Children in their environment: vulnerable, valuable, and at risk

background briefing
children and environmental health
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London, 16-18 June 1999

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This report was prepared at very short notice in order to provide a briefing paper that would complement the draft monograph on "Children & Environmental Health", being produced by the Rome office of the WHO for the London conference.

It follows other EEA activities on children and environmental health, such as proposing the issue of children and environmental health for inclusion in the WHO London conference; hosting, with WHO, Childwatch International and the Danish Ecological Council , a workshop on Children and Environmental Health in March 1998*, and supporting, in partnership with WHO and the USEEPA, the development of the International Network on Children's Environmental Health and Safety, INCHES, which will be launched at the WHO London Conference.

This report is based on some sections of the draft monograph from WHO, Rome and on the literature provided at the Copenhagen workshop; the first European conference on Children and Environmental Health, Amsterdam, 1998, organised by Peter van den Hazel of the Dutch Association of Environmental Medicine; papers from the conference, "What on Earth", 1997, organised by the Canadian Institute of Child Health; papers from the conference on "Environmental Influences on Children: Brain, Development, and Behaviour", New York , 1999, organised by the Centre for Children's Health and the Environment, Mount Sinai School of Medicine; and the US EPA, who have produced several reports since the Executive Order on Children and Environmental Health in 1997. Some key references used are shown in the text but most sources of information used for this report are listed at the back.

Particular sections of this report have befitted from helpful inputs from Carole Courage (MRC Institute of Environment and Health, Leicester, UK; Maria Caroquino and Roberto Bertolini (WHO, Rome); Philip Grandjean (Odense University, Denmark); Janne Koppe (Ecobaby Foundation, The Netherlands); Vyvian Howard (Liverpool University, UK); Peter Baumont (Pesticides Trust, UK); Dave Leon and colleagues (London School of Hygiene and Tropical Medicine); Niels Skakkebaek (Rigshospitalet, Copenhagen); Devra Lee Davies (World Resources Institute, Washington); Phillippe Landrigan and Molly Rauch (Mt. Sinai School of Medicine, New York); and Sarah Meredith (UCB Institute of Allergy, Brussels). However, responsibility for this draft report rests with the author as time constraints have prevented contributors form checking their inputs.

This report will be merged into the monograph on children and environmental health which will be produced jointly by WHO (Rome) and the EEA at the end of 1999. Critical comments on both of these draft reports will be welcomed. Please send to David Gee at the EEA ,Kongs Nytorv 6, DK-1050, Copenhagen K., Denmark. (david.gee@eea.eu.int)

Some text and several illustrations are taken from the new report from the EEA on the state of the environment, "Environment in the European Union at the turn of the century" which will be published in the EU Member States, 24-25 June 1999.

<u>Disclaimer</u>

The views expressed herein do not represent the views of the EEA, its Management Board or the other institutions of the EU.

*"Proceedings from the seminar on Environment and Child Health", Copenhagen 1998, Danish Ecological Society, Landgreven,7, 1301 Copenhagen, K, Denmark. (info@ecocouncil.dk)

Contents

This briefing paper provides a partial illustrative summary of what we know, and don't know, about children's vulnerability to a selection of key environmental hazards. It makes the case that children are potentially at greater risk to certain environmental hazards compared to adults. In the absence of comprehensive information for risk assessment, a precautionary approach to ensure the protection of children's health is needed.

It also mentions some of the economic arguments for early intervention in the prevention of childhood diseases and adult diseases related to childhood exposures, observing that

'Life expectancy at birth is one of the strongest explanatory variables of growth in GDP' (WHO, 1999)

The best way to safeguard the health of a population is to ensure that disease does not arise in the first place. Childhood presents valuable opportunities for disease prevention. Not only do lifelong chronic diseases that start in childhood have a profound effect on the quality of life, they are also very expensive to treat. Early intervention can prevent not only the loss of healthy, productive adult lives caused by childhood diseases but also the costs of adult diseases that are of childhood origin.

Throughout this report, 'children' refers to ages 0 to 18 years, except where different ages are specified), and 'environment' means all external influences associated with disease causation, or reduced well-being, during the period from pre-conception to 18 years old.

Summary

- **People are at the centre of 'their' world, but they are also part of the environment, and play a significant role in shaping it. The environment also 'shapes' people by the impact it has on their health.**
- **Most European children today benefit from better food, cleaner water, more preventive health measures, such as vaccination, and a higher standard of housing and living than ever before.**
- **However, there is increasing evidence, from tests in animals, studies of occupationally exposed workers, and some studies of the general public and children, that exposure to certain chemicals and other hazardous agents, such as radiation, are associated with increased risks of cancer, reproductive disorders, neurological damage, and other ill-health. This has been called the 'new paediatric morbidity'.**
- **Children today are routinely exposed to a number of 'hidden hazards' from micro-pollutants in air, water, food, on soils and surfaces, and in consumer products. These include newly created synthetic chemicals, which did not exist fifty years ago.**
- **For 75% of the 70-100,000 chemicals on the European market, there is insufficient toxicity information available for even the most basic risk assessments recommended by the OECD.**
- **Children are not "little adults" but are particularly vulnerable to pollutants because of their immature biological development; behaviour; metabolism; greater exposure to pollutants, relative to body weight; and longer life at risk than adults. *"It's the timing of the dose that can make the poison"*.**
- **Children are therefore potentially more vulnerable to environmental hazards than adults, and require special protection. However, this is not generally provided for since most safety standards for chemicals are based on adult data, although improvements to standards are developing continuously.**
- **Some pesticide residues in food and water, because they can accumulate in the particular diets of children, are of concern, especially for possible impacts on the brain and on behaviour. Environmental causes of autism, attention deficit/hyperactivity disorder (ADHD), and lowered IQ are being investigated and seem to be involved in some of the increases in these disorders.**
- **Some other chemicals that can damage the brain and affect behaviour are lead, mercury, PCBs and dioxins which can be absorbed via food, water, air, surfaces and consumer products. Some chemicals (PCBs, dioxins) accumulate in body fat and are passed on to the foetus and infant. Although more dose is passed on through breast milk, the lower, pre-natal dose via the mother appears to be more hazardous because of the greater vulnerability of the foetal brain. Hormones in meat may cause brain damage and cancer.**
- **Other environmental health impacts on children seem to include: reproductive disorders (cancers and defects of the testes, breast cancer, falling sperm counts); asthma; other respiratory diseases and allergies; some other cancers, such as leukaemias and nervous system tumours; and injuries, for which there is a steep difference between W. and C&E Europe. The environmental causes of these health impacts include passive smoking, pesticides and other chemicals, traffic, alcohol, diet, and poverty.**
- **Children's environmental health is now receiving special attention, especially in North America, and increasingly in Europe. Priorities for action include better exposure monitoring, research, exposure standards designed for children, reduced exposures, information to consumers and citizens about residues and emissions, and the awareness raising, education and training of health professionals and child carers, including parents.**

Some actions to prevent or reduce children's ill health from environmental factors.

- better linkages between exposure and health data via EEA & WHO's 'partnership in action'
- apply the lessons from the histories of thalidomide, DES, lead, etc. and **don't use children as guinea pigs** - especially as, compared to adults, children get little or no benefit from the environmental exposures that we give them
- **put children at the centre of government policies** on housing, poverty elimination, income support, and health.
- more **research** into the environmental causes of ill health in children, especially into neurological diseases.

E.g. there are very few studies of children and delayed effects of acute OP poisoning, despite evidence from adults that delayed psychological deficits occur. There needs to be long term prospective epidemiological studies of the health impacts of OP and OC pesticides, with a focus on intellectual development. There has been virtually no action since the 'early warnings' of Angle in 1968, on the neurotoxicological effects of OP poisonings, even though the extent of these effects 'might exceed the effects currently presented by lead' (Weiss, 1997). Data from poison centres could be the basis for some of these studies.

- **give children relevant legal protection** with safety standards for chemicals that take their special vulnerabilities into account -as in the USA Food Quality Act 1996, which provides an extra 10-fold safety margin for children, as well as provisions for the cumulative exposures of children to pesticides. 10,000 existing pesticide tolerances must be re-assessed by the US EPA by 2006. (The US EPA has also initiated projects on Children's Cumulative Exposure, a Children's Environmental Health index, and a Children's Vulnerability index as part of its response to the Executive order on Children and Environmental Health, 1997).
- **reduce children's exposures** to chemicals, radiation and other potential causes of ill-health, prioritising persistent and bioaccumulating substances, especially pesticides and other toxic chemicals to which children are exposed in food ,water, and consumer products, (such as the phthalates in children's toys), utilising **the precautionary principle** whenever risks are likely to be serious and irreversible.
- give the public the **right to know** what their children are exposed to with adequate consumer product labelling laws and accessible toxic emissions registers, like the toxic release inventories in the USA. There is no equivalent in Europe, despite OECD recommendations, although there are one or two Member State systems e.g. the UK and the Netherlands.
- improve the **education and awareness** of parents, teachers and other guardians of children so that they can help create safer environments for them. European equivalents of the American Academy of Pediatrics' "Handbook of Environmental Health for Children", and the "Resource Guide" and training materials for US doctors and nurses produced by the Children's Environmental Health Network, California, would be helpful in this. The EEA will be assisting the newly formed INCHES network (which the EEA , WHO Europe and the US EPA have helped launch) to produce European versions of these US training and information materials on children and environmental health.

1. Why children need special protection

'First, do no harm' — Hippocrates

1.1. Environment & health: likely links

'The environment is everything which isn't me.' — Albert Einstein

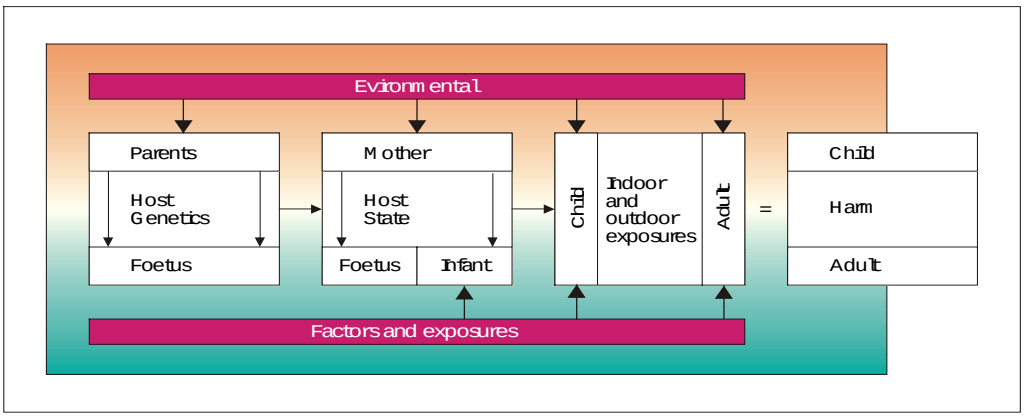
People are at the centre of 'their' world, as Einstein observed, but they are also part of the environment, and play a significant role in shaping it. The environment also 'shapes' people by the impact it has on their health.

This is not just in the obvious ways of sustaining life, through the provision of food, water and shelter, but also through the less visible impact it has on genes, cells, organs and biological systems which together can cause disease. In the more developed economies – such as the EU – where basic supplies of clean water and sewage facilities are generally available, environmental impacts on health are often less obvious – and more insidious – than in developing countries. However, unravelling the less obvious connections between the environment and health in developed economies is not easy.

Damage to health is the result of many factors acting in various combinations, over different time periods, to a diverse range of people, of varying sensitivities, and at different stages of their lives.

(Figure 1). Understanding the complexities of what causes ill health is clearly going to be difficult – and, very often the more we know, the more we realise what we don't know. It is not surprising, therefore, that scientific and public controversies over environment and health have been or are currently common within scientific and public circles (e.g. leaded petrol and brain damage in children, or antibiotic growth promoters in animal feed and increased human resistance to antibiotics)**.** Public policy decisions on environmental *hazards* (potential damage) and *risks* (probable damage) are difficult to make and evaluate. However, understanding the types of information needed for environmental health decision-making (as well as its use and limitations) will contribute to a wider appreciation of the reasons for public 'concerns', differences in expert opinions ,and the action (or inaction), of governments.

Figure 1. Environment, people and health: some key relationships



Environmental factors (e.g. overcrowding, diet, climate, stress) and exposures (e.g. from air, food, drink, surfaces) can play a part in causing and/or aggravating disease and ill health, both directly and via parents.

Source: EEA

Environmental stresses for which there are reasonably good exposure and effect data are estimated to be a major factor in an estimated 5% of disease, according to preliminary report prepared for the WHO on the basis of Dutch data. The main components of this environmental fraction are air pollution, which accounts for most of the total environment-related health loss in the Netherlands (in terms of reduced life expectancy, the quality of life and number of people affected); environmental noise; and indoor air pollution, including radon, damp and environmental tobacco smoke. Lead in drinking water is also significant. Traffic and domestic accidents, which together would bring the total environmental fraction of disease causation from 5% to 12% are very important public health hazards, but are not normally considered as environmental health issues.

1.2. The health of children: from classical diseases to 'hidden hazards'

Most European children today benefit from better food, cleaner water, more preventive health measures, such as vaccination, and a higher standard of housing and living than ever before. As a result fewer are dying from infectious diseases and their overall health and life expectancy is very much improved compared to the beginning of the century (**Table 1).** Both the age distribution at death and the leading causes of death have changed dramatically. **Figure 2** shows, for a representative country such as Chile, that the probability of a female dying before her fifth birthday has fallen from 36% to 2%. Her cause of death is now much more likely to be cancer, heart or respiratory disease than the infectious diseases of earlier times, such as measles, diphtheria, TB, cholera, and typhoid.

Figure 2: Age at death: Chile

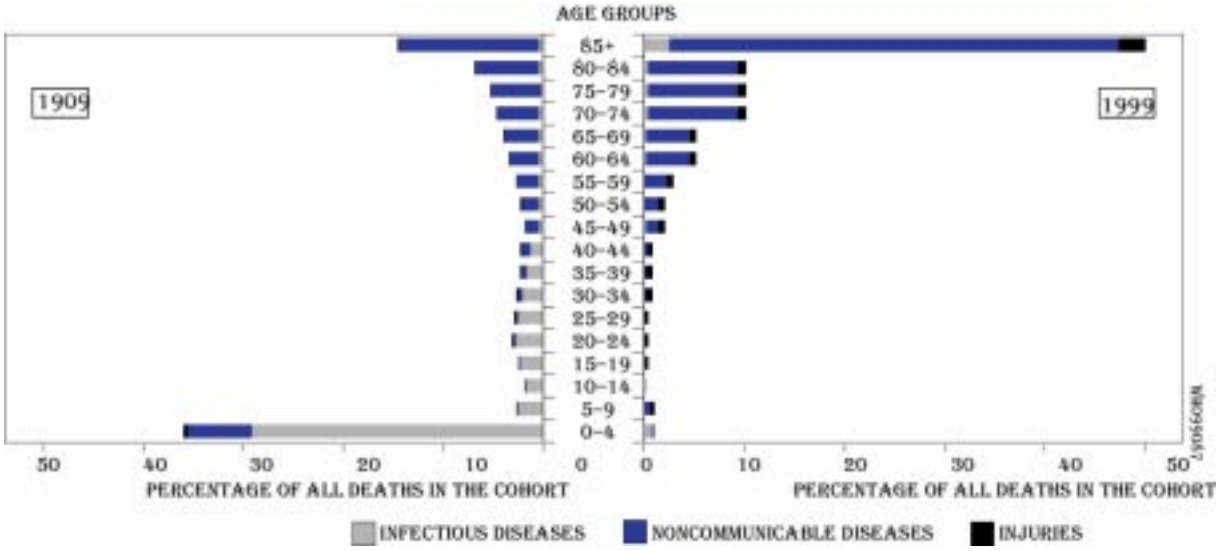


Table 1: Life expectancy 1910-1990

Table 1.1. Life expectance at birth, selected countries, around 1910 and in 1998

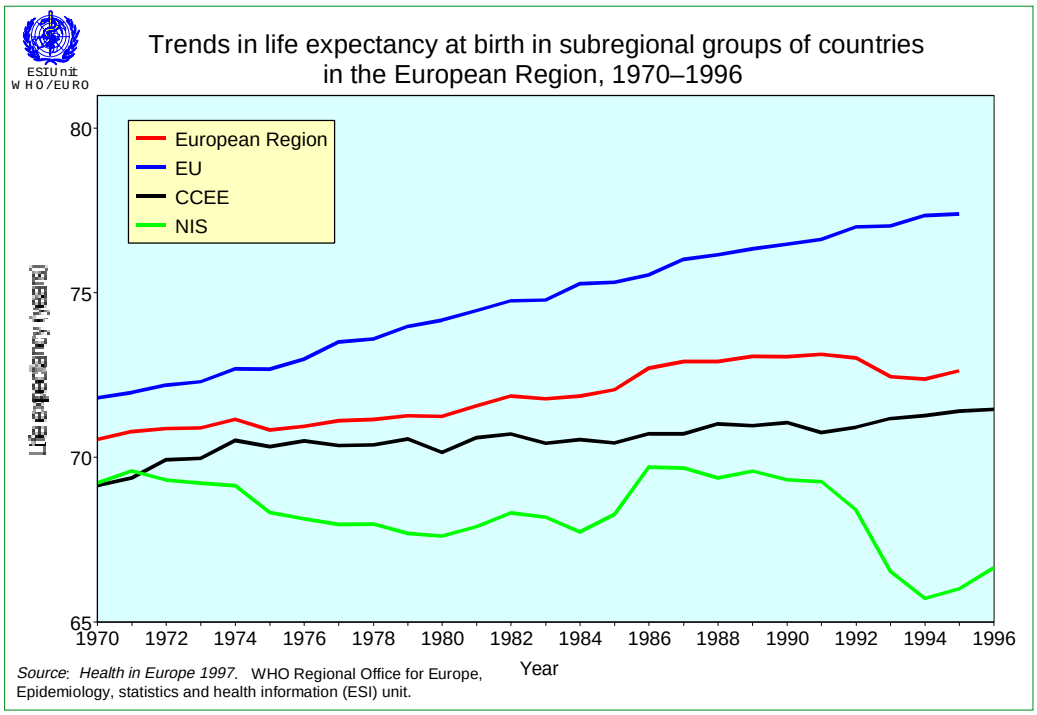
Country	Around 1910		1998	
	Male	Female	Male	Female
Australia	56	60	75	81
Chile	29	33	72	78
England & Wales	49	53	75	80
Italy	46	47	75	81
Japan	43	43	77	83
New Zealand[a]	60	63	74	80
Norway	56	59	75	81
Sweden	57	59	76	81
United States[b]	49	53	73	80

[a] Excluding Maoris
[b] Registration states only; includes District of Columbia.
Sources: 1910 data: Preston S.H., Keyfitz N., Schoen R. Causes of death: life tables for national populations. New York and London, Seminar Press, 1972. For Australia: Cumpston J.H: (Lewis M.J: ed.) Health and disease in Australia: A history. Department of Community Services and Health, Canberra, AGPS, 1989.
1998 data: United Nations Population Division. World population prospects: The 1998 revision. New York, United Nations, 1998. 'Making a Difference', WHO, 1999

The causes of this improvement in health are many and inter-connected. They include higher incomes, less poverty, the availability of vaccines and antibiotics, better nutrition, education and sanitation, and other public health measures.

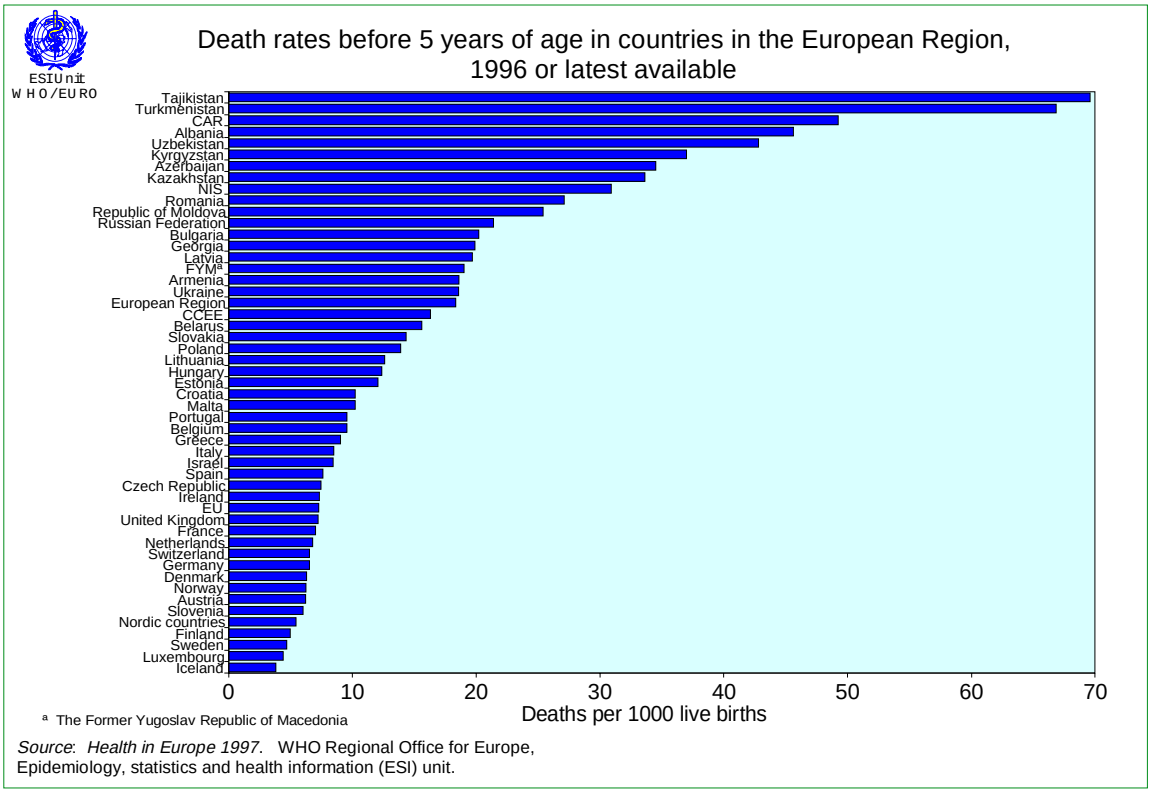
Not all countries have shared in, or retained, this 'global revolution in health' (WHO, *Making difference*, 1999). Globally, about 1 in 10 children will not live to see their fifth birthday, although this global average conceals wide variations in different parts of the world. This is chiefly due to infectious diseases, which still kill many children in the less developped world. There are also parts of Europe, such as the Newly Independent States (NIS), where, following social and economic breakdown, the classic infectious diseases, such as dipheteria, malaria, TB, cholera, and typhoid, are re-emerging. The life expectancy of people in NIS has fallen dramatically within the last decade to an average of less than 50 years in several of the more polluted and impoverished zones, such as in Uzbekhistan, Kazakhstan and Tajikhistan. (Figure 3). Infant mortality rates in Europe vary enormously (Figure 4), reflecting the large differences in social, economic, and envionmental conditions, as well as the health care systems across the European region.

Figure 3: Life expectancy in Europe 1972-1996



Source: *Health in Europe 1997*. WHO Regional Office for Europe, Epidemiology, statistics and health information (ESI) unit.

Figure 4: Death rates before 5 in Europe



[a] The Former Yugoslav Republic of Macedonia

Source: *Health in Europe 1997*. WHO Regional Office for Europe, Epidemiology, statistics and health information (ESI) unit.

While most children in Western Europe are no longer dying of infectious diseases, they are at increased risk from some cancers and birth defects, as well as asthma, allergies, brain damage

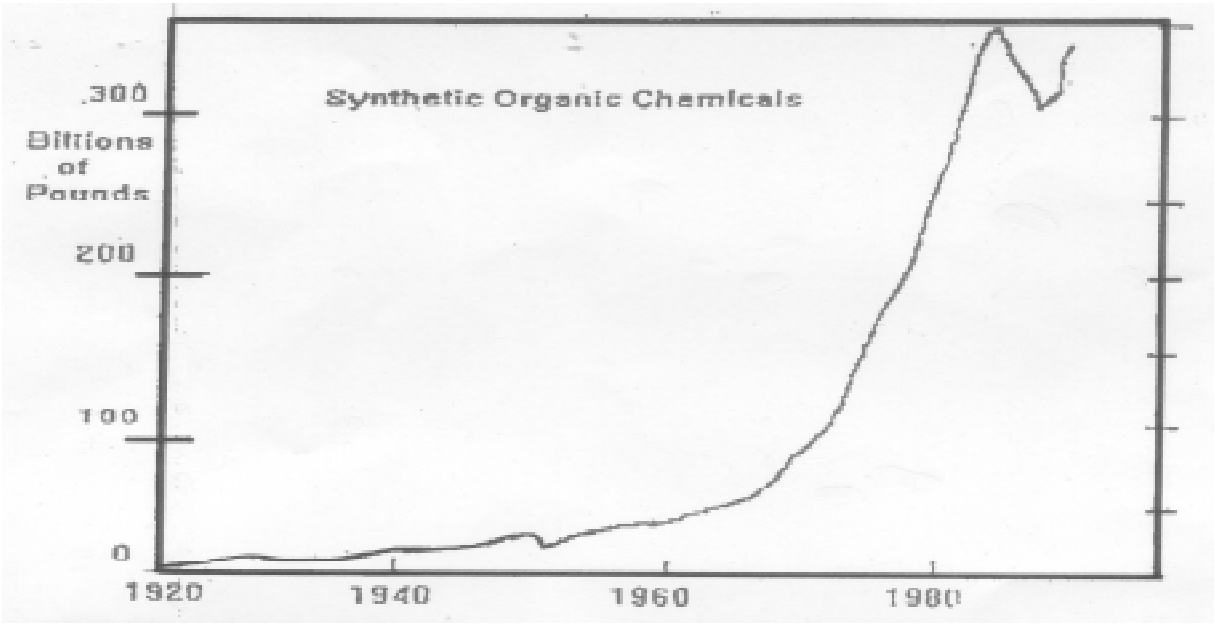
and behavioural disorders. This has been called the **'new paediatric morbidity'[1].** The causes of these diseases are not as obvious as the causes of infections, but as they have grown to prominence fairly recently, changes in the environment and other factors of modern life are likely to be playing a significant role.

There is increasing evidence, from tests in animals, studies of occupationally exposed workers, and some studies of the general public and children, that exposure to certain chemicals and other hazardous agents, such as radiation, are associated with increased risks of cancer, reproductive disorders, neurological damage, and other ill-health. It is difficult to translate these findings from generally high exposures into knowledge about the risks to children from much lower exposures to such agents. However:

- the absence of known thresholds for some of these effects,
- the possibility that even quite low doses of some chemicals may have adverse effects, and
- the greater vulnerability of children to some environmental hazards, means that a ***precautionary approach*** is needed.

Children today are routinely exposed to a number of these ***'hidden hazards'*** in air, water, food, on soils and surfaces, and in consumer products. These include newly created synthetic chemicals, which did not exist fifty years ago. **Figure 5** shows the huge growth in the production of synthetic organic chemicals in the USA, 1920-1976 There has been a similarly dramatic rise in production and use of chemicals in Europe. Many of these chemicals persist in the environment and in fatty tissues, and have become part of every child's external and internal environment.

Figure 5: Synthetic Organic Chemicals Production, USA 1920-1990



Source: US EPA

Little is known about the *hazards* (harmful potential) or *risks* (probability of harm) of most of these chemicals. **For 75% of the 70-100,000 chemicals on the European market, there is insufficient toxicity information available for even the most basic risk assessments recommended by the OECD [2].** Moreover, the relatively few chemicals for which there is enough toxicity data for risk assessments are usually tested one at a time. Children, like adults, are exposed to mixtures, but very little is known about the effects of mixtures. Although children are generally only exposed to very low levels of chemicals, it is not known whether combined exposures to many combinations of small amounts of chemicals are dangerous or not. As the

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1 Landrigan et al (1998). 'Children's Health and the Environment: A new Agenda for Prevention Research', Environmental Health Perspectives, Vol. 106 Supp. 3

2 EEA/UNEP (1998). *Chemicals In Europe: Low doses, high stakes?*

chair of the US National Research Council report on 'Pesticides in the diets of Infants and Children', 1993, Prof. Phillip Landrigan, has said:

'By default, we are conducting a massive toxicological experiment, and our children are the experimental animals'

1.3. Children are not 'little adults'

Much of what we know about environmental damage to health comes from data on adults. Similarly, many of our safety standards are based on data that do not specifically cover risks to children. But children are not little adults. Children are particularly vulnerable to some environmental pollutants. This heightened susceptibility stems from several sources:

- **'Greater exposures'** — Children have proportionally greater exposures to environmental toxins than adults. Children drink more water, eat more food, and breathe more air than do adults, relative to their body weight. For example, the air intake of a resting infant is twice that of an adult and an infant in the first 6 months of life drinks several times as much water per kilogram body weight as does the average adult. Children ages 1 to 5, eat three to four times more food per unit body weight than the average adult. Children also have unique food preferences. For example, the average American 1-year-old drinks 21 times more apple juice and 11 times more grape juice, and eats 2 to 7 times more grapes, bananas, pears, carrots and broccoli than the average adult. European data show similar differences between children and adults with respect to fruit and vegetables. Soft drink consumption of British pre-school and school children is about 6 times that of adults and pre-school children's consumption of milk and dairy products is 6 times that of school children and adults These patterns of increased consumption reflect the dietary choices and the higher energy requirements of children for growth and development.
- **'Child behaviour' —** Children's hand-to-mouth behaviour, shorter stature, and their play close to the ground increases their exposure via inhalation and ingestion to toxins in dust, soil, and carpets. It also increases exposure to any toxins that form low-lying layers in the air, such as certain pesticide vapours.

The implication for health is that children have higher exposures, per unit body weight, than adults to any toxins that are present in water, food or air.

- **'Metabolism' —** Children's metabolic pathways, especially in the first months after birth, are immature. As a consequence of this biochemical immaturity, children's ability to detoxify and excrete chemicals differs from that of adults. In a few instances, children are actually better able than adults to deal with environmental toxins. More commonly, however, they are less able than adults to deal with toxic chemicals and are thus more vulnerable to them.
- **'Biology of development' —** Children are undergoing rapid growth and development, and their delicate developmental processes are easily disrupted. Organs, such as the brain and reproductive organs double in size during the early life. Exposures to toxic materials during this time of rapid growth can be especially hazardous. During this period, structures are developed and vital nervous system connections are established. Development of the nervous system takes place all through childhood, but the nervous system has only a limited capacity to repair any structural damage that is caused by environmental toxins. Thus, if cells in the developing brain are destroyed by chemicals such as lead, mercury or solvents, or if vital connections between nerve cells fail to form, there is a high risk that the resulting neurobehavioral dysfunction will be permanent and irreversible. The consequences can be loss of intelligence and alteration of normal behaviour.
- **'Longer time at risk'** — Children have more years of life ahead of them than adults, so they have more time to develop those chronic diseases that take several decades to appear, and which may be triggered by early environmental exposure. Diseases with long latent periods include mesothelioma cancer from asbestos, skin cancer from sunlight, and leukaemia from benzene.

Children are therefore potentially more vulnerable to environmental hazards than adults. This is well recognised in radiation biology, where the increased risks of radiation-induced cancer for children is greater than for adults: it is 16 times greater for a 3 month-old; 8 times for a one year-old, 4 times greater for a 5 year-old, and 2 times greater for a 10 year-old. (ICRP, 1991) However, other specific risks that children are exposed to as a result of this vulnerability are largely unknown outside the field of radiation. As a result, children generally may not have sufficient protection from public safety standards.

1.4. Special 'safety' standards for children?

Some public health protection standards for exposure to chemicals and other pollutants are based on information relevant to adults rather than children. Such standards usually include additional safety margins to protect more vulnerable people, but these may be insufficient to protect vulnerable children **(Box 1).**

Box 1. The foetus needs special protection

'The most susceptible link in the chain of life to the action of many global chemical pollutants is during the period of development. Thus the foetus and infant have different vulnerabilities to damage than do adults and are in general more likely to suffer damage. *This aspect of toxicology has tended historically to receive relatively low priority in the setting of environmental standards.*

Every member of human society, adults and children alike, carries body burdens of an estimated 300 or more chemical residues that could not have been present in their grandparents.

The fact that a compound bioaccumulates tells us that the body has difficulties in metabolising and eliminating it. This is essentially because for many novel compounds we simply do not possess enzymes to break down their molecular structure. Therefore such chemicals tend to build up in the body with increasing age. They can then be passed on to the next generation across the placenta and in the breast milk, often at high concentrations. In the case of dioxins and PCBs it is now known that current body burdens in a proportion of the population are sufficient to cause measurable deficits in the intelligence, immune status and hormonal status of their offspring'.

Dr Vyvian Howard, Foetal and Infant Toxico-Pathololgy, University of Liverpool, UK.

There is considerable doubt about whether the maximum allowed levels for some chemicals in food are set sufficiently low to protect infants and young children. This applies, for example, to pesticide residues in fruit and vegetables and to some additives in food. However, the need for tighter safety standards for infants and children has just recently been recognised in the EU, where the residue of any individual pesticide in baby food must now not exceed 0.01mg/kg of food, compared with 0.1 mg/kg in food for adults[3].

The pesticide residues to which children are exposed can vary greatly, but some exposures may pose risks **(Box 2).**

Box 2. Pesticide residues

'In the last two years, work at the UK Pesticides Safety Directorate (PSD has shown unexpectedly high variations in pesticide residues found in carrots and some fruit:

- Between 10 and 30% of selected fruit contained Organophosphates or carbamate residues but the greatest surprise was the range of variability - the highest residue level was 29 times the mean.
- the risk of eating an apple with a very high residue (that might cause adverse health effect) was 1 in 1000; the chances of two apples (at the same sitting), 1 in 1,000,000.
- If an infant or toddler whose daily consumption of apples included one containing the maximum residues found of carbaryl, chlorpyrifos or triazophos, *the intake could exceed the Arfd (UK acute reference dose, which is the safe acute daily dose) by factors of one or two.*
- If an infant or toddler whose daily consumption of unpeeled peaches included one containing the maximum residues found of methamidophos or omethoate, the intakes could exceed the Arfd by factors of two or four.
- For adults or schoolchildren whose daily consumption of unpeeled apples included one containing the maximum residues found of triazophos, *intakes could exceed the Arfd by factors of four to six.*
- The UK Advisory Committee on Pesticides concluded there was no risk to health, but that margins of safety had been eroded. (Pesticides News 38, Children at Risk. March 1998 p3).
- At a conference in December 1998 (Proceedings of the International Conference on Pesticide Residues Variability and Acute Dietary Risk Assessment, Pesticide Safety Directorate, York: Dec 1-3 1998) attention was given to the impact on consumers of pesticides that had similar modes of action - such as organophosphates. Not only could such residues have an additive effect in diet, but there was concern for their potential impact on the brain of the developing foetus.'

Peter Baumont , The Pesticides Trust, UK (personal communication).

[3] EU press notice IP/99/395 as reported in *The Week in Europe* from the UK European Commission 0ffice, 27-28 May 99.

1.5. 'The timing of the dose can make the poison'

We know from the tragedies of the drugs thalidomide and diethylstilboestrol (DES), and from the use of x-rays during pregnancy that exposures to chemicals and radiation can cause immense damage if the dose is received at vulnerable times for the growth and development of the foetus. The story of lead, mercury and other persistent environmental contaminants such as polychlorinated biphenyls (PCBs) and dioxins, illustrate that very low environmental exposures can be damaging. Fathers' hazardous exposures prior to conception from a number of workplace chemicals and radiation, as well as environmental tobacco smoke (ETS), may also cause their offspring to have birth defects and other poor health. In some cases prolonged exposure may be necessary to induce adverse effects, in other cases a single exposure at a vulnerable point in time may be sufficient.

Table 2 illustrates how hazardous agents can cause immediate and delayed damage to health depending on the time of exposure.

Table 2. The timing of pollution exposure is critical

Pre-conception	Radiation (damage to female eggs and male sperm initiating cancer in offspring?)
Prenatally (harm evident at birth or soon after)	thalidomide (birth defects); PCBs; dioxins; ETS; lead (brain damage and behavioural difficulties)
Prenatally (delayed harm	DES (cancer in the daughters of treated mothers),;radiation of mothers (leukaemias in their offspring)
During infancy	lead; ETS; dioxins; dioxins and PCBs in breast milk (lower IQ)
During childhood	damp, mites, traffic fumes, ETS, (asthma)

2. Some environmental health impacts on children

2.1. Some developmental effects of environmental pollution

Exposures to environmental radiation and chemicals may cause early and subtle damage to developing biological systems that determine gender identity, behaviour, hormone and enzyme levels, and susceptibility to chronic diseases, such as heart disease and diabetes. However, knowledge in this area is still very poor. We currently have most knowledge about effects on the developing brain. Neurological diseases are now responsible for the largest burden of disease in high income countries, at 24% of death and disability, compared to 18% for heart disease and 15% for cancer[4].

2.1.1. Brain damage and behavioural disorders

(Lewis Carroll's Mad Hatter character in "Alice in Wonderland" was probably based on the phrase "as mad as a hatter" which comes from the neurotoxic effects of mercury vapours on 19th century felt hat makers).

Correct 'wiring' of the growing brain depends upon an intricate and inter-connected scaffolding of cells and neurones laid down in the pre-natal period which then provides essential cues for the later development of nerve connections. This creates 'windows of susceptibility' to hazardous agents that might otherwise be innocuous to the mature brain[5]. Any damage to this 'wiring' process can lead to brain damage and effects on intelligence and behavioural disorders. And if one of these development processes is changed or inhibited, there is little chance to catch up. Many of these processes continue until well after birth and vulnerability continues until the Central Nervous System is completely formed. For example, the formation of nervous connections (synapses) continues until about two years of age in humans.

The foetus and young infant may also be particularly vulnerable to the effect of neurotoxicants for other reasons. For example, the blood-brain barrier, which protects the adult brain from many toxic agents, is not completely formed until about 6 months after birth. Similarly, while the placenta protects the foetus against many unwanted compounds, it is not an effective barrier against some neurotoxicants. Methylmercury, for example, easily crosses the placenta and concentrates in the foetal brain. Lead can be mobilised from the mother's bones, especially if there is nutritional stress, resulting in significant exposure of the foetus.

Environmental exposures can potentially affect brain development in a variety of ways, though the mechanisms of action of individual neurotoxicants are still poorly understood. Chemicals may cause enzyme inhibition at very low concentrations, and the brain is vulnerable to some of these effects. For example, chemicals which act as transmitters of nerve impulses in the mature brain perform an additional function during development. They guide and control the growth and migration of nerve cells to their final locations and signal information that is essential for further development of the brain One of these substances is acetylcholine, whose duration of action is controlled by the enzyme acetylcholineseterase. It is therefore possible that insecticides, which inhibit cholinesterase, may interfere with these processes and perhaps lead to permanent brain damage When there is interference with cell migration, neurons cannot reach their correct position and make the proper connections with the neurons that should be their neighbours, so they cannot develop normal functions.

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4 WHO (1999). 'Making a difference'

5 Friedrich (1999). 'Wiring of the Growing Brain', paper to Conference on "Environmental Influences on Children: Brain Development and Behaviour" Mt. Sinai School of Medicine, New York, 24-25 May 1999.

'Pesticides absorbed by inhalation, which kill insects by harming their brains, also damage the brains of larger species, including humans. These substances include arsenic, chlordane, chlorinated cyclodienes, organophosphates, and synthetic pyrethrins.'[6]

However, our knowledge in this area is limited by lack of data. For example, despite the fact that insecticides are designed to be neurotoxicants, and children have widespread exposure to them, there is 'disturbingly sparse information on pesticide neurotoxicity' and there are 'significant blind spots' in what we know about their neurotoxic effects[7]. This is because the health studies have not been done, and the animal studies have usually not included exposure levels, or the biological endpoints, such as intellectual development, that are relevant to humans.

Box 3. The vulnerable brain and multiple risks

'Transition periods like the course of early brain development are synonymous with instability. Although the process is exquisitely controlled, its liability renders it highly susceptible to perturbations such as those induced by exposure to environmental chemicals. When such disturbances occur, they can result in outcomes ranging from death to malformations to functional impairment. The last is the most difficult to determine. First, it requires a variety of measures to assay its extent. Second, for many agents such as heavy metals, adult responses may prove an inadequate guide to the response of the developing brain. Third, such tools are deployed in complex circumstances in which many factors, including economic status, combine to produce a particular effect. Fourth, the magnitude of the effect, for most environmental exposure levels, may be relatively small but extremely significant for public health. Fifth, changes in brain function occur throughout life, and some consequences of early damage may not even emerge until advanced age. Such factors need to be addressed in estimating the influence of a particular agent or group of agents on brain development and its functional expression. It is especially important to consider ways of dealing with multiple risks and their combinations in addition to the prevailing practice of estimating risks in isolation.'

Weiss 'Vulnerability of the Developing Brain: Research, Risk Assessment, and Prevention', paper to the NY conference, 24-25 May 1999. New York Academy of Medicine.

However, despite this shortage of data there is growing evidence (from the research presented at the recent conferences described in the preface) of possible links between the environment and neurological diseases.

Neurotoxic chemicals belong to three main groups: metals and metal compounds, solvents and other simple organic compounds, and pesticides, especially the organophosphates and carbamates. These compounds are not the only neurotoxic chemicals currently in use but as they represent three different classes of chemicals and act through different mechanisms, they can be used to illustrate the sensitivity of the developing brain to environmental exposures.

Lead

The majority of lead released into the environment is from human industrial activity. Children may be exposed to lead from car emissions through leaded petrol, water contaminated by lead pipes, paint, emissions from factories, contaminated soil and improperly glazed ceramic ware for cooking and food storage.

During the years 1984 to 1987, similar to other countries in Europe, the UK developed a Blood Lead Monitoring Programme to cover the period when the maximum permissible content of lead in petrol was reduced from 0.4 to 0.15 g/l . A downward trend in blood lead levels has been observed since the late 70s and early 80s. Decreases of 25-45% in average blood lead levels in children between 1978 and 1988 have been reported by the OECD in Belgium, Canada, Germany, New Zealand, Sweden and the UK but it is not clear how much of this fall is due to changes in lead released from petrol and paints. Since the removal of lead from petrol and paints the relative impact of other identified sources, such as food from contaminated soil and soldered tins, water contaminated by lead pipes and use of improperly glazed ceramic ware for cooking and food storage, has increased.

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6 Prof. K.H. Kilburn (1998) 'Chemical Brain Injury', p. 5

7 Weiss (1999) *Vulnerability of the Developing Brain: Research, Risk Assessment, and Prevention',* paper to the NY conference, 24-25 May 1999. New York Academy of Medicine.

Children absorb up to 50% of lead taken into their bodies, compared to 10-15% in adults They may receive three times the dose of adults because they have a larger surface-to-volume ratio. Children also ingest lead from dust and dirt by thumb-sucking or by putting their hands in their mouth and infants may be exposed via their formula. Use of lead-contaminated tap water in preparing infant formula can result in elevated exposure levels. A report of the UK House of Lords Select Committee on the European Communities[8] concluded that there is no doubt that there are serious health risks from lead in drinking water, particularly for children, infants and foetuses.

Inadequate nutrition has been found to have a further effect on lead absorption and toxicity. It is known that lead tends to be absorbed in inverse relationship to the availability of iron, calcium, phosphorus, zinc, and copper in the diet Thus children who have deficiencies in these minerals may be at greater risk of lead toxicity. Children's diets in general tend to be deficient in these elements, especially iron. On the other hand, diets rich in lipids, which frequently are the case for infants and young children, tend to enhance lead absorption. Other important factors in children's diets, such as milk components and vitamin D levels, can also modulate lead absorption in a more complex way. ***Because of the possible confluence of children's malnutrition and exposures to lead among poor populations, efforts to prevent mineral-deficiency and even to implement nutritional supplementation programmes may be a low-cost strategy for mitigating the toxic effects of lead pending the reduction of lead exposures.***

The most substantial evidence of effects of low-levels of lead on health relates to effects on the central nervous system and, in particular, the developing brain of children. Intelligence is the most consistently measured outcome in lead studies. That there is an association between body lead burden and measures of child intelligence is no longer in doubt[9]. This is supported by a systematic review of 26 epidemiological studies (from Europe, New Zealand and Australia) with the aim of examining the cumulated evidence on the lead-IQ association, from both prospective and cross-sectional studies. The geometric mean for blood lead levels for age groups 6 to 14 years ranged from 7.4 μg/d to 18.9 μg/dl. The synthesis of the evidence in all 26 studies strongly supports an inverse association between body lead burden and child IQ. **A typical doubling of body lead burden (from 10 to 20 μg/dl blood lead or 5-10 μg/g tooth lead) was associated with a mean deficit in full scale IQ of around 1-2 IQ points.** While small in individual terms, an average fall in population IQ of 1 point is regarded as unacceptable.

Lead is known to be transported across the placenta during pregnancy and pregnant women are considered to be especially susceptible from occupational exposure. Several studies which examined the significance of maternal and infant blood lead levels concluded that a maternal blood lead of 10-15 μg/dl may indicate grounds for concern. However it was reported that neonatal lead exposure seems not to affect child IQ in the general population.

The Declaration of the Environment Leaders of The G-8 on Children's Environment and Health in 1997 agreed an upper limit for blood lead in children of 10 μg/dl. However existing epidemiological studies do not provide definitive evidence of a threshold for onset of adverse effects in relation to blood lead levels, and there is some evidence of an association between blood lead levels and adverse effects below this range[10].

The Expert Panel on Air Quality Standards in the UK[11] recently recommended a concentration of lead in air of 0.25 $\mu g/m^3$ as a level at which they believe any effects on health of children will be so small as to be undetectable and at which the vulnerable will be protected.

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8 House of Lords, Select Committee on the European Communities (1996). *Drinking Water* (Session 1995-96, Fourth Report).

9 IEH (1998). *Recent UK Blood Lead Surveys* (Report R9), Institute for Environment and Health, Leicester, UK.

10 WHO (1995). International Programme on Chemical Safety, Environmental Health Criteria 165. Inorganic Lead, World Health Organisation.

11 EPAQS, Expert Panel on Air Quality Standards, UK (1998). 'Lead' (Department of the Environment, Expert Panel on Air Quality Standards), London, UK, HMSO.

In areas where lead pipes, storage tanks or other fixtures and fittings are still in use, and the water is able to dissolve in it, lead can leach into water resulting in concentrations of over 50 μg/dl.

Methylmercury

Methylmercury is a well-established neurotoxicant that can cause serious adverse effects on the development and functioning of the human central nervous system, especially when exposure occurs prenatally At high exposure levels seizures and spasticity (cerebral palsy) occur. In less severe poisoning, methylmercury produces blindness, deafness, and mental retardation. A dose-response relationship has been established between maternal hair-mercury levels during pregnancy and the prevalence of severe psychomotor retardation in the children

At lower intakes widely encountered in fish-eating populations, new evidence of developmental effects at low exposures is emerging[12]. A group of 1 000 newborn children on the Faroe Islands was studied between 1986 and 1987, and methylmercury exposure was determined from the mercury concentration in the umbilical cord blood. More than 90% of these children were then examined at age 7 years. While clinical examination did not reveal any clear-cut mercury-related abnormalities, **mercury-related neuropsychological deficits were particularly pronounced in language, attention, and memory, and to a lesser extent in visuospatial and motor functions.** The associations seemed not to be due to other possible causes, and they remained after exclusion of highly-exposed children with a maternal hair-mercury concentrations above 10 μg/g.

In Brazil, cross-sectional studies of Amazonian children aged 7-12 years show mercury-associated effects that are in agreement with the Faroese findings.

Polychlorinated biphenyls (PCBs), Dioxins and other suspect neurotoxicants

Among the persistent organochlorine compounds, most attention has been focused on the polychlorinated biphenyls (PCBs). These industrial chemicals have been widely used in electrical equipment, but their use is now banned in most of Europe. However, PCBs may still leak into the environment from discarded transformers and other equipment. They concentrate in food chains and often occur alongside some chlorinated pesticides and related industrial compounds.

A Dutch study (by Paladin et al , see under psychomotor development, below) found that the relative contributions of breast feeding for 6 months contributed 12-14% of the accumulated concentrations of PCBs and dioxins studied, whereas meat/ processed meat products and dairy products contributed 15-25% and 40-55% respectively.

In Michigan and North Carolina, studies have shown IQ deficits and other impacts in children with increased exposures to maternal. pre-natal sources but no adverse effects could be determined in relation to postnatal exposures.

Although environmental PCB exposures in Western Europe may have decreased somewhat, following the banning of PCBs those groups who frequently eat contaminated fatty fish, or who reside in contaminated areas, may be particularly at risk.

The foetus and infant are exposed to substantial levels of **organochlorine (OC)** compounds such as PCBs, dioxins and organochlorine pesticides due to their presence in food and persistence in maternal body stores. Moreover, OCs readily cross the placenta. **Although the pre-natal exposure via the mother is lower than postnatal exposure from breast milk, it appears that these pre-natal doses are more toxic as they interfere with critical growth periods in brain development.**

The evidence on other suspect neurotoxicants however is much less extensive than for PCBs and dioxins. In general, only case reports or small epidemiological studies are available on the

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[12] Grandjean P, Weihe P, White RF, Debes F, Araki S, Murata K, et al (1997). 'Cognitive deficit in 7-year-old children with prenatal exposure to methylmercury'. Neurotoxicol Teratol 1997; 19: 417-28.

neurotoxic potential in children exposed to solvents, other pesticides, and other compounds. However, papers to a recent conference on 'Environmental Influences on Children: Brain, Development and Behaviour', organised by The Centre for Children's Health and Environment, Mount Sinai School of Medicine, 24-25 May 1999 presented new evidence which suggested that the influence of micro-pollutants, (additional to the well known effects of lead), on children's neurological health could be significant.

Incidence of developmental disabilities

Developmental disabilities (DDs) are a group of physical, cognitive, sensory, and speech impairments that arise during development through to 18. Some 17% of US children have one or more DDs, most of unknown cause. In 1996, 12% of US school children received special education services for one or more DDs, and about 2% of them had a serious DD such as mental retardation, or cerebral palsy. Other significant DDs are autism and Attention Deficit Hyperactivity Disorder (ADHD), which affects 3-5 % of US school children and which is strongly associated with criminal behaviour and substance abuse. An increasing number of environmnetal factors are associated with DDs in addition to the genetic components of the disorders.

The extent of DDs in Europe is likely to be less but still large enough to be a significant public health problem, with growing evidence of possible links between them and the environment. Some of these associations are summarised below.

- **Autism** is on the increase. Studies round the world have shown autism to be two or three times as prevalent as ten years ago, from about 4 cases in 10,000 people in the early 1980s to 12/10,000 a decade later. A number of small studies have shown a much higher incidence. In the search for causes, environmental factors are now being examined. For example, studies are being done in the Matedeconk river, New Jersey to see if contaminants in the water supplies might be contributing to the autism clusters; and other possible environmental causes are under investigation, such as streptococcal infection and pitocin, used in some labour inductions.
- **Attention-deficit/hyperactivity disorder (ADHD)** is a very common childhood psychiatric disorders, (often linked with **and lowered IQ)** and its cause is unknown. Recent research indicates that neurotoxins should be considered among the causes of ADHD, as well as of IQ deficiencies. Studies highlight lead in petrol and paint, pesticides, PCBs in breast milk and fish and food additives. For example, the children of mothers who ate PCB contaminated fish from and Lake Michigan, and who were mainly exposed to the PCB prenatally, (as well as through breast milk), had lower IQ scores , poorer short term memory and attention deficit when studied at infancy, 4 and 11 years old. **At 11 years of age the most exposed group had a mean IQ 6.2 points lower than the others in the sample, after controlling for other possible causes. The levels of PCB's in the L. Michigan study were only slightly above US background levels.**

  The impact of small changes in the normal distribution of IQ can be considerable. For example, in a population of 250 million, a downwards shift of 5 points in mean IQ increases the numbers below 70 (classified as mentally retarded) by about one third - from less than 6 million to 9 million. Neurotoxic effects reported on attention span, concentration, motor speed, memory, and language functions would be expected to impact on cognitive development, education, social functions, and career. Thus, a study of subjects who had suffered excess lead exposure as children clearly revealed that they were less educated and less successful in life than a control group Although documentation of such environmentally-induced effects is very limited, the implications are rather dramatic.

  Thirty years ago it was noted that effects on IQ deficiency and behaviour problems in children who had suffered OC poisoning were 'strikingly parallel' to the pioneering work on the neurotoxicity of lead published over 50 years ago, but despite the then call for long term

studies of these and other pesticide poisoning cases, virtually no studies have been done since[13].

- **Parkinson's disease.** There is evidence from manganese miners, who have high rates of psychosis and who suffer from a condition similar to Parkinson's disease, that a motor fuel additive, manganese tricarbonyl (MMT), may be neuorotoxic to the public ,particularly children, because managanese compounds can cross the placenta and are known to disturb brain functions and possibly feotal growth in rats. MMT was banned by the US EPA in 1994 but this was recently overturned by the courts[14].
- **Alzheimer's disease** may also be partly caused by some environmental toxins (as well as protected from it by others) though there is little clear evidence on this, and a Swedish review concluded that whilst the link between aluminium and Alzheimer's could not be ruled out ,the human evidence was weak, the biological evidence was negative and therefore the risk was unlikely.

- **Impaired psychomotor development**

  Children in Zaandam, Holland, exposed to dioxins were studied at the age of two years and seven months. Signs of enhanced neuromotor maturation were found and it was suggested that this may be due to the thyroxine-agonistic action of dioxins[15].

  Another group of children and their mothers from Rotterdam and Groningen were studied at pregnancy and at birth, and at 18 and 42 months. At the earlier age, impaired neuromotor development was associated with the sum of the transplacental PCB exposure. Several kinds of PCB were measured and most of these acted like phenobarbital, a known neurotoxicant. In the later study, impaired cognitive functioning and the verbal comprehension score was associated with the sum of the phenobarbital-like PCB's measured in the umbilical cord, breast milk and infant.

  The research concluded that ***"prenatal exposure to "background PCB levels " as found in the Netherlands is negatively associated with cognitive abilities in pre-school children and may have long term implications for cognitive functioning".***

  Some conclusions from this Dutch research, which was funded by the EU, is summarised in **Box 4[16].** This finding is in accordance with the PCB study of the Lake Michigan fish eaters.

Box 4. PCBs and dioxins Impacts in the Netherlands

In studies of humans effects from exposure to background levels of PCBs and dioxins in The Netherlands have been found.

Negative effects on immunity, cognitive functioning and behaviour have been found relative to dioxin exposure. More pronounced are the effects relative to the sum of the PCBs, as measured in the plasma of the mother, during her pregnancy and during the perinatal period, in the cord blood at birth, and related to the current background PCB-levels. The effects of faulty imprinting are on the immune-system; on behaviour (less attention), and on the IQ. Current levels of PCBs noted are mostly phenobarbital-like rather than dioxin-like. Using the TEQ-concept, where every dioxin is given a toxic equivalent factor in order to measure the toxic amount of dioxins and dioxin-like PCBs, may not be suitable for the biological endpoints studied. Or is the exposure to the phenobarbital-like PCBs more important than the dioxins? The relation found with these phenobarbital-like PCBs is probably a causal relationship, the more so because of what we know about the effects on humans of phenobarbital itself. However, dioxins cannot be excluded from having similar effects.

Prof Janne Koppe, Dutch PCBs and Dioxins study, The Netherlands.

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13 Weiss B (1997). 'Pesticides as a source of developmental disabilities'. MRDD Research Reviews 3:246-256, 1997.

14 Aschner M (1999). 'Manganese Fuel Additives: An Emerging Threat?' Paper to the NY conference on "Environmental Influences on Children: Brain Development and Behaviour" 24-25 May 1999.

15 Ilsen *et al.* (1996). 'Signs of enhanced neuromotor maturation in children due to perinatal load with background levels of dioxins'. Chemosfere vol.33, no.7, pp 1317-26.

16 Patandin *et al.* (1999). 'The Dutch PCB/Dioxin and Breast Milk Study', Sophia Children's Hospital, Rotterdam.

2.2. Diseases of the reproductive organs and functions

These include difficulties in fertilising and conceiving, birth defects of the reproductive organs, lower sperm counts, testicular cancer in young men, breast cancer, and premature puberty in girls. Reports from Europe and the U.S. indicate that rates of some male reproductive defects are increasing. Early life exposures to endocrine disrupting substances and other environmental toxins have been proposed as possible causes of these effects.

2.2.1. The potential risks of endocrine disruption in child health

Endocrine-disrupting substances (EDSs) are chemicals which can cause adverse health effects by interfering with the actions of hormones. EDSs are diverse in origin, structure, and activity and may affect many different points within the endocrine system, which control functions such as reproduction, development, growth and immunity. Exposure to these chemicals has adversely affected reproduction in several wildlife species, fuelling concern that a number of adverse trends in human reproductive health might also be linked to such exposure (see below). The existence of some of these trends is still being questioned and evidence linking them to exposure to EDSs is very weak. However, laboratory and field studies suggest that the effects of EDSs on human health could potentially be extensive and serious, and evidence has strengthened since the Weybridge report. (CEC, 1997)

Research with potent synthetic hormones suggests that the greatest risk from EDSs is to the developing foetus i.e. from exposure of pregnant women. Chemical interference with early development of the reproductive system, leading to permanent malformation or loss of fertility has been of particular concern. In some organs, for example the testis, development continues after birth and therefore these organs may be more at risk from permanent damage in children than in adults. Hormonally-controlled changes occurring at puberty may also be subject to chemical disruption.

2.2.2. Occurrence and routes of exposure of children

Chemicals suspected of being EDS are widespread, although usually at very low levels, and have many different origins, both natural and anthropogenic. It is likely that most people are exposed to a number of EDSs. They include phytoestrogens, naturally occurring in plants (including vegetables), synthetic steroid hormones, as found in the oral contraceptive pill, persistent organic pollutants such as dioxins, polychlorinated biphenyls (PCBs) and some pesticides (e.g. DDT) and plasticisers such as some phthalate esters. The main routes of exposure to children are through the placenta before birth, from breast milk and via food, air and consumer products. Recently, phytoestrogens in baby milk formula and phthalates in PVC toys have been the subject of intense research and public concern because of their potential hazards..

2.2.3. Potential health risks to children

Reproductive health

Prenatal exposure to EDSs has been implicated in reproductive tract defects and certain types of cancer. Use of the strongly oestrogenic anti-abortion drug diethylstilboestrol (DES) by pregnant women in the 1950s and 1960s resulted in reproductive abnormalities and increased incidence of cancer in female offspring and increases in cryptorchidism (undescended testicles), microphallus, testicular cysts and reduced sperm counts in some male offspring. The effects of DES have led to suggestions that EDSs with oestrogenic activity could induce similar effects. In men, it has been postulated that prenatal exposure to EDSs could be causing increased incidences of cryptorchidism, abnormal formation of the penis (hypospadias), reduced sperm counts and testicular cancer. In the U.S. and in some European countries, rates of hypospadias, a defect of the penis, have increased more than 50% over the past three decades. (This has not been a consistent finding. For example, the incidence in England and Wales is falling).

While the causes remain unknown, the relatively recent increase in this birth disorder suggests that some change in environmental factors may well be involved. **(Box 5)** (*Moller et al. 1998)*

Lifelong exposure to oestrogens is a risk factor in female breast cancer and exposure to oestrogenic EDSs in childhood might contribute to this risk.

Box 5. Endocrine-disrupting substances (EDSs): a hazard to the male organs?

'A possible decline in semen quality in several countries, which has been the focus of considerable controversy, parallels a well-established increase in the incidence of testicular cancer in young men in several countries. Increasing incidences of cryptorchidism and hypospadias have likewise been reported; however, time trends associated with these malformations may be difficult to interpret due to potential changes in diagnostic criteria and treatment routines. Recently, an association between foetal exposure to environmental estrogens and the impairment of male reproductive health has been suggested. In animal studies, estrogen exposure during pregnancy resulted in the development of cryptorchidism and hypospadias in the male offspring. Some pesticides have been reported to possess estrogenic or antiandrogenic properties. Prenatal exposure to such pesticides may therefore increase the risk of cryptorchidism and hypospadias. Although indicative of such associations, previous research on potential pesticide exposure and urogenital malformations is still too sparse for firm conclusions to be drawn.

A recent register-based case-control study in Denmark was designed to determine the association between parental occupation in the farming and gardening industry and the occurrence of hypospadias and cryptorchidism in the male offspring.

We found a significantly increased risk of cryptorchidism in the sons of female gardeners but no effect of paternal work in gardening on cryptorchidism. Our results are coherent with earlier studies reporting an increased frequency of orchiopexy in areas with extensive use of pesticides in Spain and an increased occurrence of cryptorchidism in boys born on Norwegian farms where pesticides had been in use.

We emphasise that the increase is of moderate magnitude and that this association can only account for a small proportion of the total occurrence of cryptorchidism in the population. However, our finding substantiates earlier reports of an increased risk of urogenital malformations among boys potentially exposed to pesticides *in utero* and confines the increased risk to maternal occupation. It remains to be established whether this association is caused by prenatal exposure to occupationally related chemicals and, more specifically, estrogenic and other hormone-disrupting agents. Studies with detailed exposure assessment are warranted in order to explore these associations more fully.

Hypospadias has been associated with maternal exposure to estrogenic and antiandrogenic compounds in rodents. A moderately increased risk of hypospadias was found among sons born on Norwegian farms where pesticides and tractor spraying equipment had been in use, whereas the risk of hypospadias was not increased among sons of agricultural workers in California. We were not able to detect an increased risk of hypospadias among sons of parents working in farming or gardening in Denmark. Either the exposure was insufficient, the association of hypospadias with gardening or farming was too weak to be detectable among the available number of cases potentially exposed to pesticides, or no such association truly exists in humans'.

Extract from 'Cryptorchidism and Hypospadias in Sons of Gardeners and Farmers", Weidner ,Moller, Jensen ansd Skakkebæk, Denmark, Environmental Health Perspectives, Vol 106, No 12, December 1998.

Note: the original article was fully referenced.

A study from Granada, Spain, found increased rates of birth defects of the testes in baby boys born to parents who worked in pesticides intensive agriculture, compared to those whose parents worked elsewhere. Although fruit and vegetable crops in this region take up only 4.65% of Spain's farmland, they receive half of the pesticides used in the country. Intensive, plastic-covered greenhouses are used, where workers regularly encounter high levels of exposures to agricultural chemicals. Baby boys born in districts in Spain where such exposures are high had more than twice as many defects of the testes, compared to areas without such exposures.

Breast cancer

Breast cancer, which is the most common cancer in women, poses a major puzzle to public health experts. Exposures that occur prenatally and early in life may be critical. Less than 10% of all cases arise in women born with defects in their genes. Most cases of this disease occur in women with few of the known risk factors (Davis *et al.* 1998). Early exposures to hormone altering materials have been shown to increase the risk of the disease, by Swedish experts. Women who experienced elevated levels of prenatal hormones, because they were fraternal twins, were found to have nearly 4 times the risk of developing breast cancer than those without such embryonic exposures. This suggests that exposures to xenohormones at critical stages of early development

can have profound effects on later development of the breast. Radiation is also a cause: girls who were irradiated prior to adolescence also have increased risks of breast cancer, as well as thyroid cancer. This is consistent with the notion that exposures prior to puberty can be especially important determinants of later health.

Early Puberty

The possible effect of EDSs on the timing and acquisition of secondary sexual characteristics at puberty has been poorly researched although precocious puberty and feminisation in males have been tentatively associated with exposure to certain EDSs. Precocious puberty has been recorded in children exposed to both synthetic and naturally-occurring EDSs (Szuets *et al.* 1997).

Multiple Impacts of Hormones

Recent evidence on potential risks to health from hormone residues in meat and meat products has been published by the EU Scientific Committee on Veterinary Measures relating to Public Health. (**Box 6**)

Box 6. Hormones in beef - risks to children

'In humans and animals, sex hormones including oestradiol, progesterone and testosterone are involved directly and indirectly in growth and development. Due to the obvious ability to improve weight gain and feed efficiency in meat-producing animals, natural hormones and/or the synthetic surrogates (zeranol, melengestrol, trenbolone) have been used in agricultural practice for several decades. This extensive use in certain parts of the world has intensified the discussion on possible adverse effects in human health. Concerns are based on the accumulating evidence on the fragility of the endocrine equilibrium in all stages of life as well as the potential genotoxicity of these compounds and their metabolites.

It is evident that when identifying the most sensitive sub-group of the human population, attention must be given to those which have the lowest physiological hormone levels. Prepubertal children are of the greatest concern. For women, some critical phases have been described as 'windows of vulnerability' corresponding in particular to the time period from adrenarch to first ovulatory cycles and possibly up to first pregnancy, as well as later on in menopause. Correspondingly for males, the most critical phase occurs in prepubertal boys.

Major conclusions

- As concerns excess intake of hormone residues and their metabolites, and in view of the intrinsic properties of hormones and epidemiological findings, a risk to the consumer has been identified with different levels of conclusive evidence for the 6 hormones in question.
- In the case of 17ß oestradiol there is a substantial body of recent evidence suggesting that it has to be considered as a complete carcinogen, as it exerts both tumour-initiating and tumour-promoting effects. The data available does not allow a quantitative estimate of the risk.
- For the other five hormones, in spite of the individual toxicological and epidemiological data described in the report, the current state of knowledge does not allow a quantitative estimate of the risk.
- For all six hormones, developmental, immunological, neurobiological, immunotoxic, genotoxic and carcinogenic effects could be envisaged. Of the various susceptible risk groups, prepubertal children is the group of greatest concern. Again the available data does not enable quantitative estimate of the risk.
- In view of the intrinsic properties of the hormones and in consideration of epidemiological findings, no threshold levels can be defined for any of the six substances.'

Extracts from: EU Scientific Committee on Veterinary Measures Relating to Public Health, 'Assessment of potential risks to human health from hormone residues in bovine meat and meat products', 30 April 1999.

'The possible biological significance of very low levels of estradiol, especially in children, is largely neglected. Steroid hormones are very potent compounds that have profound biological effects in both animals and humans. Most of our previous knowledge of the biological action of these compounds is based on the effects of adult physiological or supra-physiological doses of hormone. Recent *in vivo* studies in pre-pubertal children indicate that even small differences in hormone levels and very low doses of steroid hormone may have significant biological effects. Likewise, recent *in vitro* research has shown significant molecular effects of estrogen in extremely low doses. Special concern should be addressed to the lasting effects that may occur during specific sensitive time points of development, mainly during the foetal, perinatal and pubertal periods.

In the light of recent progress in our understanding of estrogen levels in children, we conclude that possible adverse effects on human health by consumption of meat from oestrogen-treated animals cannot be excluded.'
(Andersson and Skakkebaek, 1999)

2.3. Altered sex ratios and low birth weight

Several recent reports indicate that the ratio of males to females being born has declined in several European countries (Davis *et al.* 1998). Although evidence on this is not consistent, sex at birth is determined prior to conception. Fathers' exposures to workplace hazards have been found to alter their ability to conceive children, as well as the sex and health of their offspring, such as workers heavily exposed to the pesticide DBCP in Israel, who tended to have very few boy babies. Men employed in carbon setting jobs also had relatively few male children. Similar results were reported in a small community with exceptionally high exposure to dioxin contamination in Seveso, Italy. To the 20 couples with the highest measured blood levels of dioxin who had babies within a decade of this exposure, not a single boy baby was born. While the numbers are small, they indicate that environmental factors may be relevant.

Because stillbirths tend to be predominantly male, as a country's rate of prenatal care advances, stillbirths will decline. When this happens, there will be an increase in male births relative to female. Thus, it is important when considering sex ratio to also examine prenatal care and stillbirths. This may account for the reason why sex ratio in Southern Europe has not shown a decline, although declines are evidence in all Northern European countries that have been examined over the past two decades.

It is suggested that the adverse trends in sex ratios, testicular cancer and low sperm count may be connected via common causes, following a Danish study that found some links between these trends. (Moller *et al.* 1998).

Low birth weight sometimes seem to have environmental origins. For example, in Sweden, women with high levels of chlorinated hydrocarbons, mainly from fish eating, produced babies of low birth weight, and this characteristic has been proposed as one of a number of child related biomarkers of community ill health. (**Box 7)**

Box 7. Children as Biomarkers of Community Health?

"Environmental Health will more and more come to rely on biomarkers of exposure rather than on gross biological endpoints such as severe tissue damage or cancer. The child, with its sensitivity and rapid growth rate will become the most important indicator of community health, and will become the focus major preventative health action. Environmental health will need to focus on parameter shifts in the population rather than on the clinically abnormal few. This means carefully distinguishing between a normally distributed community parameter with a few abnormal outliers, and a clearly distinguishable "bell curve" moved from its normal mean value. It is also possible to have communities with bi-modal characteristics, that is, a sub group has the biomarker for exposure. This is a new field of health investigation, requiring new thinking and new tools… Four potential biomarkers have been noted: monocyte count in blood, death rate of low birth weight infants, and incidence rates of asthma and eczema.

(Bertell, R. *'Environmental Influences on the Health of Children',* paper to the International Conference on Children's Health and the Environment, Amsterdam 1998.)

2.4. Health effects from exposure to environmental tobacco smoke

Environmental Tobacco Smoke is also implicated in a range of birth disorders, as well as other health impacts

Environmental tobacco smoke (ETS) is a mixture of mainstream smoke, which is smoke exhaled by smokers, and sidestream smoke, which is smoke emitted from the burning tip of the cigarette.

The inhalation of ETS is known as 'involuntary smoking' or 'passive smoking'. Over 4000 compounds have been identified in laboratory-based studies as components of mainstream smoke and at least 42 of these were classed as carcinogenic to laboratory animals, many of which are known or suspected human carcinogens (NRC, 1986).

Children are exposed to ETS when people smoke, be it at home, visiting friend's homes or other venues where people smoke. It is not possible at present to measure exposure to ETS directly. However, data on the smoking habits of people in environments where the child spends time, for instance in the home, can be collected by questionnaire. The components of ETS, or their metabolites such as cotinine, a breakdown product of nicotine, can be measured in the blood, serum, urine, saliva or hair of children. Cotinine levels increase with increased exposure to ETS (IEH, 1999).

Foetal and birth disorders

Active smoking by mothers has been shown to significantly reduce **foetal growth rate** in a dose-dependent manner, resulting in the birth of small-for-age babies (There is some evidence of an association between maternal smoking and **premature birth**.) Maternal smoking during pregnancy has also been associated with increases in miscarriage (5-70%) and **perinatal mortality** of around 25% or more.

Sudden infant death syndrome (SIDS) is defined as unexplained mortality occurring in the post-neonatal period 1-12 months. The association between *maternal* smoking and SIDS is firmly established. Typically, there is an approximately 2 to 3-fold increase in risk for pre-natal maternal smoking with a slightly smaller effect for post-natal smoking only. Dose-response effects have been observed for both prenatal and postnatal maternal smoking There is limited evidence that *paternal* post-natal smoking also increases the risk of SIDS from studies of non-smoking mothers and smoking fathers.

Other health damage from ETS

ETS also causes other health damage to children such as respiratory illness (bronchitis, pneumonia, cough and wheeze). There is evidence that exposure to ETS leads to increased infant mortality from respiratory illnesses.

Asthma is a common, chronic illness among children. Several studies have shown that exposure to ETS significantly increases the severity and incidence of asthmatic attacks .

The most frequent cause of deafness in children is middle ear effusion commonly know as 'glue ear'. This condition often requires surgery to insert grommets, and can result in problems with language development and educational progress There is strong evidence for modest increases in rates of glue ear among children exposed to ETS, with children under 5 years of age being the most susceptible.

Other health effects are associated with childhood exposure to ETS (impaired mental, social and physical development, childhood cancer and exacerbation of cystic fibrosis) but the evidence is more suggestive of an association and further research is needed for confirmation. ETS is one environmental hazard that can easily be removed (compared to other hazards) from a child's environment. It is essential that parents, and the public in general, are made fully aware of the consequences to children's health, of smoking in their presence.

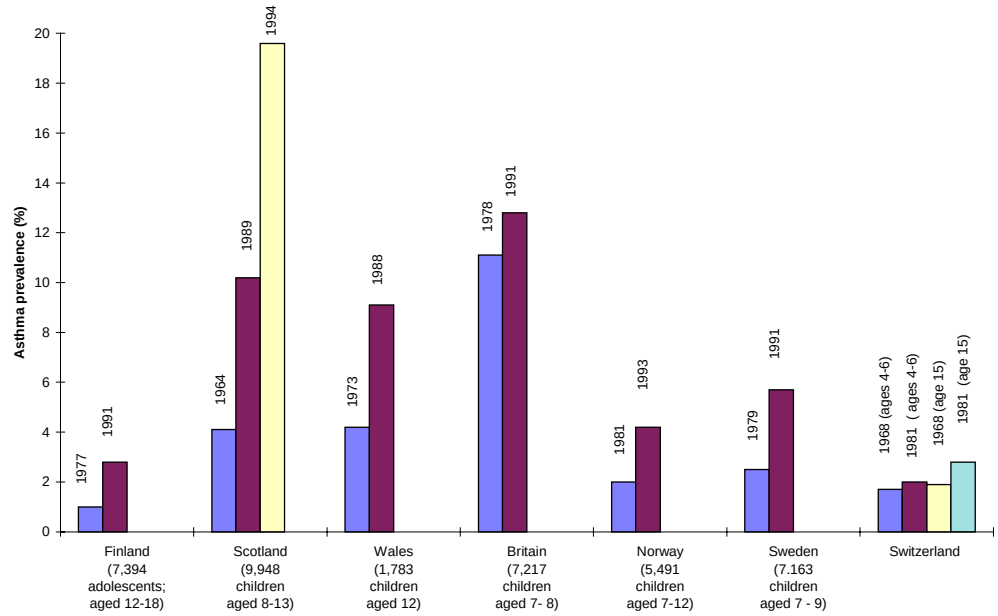
Carole Courage, MRC Institute of Environment and Health, Leicester.

2.5. Asthma and allergic diseases

2.5.1. The rising tide of allergic disease

Over the last three decades allergic diseases and asthma have become increasingly prevalent throughout Europe (Figure 6). Notably, there is more hay fever, asthma and atopic eczema, and the trend continues upward. There are large inter-country differences in these prevalences throughout Europe that require more investigation.

Figure 6: Some increases in asthma

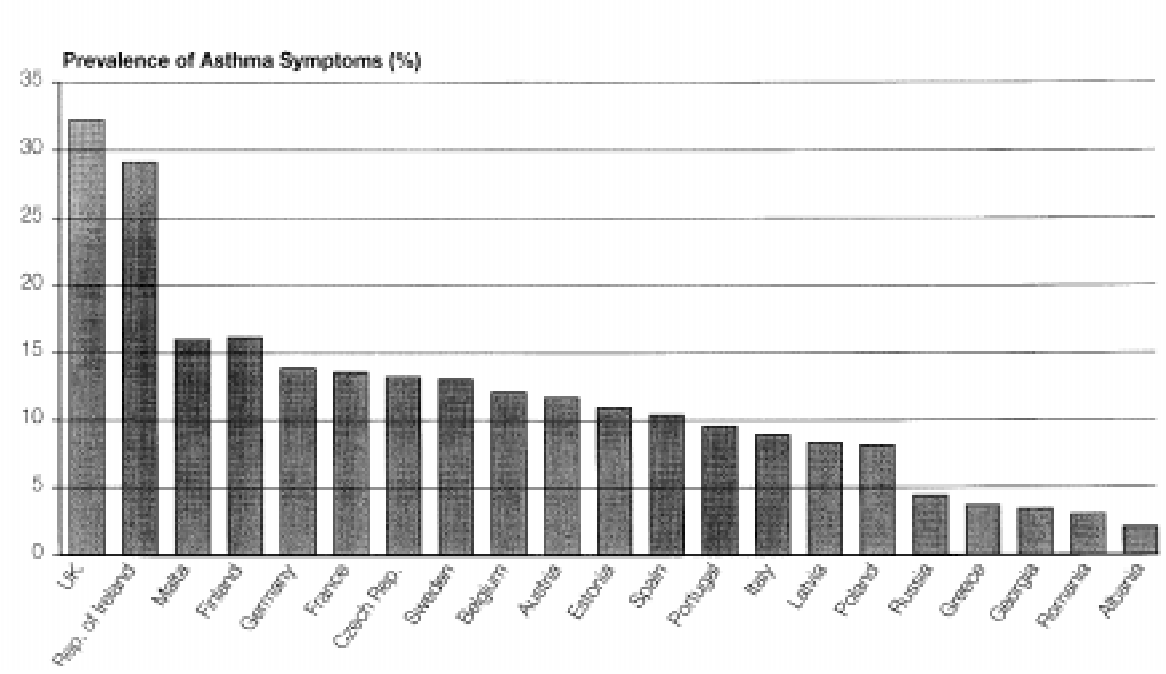


The increase in allergic diseases affects children of all social classes and leads directly to hardship for them and their families. While it is true that allergy rarely kills, it is a chronic condition and, particularly when it begins early in life, is costly to manage both financially and in human terms.

A characteristic of allergic diseases is that symptoms develop and change with age. These generally begin with atopic dermatitis (usually linked to food intolerance), followed at about the age of three years by seasonal allergic rhinitis (hay fever) which rises to an incidence of 1 to 3% per year during the first 10 years of life. Because the younger generation is affected so much by allergic diseases, a continued rise in these disorders is predictable for the near future.

Epidemiological studies of childhood asthma have shown that asthma in children is increasing in many countries, that there is a wide variation in prevalence among geographic regions (Figure 7), and that hospital admissions and asthma severity has increased.

Figure 7: Wide variations in asthma prevalence



The reasons for such increases are not known, but a study of the variability in prevalence among populations points to environmental factors as potential causes and/or triggers of the disease. Host factors such as genetics and increased immunologic susceptibility to develop asthma are also involved.

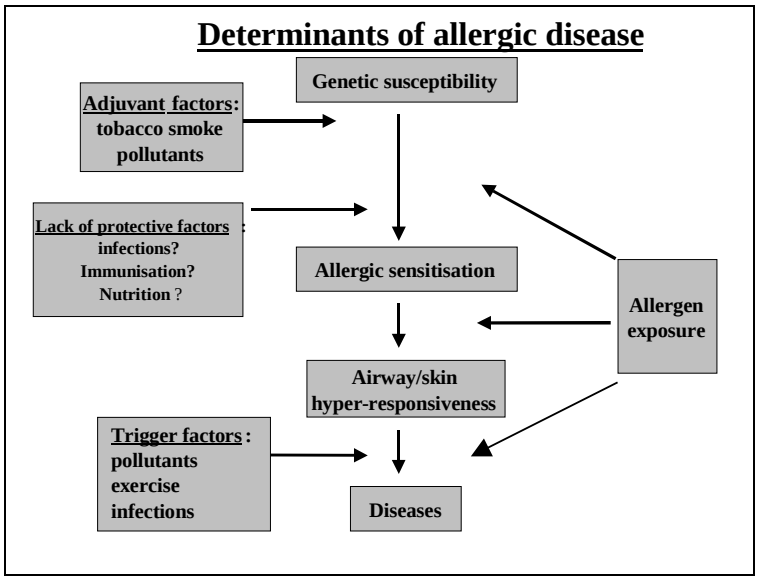
2.5.2. Risk Factors in asthma

The role of host and environmental factors in the aetiology of asthma has been widely debated. While genetic factors are considered important and may predispose some people to develop asthma **environmental factors have been singled out as probably the main contributors to the development of the disease in susceptible individuals.** The geographical differences in prevalence rates within countries, differences between urban and rural populations, and studies in migrating populations who develop more airway responsiveness and more atopy when changing environment indicate a dominant role for environmental factors. Studies of twins suggest genetic tendencies might account for 20-75% of asthma cases, leaving a substantial number unexplained. While genetic factors may predispose some people to develop asthma, it is not likely that they can account for the increase in prevalence rates over the past three decades.

Others argue that the increased prevalence of asthma is associated with a westernized lifestyle, or with changing from rural to urban living, which have altered individual and population susceptibility rather than to an increase in exposure to allergens. However, environmental influences on immune response systems can increase susceptibility to allergens.

Overall, environmental factors are considered secondary determinants (and risk factors) by worsening existing disease, by triggering symptoms, by exacerbating airway inflammation, and by increasing severity of asthma attacks**. (Figure 8).**

Figure 8: Determinants of allergic disease



Exposure to inhaled allergens, environmental tobacco-smoke, and viral infections are also usually considered as secondary determinants, but may be primary determinants of atopy 'allergic reactions', an important risk factor for asthma. It has also been suggested that early exposure to infections may protect a child from later developing the disease by stimulating an immune response that suppresses later allergic reactions. Similarly the rise in asthma in developed nations might also be due, in part, to an increase in the number of surviving premature babies, as these infants are more prone to developing asthma.

2.5.3. Determinants of allergy

Exposure to allergens can play an important role in the development of asthma and allergic diseases.

- Exposure to allergens increases the **risk of sensitisation** for a child who is predisposed to allergy. This means that further exposure can lead to allergic symptoms.
- A sensitised child's **risk of developing asthma** is increased if the allergens are airborne.
- For the child whose lungs are already affected, exposure to airborne allergens can **increase the severity or frequency of asthmatic symptoms**.

As an example, a two-fold increase in the exposure the dust-mite allergen in early childhood has been shown to significantly increase rates of sensitisation to the allergen, to double the risk that sensitised children develop asthma and to increase asthma symptoms in children who already have asthma.

There is certainly a family element involved in the development and onset of allergic diseases, but geneticists are increasingly convinced that there is no single 'allergy gene'. Several genes are involved at different stages in the development of allergy. More research is needed into the prenatal and early life origins of allergic diseases.

The key to allergic reactions seems to be the environment, both indoors and outdoors. The popularity of indoor entertainment means that children now spend many hours a day in a sedentary position and pass up to 90% of their life indoors. This brings them into prolonged contact with allergens such as droppings from house dust mites that live in carpets and mattresses, hairs from pets, moulds in poorly ventilated houses, etc. Children exposed to tobacco smoke have a higher risk of impaired lung function. Many outdoor pollutants can penetrate indoors: WHO suggests that about 70% of outdoor air pollution penetrates indoors, which means that both outdoor and indoor pollution should be considered together.

Outdoor allergens such as grasses and birches in Northern Europe and cypresses in Southern Europe are considered to be responsible for between 10 and 20% of allergic disease in Europe. Many pollutants (oxides of sulphur and nitrogen, ozone) further aggravate the poor condition of asthmatic children's lungs.

2.6. Childhood cancers

Childhood cancers are rare diseases of potential fatal outcome. Leukaemia represents one-third or more of childhood cancers in Europe and the overwhelming majority (70-80%) of these children are diagnosed with acute lymphocytic leukaemia. Central nervous system tumours account for 20% to 25%, lymphomas around 10%, and renal tumours and soft tissue sarcomas, each around 5-10% of childhood cancer cases. **Although mortality for leukaemia is decreasing due to major advances in treatment, the incidence is increasing in several areas, including the US, Canada and some parts of Europe.**

Only about 5% of cancer is due to purely genetic factors, although in children, the fraction of cancers due to environmental factors is probably somewhat lower than in adults. Age-standardised incidence rates for all childhood cancers, ages 0-14, range from 100 per million in Bulgaria and 111 per million in Iceland to 159 per million in Denmark. Reported rates are lower in some Eastern European countries, but underascertainment may be responsible. For leukemia, incidence rates range from 35 per million in Germany (former GDR) (or 33.2 in Bulgaria) to 53 per million in Denmark. While the observed variation comparing countries is not large, leukemia is often found to cluster at the local level. Thus, the real geographic variability may occur at a scale too small to capture using aggregate data at the national level.

Experiments with a number of carcinogens (including PAHs, nitrosamines) show that the risk of cancer in rodents is heightened if exposure begins in utero rather than in adulthood. In general, the susceptibility to cancer-causing compounds is exacerbated by poor nutritional status and by the occurrence of other diseases.

Studies of pesticides exposures and children have reported greater risks than studies of adults, thus suggesting that children may be particularly sensitive to carcinogenic pesticides. Nevertheless, the assessment of exposure to pesticides is always accompanied by uncertainty iin these studies, whether derived from parental occupation or parental reports of use of pesticides

in the home or garden. In general, there is not a simple way to validate this type of information, nor to know what the actual exposure is to the foetus or small child.

2.6.1. Possible causes of children's cancer

Investigating environmental causes of childhood cancer is difficult because of the rarity and multifactorial nature of the disease, the unknown critical time periods for susceptibility, and the lack of experimental studies in young animals that could provide relevant information about how cancer is caused. In addition, international comparisons of incidence rates are hampered by differences in diagnostic practices, cancer classification, and great variability in cancer registeries which record the disease.

The most frequent causes of cancer induced in children are similar to those cited for adults and result from the interaction between genetic and environment factors, such as ultraviolet and ionising radiation, electromagnetic fields (EMFs), viral infections, pharmaceuticals, tobacco, alcohol, some industrial and agricultural chemicals, as well as poor diet and nutritional status.

Reports of clusters of childhood leukaemia are frequent and have caused great concern to both the medical profession and the public in general. However the small sample sizes and generally insufficient information on environmental exposures make it difficult to link any one cluster with a specific hypothesised cause. There is conflicting information on the possible environmental causes of these clusters. However a recent, large-scale study in the UK found leukaemia and other childhood cancers to be associated with living close to industrial plants, particularly where fossil fuels were being combusted or processed (Knox and Gilman, 1997). They may also be links between infections and leukemia.

There is concern that exposure to **pesticides** may be a cause of childhood cancers, in particular leukaemia and brain tumours and the available evidence (Zahm and Ward, 1998) does suggest that pesticides have a possible role in the development of leukaemia. Most of the studies point to increased risks associated with occupationally exposed parents or with the use of home and garden pesticides. Similarly, there is some evidence of an association between elevated rates of brain tumours (particularly in children under five) and home use of flea and tick foggers by their mothers while pregnant.

Ionising **radiation** is a well-established environmental cause of childhood cancer and both *in utero* and postnatal exposures have been linked to elevated childhood cancer rates. High-dose exposures such as those experienced by atomic bomb survivors and children receiving radiation therapy have been associated with elevated rates of acute lymphoblastic leukaemia, acute myelogenous leukaemia, osteosarcoma, thyroid cancer and soft tissue sarcoma. However the risk from low-dose exposures is less clear and beset by conflicting findings. The most compelling evidence for a link with low-dose exposures is an association between childhood cancer and prenatal exposures to diagnostic X-rays Studies of other low-dose radiation exposures, such as exposure to low-level radioactive fallout, residing near a nuclear power plant, and having parents who work at a nuclear facility, have not been clearly linked to cancer risk in children.

Box 8 provides some evidence about early effects of radiation on cell development that appears to cause damage several generations of cells later.

Box 8. Late effects of early damage to cells from radiation?

New evidence is emerging on how small doses of radiation, particularly high linear-energy-transfer particles from absorbed emitters, can damage dividing cells. In the past it was believed that cells either died, were immediately damaged, or survived undamaged. Prof. Eric Wright of the Medical Research Council described a new phenomenon, *genomic instability*, in which apparently normal cells could become abnormal several generations after exposure. In bone marrow, this abnormality could be manifested as leukaemia. Cell divisions are far more numerous in the formation of sperm than ova, suggesting that genomic instability can be transmitted from one generation to another. Dr Carmel Mothersill of the Dublin Institute of Technology described radiation-induced genomic instability in urothelium, which could also give rise to cancer. She pointed out the apparent paradox that preventing cell death could be carcinogenic, and that smoking and other carcinogens could interact with genomic instability.

Dr John Stather, of the National Radiological Protection Board presented the established view that ionizing radiation damages cells by producing double-strand breaks in DNA and that cell death or survival, or immediate damage, were at the roots of epidemiologically detectable consequences. While accepting the existence of genomic instability, he was unconvinced that it affects the interpretation of safe radiation limits or could produce measurable epidemiological effects.

From 13th Low-Level Radiation Conference, 1998, UK, Dec-Jan 1999, as reported in Medicine, Conflict and survival' by D Holstock, Jan/Mar 1999

There is also a suggested association between childhood cancers and electromagnetic fields (EMFs). Many studies have demonstrated weak or ambiguous associations between cancer incidence and proximity to high-voltage power lines but most of these studies had serious limitations. More recent European studies and in particular, a large American study (Linet, 1997) found no association between leukaemia risk and EMF. However several studies are currently underway in Europe and Canada in an attempt to explain the conflicting findings.

Evidence for relationships between childhood cancers and **infectious agents** or **diet** (e.g. consumption of N-nitroso compounds) is suggestive and needs to be confirmed. To date, studies of maternal smoking and use of alcohol have not demonstrated an increased risk of childhood cancer.

Exposure to **sunlight** is a known cause of skin cancer in children, especially of the more malignant melanoma. Excessive sunburns in children of 10-15 years old have been associated with three times the risk of developing malignant melanoma later in life compared to those without excessive sunburns[17].

Occupation Several studies link childhood cancer with occupations where exposures to solvents and paints are associated with leukemias and cancers of the nervous system.

In conclusion relatively little is known about the role of environmental agents in the aetiology of childhood cancers. Except for ionising radiation, investigations of many environmental factors are still inconclusive and further research is required.

2.7. Injuries

Unintentional injuries, such as poisoning, burns, drowning, falls and transport-related injuries are a major threat to the welfare of European children that are not adequately recognised by policy-makers and governments. There is however substantial variation in injury rates across the region, providing an excellent basis for a Europe-wide initiative to learn from best practice and implement effective preventive policies.

Out of every ten children (aged 1-14 years) who die in the European Region, between three and four die as a consequence of injury. This is a considerably larger proportion than is accounted for by other broad categories of childhood death such as cancer or respiratory disease. In 1995, in the countries of the European Union 33% of deaths to children aged 1-14 were due to injuries. This compares with 40% for the countries of Central and Eastern Europe and 34% for the countries of the Newly Independent States.

[17] US EPA (1998) *Children's Environmental Health Yearbook*

Since 1970, average childhood mortality from external causes (injuries) in the European Union has fallen, along with the parallel decline for the countries of Central and Eastern Europe. In contrast, in the countries of the USSR and the Newly Independent States rates have not fallen in the period since 1990.

The most striking feature of the problem of injury mortality in Europe is the huge variation between countries, particularly between those of the East and the West.

Within the countries of Western Europe there is between a two and three-fold variation in mortality between the highest and lowest, but this variation is relatively trivial when compared to the Eastern transition countries, where for many countries in the Newly Independent States the rate can be over eight times higher than in the best in Western Europe.

If mortality rates from external causes in each of the transition countries were reduced to the average of the Western countries, the East-west gap in total childhood mortality would be reduced considerably.

The East-West differences for external causes as a whole are driven mainly by drowning, accidental poisoning, fire and falls. This group of 'other external causes' shows much more pronounced differences between the West and the transition countries than does mortality from either motor vehicle accidents or violence.

The USA and a number of Scandinavian countries, along with Australia and New Zealand stand out as countries which have begun to identify and address the public health burden posed by injuries. These societies have also demonstrated some of the many features of appropriate policy action from which other countries can learn: the importance of raising the public profile of injuries, the central role of concerned civil society organisations and the critical role of research in making the issue visible, assessing effectiveness of interventions and instituting solutions.

However, policy action and public health interventions need to be fine-tuned to local contexts: public health practitioners need to play some part in assuring this adaptation and in interfacing good practice derived elsewhere with the social, political and health system structures in other settings. For example, mobile radar control, which has been successfully used in Austria to enforce traffic speed controls, may be inappropriate, unaffordable or unsustainable given the local circumstances and resource constraints in some CEE/NIS countries. Further research on effectiveness within the transition countries will be required to inform the policy process and to ensure that interventions are based on the best evidence whenever possible. (Leon *et al.*, 1999).

3. Approaches to preventing children's ill health

3.1. Approaches to environment and children's health

3.1.1. Multifactoral causes of disease

Much ill health and many diseases in children are multifactoral. Identifying the causes of ill health in populations is therefore very difficult and quantifying the contributions of environmental exposures to adverse health impacts is even more so, particularly at the level of the child. Adverse health impacts are the results of varying combinations of host genetics, host state (including 'lifestyle' factors such as smoking, alcohol, diet, etc.) and exposures to other environmental stresses, both indoors and outdoors. All these factors can operate at different times, influencing each other in various ways, and causing changes in cells, tissues and functions that may or may not lead to adverse health impacts. The same 'dose' of air pollution for example does not have the same impact because of differences between people, with sensitive groups, such as the elderly, the sick, children, and pregnant women responding more than less sensitive groups. And the same 'exposure' may not lead to the same 'dose' because of biological and activity differences e.g. children (and joggers), who have higher breathing rates.

Several key questions need to be addressed in dealing with children and their environmental health issues:

- What is the nature and strength of the **evidence** for an adverse impact and for the role of the environment in that impact?
- What is the nature of the **impact** (trivial or serious, reversible or irreversible, immediate or long term, large or small numbers affected etc.)?
- What **level of proof** is to be used in making a decision, particularly about whether an *association* between an environmental stressor and an adverse impact is actually *causation?* (**Box 9**)
- Are **exposure or effects avoidance measures available**, and actors identifiable and willing to take action?
- The **cost** and **benefits** of **action** and **inaction**, and their **distribution** between classes, races, ages ,regions and generations?
- How **uncertainties** are to be handled?
- How can **informed consent** and public involvement in 'acceptable risks' be achieved?
- How are the consequences of action/inaction to be **evaluated**?

Box 9. Association and causality

It is often fairly easy to show that a measure of ill-health, e.g. the number of admissions to hospital per day, is **associated** with a possible cause, such as the day-to-day variation in levels of air pollutants. To show that a **causal** relationship exists, a number of guidelines or tests have been developed. These include the consistency of results between different studies, the way in which the results of different studies fit together (coherence); whether there is a 'dose-response relationship' between the proposed causal factor and the effect; and whether the sequence of events makes sense, i.e. the cause always preceding the effect.

Proof of causality is often very difficult, but by the application of these and other criteria, an expert judgement as to whether an association is likely to be causal can often be made. Where effects are likely to be serious and/or irreversible, then a low level of proof, as in the 'precautionary principle', may be sufficient to justify action to remove or reduce the probable causes (EEA/WHO, 1997).

The answers to these questions require good information for effective decision-making, but in practice, a lack of data, information or understanding, or disagreements about the interpretation of the information can lead to delays in preventing public ill health. For example, one of the main weaknesses of animal evidence is the difference between the healthy young rats used in experiments (which breathe through the nose) and a mixed age and health status human population, who partly breathe through the mouths. These three differences (age, health status and mouth-breathing) are the main reasons why experts 'dramatically' under-estimated the health impacts on humans of fine particles in air pollution in 1987 compared to 1997. (WHO, 1997)

The level of proof, used in decision-making is crucial, and it can vary from very high to low, depending on the issue being addressed. For 'sound science', and criminal prosecutions, a high level of proof is required, such as ***'beyond all reasonable doubt'***.

For other purposes in society, such as compensating injured people through the courts, a lower level of proof, such as ***'the balance of probabilities'***, is generally used. In this case society considers that the costs of being 'wrong' in reaching the lower level of proof i.e. the 'false positive' of compensating injured people for injuries that were not caused by the negligence of others, is less costly than being 'wrong' in the other direction i.e. the 'false negative' of not compensating people for the injuries that were caused by the negligence of others. Another example of the use of a low level of proof, or probability, is disaster insurance, where the cost of being wrong when no disaster happens, is generally considered more acceptable than the cost of being wrong in the other direction i.e. where no insurance premiums are paid, and disaster strikes. 'It is better to be safe than sorry ' is the popular expression of this sentiment.

For public health policy-making, where there may be serious and irreversible health impacts, the use of a lower level of proof than used in 'sound' science is recommended in various international agreements, via the 'precautionary principle' (**Box 10**).

Box 10. The Precautionary Principle

This principle featured in the 1992 Rio Declaration on Environment and Development (as Principle 15):

'In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.'

The precautionary principle permits a lower level of proof of harm to be used in policy-making whenever the consequences of waiting for higher levels of proof may be very costly and/or irreversible; the UN Intergovernmental Panel on Climate Change recently used the precautionary principle in concluding that 'the balance of evidence … suggests a discernible human influence on global climate'

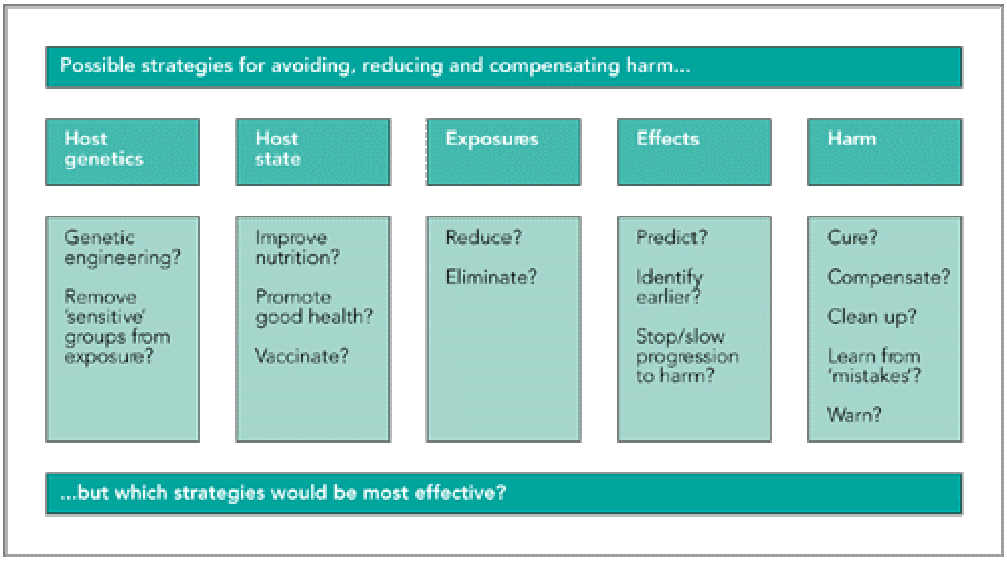
(The EEA is producing a report later in 1999 on the practical applications of the Precautionary principle, following an expert workshop in May this year .It will be entitled, ***'Late Lessons from Early Warnings, 1898-1998').***

3.1.2. Integrated approaches to prevention

The multi-causal disease process also offers several points at which strategies for avoiding reducing or compensating harm can be focused. (**Figure 9**) However, identifying and implementing the most effective strategy is difficult, and involves questions of feasibility (technical, economic and practical), cost-effectiveness and ethics. Responses can also be focused on the individual (behaviour change or medical intervention), or at the community and its environmental exposures. When the response strategy is focused on reducing exposures, say to traffic fumes, there are many points of policy intervention, involving both 'upstream', e.g. the 'driving forces' of transport policy, and 'downstream', e.g. noise barriers. In general, strategies focused 'upstream' will be more effective than those focused 'downstream', partly because of the need to take an integrated approach that embraces the linkages between different parts of transport policy. An integrated approach will also take into account the full range of benefits and costs of policy responses, and allow for adaptation to a modified transport system. For example, policies designed to reduce air pollution from traffic by reducing traffic volumes will also yield substantial benefits from reduced noise, accidents, congestion, less divided communities and

increased freedoms to play, walk and cycle in safety. Such holistic approaches can help counter the common 'tendency to over-estimate the costs and under-estimate the benefits' of policy action.

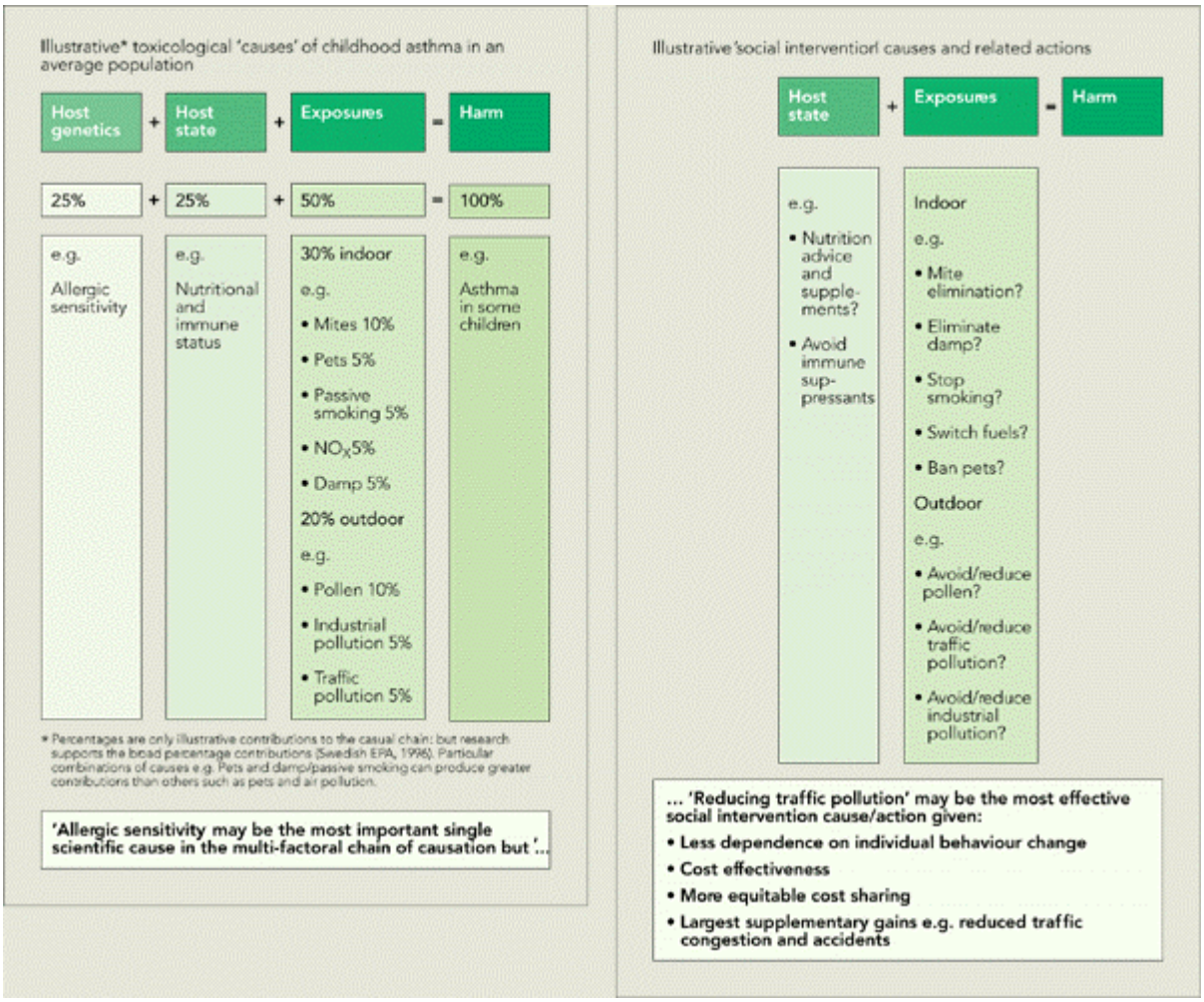
Figure 9: Possible strategies for avoiding, reducing and compensating harm



There may also be differences between causes of ill health that are most important from a scientist point of view, and causes that may be most important from a policy response point of view **Figure 10** illustrates the differences between 'scientific' (via hazard assessment) and 'social intervention' (via risk management) causes in multi-factoral disease processes, such as asthma in children. Whilst genetic pre-disposition or respiratory hyper-sensitivity from pre-natal exposures, diet or indoor air pollution from damp or mites, may be the most important scientific causes of asthma in children, the relatively minor role of traffic pollution may be the most important 'social intervention' cause, given the secondary benefits of a reduction in traffic growth, and the impact of removing one link in a multi-causal chain.

In practice, given the multi-causal nature of diseases like asthma, policy responses are needed on many causes: no single approach can hope to reduce more than a small amount of disease. Integrated approaches to prevention and hazard exposure reductions, as well as more research on the links between environment and health are needed to achieve improved health and well-being in children.

Figure 10: Differences between 'scientific' and 'social intervention' causes in multi-factoral disease processes.



4. Some costs of children's ill health and some action on prevention

The cost of treating and dealing with accidents, disease and behavioural problems of children and young people is enormous whilst the expenditure on potential environmental causes is very small. US figures show that overall, the US spent $405 billion on education in 1995, two thirds of which were devoted to K-16 education. Another $150 billion were spent on criminal justice, health and social welfare programs for children for a total of $555 billion. Yet the total amount of money spent on research related to children in 1995, in all categories of effort, was only $2 billion. (Goldmann, 1999) There is little European data on costs except for asthma and air pollution which is briefly described below.

4.1. Costs of asthma

For example, estimated total **direct** costs for **allergic asthma** in Europe amount to:

- Hospital care EUR 2,068 Mio
- Physician services EUR 2,671 Mio
- Immunotherapy & Drug therapy EUR 1,690 Mio
- **Total** **EUR 6,429 Mio**

Source: UCB Institute of Allergy

These figures do not differ widely from those obtained in other countries or regions of the world and are consistent with the reported costs of about $6 billion for asthma in 1992 in the United States.

There are only a few European studies available to allow an estimation of the **indirect** costs of allergic asthma. However, as studies from various parts of the world, including industrialised and developing countries, have reported similar figures in terms of school or work days lost, extrapolation may be justifiable. 15% of asthmatic patients have a diminished professional or domestic activity versus 5% of non-asthmatic individuals, while 40% of asthmatic are impaired but still lead a normal life.

On the other hand, the indirect costs attributable to caregivers of asthmatic children are likely to differ from one European country to another, depending on the integration of mothers of school-age children in the public work force and economy.

An estimate of the direct and indirect total costs of allergic asthma in Europe (**European Union European Free Trade Association**) amounts to about 20 billion ECU, or 55 ECU per person, or 833 ECU per asthmatic patient.

Much adult disease is laid down in childhood and the cost of prevention is less the earlier the intervention. For example, early brain damage from lead poisoning still causes symptoms 50 years later. (White 1993)

4.2 Costs of Air Pollution

A recent study of particulate matter from traffic alone, in France, Austria and Switzerland, which showed that current levels of small pollution particles were estimated to cause 300,000 cases of bronchitis , and 162,000 asthma attacks in children a year in those countries, also estimated that the costs of this ill health, including impacts on adults, came to 27,000 million EURO, or 1.7% of their GNPs. (WHO, Rome Office, 1999)

The WHO, in its latest report *Making A Difference* states that a rapid growth in literature documents the effects of ill health on children's enrolment, learning and attendance rates in school. The Asian Development Bank studies on Asia point strongly to the effect of better health on capital formation.

'Economists should never forget the intrinsic value of health – or that today's health systems have the tools to vastly improve the welfare of the poor at modest cost. But neither should health professionals forget an important message for presidents and finance ministers: investing in health accelerates economic growth and is one of the very few viable approaches to rolling back poverty.'

(WHO, 'Making a Difference', 1999)

4.3. Some actions to prevent or reduce children's ill health from environmental factors.

- better linkages between exposure and health data via EEA & WHO's 'partnership in action'
- apply the lessons from the histories of thalidomide, DES, lead, etc. and **don't use children as guinea pigs** - especially as, compared to adults, children get little or no benefit from the environmental exposures that we give them
- **put children at the centre of government policies** on housing, poverty elimination, income support, and health.
- more **research** into the environmental causes of ill health in children, especially into neurological diseases.

E.g. there are very few studies of children and delayed effects of acute OP poisoning, despite evidence from adults that delayed psychological deficits occur. There needs to be long term prospective epidemiological studies of the health impacts of OP and OC pesticides, with a focus on intellectual development. There has been virtually no action since the 'early warnings' of Angle in 1968, on the neurotoxicological effects of OP poisonings, even though the extent of these effects 'might exceed the effects currently presented by lead' (Weiss, 1997). Data from poison centres could be the basis for some of these studies.

- **give children relevant legal protection** with safety standards for chemicals that take their special vulnerabilities into account -as in the USA Food Quality Act 1996, which provides an extra 10-fold safety margin for children, as well as provisions for the cumulative exposures of children to pesticides. 10,000 existing pesticide tolerances must be re-assessed by the US EPA by 2006. (The US EPA has also initiated projects on Children's Cumulative Exposure, a Children's Environmental Health index, and a Children's Vulnerability index as part of its response to the Executive order on Children and Environmental Health, 1997).
- **reduce children's exposures** to chemicals, radiation and other potential causes of ill-health, prioritising persistent and bioaccumulating substances, especially pesticides and other toxic chemicals to which children are exposed in food ,water, and consumer products, (such as the phthalates in children's toys), utilising **the precautionary principle** whenever risks are likely to be serious and irreversible.
- give the public the **right to know** what their children are exposed to with adequate consumer product labelling laws and accessible toxic emissions registers, like the toxic release inventories in the USA. There is no equivalent in Europe, despite OECD recommendations, although there are one or two Member State systems e.g. the UK and the Netherlands.

improve the **education and awareness** of parents, teachers and other guardians of children so that they can help create safer environments for them. European equivalents of the American Academy of Pediatrics' "Handbook of Environmental Health for Children", and the "Resource Guide" and training materials for US doctors and nurses produced by the Children's Environmental Health Network, California, would be helpful in this. The EEA will be assisting the newly formed INCHES network (which the EEA , WHO Europe and the US EPA have helped

launch) to produce European versions of these US training and information materials on children and environmental health.

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