched case-control study of infant boys with congenital malformations in the reproductive organs was made. http://ec.europa.eu/research/environment/pdf/env_health_projects/chemicals/c-expored.pdf	EDCs	2002-2005
PLUTOCRACY - Placental uptake and transfer of environmental chemicals relating to allergy in childhood years	The aim was to study the association between in utero exposure to environmental pollutants and alterations in the immune response and manifestation of allergies in children. Small size mother-child cohorts were performed in Rumania, Slovakia and Belgium. Chemical pollutants and immune parameters were measured in placental tissues, blood and breast milk and the findings were correlated to the incidence of allergies in the offspring. In addition, <i>in vitro</i> and <i>in vivo</i> models were designed for investigating placental uptake of e.g. DDT and DDE. http://www.bris.ac.uk/plutocracy/	Organochlorine compounds, lead and cadmium	2001-2006

<p>AIRMEX - European indoor air monitoring and exposure assessment project</p>	<p>The aim of the study was to investigate indoor air pollutants in various European countries, by measuring indoor air contaminants in schools, day-care centres, homes and public buildings. In addition, estimations of human exposure to these contaminants were made.</p> <p>http://hcp.jrc.ec.europa.eu/our_databases/airmex</p>	<p>Volatile organic compounds (aromatics, carbonyls, terpenes)</p>	<p>2003-2008</p>
<p>PBDE-NTOX</p>	<p>The project used animal studies to evaluate the possible association between exposure of brominated flame retardants (BFRs) during gestation and lactation and effects on the developing central nervous system.</p> <p>http://ec.europa.eu/research/environment/pdf/tenv_health_projects/chemicals/c-pbde.pdf</p>	<p>BFRs</p>	<p>2000-2003</p>
<p>FIRE- Flame retardants integrated risk assessment for endocrine effects</p>	<p>The aim of the project was to improve the risk assessment of BFRs in humans and wildlife. The methodology included initial <i>in vitro</i> studies and subsequent <i>in vivo</i> studies, including reproductive studies, with focus on the immune system and endocrine effects. Toxicokinetics of BFRs in human volunteers and animals were also studied. Furthermore, BFRs in food as well as human breast milk and serum were measured and the results from different European countries were compared.</p> <p>http://www.rivm.nl/fire/</p>	<p>BFRs</p>	<p>2002- 2006</p>
<p>ENDOMET</p>	<p>The objectives were to study the potential endocrine disruptive effects of plasticisers, using <i>in vitro</i> model systems and proteomics/genomics and to develop biomarkers for endocrine disrupting effects of chemicals.</p> <p>http://ec.europa.eu/research/environment/pdf/tenv_health_projects/chemicals/c-endomet.pdf#view=fit&pagenode=none</p>	<p>Plasticisers (e.g. phthalates, alkylphenols, BPA)</p>	<p>2003-2006</p>
<p>PINCHE - Policy interpretation network on children's health and environment</p>	<p>PINCHE is a network of scientists, NGOs, patient's organizations, industry representatives and policy-makers, aiming to help decision-makers to develop policies on children's health and the environment in Europe. The network collected and evaluated existing research results on children's environmental health.</p> <p>http://ec.europa.eu/research/environment/pdf/tenv_health_projects/multiple_stressors_and_factor_s/m-pinche.pdf</p>	<p>--</p>	<p>2003-2005</p>

FP6

<p>NewGeneris – The newborns and genotoxic risks</p>	<p>The aim of the project was to study the association between exposure to genotoxic chemicals in food and environment in prenatal and early-life stages and the development of childhood cancers and immune disorders. The research was mainly based on biomarkers, predominantly measured in maternal and umbilical cord blood from various birth cohorts, in combination with questionnaire data. http://www.newgeneris.org/Default.aspx?tabid=59</p>	<p>Polycyclic aromatic hydrocarbons, heterocyclic amines, nitrosamines, acrylamides, mycotoxins, alcohols organochlorinated compounds, DNA reactive aldehydes</p>	<p>2006-2011</p>
<p>PHIME - Public health impact of long-term, low-level mixed element exposure in susceptible population strata</p>	<p>The project investigated the exposure to toxic metals and impact on human health. Numerous sub-projects were performed out of which a few focused on vulnerable populations (foetuses, children, women and elderly). http://www.york.ac.uk/res/phime/about.htm</p>	<p>Lead, mercury, arsenic, cadmium, manganese, uranium, platinum, palladium, rhodium</p>	<p>2006-2011</p>

FP7

<p>COPHES – Consortium to perform human biomonitoring on a European scale</p>	<p>The main goal is to harmonise human biomonitoring projects throughout Europe, create an international framework and enable comparison of studies. In the pilot project DEMOCOPHES questionnaires are combined with measurements of cadmium, phthalates and methyl mercury in urine and hair collected from mother and child couples in 17 European countries, Sweden included. http://www.eu-hbm.info/democophes</p>	<p>Methyl mercury, cadmium, phthalates etc.</p>	<p>2009-2012</p>
<p>CHICOS - Developing a child cohort research strategy for Europe</p>	<p>The aim of the project is to make and inventory of European birth cohorts, evaluate the information and identify knowledge gaps. http://www.chicosproject.eu/</p>	<p>--</p>	<p>2010-</p>
<p>ENRIECO - Environmental health risks in European birth cohorts.</p>	<p>The main objective is to study the relationship between early-life environmental exposure and disease in children, by performing an inventory of birth cohorts which are funded by the EC. Furthermore, databases are developed and recommendations for future data collection are created. www.enrieco.org</p>	<p>--</p>	<p>2009-2011</p>

<p>OBELIX - Obesogenic endocrine disrupting chemicals: linking prenatal exposure to the development of obesity later in life.</p>	<p>The project investigates the possible association between prenatal exposure to EDCs present in food and the incidence of obesity and related diseases (diabetes type 2, hypertension etc) later in life. The research methods include animal studies and mother-child cohorts. http://www.theobelixproject.org/</p>	<p>Dioxin-like and non-dioxin like compounds, phthalates, pesticides, BFRs and perfluorinated compounds (PFC)</p>	<p>2009-2013</p>
<p>CLEAR - Climate change, environmental contaminants and reproductive health</p>	<p>The main objective is to investigate the possible association between global climate changes, which may alter the human exposure to environmental chemicals, and the effects on human reproductive health. The project includes further analyses of human samples and data collection from previously made mother-child cohorts in Greenland, Ukraine and Poland. Furthermore, literature research is performed in order to evaluate the endocrine disruptive effects of the studied chemicals. http://www.inuendo.dk/clear/</p>	<p>PBDE, phthalates, hexachlorbenzen, PFC, lead, mercury</p>	<p>2009-2013</p>
<p>CONTAMED - Contaminant mixtures and human reproductive health - novel strategies for health impact and risk assessment of endocrine disrupters</p>	<p>The main objective is to investigate the relationship between cumulative exposure to EDCs and male reproductive health. The project includes development of novel biomarkers for measuring the total internal load of a mixture of EDCs, screening for previously unknown EDCs in humans and investigation of the effects on the reproductive system after prenatal exposure to EDCs. The methods include further analyses of human samples from existing birth cohorts as well as animal studies. http://www.contamed.eu/index.htm</p>	<p>EDCs</p>	<p>2008-2011</p>
<p>DEER - Developmental effects of environment on reproductive health</p>	<p>The main objective is to investigate the relationship between foetal and childhood chemical exposures and development of testicular dysgenesis syndrome. The project includes a pubertal follow-up of existing birth cohorts by collecting questionnaire data and measure hormones and chemicals in biological samples. Furthermore, a cross-sectional puberty study was performed. In addition, to investigate the mechanisms of EDCs, metabolomics, <i>in vitro</i> and <i>in vivo</i> studies have been made. http://www.eu-deer.net/</p>	<p>EDCs</p>	<p>2008-2012</p>
<p>REEF - Developmental effects of environment on reproductive health</p>	<p>The project investigates the effects of prenatal exposure of environmental chemicals on the developing female reproductive system, using <i>in vitro</i> and <i>in vivo</i> systems. http://www.abdn.ac.uk/reef/</p>	<p>PCB, DEHP etc.</p>	<p>2008-2011</p>

<p>RICHE - a platform and inventory for child health research in Europe</p>	<p>RICHE aims to be a platform for scientists, policy-makers, advocates, funders and others with interest in research in children's health. Activities include measurements and indicators of children's health, an inventory of research concerning children's health in Europe and identification of research gaps and research priorities. However, environmental chemicals are not specifically mentioned in this project.</p> <p>http://www.childhealthresearch.eu/</p>	<p>--</p>	<p>2010-2013</p>
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4. ACTIVITIES OF NATIONS

A multitude of activities related to children's health and chemicals have been or are currently being performed in many nations worldwide. The aims of the activities differ depending on the priorities and needs in respective country. In the current inventory, seven countries in Europe and North America have been chosen to exemplify relevant national activities in developed countries. Only activities associated with governmental agencies are mentioned, thus independent research projects by universities or industries are not included.

A summary of national activities, documents and action plans related to children and chemical safety is presented in Table 4.

Table 4. Activities related to chemicals and children's health performed on a national level.

AGENCY	ACTIVITY	TYPE OF ACTION
SWEDEN		
EPA, IMM	Health-Related Environmental Monitoring	Biomonitoring, environmental monitoring
SoS, IMM	Environmental Health Survey and Environmental Health Report	Risk identification, awareness-raising
SoS	National action plan for children's environmental health	Action plan
DENMARK		
EPA	Reports on specific consumer products relevant for exposure in children	Risk assessment, product screening, awareness-raising
EPA	Exposure of pregnant consumers to suspected endocrine disruptors	Exposure assessment, environmental monitoring, awareness-raising
EPA	Study of exposure to chemicals in 2 year old children	Exposure assessment, environmental monitoring, awareness-raising
EPA	Brochures and web site for pregnant and nursing mothers	Awareness-raising
THE NETHERLANDS		
RIVM	Risk Assessment of Chemicals: What About Children	Risk assessment methodology
RIVM	Non-Food Products: How to Assess Children's Exposure?	Exposure assessment methodology
RIVM	Guidance for assessment of chemical risks for children	Risk assessment methodology
RIVM	Chemicals in Toys. A General Methodology for Assessment of Chemical Safety of Toys with a Focus on Elements	Risk assessment methodology
GERMANY		
EPA	Environmental Health Risks: What are the Differences Between Children and Adults?	Exposure assessment methodology

UNITED KINGDOM		
HPA	Children's Environmental Health Strategy	Action plan
HPA	Children's Environmental Health Indicators	Risk identification, risk assessment methodology, monitoring progress
UNITED STATES OF AMERICA		
EPA	Voluntary Children's Chemical Evaluation Programme	Awareness-raising
EPA	Toxicity and Exposure Assessment for Children's Health	Awareness-raising
EPA	The Children's Total Exposure to Persistent Pesticides and Other Persistent Organic Pollutants	Exposure assessment, biomonitoring, environmental monitoring
EPA	Probabilistic Stochastic Human Exposure and Dose Simulations	Exposure assessment methodology
EPA	Integrated Pest Management programmes in schools	Exposure reducing strategy
EPA	Understanding Children's Exposure to Chemicals	Exposure and risk assessment methodology, analytical methodology
EPA	Supplement guidance for Assessing Susceptibility from Early-Life exposure to Carcinogens	Risk assessment methodology
EPA	Child Specific Exposure Factors Handbook	Risk assessment methodology
EPA	Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants	Risk assessment methodology
EPA	Food Quality Protection Act	Risk assessment methodology
EPA	A Framework for Assessing Health Risks of Environmental Exposures to Children	Risk assessment methodology
EPA	Protecting Children's Health – The national Pesticide Programme	Risk identification, risk assessment
Cal/EPA	Development of child-specific reference doses for chemicals common in Schools	Risk assessment
CDC	National Health and Nutrition Examination Survey	Biomonitoring
NIH	National Children's Study	Birth cohort
NIH	Longitudinal Investigation of Fertility and the Environment Study	Longitudinal study
NIH	International Childhood Cancer Cohort Consortium	Cohort consortium, harmonization of birth cohorts
CANADA, MEXICO, USA		
CEC	Development of indicators of children's environmental health	Risk identification, risk assessment methodology, monitoring progress
CEC	Trinational Biomonitoring Study	Biomonitoring
CEC	Toxic Chemicals and Children's Health in North America	Risk identification, risk assessment

CANADA		
Health CAN	Canadian Health measure survey	Biomonitoring
Health CAN	Maternal-Infant Research on Environmental Chemicals	Biomonitoring
Health CAN	Plastics and Personal-care Products in Pregnancy study	Biomonitoring, exposure assessment
Health CAN	Children's exposure to residential lead sources	Exposure assessment, biomonitoring
Health CAN	Brochures and web sites for public information	Awareness-raising

4.1 Sweden

4.1.1 Health-Related Environmental Monitoring

Since 1993, the Swedish Environmental Protection Agency (Swedish EPA) has coordinated health-related environmental monitoring in order to evaluate human exposures to environmental factors, detect trends and monitor effects of interventions. The monitoring activities have involved several national agencies and institutes. The Institute of Environmental Medicine (IMM) is hosting the monitoring data and the results are available from <http://www.imm.ki.se/Datavard/index.htm>. The following monitoring activities regard children's exposure to chemicals:

- Blood lead levels in children of 3-19 years of age were measured annually between 1978 and 2006, by the Division of Occupational and Environmental Medicine of the Lund University. From 2009, blood lead levels in children are measured every second year (Naturvårdsverket, 2011a).
- Since 1996, the Swedish Food Agency (SLV) has measured methyl mercury in hair and POPs (PCBs, dioxins, chlorinated pesticides and BFRs) in breast milk and blood from first time mothers. The children of women enrolled after 2008 will be followed up at 4, 8, and 12 years of age. In addition, since 2009, SLV has also collected urine samples from these mothers and plans to use the samples for measurements of e.g. BPA (SLV, 2011).

According to the health-related environmental monitoring annual report for 2011, ongoing monitoring activities related to children are measurements of lead, cadmium and methyl mercury in children's blood and metals in breast milk (Naturvårdsverket, 2011b).

4.1.2 Environmental Indicators

The Swedish environmental indicators are presented at the Environmental Quality Objectives Portal: <http://www.miljomal.se/Alla-indikatorer/>, coordinated by the Swedish EPA. The indicators target sixteen environmental quality objectives, including one for a non-toxic environment. However, these indicators concern the environment and population as a whole and the only indicator specifically related to children and environmental chemicals is; environmental pollutants in breast milk.

In 2010, the Karolinska Institutet School of Public Health (KFA) was commissioned by the Stockholm County Council (SLL) to map which children's health indicators that have been suggested by various national organisations e.g. the National Board of Health and Welfare (SoS), SLL, the Swedish National Agency for Education, the Ombudsman for Children, Statistics Sweden and the Swedish National Institute of Public Health. However, these indicators cover a

broader spectrum of children's health, besides environmental health and the only indicator concerning children and chemical safety in specific is nickel allergy in children (KFA, 2010).

4.1.3 The national environmental health survey and the national environmental health report

A national surveys on environmental health have been performed every fourth year since 1999. The target group have been pending between adults and children. To date, two surveys have been performed solely concerning children. In 2003, 30 000 questionnaires related to exposure and health outcomes were answered by the parents of children aged 8 months, 4 and 12 years and the results were analysed together with input from registers held by Statistics Sweden and other data sources. The results and conclusions were presented in "*Miljöhälsorapport 2005*" (Environmental Health Report 2005) (SoS/IMM/SLL, 2005). The report describes the state of children's environmental health in Sweden and includes chapters about e.g. metals, organic environmental pollutants and indoor environment. The latest environmental health survey for children was performed by the Institute of Environmental Medicine in collaboration with the National Board of Health and Welfare in 2011 and the results and analyses will be presented in 2013.

4.1.4 National CEHAPE

In 2005, the Swedish Government commissioned the Board of health and welfare to develop a proposal for a *national action plan for children's environmental health*, targeting the four RPGs in line with the CEHAPE initiative. In 2007, a proposed national action plan was published (SoS, 2007), suggesting 41 actions, out of which the following four regard children's chemical safety:

- Within the EU, Sweden should promote a policy of special concern for children in risk assessments and the framing of regulations.
- Manufacturers and retailers of goods which are intended for children, or are used in children's vicinity, should work actively to reduce chemical health risks to children.
- Children's environments should be as free as possible from chemical health risks.
- Track the share of children with nickel allergy by means of an indicator.

4.2 Denmark

4.2.1 Danish Environmental Protection Agency (Danish EPA)

As a part of the Danish Ministry of the Environment, the Danish Environmental Protection Agency (Danish EPA) is working to protect the environment, nature and people. In 2012, the Danish EPA finished a project investigating pregnant women's total exposure to 35 suspected EDCs (e.g. phthalates, parabens, pesticides, BPA and triclosan) in consumer products, food and indoor environment. The conclusion was that most pregnant women are not exposed to the selected EDCs in levels that cause concern, however, some pregnant women need to reduce their exposure. Aiming to inform pregnant women how to minimize their exposure to EDCs, a leaflet was created based on the study results (Danish EPA, 2012a). More information about the study can be find in the report *Exposure of pregnant consumers to suspected endocrine disruptors* (Danish EPA, 2012b).

In addition, the Danish EPA performed a study in 2009, aiming to investigate 2-year old children's 24-hour combined exposure to EDCs via food, products, articles and the environment. Based on the result from the study, a leaflet was published which provides parents with overview information on how to protect children from chemicals (Danish EPA, 2009). Another activity, related to awareness-raising information is a website for pregnant and nursing mothers, providing advice for chemical safety, information about chemicals and a self-evaluation test (Danish EPA, 2006).

To evaluate consumer exposure to chemicals, the Danish EPA has created a series of reports on chemicals in various products and articles (Danish EPA, 2011). The following reports present health assessments and quantitative analyses of chemicals in products that children come in contact with:

- *“Phthalates in products that children are in direct contact with”*
- *”Survey and health assessment of chemical substances in hobby products for children”*
- *”Survey, emission and health assessment of chemical substances in baby products”*
- *“A survey and health assessment of cosmetic products for children”*
- *”Survey as well as health assessment of chemical substances in school bags, toy bags, pencil cases and erasers”*
- *”Survey and release of chemical substances in ‘slimy’ toys”*
- *”Migration and health assessment of chemical substances in surface treated wooden toys”*
- *“Survey, migration and health evaluation of chemical substances in toys and childcare products produced from foam plastic”*
- *“Mapping of perfume in toys and children's articles”*
- *“Chemical substances from tents and tunnels for children”*

4.3 The Netherlands

4.3.1 The National Institute for Public Health and Environment (RIVM)

RIVM is a Dutch government agency working with public health, nutrition, safety and environmental management. For example, RIVM performs research to improve methods for risk assessments of chemicals and has published the following reports concerning chemical risk assessments in children:

“Risk Assessment of Chemicals: What About Children?” (Wolterink et al, 2002) presents the differences between children's and adult's chemical exposure patterns, toxicokinetics and toxicodynamics and evaluates the accuracy of the current risk assessment approaches concerning children.

“Non-Food Products: How to Assess Children's Exposure?” (van Engelen and Prud'homme de Lodder, 2007) accounts for the particular exposure patterns at different ages and provides guidance on risk assessments of consumer products. In addition, information on child-specific exposure to various biocides in products is given.

“Guidance for assessment of chemical risks for children” (Wolterink et al, 2007) describes children's specific exposure patterns, toxicokinetics and toxicodynamics, aiming to help risk

assessors to evaluate chemical risks in children. Furthermore, data gaps in current risk assessment methods for children are identified and recommendations are given.

“Chemicals in Toys. A General Methodology for Assessment of Chemical Safety of Toys with a Focus on Elements” (van Engelen et al, 2008) presents a risk based methodology for risk assessment of chemicals in toys which are made for children under 3 years of age and/or are intended to be put in the mouth.

4.4 Germany

4.4.1 Federal Environment Agency

The Federal Environment Agency hosts the secretariat for the Action Programme Environment and Health (APUG), which was established in 1999 by Germany’s Federal Environment Ministry and Federal Health Ministry. The main objective of APUG is to protect human health from adverse environmental impact, emphasizing on children’s health. They have also worked with development and implementation of a national CEHAP.

With the aim to measure the exposure of environmental contaminants in the German population, the German Environmental Study (GerES) has been performed in four cycles. Cycle one and three solely involved the adult population, whereas cycle two included adults as well as children between 6 and 14 years of age. The fourth cycle, running from 2003 to 2006, solely included children from 3 to 14 years of age. The latter study combined blood and urine analyses with questionnaires from 1800 participants and, in selected cases, analyses of house dust and indoor air. Studied outcomes were e.g. allergies after exposure to nickel, chromium or scents as well as respiratory tract or eye irritation after exposure to formaldehyde, aldehydes and VOCs in indoor air (Umweltbundesamt, 2008a).

The German Federal Environment Agency has published the following reports related to children and chemicals:

“Environmental health risks: What are the differences between children and adults?” (Umweltbundesamt, 2004). The document describes exposure susceptibilities in different developmental stages, from embryos to adolescents.

“Children! The link between the environment and children’s health” (Umweltbundesamt, 2005) and *“Start in life – Environmental influences on infants, unborn babies and fertility – Questions and Answers”* (Umweltbundesamt, 2008b) are two brochures aiming to provide information to parents and young people who wants to know more about environmental impacts on children’s health.

4.5 United Kingdom

4.5.1 Health Protection Agency (HPA)

UK HPA has been commissioned by the Department of Health to evaluate children’s environmental health in the UK and recommend actions for implementation of CEHAPE. This work resulted in the report *“A Children’s Environment and Health Strategy for the UK”* (HPA, 2009), published in 2009. The report gives an overview of children's health in relation to their environment in the UK and recommends areas that should be prioritized in order to protect

children's health. Proposed actions regarding chemical risks include to increase the understanding for trends in accidental poisoning, improve the understanding of where and how children are exposed to chemicals, initiate a biomonitoring programme, improve the knowledge of the impact of chemical exposure during prenatal development on the embryo and later in life and evaluate systems for monitoring congenital abnormalities. As a step in the development of the strategy, HPA published the report "*Children's Environment and Health Action Plan: A summary of current activities which address children's environment and health issues within the UK*" (HPA, 2007) accounting for actions that had already been undertaken in the UK in order to implement CEHAPE and identify gaps and priorities.

In line with CEHAPE, UK HPA has also been involved in the development of a toolkit of children's environmental health indicators. A core set of 17 indicators was developed in a pilot study performed in the West Midland Region of the UK and presented in the report "*Children's Environment and Health Action Plan (CEHAP): Pilot Environmental Health Indicators Toolkit*" (Stewart et al, 2010). The only indicator related to children and chemical safety was; Potential exposure of children to uncontained chemical incidents.

HPA is performing a surveillance project, monitoring children with elevated lead concentration in blood (HPA, 2011). In addition, a workshop named "Children's Exposure to Lead in the UK - Is there still a problem?" was hosted by HPA in London, UK in 2008. The aim was to discuss if children in the UK are currently properly protected from lead exposure and propose priorities for the future (HPA, 2010).

4.6 United States

4.6.1 United States Environmental Protection Agency (US EPA)

Under the US EPA, several offices are working with chemical and/or health research, such as the Office of Chemical Safety and Pollution Prevention (OCSPP), the Office of Pesticide Programs (OPP), the Office of Pollution Prevention and Toxics (OPPT) and the Office of Children's Health Protection (OCHP).

The Voluntary Children's Chemical Evaluation Program (VCCEP) was initiated by OPPT in 2000, aiming to provide the public with comprehensive information on chemical risks. In the VCCEP pilot project, manufacturers or importers of chemicals were asked to provide information on 23 chemicals, to which children are likely to be exposed. The main inclusion criteria was that monitoring data indicated that the chemical is present in human samples and in the environment (food, water and air). In addition, chemicals were not selected if they were adequately assessed in another programme, going to be phased out or not produced or imported to the US (for more information see "*Methodology for Selecting chemicals for the Voluntary Children's Chemical Evaluation Program (VCCEP) Pilot*" (US EPA, 2000)). 20 out of the chosen 23 chemicals are now being sponsored. The pilot project operates in three segments during which the sponsors collect and/or develop specific toxicological information on the chemicals and use the data in risk assessments. The submitted information is finally evaluated by scientific experts. The project is currently running (US EPA, 2010a).

Chemicals under investigation in the VCCEP (*=not sponsored):

- Acetone
- Benzene
- Chlorobenzene*
- Decabromodiphenyl ether
- Decane
- m-Dichlorobenzene*
- p-Dichlorobenzene
- p-Dioxane
- n-Dodecane
- Ethylbenzene
- Ethylene dibromide*
- Ethylene dichloride
- Methyl ethyl ketone
- Octabromodiphenyl ether
- Pentabromodiphenyl ether
- a-Pinene
- Tetrachloroethylene
- Toluene
- Trichloroethylene
- Undecane
- Vinylidenechloride
- m-Xylene
- o-Xylene

The Toxicity and Exposure Assessment for Children's Health (TEACH) provides chemical summaries on 20 specific chemicals and their impact on children's health. The assessments are based on scientific and governmental resources, without further evaluation or validation of the research. In addition, the project also includes the TEACH database which contains thousands of summaries of articles regarding the chosen chemicals (US EPA, 2011a).

Chemicals presented in the TEACH summaries:

- Arsenic
- Atrazine
- Benzene
- Benzo(a)pyrene
- BPA
- DEET
- 2,4-Dichlorophenoxyacetic acid
- Dichlorvos
- Formaldehyde
- Manganese
- Mercury (elemental)
- Mercury (inorganic)
- Mercury (methyl- and ethyl)
- Nitrates/nitrites
- PBDEs
- PCBs
- Permethrin and resmethrin
- Phthalates
- Trichloroethylene
- Vinyl chloride

In 2010, US EPA OPP published "*Protecting Children's Health – The National Pesticide Programme*" (U.S EPA, 2010b), which describes activities undertaken by US EPA, to reduce pesticide exposure where children live, learn, play and work. For example, US EPA provides Integrated Pest Management (IPM) programmes for schools and other environments, which introduce strategies to reduce children's exposure to pesticides in food, water and buildings. Furthermore, the US EPA encourages development of new tests methods for improving the pesticide risk assessment in children and infants, with emphasize on the need for developmental and reproductive studies as well as comparative studies of children and adults. In line with the Food Quality Protection Act (FQPA) (US EPA, 1996), the US EPA uses stricter criteria when assessing pesticide risks in children, than in adults. An extra factor of 10 is used as default, when assessing children's exposure to pesticides residues in food, unless data disproving the use of this factor is available. Since the FQPA was established, the US EPA has taken children's exposure patterns and age-specific susceptibilities into account, when reassessing nearly 10 000 maximum limits for pesticide residues in food.

The US EPA research program Human Exposure and Atmospheric Sciences Division (HEASD) have performed several research projects related to chemicals and children, including the following:

The Children's Total Exposure to Persistent Pesticides and Other Persistent Organic Pollutants (CTEPP) project aimed to investigate through which exposure routes and sources children are exposed to common chemicals in their home and day-care environment. In 2000-2001, exposure to more than 50 pesticides and chemicals were measured in over 250 children (2-5 years old) and their caregivers. The participants were monitored for 48 hour and samples of urine, food, water, air, soil, residues on floors and surface wipes were collected. The project was recently completed and presented in the report "*A Pilot Study of Children's Total Exposure to Persistent Pesticides and Other Persistent Organic Pollutants*" (CTEPP) (US EPA, 2011b).

The probabilistic Stochastic Human Exposure and Dose Simulation (SHEDS) model was developed and used to estimate the exposure of residues of chromium and arsenic in children, who are playing on playgrounds with chromated copper arsenate treated wood. The have been presented in the report "*A Probabilistic Exposure Assessment for Children Who Contact CCA-Treated Playsets and Decks*" (US EPA, 2009a; Zartarian et al, 2005).

Understanding Children's Exposure to Chemicals is a program aiming to identify chemicals to which children are like to be highly exposed and investigate the routes and sources of exposure, in order to fill research gaps and improve risk assessments with concern for children. Activities include to collect monitoring data on exposure in children, provide analytical support in the research on pesticide exposure in children, develop analytical methods for analysing chemicals such as PBDE, phthalates and perfluorinated chemicals, improve analytical methods on dietary models and support the National Children's Study (see section 4.6.3). The program is still ongoing (US EPA, 2009b).

In addition to the programs the US EPA has also been published several guidance documents concerning assessment of health risks of environmental exposures in children. The most relevant include the following:

The National Center for Environmental Assessment of the EPA Office for Research and Development has published the "*Child-Specific Exposure Factors Handbook*" (US EPA, 2008). The first handbook was developed in 1997 and the latest updated version was published in 2008. The handbook summarizes data and recommends values to be used on factors which affect chemical exposures in children. Examples of factors are mouthing frequency, inhalation rate, dermal exposure factors and intake of various food groups, water, human milk, dust and soil.

"*A Framework for Assessing Health Risks of Environmental Exposures to Children*" (US EPA, 2006) describes a risk assessment approach which includes evaluation of development stages-specific susceptibilities and subsequent health effects, with focus on life stage-specific mode of actions. The document is based on existing guidelines, guidance and policy papers.

"*Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens*" (US EPA, 2005a) provides guidance in assessment of carcinogenic chemicals, taking childhood exposure into account. Age-dependent adjustment factors (ADAF) are presented, applicable for carcinogens with mutagenic mode of action and when chemical-specific data concerning early life stage susceptibility is lacking. The recommended ADAFs are; factor 10 for children from birth to 2 years of age, factor 3 for children of 2-16 years of age and factor 1 for individuals of 16-70 years of age.

“*Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants*” (US EPA, 2005b) provides ten post-natal age bins based on behavior and physiology, to be used in risk assessments.

4.6.2 Californian Environmental Protection Agency (Cal/EPA)

Furthermore, individual states may perform actions on children’s chemical safety. One of the most active states authorities is the EPA California (Cal/EPA) with a long history of listing chemicals that may cause birth defects and other reproductive harm (Proposition 65) (OEHHA, 2012).

Cal/EPA has a Children’s Environmental Health Program under which various activities are undertaken. In example, the Cal/EPA Office of Environmental Health Hazard Assessment (OEHHA) has been identifying chemicals in Californian schools with particularly concern for children’s health. Child-specific reference doses for these substances are being developed in order to assess the school environment. Child-specific reference doses are available for the following chemicals: atrazine, cadmium, chlordane, chlorpyrifos, deltamethrin, heptachlor, heptachlor epoxide, lead, manganese, methoxychlor, nickel and pentachlorophenol (OEHHA, 2011).

4.6.3 United States Centers for Disease Control and Preventions (CDC)

As a federal agency under the US Department of Health and Human Services, CDC has been assigned the mission to protect the public health and safety. With the aim to provide environmental exposure information to scientists, physicians and other health officials, the “*National Report on Human Exposure to Environmental Chemicals*” (CDC, 2009) is updated and re-published every second year, the latest edition was published in 2009 (the 4th report). The document describes the US population’s exposure to more than 200 environmental chemicals, based on biomonitoring data from the National Health and Nutrition Examination Survey (NHANES), which was conducted between 1999 and 2004. A wide age range is represented, allowing comparisons of the chemical body burdens in various age groups. However, the age range of the participants varies for different chemicals. Blood samples were taken on children over 1 year of age and urine samples were taken on children over 6 years of age. However, blood samples from children of 1-5 years of age were only analysed for cadmium, lead and mercury.

4.6.4 National Institute of Health (NIH)

NIH is an agency under the US Department of Health and Human Services and is the main agency of the US government responsible for biomedical and health-related research. The National Institute of Environmental Health Sciences (NIEHS) is one of the institutes under NIH. NIEHS has a programme on children’s health and funds numerous research projects regarding environmental impact on children’s health. Primary research areas include the impact on development after prenatal and childhood exposure to environmental contaminants and the association between air pollution and respiratory diseases in children (NIEHS, 2011).

In collaboration with US EPA and CDC, NIH performs the *National Children’s Study* which is planned to involve 100.000 children, thus it will be biggest US study on children’s health and development to date. Starting from 2009, participants have been enrolled from 105 study locations in the US Participating children will be followed from prenatal stage to 21 years of age and health and developmental impacts of a wide range of factors, chemicals included, will be studied. The methodology includes questionnaires, biological sampling as well as dust and water

sampling in homes (NIH, 2011a). In addition, a pilot project is being performed, aiming to measure more than 100 environmental chemicals and nutritional indicators in milk, blood and urine collected from more than 500 mother and child couples (CDC, 2010).

Addressing the problem with existing birth cohort studies being too small to allow investigation of environmental causes of childhood cancers, the agencies behind the National Children's Study have initiated the *International Childhood Cancer Cohort Consortium* (I4C). At the first I4C workshop, held in 2005, an international alliance of 11 finished or currently performed birth cohort studies, together involving approximately 700 000 children, was established. The studies vary in design and studied outcomes, however, a pilot study investigating the possibility of pooling data from two, not harmoniously designed cohorts brought promising conclusions. Subsequent I4C workshops have been held in 2007, 2009 and 2011, discussing topics such as cohort design, data pooling, progress of the participating cohorts, possibility of new collaborations and ideas for future actions. A broad variety of environmental and biological determinants are investigated, such as maternal folate intake, genetic polymorphisms, cigarette smoke and prenatal pesticide exposure (Brown et al, 2007; NIH, 2011b).

Another institute under NIH is the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) also performs research on children's health within the areas of biostatistics, epidemiology and prevention (NICHD, 2012). An example of the ongoing chemical orientated research is the *Longitudinal Investigation of Fertility and the Environment* (LIFE) study, which investigates environmental chemicals (e.g. PCBs, PBDEs, PFOS) and lifestyle factors and the impact on fertility, fecundity and pregnancy loss. In 2009, 500 couples who were striving to get pregnant were enrolled and subsequently followed during one year, or to the end of the pregnancy if the woman got pregnant (NICHD, 2007).

4.6.5 Commission for Environmental Cooperation for North America (CEC) (CAN/MEX/US)

In 1994, CEC was established with the aim to implement the North American Agreement on Environmental Cooperation (NAAEC), which is a part of the North American Free Trade Agreement (NAFTA). The mission of CEC include to monitor the environmental impact of NAFTA, to work with regional environmental issues and to improve policies on the environment (CEC, 2011a).

CEC organised a trilateral biomonitoring study in Canada, Mexico and the US, including measurements of POPs and metals, in primiparous mothers and women of childbearing age. The results from the study are available in the report "*Trinational Biomonitoring Study*" (CEC, 2011b).

The report "*Children's Health and the Environment in North America: A First Report on Available Indicators and Measures*" (CEC, 2006a) was a collaboration project between CEC and the International Joint Commission Health Professionals Task Force, WHO, the Pan American Health Organization and Canada, Mexico and the US This was the first regional report on indicators of children's health and the environment and presented 13 indicators for toxic substances, asthma, respiratory diseases and waterborne diseases. The following indicators are related to chemical exposures; Blood lead levels in children; Children living in homes with a potential source of lead; Pollutant release and transfer register (PRTR) data on industrial releases of lead; PRTR data on industrial releases of 153 chemicals, and; Pesticide residues in food .

In 2006, CEC published the report “*Toxic Chemicals and Children’s Health in North America*” (CEC, 2006b) focusing on the release of numerous industrial chemicals, particularly carcinogens, developmental toxicants and neurotoxicants in the environment and the potential impacts on children’s health. In addition, current programmes and potential future actions for reducing children’s exposure to chemicals are also presented in the report.

4.7 Canada

4.7.1 Health Canada

The federal departments Health Canada and Environment Canada, working under the Canadian Government, launched the *Chemicals Management Plan* (CMP) in 2006, with the overall aim to protect the Canadian population and environment from harmful chemicals. Numerous projects have been initiated to fulfil the CMP and the relevant actions taken to improve children’s environmental health are presented below.

The *Canadian Health Measure Survey* (CHMS) is led by the Statistics Canada federal agency, in partnership with Health Canada and the Public Health Agency of Canada. Various indicators of the general health in the population are measured, including blood and urine levels of environmental chemicals, such as phthalates, PCBs, brominated flame retardants, pesticides, insecticides, herbicides, perfluorinated chemicals, BPA and metals. The survey is performed in three cycles, each involving approximately 5000 participants. Cycle one (2007-2009) involved participants from 6 to 79 years of age, whereas cycle two (2009-2011) and cycle three (2012-2013) involve participants from 3 to 79 years of age (Health Canada, 2010a).

The *Maternal-Infant Research on Environmental Chemicals study* (MIREC) is performed from 2007 to 2012 and includes 2000 pregnant Canadian women. The main objectives are to measure the levels of common environmental chemicals in pregnant women and their babies, measure the levels of chemicals as well as beneficial components in breast milk, and assess the possible health risks of the exposures. The study focuses on heavy metals, however other chemicals including plasticizers (e.g. phthalates and BPA), POPs, BPDEs and pesticides are also investigated (Health Canada, 2010b).

In 2008, a three year study was initiated, aiming to investigate 1 to 5 year old children’s exposure from residential lead sources such as lead line contaminated drinking water, dust and paint. In 2009, another two years study was initiated measuring blood lead levels in children and the lead content in housing samples, aiming to compare the results from houses built at different times and investigate the exposure sources (Health Canada, 2009).

The four year study *Plastics and Personal-care Products in Pregnancy* (P4), initiated in 2008, measures the levels of BPA and phthalates in urine collected from 80 pregnant women. By combining these results with questionnaire data, the sources of exposure are investigated. In addition, the changes in urine levels of these compounds over time are measured and the accuracy of one-time urine samples are evaluated (Health Canada, 2010c).

Health Canada’s homepage also provides information on chemical safety addressing parents, children and other groups of the society. Examples of such resources are the brochure “*Healthy Environment for Children: What can you do*” (Health Canada, 2004) and the webpages *Hazards in your environment: What you can do!* (Health Canada, 2012a) and *Environmental health: What you can do!* (Health Canada, 2012b).

5. ACTIVITIES OF NON-GOVERNMENTAL ORGANIZATIONS AND NETWORKS

Several NGOs and networks are working with chemical safety and/or children’s health. However, only a few provide assessable information about relevant activities regarding children and chemical safety within the delimitations of this inventory. A summary of activities and documents performed by NGOs and networks are presented in Table 5.

Table 5. Activities related to chemicals and children’s health performed by NGOs and networks.

ACTIVITIES	TYPE OF ACTIVITY
HEALTH AND ENVIRONMENT ALLIANCE	
Healthier Environment for Children	Webpage
INTERNATIONAL RESEARCH AND INFORMATION NETWORK ON CHILDREN’S HEALTH, ENVIRONMENT AND SAFETY	
INCHES official homepage	Information sharing, influencing policy-making
INTERGOVERNMENTAL FORUM ON CHEMICAL SAFETY	
Chemical Safety and Children’s Health - Protecting the world's children from harmful chemical exposures: a global guide to resources	Information sharing, action recommendations, resource reviewing
Protecting Children from Harmful Chemical Exposures: Chemical Safety and Children’s Health	Information sharing, action recommendations
Toys and Chemical Safety – a Thought Starter	Risk assessment

5.1 Health and Environment Alliance (HEAL)

In 2003, HEAL was initiated as an environmental arm of the European Public Health Alliance. HEAL composes a network of more than 70 international non-profit organizations, environmental groups and public health institutes, aiming to influence environmental policy-making by providing expertise information to decision-makers. According the official homepage, topic areas include chemicals, pesticides and biocides with particular concern for exposures in children. Actions undertaken in the environment and health area include implementation of CEHAPE.

Furthermore, in 2005 HEAL launched a website called “Healthier environment for children” which provides information about European NGOs which are promoting children’s environmental health. The main aim of the website is to monitor actions that have been done to accomplish the goals of CEHAPE.

In 2011, the Paris Appeal Third International Congress; Children’s health and the environment, was organized by HEAL, Association for Therapeutic Research against Cancer and International Society for Doctors for the Environment. Topics under discussion were environmental pollutants and the impact on children’s health, with particular focus on cancer, developmental problems, congenital abnormalities, fertility among men, asthma and allergy (HEAL, 2011).

In order to include children’s voices in decision-making, HEAL organized the workshop Young People’s Investigations into Chemicals and Health in Brussels, in 2005. Before the meeting, European youth delegates from four countries had gathered information on chemicals in school

and at home. On the workshop, the students were given the opportunity to ask chemical and environment related questions and propose actions to a panel of experts from WHO, EC, UK HPA, NGOs and industries. The student's recommendations were sent out to e.g. members of the European Parliament and presented at the European Environment and Health Committee held in Helsinki, Finland, in 2005 (HEAL, 2005)

5.2 International Research and Information Network on Children's Health, Environment and Safety (INCHES)

INCHES is an international network on children's health and safety, coordinating national and international professional associations, research and policy institutes, advocacy organizations, universities, parents' and children's organizations, national and intergovernmental agencies, and individuals. INCHES main goal is to promote a healthy environment that protects children from environmental and safety hazards. The strategies include increasing the understanding of environmental impact on children's health, promoting exchange of information on strategies and policies, finding research gaps and performing advocacy internationally for improved policies on children's health and environment.

INCHES regularly organizes conferences, most recently the 6th International Conference on Children's Health, Environment and Safety in Lodz, Poland, in 2011. Topics under discussion were the impact of environmental contaminants exposure on children's health, strategies of decreasing prenatal and childhood exposure, and the importance of prenatal exposure on pregnancy outcome and later effects in the children (INCHES, 2011).

5.3 Intergovernmental Forum on Chemical Safety (IFCS)

IFCS aims to facilitate cooperation initiatives, information sharing and monitoring, by providing a global network of governments, international and national organizations, industry representatives, public interest associations, labour organizations, scientific organizations and society representatives.

Actions undertaken by IFCS Champions Group on Children and Chemical Safety include to provide children and care takers with information on chemical safety, advocate the importance of children's environmental health to policy-makers and educate professional groups (e.g. teachers, environmental and toxicological groups) about children and chemical safety.

IFCS has published the following reports concerning children's environmental health:

“Chemical Safety and Children's Health - Protecting the world's children from harmful chemical exposures: a global guide to resources” (IFCS, 2005) suggests strategies and describes the available resources for reducing children's exposure to environmental risks. The report was based on background information, prepared at the Fourth Session of the Intergovernmental Forum on Chemical Safety held in Bangkok, Thailand, in 2003, and publicized in the document *“Protecting Children from Harmful Chemical Exposures: Chemical Safety and Children's Health”* (IFCS, 2003). The background information includes developmental stage-specific susceptibilities and examples of chemicals of concern for children's health i.e. lead, mercury PCBs, POPs, pesticides, nitrates and household products .

“Toys and chemical safety – a thought starter” was prepared by IFCS at the Fifth Intergovernmental Forum on Chemical Safety held in Budapest, Hungary, in 2006. The report

presents aspects of risk assessments for chemicals in toys, actions for toy safety and case studies (IFCS, 2006).

6. DISCUSSION

6.1 Activities of organizations and agencies

An overview of the most important projects, documents and programmes related to chemicals and children's health is presented in the text and tables of this inventory report. The spectra of activities include monitoring, investigations, and support of research. In addition, several organizations have performed risk assessments and developed methodologies to improve methods of including children in risk assessment. The activities are clearly linked to strategy documents and international agreements that have often been developed by international and supragovernmental organizations like the WHO. In Appendix 1, the identified activities are listed in relation to their different types, i.e. action plans, birth cohorts, risk assessment methodology, etc.

6.1.1 Risk assessments

In recent years, focus has been directed towards incorporating developmental stage-specific susceptibilities in risk assessments of chemicals. Risk assessors are generally aware of the fact that because of their unique physiology and exposure patterns, children cannot be considered as "small adults". Organizations and agencies have developed tools for risk assessments in children and several documents are currently available aiming to describe developmental stage-specific susceptibilities, provide factors for exposure evaluations, propose age-dependent adjustment factors and suggest appropriate age bins for risk assessments.

Awareness of these tools and the ability to take all available aspects into account when performing risk assessment will enable risk assessors to more accurately evaluate chemical impacts on children's health. However, no standardized global approach for risk assessment concerning chemical impacts on children's health has been established and substantial knowledge gaps remain before risk assessment can be considered accurate and safe for children.

6.1.2 Research and monitoring activities

Independent birth cohort studies have been or are currently being performed worldwide. In the EU, several research projects focusing on chemicals and children's health have been funded by the EC FP5, FP6 and FP7. The majority of these projects are associated with birth cohort studies and the most studied health outcomes are within the reproductive and hormonal systems. An overview of these research projects is presented in Table 6. However, in cohort studies, a large number of participants are required to enable study of rare outcomes, such as childhood cancer, premature birth or autism. Therefore, projects have been initiated aiming to harmonize birth cohort methodologies in order to increase the sample sizes by data pooling and facilitate comparison between countries. Table 7 presents a selection of European birth cohorts in which environmental exposures and health effects in children are being investigated.

Human biomonitoring studies which involve children are being performed in numerous countries in order to investigate the chemical body burden in the population. Inclusion of children in biomonitoring activities is important since the chemical body burden can vary significantly between age groups. In addition, the sources of exposure can be investigated when biomonitoring results are combined with data from questionnaires and environmental sampling of e.g. air and dust. Furthermore, projects have been initiated aiming to harmonize the biomonitoring

methodology and to identify chemicals that are of high relevance for children and their environments.

6.1.3 Children's environmental health indicators

In order to evaluate the state of children's health as well as the effectiveness of interventions, children's environmental health indicators are being developed by organizations and agencies nationally, regionally and globally. However, these concern a broad area of environmental health issues, and indicators exclusively focusing on children's exposure to chemicals are few. In Sweden, there is currently no agreed set of indicators directed towards child health and the environment, although the national environmental health survey and the database for the health-related environmental monitoring programme may hold a potential for indicators.

6.1.4 Advocacy and education

Several organizations and agencies aim to inform decision-makers about chemicals and children's health. By continuously monitoring the state of children's environmental health and evaluating outcomes of interventions, decision-makers can be guided in the development of new, improved policies on environmental health.

Some organizations and agencies perform awareness-raising activities, intended to educate e.g. parents, teachers and other members of the general public on how to protect children from chemical exposures. Examples of such activities include brochures, documents and Internet-based information about children's chemical safety.

In addition, several documents and activities, primarily coordinated by the WHO, aim to train health care professionals to identify, treat and prevent environmentally caused health problems in children.

6.1.5 International agreements and action plans

Several action plans and agreements between organizations, nations, NGOs, agencies and other stakeholders have been initiated in order to improve children's environmental health. These include e.g. the *Miami Declaration* of 1997, the *Bangkok Statement* of 2002, *A World Fit for Children* of 2002, the *Buenos Aires Declaration* of 2005, the *Busan Pledge for Action* of 2009 and the *Plan of Action for Children's Health and Environment (2010–2015)* of 2010. However, it should be emphasized that these action plans cover a broader spectrum of environmental hazards than chemical exposure.

In addition to global action plans, regional action plans on children's health and the environment have been established. The most relevant for this inventory are the CEHAPE by the WHO's Office for Europe and the *EU's Environmental and Health Strategy*. Furthermore, CEHAPs at national level are now being established in various countries. An overview of important agreements and action plans is presented in Table 8.

Table 6. Project related to chemicals and children's health, funded by the EC FP5, FP6 and FP7.

Programme	Project	Type of project	Studied health effects
EC – FP 5	INUENDO	Birth cohorts	Reproductive and hormone system
	PLUTOCRAZY	Birth cohorts	Immune system
	EXPORED	Birth cohorts	Male reproductive and hormone system
	ENVIR.PROD.HEALTH	Birth cohorts, animal studies	Male reproductive system
	PBDE-NTOX	Animal studies	Central nervous system.
	FIRE	Biomonitoring, food analysis, animal studies and <i>in vitro</i> studies.	Immune- and hormone system
	ENDOMET	<i>In vitro</i> studies	Hormone system
EC – FP 6	AIRMEX	Environmental monitoring	-
	PINCHE	Influencing policy making	-
	NewGeneris	Birth cohorts	Cancer and immune system
	PHIME	Biomonitoring, birth cohorts, study of metal-uptake mechanisms etc.	-
	COPHESOPHES	Harmonization of biomonitoring	-
	CHICOS	Inventory of birth cohorts	-
	ENRIECO	Inventory of birth cohorts	-
	OBELIX	Birth cohorts, animal studies	Obesity and related diseases
	CLEAR	Birth cohorts, biomonitoring	Reproductive and hormone system
	CONTAMED	Birth cohorts, biomonitoring, animal studies and biomarker development	Male reproductive and hormone system
EC – FP 7	DEER	Birth cohorts, cross-sectional- and metabolomics studies, animal and <i>in vitro</i> studies	Male reproductive and hormone system
	REEF	Animal and <i>in vitro</i> studies	Female reproductive and hormone system
	RICHE	Inventory of child health research	-

Table 7. European birth cohorts studying children's exposure to chemicals. Besides the sources of exposure listed below, in some of the birth cohort studies additional sources such as second hand tobacco smoke, water contamination, outdoor air pollution and radiation were studied.

Cohort	Year of enrolment	Country	No. of children	Indoor air pollution	Heavy metals	Pesticides and POPs	Emerging exposures
ABCD	2003-2004	Netherlands	7 900	-	√	-	-
ALSPAC	1991-1992	UK	14 100	√	√	-	-
APREG	2000-2006	Hungary	2 800	√	-	-	-
BAMSE	1994-1996	Sweden	4 100	√	-	-	-
Faroës (4studies)	1986-2009	The Faroë Islands	2 400	-	√	√	√
Co.N.ER	2004-2005	Italy	700	√	-	-	-
DNBC	1996-2002	Denmark	97 000	√	-	-	√
Duisburg	2000-2003	Germany	200	√	√	√	√
EDEN	2003-2006	France	1 900	√	√	-	√
ELFE	2011-2012	France	20 000	√	√	-	√
FLEHS	2002-2004	Belgium	2 000	√	√	√	-
GASP II	2003-2004	Italy	700	√	-	-	-
Generation R	2001-2005	Netherlands	10 000	√	-	√	√
GINIplus	1995-1998	Germany	6 000	√	-	-	-
HUMIS	2002-2011	Norway	2 500	√	√	√	√
INMA (7studies)	1997-2008	Spain	3 800	√	√	√	√
INUENDO	2002-2004	Sweden, Poland, Ukraine, Greenland	1 300	-	√	√	√
KOALA	2000-2003	Netherlands	2 900	√	-	-	-
LISApplus	1997-1998	Germany	3 100	√	-	-	-
LUKAS	2002-2003	Finland	400	√	√	√	√
MAS	1990	Germany	1 300	√	-	-	-
MoBa	1999-2008	Norway	107 000	√	√	√	√
NINFEA	2005--	Italy	7 500	√	√	-	√
PCB cohort	2001-2003	Slovakia	1 100	√	√	√	√
PÉLAGIE	2002-2006	France	3 400	√	√	√	√
PIAMA	1996-1997	Netherlands	4 000	√	-	-	-
REPRO_PL	2007-2011	Poland	1 300	-	√	√	-
RHEA	2007-2008	Greece	1 500	√	√	√	√

The present table is a modification of an original table developed for the ENRIECO project, available at: <http://www.enrieco.org/LinkClick.aspx?fileticket=tRPZc7PXB6A%3D&tabid=56>

Abbreviations: ABCD = Amsterdam Born Children and the Development; ALSPAC = Avon Longitudinal Study of Parents and Children; BAMSE = The Stockholm Children Allergy and Environmental Prospective Birth Cohort Study; Co.N.ER = Bologna Birth Cohort; DNBC = Danish National Birth Cohort; EDEN = Etude des Déterminants pré et post natals du développement et de la santé de l' Enfant; ELFE = Etude Longitudinale Française depuis l'Enfance; Faroës = Children's Health and the Environment in the Faroës; FLEHS = Flemish Environment and Health Survey; GESPII = Gene and Environment: Prospective Study on Infancy in Italy; GINIplus = German Infant Nutritional Intervention study; INMA = Infancia y Medio Ambiente; LISApplus = Influence of life-style factors on the development of the immune system and allergies in East and West Germany plus the influence of traffic emissions and genetics; MAS = Multicentre Allergy Study; MoBa= The Norwegian Mother and Child Cohort Study; PÉLAGIE = Endocrine Disruptors: Longitudinal Study on Pregnancy Abnormality, Infertility and Childhood; PEPRO_PL = Polish Mother and Child Cohort; RHEA = Mother Child Cohort Crete.

Table 8. Global and European agreements and action plans related to children's health and/or environmental health between 1997-2010

YEAR	NAME (organization)
1997	Miami Declaration (G8)
2002	A World Fit for Children (UN)
2002	The Bangkok Statement (WHO)
2002	6 th EU Environment Action Programme (EU)
2003	EU Environment and Health Strategy, SCALE (EU)
2004	European Environment and Health Action Plan 2004-2010 (EU)
2004	Children's Environment and Health Action Plan for Europe, CEHAPE (WHO Europe)
2005	The Buenos Aires Declaration (WHO)
2009	The Busan Pledge for Action (WHO)
2010	Plan of Action for Children's Health and the Environment 2010-2015 (WHO)
2010	Commitment to Act (WHO Europe)

7. CONCLUDING REMARKS AND RECOMMENDATIONS

7.1 Potentials for action

Numerous activities concerning children and chemical safety have been performed by organizations and agencies worldwide. Today, children's unique susceptibilities and exposure patterns are recognized; however, further actions are needed to ensure and sustain a healthy environment and protect children from exposure to hazardous chemicals. This inventory can be used as a map to sources of knowledge and experience from international activities. Based on the results from the present inventory, the following potentials for action have been identified:

Promoting the development of *children's environmental health indicators*, especially concerning chemical exposures during childhood. The indicators can potentially be integrated with activities within the health-related environmental monitoring programme.

Investigating whether further *child-specific monitoring activities* regarding children and chemical safety can be initiated. Health-related environmental monitoring is an important tool for evaluating the state of the environment and the population's health. Most national and international biomonitoring programmes have focused on persistent environmental pollutants such as PCBs and heavy metals. In addition to this information, a programme to identify chemicals relevant to children for monitoring in children and in the children's environment (including chemicals in products) should be supported.

Promoting *birth cohort studies* investigating the impact of chemical exposures on children's health. Preferably, the mothers should be enrolled at an early time point during pregnancy, or alternatively before conception, and the children should be followed up throughout the whole of childhood including adolescence. In order to enable comparisons and international collaboration, the work identified in relation to harmonization of different organizations and their efforts, e.g. regarding standardization of sampling methods and age bins, should be considered.

Providing *information* related to chemicals surrounding children and means to avoid exposure. The information should be easily available, preferably online. For example, interactive homepages for active learning can raise awareness among parents and children (at an appropriate age). Furthermore, educational materials explaining chemical exposure routes, risks and management should be provided to institutions such as preschools and schools. In addition, education should be offered to industry representatives, policy-makers, the media and health professionals, in order to raise awareness of children's unique susceptibilities to chemicals.

Taking responsibility for protecting children. Given the fact that children cannot choose their environment, the community at both a local and a national level has to take responsibility for protecting the young from chemical risks. *Evaluations of the school and day care environment* by identifying and monitoring relevant chemicals should be promoted.

Strengthening research. Even though the knowledge of children's specific susceptibility to chemicals is increasing, strengthening research is needed to fill knowledge gaps and create a sustained system for development in risk assessment and capacity building.

Miljöforskningsberedningen (The Swedish Environmental Research Council) may be a suitable forum where the importance of child health and environment can be put forward, since it has a direct role of counselling the government and is chaired by the Minister of the Environment.

There are no harmonized *risk assessment methodologies* for evaluating risks in early life stages. Sweden should actively promote, at an international level, the development of a standardized framework for risk assessments, which considers developmental stage-specific susceptibilities. In addition, we should evaluate the potential use of age-dependent assessment factors in risk assessments of chemicals, when data on effects in early life stages are lacking. In order to interpret biomonitoring data on children and monitoring data from children's environment there may also be a need to develop methodology and examples of *child-specific reference doses* and *reference concentrations*.

In order to guide research and investigations, as well as other activities, there is a need to develop a *priority list of chemicals* suitable for Sweden. Currently, health-based monitoring is mainly concerned with monitoring persistent organic pollutants and heavy metals but monitors fewer than a handful of chemicals that may be found in products. A priority list of at least 25 chemicals is suggested.

The vast majority of research, investigations and other activities worldwide regarding children's health and environment relate to early exposure. Activities, as well as knowledge, related to *adolescence* are missing. There are several reasons why this gap needs to be filled. For example, these children undergo rapid maturation and development and may have a specific pattern of exposure. To include children from early puberty until late adolescence in the planned activities should be given priority.

Collaborating with other organizations and countries, and revising national action plans. Sweden has a long tradition of active *international collaboration* and has made a significant contribution to the development of intergovernmental strategic documents. This inventory clearly shows that most activities are related to these documents and agreements. It is therefore important that Sweden works in accordance with agreed plans and contributes to further international collaboration, e.g. within the WHO. Swedish activities could thereby also be used as case studies for other countries to follow. The national action plans also need to be revised and evaluated in order to develop a sustained development towards a toxic-free child environment.

Chemicals and their impact on health is a matter that affects a multitude of regulatory arenas. A network for *national intersector collaboration* should therefore be encouraged, including several central authorities and academic institutions as well as the private sector.

7.2 Recommended actions by international agencies and organizations

In addition to the suggestions above, actions have also been recommended in some of the identified documents by international organizations. These suggestions for actions are related to a variety of levels including need for risk assessments, research, monitoring and information/education and are summarized in Table 9.

Table 9. Recommendations for actions given by IPCS, IFCS, US EPA and UNEP, concerning children and chemical safety.

Reference*	RISK ASSESSMENT, MONITORING AND RESEARCH
1	Determine which exposure reductions will have the greatest overall impact on children's health.
1	Identify subpopulations with the highest exposure levels.
1	Design and implement prospective cohort studies of pregnant women, infants, and children with a longitudinal capture of exposures at critical windows and sensitive health end-points along the continuum of human development. Efforts to recruit couples prior to conception are needed to address critical data regarding periconceptional exposures and children's health.
1	Improve characterization of the differences in toxicokinetic and toxicodynamic properties of xenobiotics at different developmental stages. Also, to develop databases of developmental stage-specific physiological and pharmacokinetic parameters in both human and animal studies.
1	Conduct studies focusing on mechanisms of action during different developmental stages by which exposures may cause adverse outcomes.
1	Develop end-points that can be used to assess organ system functions in both humans and animal species and to identify analogous periods of development across species.
1	Examine the utility of newer molecular and imaging technologies to assess causal associations between exposure and effect at different developmental stages. Also, to improve characterization of the windows of susceptibility of different organ systems in relation to structural and functional end-points.
1	Develop and validate biological models and animal testing guidelines that can address health outcomes at different developmental stages.
1	Strengthen exposure monitoring efforts in children during different developmental stages, including efforts to assess aggregate and cumulative exposures.
1	Develop validated, sensitive, and cost-effective biomarkers of exposure, susceptibility, and effects, particularly during early developmental stages.
1	Continue to develop and enhance population-based surveillance systems for the real-time capture of sentinel health end-points. This includes current surveillance systems such as vital registration for birth size and gestation and birth defects registries for capturing major malformations. Also, the consideration of emerging sentinel end-points such as fecundability, as measured by time to pregnancy and sex ratios, should receive added research consideration.
2	Continue to improve and implement risk assessment approaches that account for child specific issues.
2	Adopt the precautionary approach in the context of children's environmental health.
2	Increase and support further scientific research on the link between chemical exposure and health outcomes in different age groups, and in different settings.
2	Develop a better understanding of foetal (maternal) and early childhood exposure.
2	Develop toxicity testing data which further explore the toxicological impact of early life exposure.
2	Determine how to incorporate new scientific information (i.e. genomics, proteomics) toward understanding the mechanisms of toxic action which are associated with early life exposure and their risks.
2	Develop appropriate indicators of chemical safety and children's health.
2	Use appropriate indicators of chemical safety and children's health to measure progress in protecting children from chemical hazards.
3	Investigate how activity pattern data can be used to classify children for exposure characterization.
3	Investigate how available data from children can be interpreted across developmental stages for which there are limited data.
3	Evaluate what resources or approaches one can use to address risk methodology for extrapolating inhalation dose to developmental lifestages.
3	Develop guidance on incorporating critical window of vulnerability to reduce uncertainty, specifically for the time frame over which exposure should be averaged.
3	Study how risks can be extrapolated to developmental exposure to non-genotoxic carcinogens.
3	Study how developmental lifestage-specific mode of actions can influence latent expression of adverse outcomes.

3	Since toxicokinetics and toxicodynamics in children can rarely be studied, investigate how model variability in internal dose and sensitivity to toxicant action better can be characterized.
3	Investigate how biomonitoring data can be interpreted to characterize exposure and how available adult biomonitoring data can be applied to children.
4	Develop guidance materials to assist in the preparation of initial national assessments of children's environmental health and the identification of priority concerns. Develop and implement action plans to address those priority concerns.
4	Consider potential enhanced exposures and vulnerabilities of children when setting nationally acceptable levels or criteria related to chemicals.
4	Establish needed infrastructure for research that will reduce uncertainty in risk assessment.
4	Develop mechanisms to share and disseminate information that can be used to reduce uncertainty in risk assessment.
4	Develop broad strategies specifically directed to the health of children and young families.
4	Establish needed infrastructure for research into the impact of exposure to chemicals on children and women.
4	Promote the use of comparable indicators of children's environmental health as part of a national assessment and prioritization process for managing unacceptable risks to children's health.
EDUCATION AND AWARENESS-RAISING	
2	Ensure that effective safety information labels are included on consumer products that are potentially hazardous to children, providing guidance on handling, transport, use and disposal, and information about first aid and contacting poison information centres.
2	Strengthen community right-to-know where children are potentially exposed so that parents and others responsible for children have adequate and reliable information on emissions and discharges and on the safety and safe use of products, including, where appropriate, relevant information on chemical constituents of consumer products, to take action to protect children.
2	Educate parents, children, teachers, and communities about types and routes of exposure and how to recognize and avoid unsafe levels of exposure, e.g. safe chemical use and distribution, disposal, and appropriate alternatives.
2	Design educational materials and implement school programs and media campaigns in the local language, taking into account local needs, to alert and teach children, parents and the public about the potential dangers of improper chemical use and potential unintentional chemical exposures.
2	Encourage further industry participation in educational campaigns to raise awareness about children's special vulnerability and the need to protect them through safe use of chemicals.
2	Offer education to representatives of industry, public interest groups, the media, policymakers and other professionals about chemical risks and risk communication.
2	Raise the awareness of decision-makers about the risks to children's health and development associated with chemical use and encourage policies that take into account any specific vulnerabilities to chemicals that children may have.
2	Train health professionals about children's unique vulnerabilities to certain chemicals and the risk of chemical exposures in different settings, the most common exposure pathways, as well as how to diagnose, identify the cause, prevent and treat exposures.
2	Encourage donors to fund innovative educational programmes incorporating children and chemicals into development assistance programmes, and taking the opportunities offered through existing convention funding mechanisms to address children and chemicals issues.
4	Promote education and training on children's chemical safety.

* The numbers resemble the original document for each recommendation. 1 = *Environmental Health Criteria 237: Principles for Evaluating Risks in Children Associated with Exposure to chemicals* (IPCS, 2006). 2 = *Protecting Children from harmful Chemical Exposures: Chemical Safety and Children's Health* (IFCS, 2003). 3 = *A Framework for Assessing Health Risk of Environmental Exposures to Children* (US EPA, 2006). 4 = *Strategic Approach to International Chemicals Management (SAICM) Global Plan of Action* (UNEP, 2005).

8. ABBREVIATIONS

6EAP	6 th Environment Action Programme
ADAF	Age-Dependent Adjustment Factor
APUG	Action Programme Environment and Health
BFR	Brominated Flame Retardant
BPA	Bisphenol A
Cal/EPA	Environmental Protection Agency California
CDC	United States Centers for Diseases Control and Prevention
CEC	Commission for Environmental Cooperation for North America
CEH	Children's Environmental Health
CEHAPE	Children's Environment and Health Action Plan for Europe
CEHU	Children Environmental Health Unit
CMP	Chemicals Management Plan
DG	Directorate General
EC	European Commission
ED	Environmental Directorate
EDC	Endocrine Disrupting Chemical
EEA	European Environmental Agency
EEHC	European Environment and Health Committee
ENHIS	European Environment and Health Information System
EPA	Environmental Protection Agency
EU	European Union
FAO	Food and Agricultural Organization
FP	Framework Programme for Research and Technological Development
G8	Group of Eight
HEAL	Health and Environment Alliance
HECA	Healthy Environments for Children Alliance
HPA	Health Protection Agency
I4C	International Childhood Cancer Cohort Consortium
IARC	International Agency for Research on Cancer
IFCS	Intergovernmental Forum on Chemical Safety
ILO	International Labour Organization
INCHES	International Research and Information Network on Children's Health, Environment and Safety
IPCS	International Programme on Chemical Safety
IPM	Integrated Pest Management
NAFTA	North American Free Trade Agreement
NGO	Non-Governmental Organization
NHANES	National Health and Nutrition Examination Survey
NICHD	National Institute of Child Health and Human Development
NIEHS	National Institute of Environmental Health Sciences
NIH	National Institute of Health
OECD	Organisation for Economic Co-operation and Development
OPP	Office of Pesticide Programs
OPPT	Office of Pollution Prevention and Toxins

PBDE	Polybrominated Diphenyl Ethers
PCB	Polychlorinated Biphenyl
PFC	Perfluorinated Compounds
POP	Persistent Organic Pollutant
RIVM	National Institute for Public Health and Environment
RPG	Regional Priority Goals
SAICM	Strategic Approach to International Chemicals Management
SCALE	Science, Children, Awareness, Legal instrument, Evaluation
SLL	Stockholm County Council
SLV	Swedish Food Agency
SoS	National Board of Health and Welfare
TEACH	Toxicity and Exposure Assessment for Children's Health
UN	United Nations
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund
VCCEP	Voluntary Children's Chemical Evaluation Program
VERHI	Valuation of Environment-Related Health Impacts
WHO	World Health Organization
WSSD	World Summit in Sustainable Development

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APPENDIX 1. Overview of activities concerning chemicals and children's health initiated by organizations and agencies on global, European and national levels.

ORGANISATION	ACTIVITY	TYPE OF ACTION
IPCS	Environmental Health Criteria 237	Risk assessment methodology
IPCS	Environmental Health Criteria 59	Risk assessment methodology
IPCS	Environmental Health Criteria 30	Risk assessment methodology
IPCS	Harmonization of Approaches to the Assessment of Risk from Exposure to Chemicals	Risk assessment methodology
IPCS	Identifying Important Life Stages for Monitoring and Assessing Risks from Exposures to Environmental Contaminants	Risk assessment methodology
RIVM (NL)	Risk Assessment of Chemicals: What About Children	Risk assessment methodology
RIVM (NL)	Guidance for assessment of chemical risks for children	Risk assessment methodology
RIVM (NL)	Chemicals in Toys: A General Methodology for Assessment of Chemical Safety of Toys with a Focus on Elements	Risk assessment methodology
US EPA	Supplement guidance for Assessing Susceptibility from Early-Life exposure to Carcinogens	Risk assessment methodology
US EPA	Child Specific Exposure Factors Handbook	Risk assessment methodology
US EPA	Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants	Risk assessment methodology
US EPA	Food Quality Protection Act	Risk assessment methodology
US EPA	A Framework for Assessing Health Risks of Environmental Exposures to Children	Risk assessment methodology
IFCS	Toys and Chemical Safety – a Thought Starter	Risk assessment methodology
US Cal/EPA	Development of child-specific reference doses for chemicals common in Schools	Risk assessment
US EPA	Protecting Children's Health – The national Pesticide Programme	Risk identification, risk assessment
OECD	Children's Environmental Health Indicators	Risk identification, risk assessment, monitoring progress
WHO	National Children's Environmental Health Profiles	Risk identification, risk assessment, monitoring progress
WHO	Children's Environmental Health Indicators	Risk identification, risk assessment, monitoring progress
CEC (Can/Mex/US)	Development of indicators of children's environmental health	Risk identification, risk assessment, monitoring progress

WHO Europe	Children's Environmental Health Indicators for Europe	Risk identification, risk assessment, monitoring progress
UK HPA	Children's Environmental Health Indicators	Risk identification, risk assessment, monitoring progress
CEC (Can/Mex/US)	Toxic Chemicals and Children's Health in North America	Risk identification, risk assessment
US EPA	Understanding Children's Exposure to Chemicals	Exposure and risk assessment methodology, analytical methodology
US EPA	Probabilistic Stochastic Human Exposure and Dose Simulations	Exposure assessment methodology
RIVM (NL)	Non-Food Products: How to Assess Children's Exposure?	Exposure assessment methodology
German Federal Environment agency	Environmental Health Risks: What are the Differences Between Children and Adults?	Exposure assessment methodology
Health CAN	Children's exposure to residential lead sources	Exposure assessment, biomonitoring
Health CAN	Plastics and Personal-care Products in Pregnancy	Exposure assessment, biomonitoring
Danish EPA	Study of exposure of chemicals in 2 year old children	Exposure assessment, environmental monitoring
Danish EPA	Exposure of pregnant consumers to suspected endocrine disruptors	Exposure assessment, environmental monitoring, awareness-raising
US EPA	The Children's Total Exposure to Persistent Pesticides and Other Persistent Organic Pollutants	Exposure assessment, biomonitoring, environmental monitoring
Swedish EPA, IMM	Health-Related Environmental Monitoring	Biomonitoring, environmental monitoring
CDC (US)	National Health and Nutrition Examination Survey	Biomonitoring
Health CAN	Canadian Health measure survey	Biomonitoring
Health CAN	Maternal-Infant Research on Environmental Chemicals	Biomonitoring
CEC (Can/Mex/US)	Trinational Biomonitoring Study	Biomonitoring
WHO	Pilot projects (asthma, arsenic, biomonitoring, cohorts)	Biomonitoring, birth cohort, other research
WHO	Harmonization of birth cohort studies	Harmonization of birth cohort studies
NIH (US)	International Childhood Cancer Cohort Consortium	Cohort consortium, harmonization of birth cohort studies
IARC	AGRICOH	Cohort consortium
NIH (US)	National Children's Study	Birth cohort
NIH (US)	Longitudinal Investigation of Fertility and the Environment Study	Longitudinal study
EU	Framework Programme for Research and Technological Development	Research funding
OECD	Valuation of Environment-Related Health Impacts, with a Particular Focus on Children	Cost-benefit analysis of children's environmental health
IARC	Automated Childhood Cancer Information System	Cancer data base
US EPA	Voluntary Children's Chemical Evaluation Programme	Awareness-raising
US EPA	Toxicity and Exposure Assessment for Children's Health	Awareness-raising

WHO Europe	Environment and Health Information System	Information sharing, risk assessment, awareness-raising
Swedish SoS, IMM	Environmental Health Survey and Environmental Health Report	Awareness-raising, risk identification
Danish EPA	Reports on children and specific consumer products	Risk assessment, product screening, awareness-raising
IFCS	Protecting the World's Children from Harmful Chemical Exposures: a Global Guide to Resources	Awareness-raising, action recommendations, resource reviewing
INCHEs	INCHEs official homepage	Information sharing, influencing policy-making, awareness-raising
EEA	Children's Health and Environment: a Review of Evidence	Risk identification, influencing policy-making
UNEP	Children's Environmental health Project	Risk identification, monitoring progress, influencing policy-making
WHO	Children in the New Millennium: Environmental Impact on Children	Risk identification, influencing policy-making, action recommendations
UNEP	Childhood Pesticide Poisoning	Awareness-raising, action recommendations
WHO	Healthy Environments for Children Alliance	Advocating, influencing policy-making, information sharing
WHO	Healthy Environments for Healthy Children: Key Messages for Action	Education of decision-makers and the public
WHO	Childhood Lead Poisoning	Education of health care providers and decision-makers
WHO	Children's Exposure to Mercury Compounds	Education of health care providers and decision-makers
WHO	Harmonized training package	Education of health care providers
WHO	Children's Health and the Environment – a Global Perspective. A Resource Manual for the Health Sector	Education of health care providers
WHO	Persistent Organic Pollutants - Impact on Children's Health	Education of health care providers
WHO	Children's Environmental Health Units	Education of health care providers and the public, influencing policy-making
Health CAN	Brochures and web sites for public information	Awareness-raising
Danish EPA	Brochures and web site addressing pregnant and nursing mothers	Awareness-raising
HEAL	Healthier Environment for Children	Webpage
EU	The EU Environment and Health Strategy SCALE and the Action plan for 2004-2010	Action plan
EU	6th Environmental Action Programme	Action plan
Swedish SoS	National action plan for children's environmental health	Action plan
WHO Europe	CEHAPE / National CEHAPs	Action plan
G8	Miami Declaration	Action plan
WHO	Plan of Action for Children's Health and Environment (2010-2015)	Action plan
UN	A World Fit for Children	Action plan
UN	Plan of Implementation	Action plan

UK HPA	Children's Environmental Health Strategy	Action plan
UNEP	SAICM and Global Plan of Action	Action plan, framework policy
US EPA	Integrated Pest Management programmes in schools	Exposure reducing strategy



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