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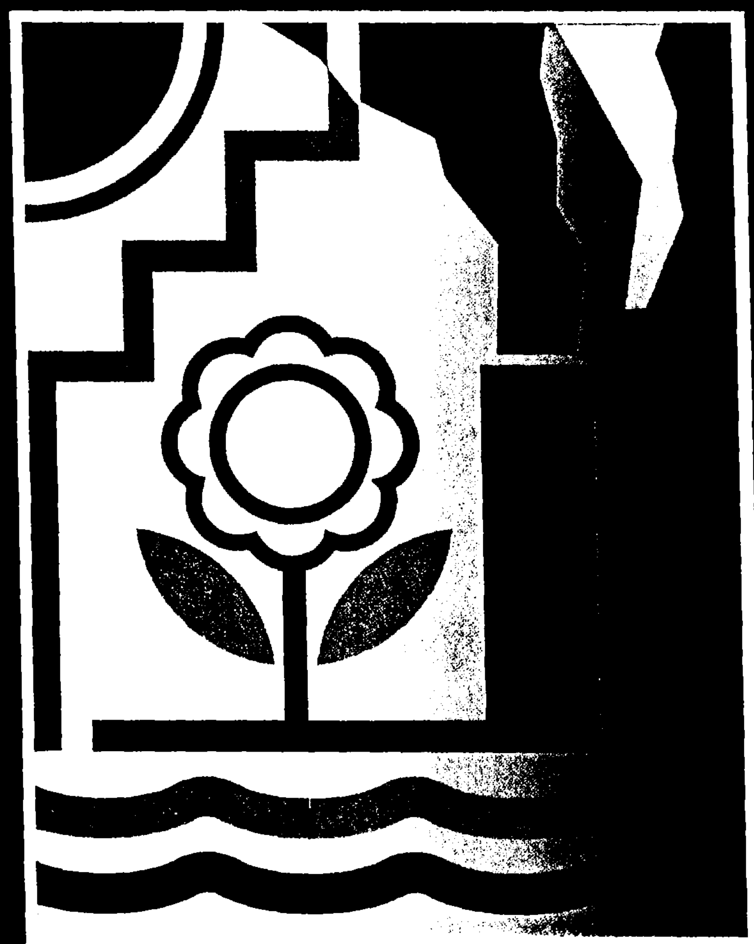
ENVIRONMENT AND HEALTH IN CENTRAL AND EASTERN EUROPE



CLYDE HERTZMAN

A REPORT FOR THE ENVIRONMENTAL ACTION PROGRAMME FOR CENTRAL AND EASTERN EUROPE

Environment and Health in Central and Eastern Europe

Clyde Hertzman

with contributions by

Zoltan Annau, Wendy Ayres, Gordon Hughes,
Michal Krzyzanowski, and Barry Levy

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for Central and Eastern Europe

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This report was prepared for the World Bank by Clyde Hertzman. The report also incorporates contributions by Zoltan Annau, Wendy Ayres, Gordon Hughes, Michal Krzyzanowski, and Barry Levy. The editor was Wendy Ayres. The work was carried out under the general direction of Richard Ackermann. Clyde Hertzman is an Associate Professor in the Department of Health Care and Epidemiology, Faculty of Medicine at the University of British Columbia. He is also a Fellow of the Programs in Population Health and Human Development in the Canadian Institute for Advanced Research.

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Preface

The nature of the problems that we ascribe to environmental pollution, their intensity as threats to public health, and the methods we use to evaluate them and set priorities have all changed dramatically over the last 40 years.

Threats to human health from environmental pollution have come in three classes whose recognition has followed one another over time. The first class might be called traditional occupational diseases. This includes silicosis, silicotuberculosis, acute lead poisoning, and other syndromes which have been recognized to be associated with high dose exposures at work for several centuries.

The second class might be called epidemiologically detectable risks. These are the problems which began to receive attention in the 1960s and 1970s, in the wake of the recognition of the relationship between cigarette smoking and lung cancer. They include the whole family of occupational and environmental cancers, sensitivity syndromes (for example, chemically induced asthma), neurobehavioral syndromes, etc., which require the methods of chronic disease epidemiology to detect because they are usually related to long-term, low dose exposures.

The final class might be called the sub-epidemiologic risks. These relate to problems, such as chemically induced cancers and allergic sensitivity syndromes, which might be due to non-threshold processes. Sub-epidemiologic risks might also arise from problems which pertain to special populations (such as those living near toxic waste sites) which might be exposed at very low doses. In other words, the concern here is focused on putative risks from exposures to industrial chemicals at doses too low to lead to epidemiologically detectable increases in disease rates. Concerns regarding this latter class of threat to human health have developed more recently than the previous classes.

The sub-epidemiologic risks have recently come to the forefront of environmental health in North America, but this is not the situation in Central and Eastern Europe (CEE). When the political changes struck, the region was still in an era in which epidemiologically detectable risks had not yet been recognized and addressed. Moreover, the available evidence from environmental and public health sources strongly implied that in the large hot spots, in old industrial areas, and in communities which were located too close to point sources of pollution, there were, indeed, epidemiologically detectable risks, up to and including risks of mortality.

This raises an important methodological question: if it is true that the nature and intensity of the environmental health problems in Central and Eastern Europe today are similar to those from a previous era in Western Europe and North America, would the most appropriate methods of evaluation and priority-setting be ones currently used for the leading edge problems of advanced industrial societies? This volume is based on the principle that the analysis and priority-setting process should be tailored to the special features of the environmental situation in the region. In Central and Eastern Europe, this means beginning with a search for a rough dividing line between epidemiologically detectable risks and sub-epidemiologic risks, and giving priority to the former.

A draft of this document and the approach it entails was discussed at high-level meeting of health and environment officials from Central and Eastern Europe in Copenhagen, Denmark in March 1993. The meeting was sponsored by the World Health Organization, the United Nations Environment Programme, and the World Bank.

Wilfried Thalwitz
Vice President
Europe and Central Asia,
The World Bank

BASIC FIGURES FOR COUNTRIES IN CENTRAL AND EASTERN EUROPE [1]

	Area (000s sq km)	*Area relative to France*	*1992 Population (000s)*	*Population density per sq km*	*Percent urban*	*Cars* [2]	*Telephone lines* [3]	*Physicians* [4]	*Infant mortality* [5]
Albania	28.8	0.05	3,250	115	36	5	1.4	n.a.	32
Armenia	30.0	0.05	3,680	120	68	79	16.6	38	21
Azerbaijan	86.6	0.16	7,370	84	54	n.a.	9.5	40	32
Belarus	207.6	0.38	10,300	49	65	75	17.3	40	15
Bulgaria	110.9	0.20	8,500	77	69	171	27.2	31	16
Croatia	56.5	0.10	4,790	85	n.a.	135	20.1	n.a.	n.a.
Czech Republic	78.9	0.14	10,320	n.a.	n.a.	261	19.0	n.a.	10
Estonia	45.1	0.08	1,550	35	72	211	22.9	48	13
Georgia	69.7	0.13	5,470	79	56	n.a.	9.2	59	19
Hungary	93.0	0.16	10,310	111	66	187	14.6	29	15
Latvia	64.5	0.11	2,640	41	71	152	27.0	50	17
Lithuania	65.2	0.12	3,760	58	68	161	22.9	45	16
Moldova	33.7	0.06	4,360	130	47	51	12.0	40	23
Poland	312.7	0.57	38,370	122	63	176	11.5	20	14
Romania	238.0	0.43	22,750	97	53	79	11.5	18	23
Russian Federation (Eu	4,253.0	7.71	115,050	27	74	n.a.	15.6	48	20
Slovak Republic	49.0	0.09	5,300	n.a.	n.a.	n.a.	16.8	36	13
Slovenia	20.3	0.04	2,000	99	n.a.	320	25.9	n.a.	8
Ukraine	603.7	1.09	52,130	86	67	73	15.0	43	18
France	551.5	1.00	57,370	103	73	422	51.0	29	7
Netherlands	37.3	0.07	15,180	404	89	375	47.6	24	6

n.a. No statistics available.

1/ Refers to most recent year for which data are available. Figures for population, population density, percent urban are for 1992; car figures for Albania and Armenia are 1991, for Hungary 1992, for all others 1993; telephone lines for countries of Central and Eastern Europe 1993, for France and the Netherlands 1991; for physicians and infant mortality, 1990.

2/ Passenger cars per 1,000 inhabitants.

3/ Main telephone lines per 100 inhabitants.

4/ Physicians per 10,000 inhabitants.

5/ Number of deaths before age one per 1,000 live births.

6/ Figures for cars, telephones, physicians, and infant mortality are for the Russian Federation as a whole, not just European Russia.

Sources: Area, population, population density, and percent urban: World Bank. 1994. *Social Indicators of Development.*
Passenger cars, *International Road Federation. 1994. International Road Statistics 1989-1993;*
Telephone lines: International Telecommunications Union (ITU) and OECD. 1994. *Telecommunication Indicators for Economies in Transition;* ITU. 1992. *European Telecommunication Indicators.*
Physicians and infant mortality: World Bank. 1994. *World Development Report 1994*;

Executive Summary

Introduction

The purpose of this report is to evaluate the influence of environmental pollution on human health in comparison with other determinants of health in Central and Eastern Europe; to summarize current knowledge about locations in Central and Eastern Europe where environmental pollution has influenced human health; and to identify the principal types of environmental exposure which are affecting human health and could be subject to remediation through concerted environmental action.

In general, there have been few well-designed studies of the effects of environmental pollution on human health, so that environmental exposures have been inadequately characterized. The people of Central and Eastern Europe (CEE) have had to contend not only with environmental problems, but also with many other threats to their health, from social conditions, behavioral and lifestyle factors, and shortcomings in medical care. While environmental exposure is not the only threat to health in the region, the evidence suggests that health damage due to pollution is significant.

The Determinants of Health

What has been the relative contribution of environmental pollution to human health in Central and Eastern Europe? One approach to answering this question is to trace the causes of the widening life expectancy gap between countries of Central and Eastern Europe and Organisation for Economic Co-operation and Development (OECD) countries over the past three decades.

The evolution of life expectancy in CEE countries has undergone two phases. Until the mid-1960s, rapidly declining infant mortality rates led to a near convergence of East-West life expectancy. Since the mid-1960s, life expectancy in the countries of Central and Eastern Europe has fallen behind Western Europe, North America and Japan by approximately 5 years. Life expectancy in the OECD countries has continued to rise, while in CEE countries life-expectancy has remained static or even declined. This gap is primarily attributable to differences in mortality from chronic diseases in mid-life. However, the reasons for these differences are not yet clear. The explanation must involve some combination of factors in the socio-economic and physical environments, behavior patterns and social habits such as smoking and diet, and differences in health care.

The analysis shows that the impact of environmental pollution on health in Central and Eastern Europe has not been as dramatic as some popular journalistic descriptions would suggest. Instead, environmental pollution can be seen in context as one of a series of competing determinants of health. On average, the relative impact of environmental pollution on life expectancy in heavily polluted areas of Central and Eastern Europe turns out to be no more important than shortcomings of medical care and life style factors such as diet, smoking and exercise.

On the other hand, environmental pollution is clearly damaging health. Life expectancies in rural areas in Poland have surpassed those in urban areas in recent years, a highly unusual demographic trend which is associated with the fact that environmental pollution is concentrated in urban areas. In the Czech Republic, there is good evidence that dust and sulfur dioxide pollution increase the risk of infant mortality. Moreover, life expectancy in the Czech Republic is lower in regions affected by heavy air pollution. Recent evidence from studies done in the West will allow us to estimate the impact of respirable dust on overall mortality in Central and Eastern Europe. Preliminary estimates show that the effect is likely to be substantial.

Health and Environmental Pollution

Data from twelve countries in Central and Eastern Europe have been used to tentatively identify locations where people are exposed to specific health risks from particular kinds of pollution. (The specific locations are described in Annex 4.) The most common health problems are the result of exposures to a fairly narrow range of pollutants:

- *Lead in Air and Soil.* If children are overexposed to lead, their mental development may be retarded, with long-term effects on their educational attainment. Lead pollution comes mainly from industries such as lead and zinc smelters. People living near main roads may be affected by lead from vehicle exhausts.

• *Airborne Dust.* This may cause acute and chronic respiratory conditions, such as sinusitis, pharyngitis, bronchitis, conjunctivitis, and asthma. Exposure to dusts and other gases may also cause lung cancer and abnormal physiological development. Dust comes from burning coal in household furnaces, small enterprises, power and heat plants, and metallurgical industries. In some of the worst affected places, high concentrations of suspended particulates are combined with high levels of sulfur dioxide. All countries for which data were reviewed have places with high cadmium emissions caused by energy combustion and emissions from the non-ferrous metal industry.

• *Sulfur Dioxide and other Gases.* These come mainly from power and industrial plants, as well as households using high-sulfur coal or high-sulfur fuel oil (3 percent sulfur) typically imported from Russia. In the longer term, transportation will contribute significantly to emissions of nitrogen oxides.

Pollutants in food and water have some effect on health, but are on average less prevalent and/or less clearly related to ill health than lead, dust and airborne gases. The most important contaminants in food and water in Central and Eastern Europe are:

• *Nitrates in Drinking Water* from inadequately maintained/designed or improperly located rural septic tanks, feed lots and agricultural enterprises, and inappropriate fertilizer application.

• *Contaminants in Food* from the inappropriate handling or disposal of lead dust, heavy metals, pesticides, polycyclic aromatic hydrocarbons, and chlorinated organics such as PCBs. Many of these substances have well-documented toxic properties, yet the human health significance of ingestion at largely unknown doses is uncertain.

• *Other Contaminants in Water* from the inappropriate handling or disposal of water contaminated with arsenic, viruses/bacteria, pesticides, radionuclides, and chlorinated organics. Waterborne arsenic and viruses or bacteria have been directly implicated in a number of episodes of human disease in the region. The other contaminants, like their counterparts in food, represent risks of unknown prevalence, magnitude, and certainty.

In assessing the most important health problems from pollution, the following considerations apply:

• *Dust versus Gases.* The impact of respirable dust on mortality (in addition to its role in respiratory morbidity) is being recognized from studies of a variety of major urban centers in the West where ambient dust concentrations are much lower than in many places in Central and Eastern Europe. The list of places in the region with human health problems associated with air pollution include some where the primary problem is dust; some where it is one or more gases or vapors; and many where the problem is a combination of the two.

• *Air versus Water.* Airborne pollution is almost certainly a greater threat to human health than waterborne pollution in Central and Eastern Europe. Polluted air is harder to avoid than polluted water. Thus, any country which has zones where ambient air quality could affect human health tends to have evidence that it has affected health, and the more people who live in the zone, the greater the public health significance of poor air quality. For water pollution, larger settlements tend to have more resources available to replace polluted surface water with deep ground water and to treat microbiologically contaminated sources with coagulation and chlorination. The situation in rural areas is somewhat different. In the countryside the only alternative to surface water will usually be shallow ground water, which is vulnerable to nitrate contamination.

• *Definition of Pollutant Categories.* Some of the exposure categories which have been used here may seem very broad, at least from the perspective of exposure assessment and epidemiologic toxicology. This is because they represent a compromise between a desire to come to terms with the rich knowledge base of environmental health, on the one hand, and the necessity of using exposure categories which are practical from the perspective of remediation, on the other hand.

Environmental Investment Priorities to Protect Human Health

Because resources for environmental improvement are scarce in Central and Eastern Europe, it is necessary to set priorities which reflect the urgency and importance of environmental concerns. The damage to human health due to exposure to environmental pollution is the first environmental concern in the region. Evidence from selected OECD countries suggests that the costs of damage to health due to poor environmental quality almost certainly outweigh the costs of damage to physical or natural capital.

Investments, policies, and institutional actions which will effectively reduce or eliminate specific environmental exposures will have a positive impact on human health. Furthermore, the potential benefits of reducing health problems such as neurobehavioral dysfunction due to lead overexposure and acute and chronic respiratory problems associated with dusts and gases will likely have positive economic impacts in addition to meeting social and humanitarian objectives.

Market reform, industrial restructuring, and environmental incentives and regulations should gradually address a large part of the emissions causing the most serious health damage in the region. Projections of the levels of reduction in emissions for each major air pollutant have been made for (relatively) high and low emission countries in the region, based on alternative reform scenarios. In many countries, total emissions of particulates and sulfur dioxide are expected to decline by 70 percent or more in the period 1990-2005, even if their Gross Domestic Product recovers to pre-reform levels. Declines of 50 percent or more in other air pollutants such as nitrogen oxides and airborne lead are likely. However, in order to sustain these declines over time, and to achieve them in countries where some pollution levels are very high to begin with (especially in the former Soviet Union), public investment will be required to speed up the process of environmental improvement or to address environmental problems which will persist in spite of the transition to a market economy.

New investment is only one part of the way that economic change will bring about environmental improvement. Indeed it may not even be the most important part. Major improvements can be made with minimal resources, simply by ensuring that plant and equipment is properly maintained, that environmental controls work according to specification, and that leaks and spills are promptly dealt with. In large part this is a matter of commitment to and pride in achieving a better environmental record. Thus, trivial but symbolic steps such as publicizing the achievement of plants or work groups which make significant environmental improvements can produce surprisingly large benefits. It follows that investments must be reinforced by expenditures on management and worker training and other programs to ensure they bring the best possible returns in terms of improvements in environmental quality.

Immediate Priorities for Environmental Investments

The immediate priorities for environmental investments to protect health are:

- The installation of dust collection systems and filters to non-ferrous metal smelters which are located, say, within 5 kilometers upwind of significant centers of population. Priority should, in particular, be given to lead, zinc, copper and aluminum plants. In the longer term, pollution abatement strategies should be developed to reduce lead emissions from transport sources.
- The installation of equipment to reduce emissions of dust, smoke and soot, and carbon monoxide from iron and steel plants, especially those relying upon open hearth furnaces.
- Investments either to replace coal by gas or to permit the burning of smokeless solid fuels in district heating plants, commercial premises and households in those towns and cities where the average ambient concentration of particulates during the winter months exceeds 150 micrograms per cubic meter.
- Assistance to facilitate the proper installation of domestic septic tanks and the appropriate disposal of manure from intensive livestock operations in rural areas where levels of nitrates in drinking water drawn from shallow wells typically exceed 10 milligrams of nitrate-N per liter.

The Need for Remediation-oriented Health Data

To evaluate the effectiveness of investments, policies, and institutional actions to reduce health damage from pollution will require reliable data on environmental conditions and health outcomes. In the short term, priority should be given to collecting and evaluating data on the effectiveness of (a) reducing exposures to lead; (b) reducing threats to respiratory health, and (c) controlling morbidity and mortality from nitrates in drinking water.

Note

1. The proposed threshold is based on the standard WHO guideline, which is identical to the US guidelines for the quality of public drinking water. The threshold allows a considerable margin of safety so that a less strict threshold of 20 mg/l of nitrate-N would prevent almost all cases of methemoglobinemia. The EC drinking water standard specifies that nitrates should not exceed 50 mg/l of NO_3 which is equivalent to 11 mg/l of nitrate-N.

ECONOMIC INDICATORS FOR COUNTRIES OF CENTRAL AND EASTERN EUROPE, 1991-94

	GDP [1]				*Industrial production* [1]				*Agricultural production* [1]				*Unemployment rate (%)*				*Gross foreign debt (billion US$)*		
	91	92	93	94	91	92	93	94	91	92	93	94	91	92	93	94	91	92	93
Albania	-27.1	-9.7	11.0	..	-40.0	-60.0	-10.0	..	..	18.0	14.4	..	..	..	18.0	14[7]	0.6	0.7	0.83
Bulgaria	**-16.7**	**-5.7**	**-4.2**	..	**-27.5**	**-7.7**	**-9.0**	**-4.8**[4]	**-13.2**	**-9.0**	..	..	**10.2**	**15.6**	**15.9**	**13.4**[9]	**11.4**	**14.2**	**14.7**
Czech Republic	-16.0	-7.0	0.0	3.5[2]	-25.0	-11.0	-5.0	-4.6[8]	-14.0	-12.0	-1.0	..	4.0	3.0	3.0	3.0[9]	9.3	9.5	8.7
Estonia	**-11.8**	**-23.0**	**-7.8**	..	**-9.5**	**-38.7**	**-28.4**	..	**-20.8**	**-21.3**	..	..	..	**1.5**	**1.7**	**2.1**[8]	**0.04**	**0.07**	**0.09**
Hungary	-11.9	-4.3	-2.3	..	-19.1	-9.8	4.0	7.8[3]	-5.0	-23.0	-6.0	..	8.5	12.2	12.1	11.0[9]	22.7	21.4	24.5
Latvia	**3.5**	**-32.9**	**-12.0**	..	**0.0**	**-35.1**	**-39.6**	..	**-3.6**	**-13.0**	**-2.8**	..	..	**2.3**	**5.3**	**32.4**[3]	**0.08**	**0.02**	..
Lithuania	-12.8	37.7	-17.0	..	-1.3	-51.6	-46.0	..	-8.0	-24.0	-8.0	..	..	1.0	1.6	3.2[9]	0.1	0.13	..
Poland	**-7.6**	**1.5**	**3.8**	..	**-14.0**	**4.2**	**7.9**	**9.9**[5]	**-0.9**	**-11.0**	**1.5**	..	**11.8**	**13.6**	**16.1**	**16.6**[9]	**48.4**	**49.9**	**47**
Romania	-13.0	-13.6	1.0	..	-18.7	-21.8	1.3	-1.8[4]	-5.0	-12.1	14.0	..	2.9	8.4	10.2	10.8[9]	1.9	3.4	4.4
Russia	**-9.0**	**-19.0**	**-12.0**	**-17.0**[5]	**-8.0**	**-18.8**	**-16.0**	**-25.8**[5]	**4.7**	**-9.0**	**-5.0**	**-4.5**[2]	**0.1**	**1.0**	**1.4**	**1.6**[9]	**67**	**77.7**	**83.5**
Slovak Republic	-16.0	-6.0	-4.0	3.6[2]	-25.0	-13.0	-14.0	3.0[6]	-14.0	-12.0	-7.0	..	12.0	1.0	14.0	13.9[8]	9.3	9.5	3.4
Slovenia	**-9.3**	**-6.5**	**1.0**	..	**-12.4**	**-13.2**	**-2.8**	**5.8**[4]	**-1.0**	**-17.0**	..	..	**10.1**	**13.3**	**15.4**	**14.6**[7]	**1.8**	**1.8**	**1.9**
Ukraine	-10.0	-17.0	-14.0	-34.0[2]	-13.0	-15.0	-16.0	-38.0[4]	-4.0	-9.0	-1.0	-5.0[2]	0.0	0.0	0.3	0.3[2]	..	10	..

.. No statistics available

1/ Percentage change over the same period of the previous year.

Latest period for which data are available:

2/ January-March
3/ January-April
4/ January-May
5/ January-June
6/ Feb
7/ April
8/ May
9/ June

Sources: European Commission, Directorate-General for Economic and Financial Affairs. 1994. Economic Trends, Supplement A (8/9).

Chapter One

Introduction

This report has been written to fulfill three objectives:

- *first*, to evaluate the influence of environmental pollution as a determinant of health in comparison with other determinants of health in Central and Eastern Europe;
- *second*, to summarize current knowledge about locations in Central and Eastern Europe where environmental pollution has influenced human health; and
- *third*, to identify the principal types of environmental exposure which are affecting human health and could be subject to remediation through a concerted environmental action plan.

Human health concerns have long served as a principal basis for environmental standard setting and intervention among the countries of the Organisation for Economic Co-operation and Development (OECD). New knowledge of the toxic effects of even low doses of lead on children have led to policies to reduce and eliminate lead in gasoline. Similarly, evidence that particular chemicals cause cancer has resulted in increasingly stringent controls on their production, use, and disposal. At present, increasingly sophisticated methods of risk assessment are being used by regulatory agencies in the United States and elsewhere to estimate the risks to human health of environmental exposures. This new information is being used to set environmental policy.

Are environmental conditions in Central and Eastern Europe damaging health? If so, what are the key pollutants causing the most serious health damage? What are the interventions likely to provide the largest benefits for the resources spent? It is not a simple matter to answer this question. The populations of Central and Eastern Europe are large and environmental conditions vary widely from locality to locality throughout the region. In general, information about environmental quality has been scarce and studies of the impacts of environmental exposures on human health have been inadequate in both number and design. Furthermore, there are many other factors affecting the health of people of Central and Eastern Europe, including social conditions, behavioral and lifestyle factors, and poor quality medical care. It is not easy to disentangle the impacts of environmental exposures from other health risks. Still, while environmental exposure is not the only threat to health in the region, the evidence suggests that health damage due to pollution is significant and that action to reduce exposures will provide substantial benefits.

What has been the relative contribution of environmental pollution to human health in Central and Eastern Europe? One approach to answering this question is to trace the causes of the widening life expectancy gap between countries of Central and Eastern Europe and OECD countries over the past three decades. The life expectancy gap is a remarkable phenomenon which provides an opportunity to make large-scale comparisons of the impact on health status of social conditions, environmental pollution, behavioral and lifestyle factors, and inadequate medical care. The analysis presented in Chapter 2 shows that the impact of environmental pollution on health in Central and Eastern Europe, while significant, has not been as dramatic as some popular journalistic descriptions suggest. Chapter 3 presents evidence regarding the impact on health from environmental exposures and identifies the key pollutants damaging health. The evidence shows that morbidity due to air pollution in particular is widespread. Together, Chapters 2 and 3 describe what the health impact of environmental pollution in the region has been, and what it has not been.

The final section discusses investment priorities to protect human health in the region. These investment priorities follow from the analysis of this report and form the basis for the major recommendations contained in the *Environmental Action Programme for Central and Eastern Europe* submitted to the ministerial conference in Lucerne, Switzerland, on April 28–30, 1993.

Chapter Two

The Determinants of Health in Central and Eastern Europe

The patterns of health and disease among populations of Central and Eastern Europe differ greatly from those of OECD countries. While there are variations among countries of Central and Eastern Europe, in general life expectancy for both males and females is much lower there than in the OECD countries. This gap first appeared in the 1960s and has been widening over the past three decades.

What are the reasons for the widening life-expectancy gap between countries of Eastern and Central Europe (East) and OECD countries (West)? There are many possible explanations. Some have suggested that low life expectancies in the East may be due to high environmental pollution, difficult socio-political conditions, lifestyles characterized by diets high in fat and heavy smoking, and poor quality medical care. The purpose of this section is to identify the relative contributions of different factors to the life expectancy gap which emerged between the West and the East between the 1960s and the 1980s.

The Evolution of the East-West Life Expectancy Gap

The evolution of life expectancy in the countries of Central and Eastern Europe has passed through two distinct phases since World War II. First came a phase of rapid convergence with Northern and Western Europe and North America, which historically had higher life expectancies. This phase began in the late 1940s throughout Central and Eastern Europe, in the aftermath of World II, and continued until the mid-1960s. (Its end date, however, is somewhat indistinct, varying from the early 1960s in the former Czechoslovakia to the early 1970s in Bulgaria.) This convergence was the result of rapid increases in life expectancy in the East concurrent with slower increases in the West.

The second phase, which has continued to the present, has involved a re-emergence of the East-West life expectancy gap. During this phase, life expectancy in the West has continued to rise while life expectancy in the East has stopped rising, or has even been declining. The two phases are illustrated graphically in Annex 2.1 for males and Annex 2.2 for females.

The reasons for the narrowing life expectancy gap are very different from those characterizing its later re-emergence. The rapid improvements in life expectancy in the East that started immediately after World War II were due primarily to a sharp decline in infant mortality. In the late 1940s and early 1950s, infant mortality rates in the East were markedly higher than in the West. But by the 1960s the difference had been dramatically reduced. Annex 3.1 and 3.2 show this convergence between East and West. For instance in 1952, infant mortality rates in the former Czechoslovakia, the lowest in the East, were 61.6 and 48.9 per 1,000 live births for males and females, respectively. By comparison, infant mortality rates in Sweden in 1950 were 24.3 for males and 18.5 for females. By the early 1960s, this gap of 37.3 deaths per 1,000 live births in male infant mortality had narrowed to less than 8.7, while for females the gap had shrunk from 30.4 deaths per 1,000 live births to 6.9. In Poland and Hungary, infant mortality rates continued to converge rapidly to Western levels until the mid-1970s. Thereafter, while infant mortality continued to decline in most countries of Central and Eastern Europe, there was not enough uncontrolled mortality left in infancy to influence life expectancy trends very much.

The reasons for the re-emergence of the life expectancy gap between East and West appear to be due mainly to differences in health status after middle age in the two regions. In general, life expectancies for those *older than age 30* have not improved much, if at all, in the countries of Eastern and Central Europe. This is especially true for males. In the West, life expectancies for males have improved during the last three decades, while in the East, life expectancies have been stagnant or have even declined. Life expectancies for females over age 30 have improved in the East during the post-war period, but not by as much as in the West. The following table illustrates these patterns aggregated over seven countries.

In summary, the evolution of life expectancy in the East has undergone two phases. During the first, lasting from the late-1940s until the mid-1960s, rapidly declining infant mortality rates led to a near convergence of East-West life expectancy. During the second phase, lasting from the

Table 2.1 The emerging gap in life expectancy after age thirty

	Males			*Females*		
	1946-52	*1984-87*	*Change*	*1946-52*	*1984-87*	*Change*
CSFR	39.1	39.5	-0.2	43.0	46.2	3.2
Poland	38.9	39.4	0.5	43.0	46.9	3.9
Hungary	39.6	38.2	-1.4	42.7	45.5	2.8
Canada	41.6	44.9	3.3	44.9	51.0	6.1
US	40.0	43.7	3.7	44.9	49.7	4.8
Sweden	43.0	45.6	2.6	44.6	51.1	6.5
Japan	36.7	46.9	10.2	40.0	52.3	12.3

Source: Hertzman 1992 (a)

mid-1960s to the present, East-West differentials in survival re-emerged, due primarily to differential survival starting in middle age.

A New Approach to Analyzing the Life Expectancy Gap

The evolution of life expectancy trends in Japan forces us to think beyond the usual explanations for international differentials in life expectancy. Japan now has the highest life expectancy in the world, with both low infant mortality rates and high supplementary life expectancy for males and females from early middle age onwards. Furthermore, Japan began the post-war period with lower life expectancies than the East. Why has Japan been so successful in improving life expectancies while other countries with similar per capita incomes have not?

In the past, analysts tended to assume that beyond a certain level of per capita income, there were few additional health gains with increasing prosperity. Here we look beyond pure economic factors to explain international differentials in life expectancy to socioeconomic conditions, including such phenomena as social morale. We assume that the socioeconomic conditions of a society can directly influence the health status of the population. This approach is based on an analogy between life expectancy gradients by socioeconomic class within a given society, and life expectancy differences between societies which differ in their level of socioeconomic development.

Conceptual and Accounting Framework

A broad framework is needed to evaluate the evolution of international differences in life expectancy. To be useful, the framework should allow us to consider a full range of possible determinants of health. The following discussion presents such an approach, which serves both as a conceptual and as an analytical accounting framework for the determinants of health across populations.

The framework can be represented as a cube (Figure 2.1), with the three axes representing the three key dimensions for analysis. These are labeled as stages of the life cycle, population partitions, and sources of heterogeneity. In this context, heterogeneity means variations/differences/inequalities in health status. The three dimensions were chosen specifically to address differences in health status between defined populations, and do not constitute a general model of health and disease.

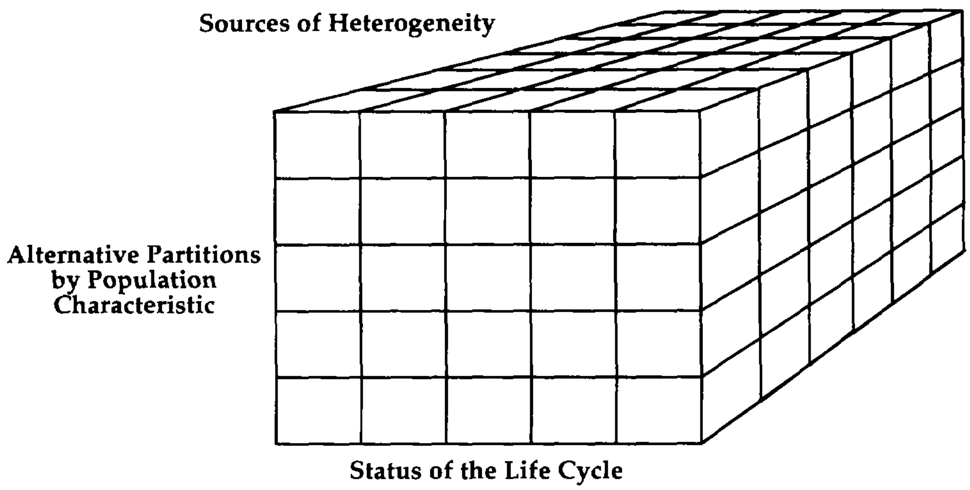
STAGES OF THE LIFE CYCLE. The life cycle is fundamental to the study of heterogeneities in health status because it is the basis of biological change in all individual organisms. Here we identify four stages in the life-cycle during which different types of diseases or conditions are predominant. The perinatal period is a subdivision of the life cycle that is so important that its statistics have often been used as major health indicators for populations (e.g. perinatal mortality rate and birth weight distribution). The period of "misadventure" extends from less than one year to the age at which chronic diseases of middle life begin to have significant impact. In the West, this point may be in the mid-40s, but in the East may be in the late-30s. During this time, the principal threats to health are not disease-based but rather accidents, violence, and suicide. In general terms, the East-West life expectancy gap *cannot* be explained by health outcomes in this period.

The period from ages 45 to 74 years may be called the period of "premature" chronic degenerative disease. During this period, heart disease, stroke, arthritis and cancer are the principal diseases which threaten health and life. The term "degenerative" is used here not to indicate predestination or inevitability, but to highlight the fact that previous decades of "wear and tear" (as well as a rich diet, lack of exercise, smoking, etc.) are significant causal influences. These chronic conditions are so prevalent in the later years of this age range that one may rightly term their occurrence by mid-life as premature—reflecting an accelerated natural history in such individuals. It is the *relative* increase in mortality from these conditions in the East, compared to the West, which characterizes the East-West life expectancy gap.

The age of 75 is arbitrarily identified as the onset of the period of more generalized senescence, during which time health status is often determined by the late and usually less specific effects of chronic degenerative disease throughout the body, leading to multiple organ system dysfunction. Differential survival in this period is not a principal contributor to the East-West life expectancy gap.

The life cycle approach focuses attention on differential mortality at a specific stage of the life cycle: the period of

Figure 2.1 Model for investigating heterogeneities in population health status



Stages of the Life Cycle
1. Perinatal: pre-term to 1 year
2. Misadventures: 1–44 years
3. Chronic disease: 45–74 years
4. Senescence: 75+ years

Population Partitions
1. Socioeconomic status
2. Ethnicity/migration
3. Geographic
4. Gender
5. Special populations

Sources of Heterogeneity
1. Reverse causality
2. Differential susceptibility
3. Individual Lifestyle
4. Physical environment
5. Social environment
6. Differential access to/response to health care services

premature chronic degenerative disease. But this is not necessarily the time at which the principal determinants of differential mortality begin to have their biological effect. Since the framework attempts to account for between-population differences in health status it must, by definition, begin by recording the expression of health status and then work backwards in time to explore its determinants.

POPULATION PARTITIONS. Populations can be partitioned according to any number of different characteristics, but the interesting partitions are those which show important differences in health status across population sub-groups in many diverse settings. For instance, socioeconomic status might be broken up into quintiles based on income, occupation, or education (or combinations thereof). A number of studies have found significant gradients in life expectancy and health status across such quintiles which have persisted over decades, despite major public policy initiatives in health and social services to reduce them. Other partitions which also demonstrate differences in health status include ethnicity and migration, geographic location, and gender. Here the primary partition is "industrialized nations" and the sub-groups are simply "East" and "West."

SOURCES OF HETEROGENEITY. There are many types of causal pathways or mechanisms which might lead to the differences in health status which are observed across population partitions and stages of the life cycle. Each has radically different implications for how we think about the origins of health and disease, and about policies to address them. Discussion often focuses on the following six mechanisms:

a) *Physical environment.* Differential exposures to physical, chemical, and biological agents at home, at work, and in the community cause differences in health status.
b) *Differential access to or response to health care services.* Differences in health status may be related to differences in care seeking behavior, the quality of health services and access to them, or to differential outcomes for a given treatment.
c) *Individual lifestyle.* Health habits and behaviors of those in different sub-groups result in different risks of particular life-threatening or disabling conditions.
d) *Social and economic environment.* Differences in social and economic conditions in which people live result in differential health outcomes. Important conditions which may affect health include social isolation, deprivation, stress, and a sense of control.

The final two sources of heterogeneity have to do with the way we conceptualize the problem.

e) Reverse causality. The actual causal pathway is posed in reverse of what is initially supposed. For example, if the prevalence of persons with mental health problems were higher in the city than the suburbs, the reverse causality approach would ask "to what extent do persons with mental health problems migrate to the cities, rather than the cities being a source of threat to one's mental health?"

f) Differential susceptibility. Given levels of the partition represent differences in inherited biologic potential or else changes in the level of the characteristic are dependent, in part, on "biological host factors" which also determine health status. For instance, the argument may be made that upward social mobility is itself based on inherently favorable characteristics of the individual (e.g. as a result of genetic or early childhood exposures) which also determine better prospects for health status.

Competing Explanations for the Current Life Expectancy Gap

The six sources of heterogeneity identified above are reflected in five approaches to the East-West life expectancy gap. These five approaches are discussed in the remainder of this chapter.

The historical long wave

This approach, which is related to both *reverse causality* and *differential susceptibility* begins with life expectancy data from "Mitteleuropa" reaching back into the 19th Century, which show that East-West differences in life expectancy have been the norm over the past hundred years, with patterns of life expectancy in the East lagging behind the West by a generation or so. In this context the phase of convergence in life expectancy after World War II appears to be an anomaly which can easily be explained as follows. In the post-war period, the East experienced a decline in infant mortality similar to the one that had occurred earlier in the West. However, during this period, the West was experiencing an increase in mortality from chronic diseases and therefore was not making significant gains in life expectancy. Thus, the period of convergence was a historical artifact, and the long-run trend was restored when the West entered a period of postponement of mortality from chronic disease and the East, *inevitably*, started to experience increased mortality from chronic diseases.

In the extreme, this approach leads to two conclusions, namely, that chronic disease mortality will inevitably begin to decline in the East, and, presumably, that no special measures need to be taken to assist the process.

At first glance, the historical long wave approach appears difficult to refute. By definition, it is solidly grounded in the empirical evidence of East-West life expectancy patterns, and it cannot easily be challenged by further analysis of these patterns. The principal point of vulnerability is the presumption that the East's current period of stagnation or decline in post-middle age supplementary life expectancy must *inevitably* have followed the period of decline in infant mortality. In order for the process to be inevitable, the infants whose mortality was prevented during the period of declining infant mortality would have to be more fragile than the infants who would have survived anyway. These fragile infants would have to reach middle age and begin to die of chronic diseases (primarily circulatory diseases) at higher rates than their hardier siblings. In other words, the increase in chronic disease mortality would have to follow the decline in infant mortality rates by at least 30–40 years. In the case of the East, infant mortality declined most dramatically in the 1950s, but increases in chronic disease mortality were notable beginning in the 1960s. The timing is wrong for the fragility hypothesis, or, at least, a parsimonious rendering of it.

In addition, the Japanese experience does not support the historical long wave approach. During the post-war period, Japan, like the East, experienced a rapid decline in infant mortality. But it was not accompanied, or followed, by notable increases in chronic disease mortality. In fact, Japan experienced rapid gains in supplementary life expectancy after age 30 during and after the period when infant mortality was declining. It might be argued that comparisons with Japan are unfair since immediately after the war, Japan was merely recovering a level of public health that had been achieved before the war and lost through devastation. Still, the Japanese experience shows that there is no inevitable historical sequence of declining infant mortality and stagnating or declining supplementary life expectancy from middle age onwards.

Historical comparisons of the evolution of life expectancy between the Baltic countries and Finland also provide important evidence to refute the historical long wave approach. The Finnish experience is vital because it was part of the Czarist empire until 1917, and, like the Baltics, experienced a period of independence between the wars. However, following World War II, Finland remained independent while the Baltics were reincorporated into the Soviet Union. This makes the historical comparison of the evolution of life expectancy a kind of quasi-experiment, with all variables held constant except the nature of the post-war political and economic system.

Table 2.2 contains data for Finland and Latvia. These two countries emerged from more than a century of Czarist domination with virtually identical life expectancies. This similarity remained unchanged throughout the interwar period and afterward until the late 1960s! During the 1970s and early 1980s, a life expectancy gap emerged: 6 years for males and 4 years for females. This is the best evidence we have so far that the life expectancy gap cannot be attributed to a historical lag of East behind West, or to changes which were evident immediately following the establishment of the Soviet Union. The gap must be firmly rooted in East-West differences in the conditions of life during the 1960s, 1970s, and 1980s.

The contribution of the chemical and physical environment

This approach attempts to determine the extent to which differential exposures to environmental pollution are responsible for the East-West life expectancy gap. The life expectancy gap started to widen during the same period that the countries in the West started to address the problems of air, water, soil, and food pollution. While countries of Eastern and Central Europe had adopted environmental policies similar to those in the West, these were not generally enforced. Exposure to high levels of pollution can cause illness and death from both acute and chronic diseases such as respiratory diseases, certain cancers, and perhaps cardiovascular diseases, and can lead to congenital and developmental abnormalities. Moreover, living in a polluted environment can be very damaging to people's sense of well-being, instilling a sense of imminent threat. Under such conditions people may not be responsive to messages that tell them to modify personal habits that threaten their health over the long term, since the relevant threat is seen to be in the present, not the future.

There is substantial evidence suggesting that pollution of the physical environment has affected health in Central and Eastern Europe even though this evidence does not add up to a convincing case that the degradation of air, water, soil, and food is the *principal* cause of the East-West life expectancy gap. Studies of short-term, narrowly defined, geographically localized, and non-life-threatening health problems offer evidence of health effects due to environmental pollution. These provide some basis for identifying the principal causes of environmental *morbidity* in the East. In contrast, there are few convincing studies of life-threatening conditions among large segments of the population in the East with which to estimate *mortality* attributable to environmental exposures. Since excess mortality is primarily due to exposures over long periods of time, such studies should be based on the methods of chronic disease epidemiology. This would require either (i) long-term studies of well-defined groups exposed to pollution compared with groups not exposed, or (ii) carefully designed "retrospective" studies in which adequate account of exposure to various pollutants were taken *post hoc*. Of course these studies would have to take account of health risks from lifestyle and socio-economic factors in the design and analysis. There is a shortage of chronic disease epidemiologists in all countries of Central and Eastern Europe. Most of the studies to date have looked for relationships between environmental exposures and mortality by either geographic area or over time, without controlling sufficiently for competing sources of risk or the patterns of individual exposure over time.

AIR POLLUTION. Poor ambient air quality is the principal environmental problem theoretically capable of influencing national trends in life expectancy. In parts of Central and Eastern Europe, high ambient concentrations of particulate matter and sulfur dioxide affect large areas of land and many people. Air pollution is worst in areas where coal is used for heating homes and generating power such as in northern Bohemia and Silesia (particularly Katowice Province). Studies carried out in such locations should help us determine whether or not air pollution is affecting national trends in life expectancy.

Because there is an extensive literature in the West which relates ambient dust concentrations and sulfur dioxide to levels of excess mortality, it is possible to estimate the potential contribution to mortality using only ambient air quality data and not relying on direct evidence from epidemiological studies. These calculations will be presented later in this section. First we describe the available data on human health which support the hypothesis that environmental pollution is contributing to excess mortality in Silesia and northern Bohemia. These observations are not confined to air pollution.

SILESIA. In 1983, the Polish Council of Ministers officially designated 27 areas in Poland as "areas of ecological hazard," based on measurements of air, water, and soil pollution. These comprised 11 percent of the country's territory and 35 percent of its population. The five worst were identified as "areas of ecological disaster." Since these areas correspond reasonably well to the boundaries of Poland's 49 provinces (voivodships), and certain health data are reported by province, it is possible to evaluate whether or not some indicators of helath are negatively associated with the areas of ecological disaster.

For males, 7 provinces in Poland were among the highest 10 in all-cause mortality for each of two years for which data were available (1987 and 1988). The list of 7 includes 2 areas of "ecological disaster": Katowice and Elblag, (the latter falls within the Gdansk area of "ecological disaster"). Four are regions of "ecological hazard." For females, 5 provinces were similarly among the highest 10 for mortality in both 1987 and 1988. These included the Katowice area of "ecological disaster," and 3 areas of "ecological hazard." When one is concerned with general environmental influences on health status rather than occupational influences, finding similar patterns for males and females is of great importance. Thus, Katowice stands out as an area of where environmental conditions could be affecting health, because both male and female mortality rates are high there and because it is classified as an area of "ecological disaster."

Within Poland, there are large differences in infant mortality rates by province. For instance, in 1987 there was a 75 percent difference between the lowest and highest provincial infant mortality rates. Three provinces had infant mortality rates consistently among the 10 highest in the country for three consecutive years (1986–88). Katowice was one of these provinces. Because of its industrialization, Katowice is relatively prosperous by Polish standards and so it would be difficult to explain this pattern on the basis of socio-economic factors. Furthermore, one study done within the Katowice region found that infant mortality was associated with ambient air quality over a six-year period during the 1980s. The strongest association was with dust fall, which accounted for 14 percent of the variation in infant mortality. This likely underestimates the explanatory power which might have been found with a dust measure more relevant to human respiratory exposure, such as PM_{10} (particles equal to or below 10 microns in diameter.).

Another feature of mortality in Poland which suggests an environmental etiology is the relationship between urban and rural mortality. In the West, urban life expectancies are consistently higher than rural ones. This is thought to be due to the socio-economic advantages of urban living in the West which more than offsets the dangers due to pollution, violence, and motor vehicle injuries. However, in Poland, age standardized mortality rates are

Table 2.2 Historical evolution of life expectancy in Finland and Latvia

	Males		*Females*	
	Finland	*Latvia*	*Finland*	*Latvia*
1921-30	50.7	50.7	55.1	56.9
1931-40	54.5	55.4	59.6	60.9
1956-60	64.9	65.2	71.6	72.4
1961-65	65.4	66.5	75.2	74.7
1971-75	66.7	65.2	75.2	74.4
1981-85	70.1	64.1	78.4	74.4
1988	70.7	66.3	78.7	75.1

Source: Valkonen *et al.* 1991

consistently higher in urban areas than rural areas, both for males and females. Significantly, this trend has emerged over the past 15–20 years for females and over the last 25–30 years for males. Thus, the advantages of city-living apparent in the West either never developed in Poland or have been reversed in the last few decades. It is certainly true that the socio-economic advantages of living in Polish cities, if they exist, are not likely to be as large as in the West. And pollution in urban, industrial areas of Poland may be making a significant contribution in the opposite direction. The high mortality rates in the province of Katowice are a result of urban, rather than rural mortality. In the late 1980s, urban life expectancies for males and females in Katowice lagged behind the national average for urban areas by more than one year, while life expectancies in the rural parts of Katowice were actually slightly higher than in other rural areas of Poland.

NORTHERN BOHEMIA. Life expectancy in northern Bohemia in the Czech Republic exhibits some of the same patterns as in Katowice: life expectancy is lower in districts with the worst air pollution. Since 1960, life expectancy in northern Bohemia has been 1–2 years below the national average for both males and females (see Table 2.3). In addition, the mining regions of northern Bohemia and adjacent residential areas have the highest age-standardized mortality ratios for all cancers combined, lung cancer, and circulatory diseases.

The mining districts of northern Bohemia also have higher age-standardized mortality and incidence ratios for lung, colon, and stomach cancer (as well as cancer of the uterus for females) than the non-mining districts.

However, one must be cautious in drawing conclusions from this data since there are many possible explanations for the differences. The districts differ in other ways as well. For example, the mining districts have much higher divorce rates and a higher proportion of Gypsies than do the non-mining districts, although the proportion of the population with at least basic education does not differ markedly between the two groups of districts. Socio-demographic variables are often associated with health status. Therefore, it is important to consider the degree to which social disadvantage, isolation, and disorganization might contribute to or exacerbate the influences of environmental pollution on the health status of the population. Well-designed multivariate studies would help researchers to estimate the independent effect of socio-demographic and pollution variables on health status.

Table 2.3 Evolution of life expectancy in the Czech and Slovak Republics by province

	Males			*Females*		
	1960/61	*1970/71*	*1986/87*	*1960/61*	*1970/71*	*1986/87*
Northern Bohemia	66.2	64.6	66.1	72.2	71.9	73.8
Western Bohemia	66.4	65.1	66.8	72.8	72.3	73.8
Middle Bohemia	67.4	65.9	67.1	73.2	73.2	74.6
Southern Bohemia	67.5	66.5	67.2	73.2	73.8	74.9
Prague	67.7	66.4	68.7	73.3	72.8	74.9
Eastern Bohemia	68.2	66.8	68.3	73.8	73.6	75.2
Northern Moravia	67.3	66.2	68.4	73.5	73.2	74.6
Southern Moravia	69.0	67.2	68.4	74.4	74.2	75.7
Middle Slovakia	68.0	66.8	67.0	72.4	73.2	75.3
Eastern Slovakia	68.4	66.3	66.6	72.6	72.9	74.9
Western Slovakia	68.7	66.8	66.9	73.1	73.1	74.6
Bratislava	..	67.7	69.4	..	73.2	75.5

Source: Institute of Health Information and Statistics 1990

Table 2.4 Relative risks of neonatal problems in districts of the Czech Republic ranked by air pollution

	Concentration Quintile				
	Lowest	*2*	*3*	*4*	*Highest*
Infant mortality rate	1.0	1.14	1.15	1.23[2]	1.38[3]
Postneonatal mortality rate	1.0	1.24	1.37[1]	1.24	1.61[2]
Postneonatal respiratory mortality rate	1.0	1.37	2.01	5.67[3]	7.79[3]
Low birth weight	1.0	1.02	1.02	1.02	1.18[3]

1. < 0.05
2. < 0.01
3. < 0.001

(p trend < 0.01 for each analysis)
Source: Bobak 1991

One well-designed multivariate study looked at infant mortality in relation to ambient air pollution from 1986–88 in 42 districts of the Czech Republic. The study included socio-demographic variables obtained from vital statistics and from a survey done by the Federal Bureau of Statistics in 1978. The researchers divided the districts into quintiles according to the sum of the annual geometric means of sulfur dioxide and suspended dust. Table 2.4 presents the relative risks for infant mortality, postneonatal mortality, postneonatal respiratory mortality, and low birth weight by concentration quintile. The relative risk is arbitrarily set at 1.0 for the lowest concentration quintile, so values greater than 1.0 indicate increased risk of mortality (or low birth weight) for other exposure quintiles. Each analysis is adjusted for mean income, mean savings, mean car ownership, proportion of illegitimate births, and abortion rate.

These data support the hypothesis that air pollution is contributing to high infant mortality, especially mortality from respiratory causes.

GENERAL APPROACH. A more general approach to measuring the health impacts from exposure to pollution comes from an emerging literature which defines dose-response relationships between exposure to dust and sulfur dioxide on the one hand, and mortality on the other. The studies for particulate matter, which have been carried out for a variety of locations and climates in Europe and North America, have produced very consistent results. These suggest that a 10 microgram per cubic meter ($\mu g/m^3$) increase in annual average concentrations of respirable dust may increase mortality by between 0.3 and 1.5 percent, with a mean of 1 percent. Studies for sulfur dioxide, while somewhat less consistent, also show a relationship between concentrations of sulfur dioxide and mortality. These suggest a 10 $\mu g/m^3$ increase in annual average sulfur dioxide concentrations may increase mortality by between 0.2 and 1.2 percent, with a mean of 0.5 percent.

Conceptually, the contribution of these air pollutants to the East-West life expectancy gap could be based on estimates of the relative increase in the gap between average ambient concentrations of PM_{10} or sulfur dioxide in Central and Eastern Europe compared to the West over time, multiplied by a best estimate of the response to this "dose." For example, consider the data presented in Table 2.5.

These data show that, over the 15-year period 1970–85, the average sulfur dioxide level in OECD cities declined by 114 micrograms per cubic meter while increasing by 69 micrograms per cubic meter in the regions of northern Bohemia. Thus, by 1985, the annual average concentrations of sulfur dioxide was 183 micrograms per cubic meter higher in regions of northern Bohemia (i.e. 69 – [–114]) compared with OECD cities with a range of impact on mortality of between 4 and 22 percent.

We are lacking historical trend data for particulate matter for Central and Eastern Europe which would enable us to make a similar calculation for dust. Instead we have made two cross-sectional comparisons using data from the 1980s. In the first, we compared the maximum and minimum annual average dust levels from 7 cities in northern Bohemia and 13 OECD cities for the years 1981–88.[1] We then calculated the differences in minimum and maximum annual average PM_{10} levels to represent the plausible range of differences that might exist between northern Bohemia and major population centers in the OECD. The range was 31 to 62 micrograms per cubic meter. Applying the minimum estimate of mortality impact (0.3) to the minimum estimated difference and the

Table 2.5 Historic changes in average annual sulfur dioxide concentrations
(micrograms per cubic meter)

	1970	*1975*	*1980*	*1985*
OECD cities	151[1]	76[2]	59[2]	37[2]
Chomutov region	53	71	94	126
Most region	57	80	102	132
Teplice region	51	77	93	110

1. Based on data from 6 cities for which data were available.
2. Based on data from 18 localities.

Source: OECD 1991 (b) and Czechoslovakia Department of the Environment 1990 maximum mortality estimate (1.5) to the maximum difference, respectively, 1 to 9 percent of total mortality might be attributable to higher levels of PM_{10} in northern Bohemia than in OECD cities.

The second calculation compares estimated annual average ambient concentrations of PM_{10} in 11 Silesian cities with concentrations in 11 OECD cities for 1987, a year for which usable data are available for Silesia. The average for Silesia was 185 micrograms per cubic meter compared to 33 micrograms per cubic meter for the 11 OECD cities. This difference of 152 micrograms per cubic meter corresponds to a range of excess mortality of 5–23 percent.

There are several methodological problems with these analyses which limit both their validity and scope of interpretation. Some estimates of the exposure-response relationship have been derived from large population surveys which have not controlled for significant confounding factors that might explain excess mortality, such as neighborhood differences in smoking patterns. Those that best control for such factors are the ones which relate short-term fluctuations in mortality in a given community to changes in the average daily ambient concentration of the pollutant of interest. It is a large methodological jump to apply exposure-response relationships from such studies to differences in average annual concentrations between separate regions of the world, as has been done here.

The possibility of a threshold below which mortality cannot be attributed to air pollution has not been taken into account. If a threshold does exist, then the levels of excess mortality presented here would likely be too high.However, there is little conclusive evidence that a threshold exists. In fact new studies have detected associations between air pollution and health well below current international standards, at least for PM_{10} (see Dockery, et.al, 1993).

In addition, ambient data from East and West may not be comparable. There are several accepted methods for collecting, measuring, and analyzing data, and different methods are used in different places. Of course techniques evolve and improve over time, making data from different time periods difficult to compare. These problems are especially severe for particulate matter, for which at least 6 alternative measures are in use. For this analysis we had to use two conversion factors: one to make standard European and North American measurements of dust roughly equivalent and another to make both of these roughly equivalent to PM_{10}. Each of these conversions is subject to error.

There are additional uncertainties regarding the extent to which excess mortality attributable to air pollution is responsible for the East-West life expectancy gap. The first problem, mentioned before, is the lack of access to data from the mid-1960s which would allow us to calculate net changes in ambient air pollutant concentrations over the decades of interest. Next, it is not clear how to translate air pollution effects into life expectancy terms when these effects will primarily accrue to the aged, the newly born, and the medically vulnerable and not to a representative sample of the population. Finally, the calculations above have only been made for heavily polluted areas and do not represent the average experience of people in Central and Eastern Europe.

Despite these problems, there is sufficient evidence to suggest that air pollution has affected mortality in the most heavily polluted parts of Central and Eastern Europe. However it is difficult to precisely measure the magnitude of this effect.

If Silesia and northern Bohemia help to put a conceptual upper bound on the contribution of air pollution to the life expectancy gap, then country-to-country variations in life expectancy within Central and Eastern Europe help to establish the lower bound. It turns out that the same basic pattern of evolution in life expectancy exists in all of the countries of Central and Eastern Europe despite the fact that pollution conditions in these countries are markedly different from one another. For instance, the Baltic countries do not have any areas which compare to Silesia or northern Bohemia and yet life expectancies are no higher than in the Czech Republic or Poland. Thus, when the mortality impacts in the most polluted parts of the countries of Central and Eastern Europe are averaged out across the whole population's life expectancy, they become difficult to detect.

Health care and the economy

According to this approach, centrally-planned societies were well suited to provide public health services to the masses, but unable to adapt to high-tech modern medicine. Just as the economies of the East seemed unable to make the transition from industrial to service and information societies, they could not meet the need for increased local autonomy, professional independence, and strategic capital formation that some observers believe is fundamental to a successful health care system. Furthermore, these problems were exacerbated by a shortage of hard currency in the East, increasingly needed to purchase Western equipment that was not available from Central and Eastern European producers. Thus, despite its large supply of health professionals, the East was increasingly unable to match Western standards of diagnosis and treatment of the chronic diseases that are the principal causes of mortality. The validity of this approach depends, in principle, upon whether or not the case-fatality rates for these principal life-threatening conditions differ significantly between East and West.

There is considerable divergence of opinion about the extent to which medical care has contributed to improving the health status of populations over time. For instance, it is widely believed that vaccination and the use of antibiotics are responsible for the near elimination of mortality from infectious diseases in the West. Yet, massive declines in mortality from such major infectious diseases as tuberculosis, smallpox, and measles occurred several decades to two centuries before the introduction of effective vaccinations. This observation, which is most closely associated with the work of Thomas McKeown, has led to debate about the relative importance of nutrition, housing, public health interventions, increased child spacing, and other aspects of economic and social development. Some observers have suggested that new techniques which have made health care less dangerous, such as anti-sepsis, have contributed significantly to improvements in health. It is likely that human life expectancy increased from approximately 40 years to 60 years without significant assistance from effective, individual-based treatment of society's most life-threatening and prevalent diseases.

Does the same situation prevail today? Is medical care in this period of chronic diseases making as small a contribution to reductions in mortality as it did in the era of infectious diseases? Although we know that many current methods of clinical prevention and treatment of disease are effective, we do not have convincing evidence that medical care is contributing more to health status now than in the past.

More to the point, however, is whether or not health services in the East are less effective (or more dangerous) than in the West—enough to contribute substantially to the East-West life expectancy gap.

Many indicators of the quality of health care are similar in East and West. For example, the numbers of physicians, nurses, and pharmacists per capita are about the same in both regions. In addition, people in both regions utilize health services at about the same rate. In Eastern and Central Europe, hospital beds, admission rates, average lengths of stay, patient days, and physician visits per capita are all currently within the range of OECD countries.

And while health expenditures as a fraction of total output are generally lower in the East than the West, this is not likely to explain differences in life expectancy between the two regions. As an example, in 1987, the former Czechoslovakia spent about 5.8 percent of its Gross Domestic Product on health care, not significantly different from Britain and Denmark, both of which spent about 6 percent of GDP on health care. Japan, with the longest life expectancy in the world, spent only 6.8 percent of its GDP on health care in 1987, while the United States, which has comparatively high infant mortality and low life expectancy, spent 11.2 percent of GDP on health care.

Moreover, among countries of the European Union, the national level of health care expenditure does not even correlate with mortality rates for "medically avoidable causes of death," a composite indicator of causes of death which ought to be avoidable through prompt and appropriate medical attention in the acute phase of the disease or through effective secondary prevention. One study has compared mortality in selected Western countries and the former Czechoslovakia, Hungary, and Poland using a similar index of "conditions amenable to medical care." The index includes 22 conditions or families of related conditions among individuals 0–64 years old. Although the study was not meant to highlight changes in the *relative* rate of mortality from medically avoidable causes between East and West, it is possible to partially reconstruct this from the data presented. Table 2.6 presents data on mortality rates standardized per 100,000 European standard population for the former Czechoslovakia and England and Wales.

The table shows that while deaths from medically avoidable causes increased in the former Czechoslovakia relative to England and Wales between the two time periods, deaths from non-avoidable causes increased even more. Thus only about 9 percent of the total (relative) increase in mortality rates in the former Czechoslovakia compared to England and Wales can be attributed to medically avoidable causes.[2] Similarly, about 12 percent of Hungary's and 15 percent of Poland's mortality differentials with England and Wales can be attributed to medically avoidable causes.

The contribution of individual lifestyle factors

This approach begins with the observation that, for both sexes, most of the age standardized mortality differential between East and West can be attributed to a single cause: higher circulatory disease mortality rates in the East, which emerged concurrently with the life expectancy gap. Therefore, East-West differences in smoking habits, blood pressure control, and diet or cholesterol levels—the epidemiologically validated risk factors for heart disease and stroke—can explain the life expectancy difference. The public policy corollary of this approach is that well-designed health promotion programs will be the most effective way of eliminating the life expectancy gap.

The risk factor approach starts by identifying the diseases that appear responsible for the East-West mortality differential, then attempts to identify and analyze the risk factors for the diseases. The evidence indicates that cardiovascular mortality (sometimes referred to as circulatory disease mortality) is the principal cause of East-West mortality differentials for both males and females. Table 2.6 shows that in the West, cardiovascular disease mortality rates declined sharply for people of both sexes aged 45 to 74 years from 1960 to 1979. By contrast, mortality rates for this cause increased sharply in the East for males aged 45 to 64 over this same period, and for males aged 65 to 74 from 1960 to 1976. For example, the rate for males aged 65 to 74 in Czechoslovakia increased from 2,225 per 100,000 in 1960 to 2,772 per 100,000 in 1976. These increases were followed by only small increases (in Czechoslovakia and Poland) or even declines (in Hungary) in the late 1970s and 1980s. For females aged 45 to 74 in the East, cardiovascular mortality rates have in general fallen between 1960 and 1989, but at a much slower rate than in the West. Therefore, for both males and females, the gap between East and West in cardio-

Table 2.6 Medically avoidable death rates

	1970–74		*1985–87*	
	Avoidable deaths	*Non-avoidable deaths*	*Avoidable deaths*	*Non-avoidable deaths*
CSFR	101.0	336.1	72.5	351.6
England & Wales	69.6	298.2	35.0	252.0

Source: adapted from Forster and Jozan 1990 vascular disease mortality rates has widened greatly over the last three decades.

What is the cause of the increasing differential in East-West cardiovascular mortality rates? The gap has been increasing during a time when per capita cigarette consumption by men, and to a lesser extent among women, was increasing in the East: cigarette sales per capita increased by approximately 30 percent between 1965 and 1985. There is also evidence that people in Hungary have been consuming more fat, especially animal fats, over the past several decades. Between 1934 and 1988, annual per capita consumption of fats increased by approximately 50 percent in Hungary, while consumption of animal fats increased by about 30 percent.

These trends do not, by themselves, make a strong case that lifestyle factors are responsible for the life expectancy gap. Studies trying to ascertain the impact of measures to lower cholesterol have consistently demonstrated no impact on overall mortality, even when the interventions successfully lower cholesterol levels in the study populations. Moreover, even if we accept the most optimistic estimates of the mortality benefits for *individuals*, the contribution of lower cholesterol levels on *population* life expectancies would likely be modest. One group of investigators using the most optimistic assumptions estimated that, if Americans reduced fat consumption from 37 to 30 percent of their energy intake, population life expectancy would rise by only 3 to 4 months.

Fortunately, there exist better data to help evaluate the extent to which cardiovascular disease risk factors are responsible for international differentials in life expectancy. During the 1980s the World Health Organization (WHO) set up the MONICA project to monitor trends and determinants in cardiovascular disease across many countries. This project provides comparable information on cardiovascular risk factors for 52 centers in different countries. Early results from centers in Czech Republic and Hungary are illuminating and quite contrary to the predictions of the risk factor approach.

Cardiovascular mortality rates for males aged 35-64 in Budapest were *third* highest among the participating centers, and *second* highest for females of the same age range. However, the proportion of males with serum cholesterol levels above 250 milligrams per deciliter was not especially high, ranking only *twenty-sixth* among participating centers. The proportion of males with elevated diastolic and systolic blood pressures ranked *thirtieth* and *twenty-third* respectively, while the proportion with grossly elevated body mass indexes ranked *twenty-second* overall. The proportion of females with serum cholesterols above 250 milligrams per deciliter and the proportions with elevated diastolic and systolic blood pressures all ranked *twenty-fourth* among participating centers, while the proportion with grossly elevated body mass indexes ranked *twenty-sixth*. Only the proportion of regular cigarette smokers, *sixth* among males and *fifth* among females, came close to Budapest's rank for cardiovascular disease mortality.

In the Czech Republic, cardiovascular mortality rates were *twelfth* highest for males and *thirteenth* highest for females among participating centers. However, the proportions of males and females with elevated cholesterols ranked *fourth* and *third*, the proportions with grossly elevated body mass indexes ranked *fourth* and *seventh*, and the proportions of regular cigarette smokers ranked *eighteenth* and *twenty-second*, respectively. (Blood pressure measurements had not yet been reported from the Czech centers.)

These data do not support a view that the East-West life expectancy gap can be accounted for primarily by differences in diet, obesity, or lack of blood pressure control. It is true that the MONICA data do not take into account changes over time in the prevalence of risk factors or the possibility that intervals between the time of first exposure to a risk factor and the expression of disease might make it difficult to compare data across countries. Yet they are the best data currently available and deserve careful attention until better data (not just more complicated arguments) are produced.

The MONICA data do not negate the possibility that differences in cigarette smoking may be contributing to international differences in life expectancy. But how important is this? The crucial aspect of this question is this: do factors other than cigarette smoking, which differ between countries, serve to modify the behavior of a risk factor, such as cigarette smoking? In fact there is evidence of a regional effect which modifies the strength of the association between cigarette smoking and cardiovascular disease mortality. The monograph *Seven Countries* by A. Keys, which presents dose-response relationships between cigarette consumption and cardiovascular mortality for the United States, Japan, northern Europe, and southern Europe, clearly demonstrates this regional effect. The studies summarized in this monograph show very different results by region: with a strong relationship in northern Europe and the United States, a weaker relationship in southern Europe, and no relationship in Japan.

Studies done in different countries relating cigarette smoking to lung cancer have shown similar country by country variations in dose-response, as Hirayama shows. The relationship was weakest in a Japanese study, where life expectancy is highest, but stronger in studies from the United States and Britain, where life expectancy is lower. For example, a British study found that smoking 30 cigarettes per day increased the risk of lung cancer 17-fold relative to British non-smokers. A study done in Japan found only an 8-fold increase.

If it is indeed the case that dose-response relationships vary across countries, then this might be due to factors other than just cigarette smoking. We must be cautious before attributing the East-West life expectancy gap to lifestyle factors.

The contribution of the social, political, and economic environment

Underlying this approach is the premise that the political, social, and economic conditions in the East created a climate of powerless and alienation which simulated, in varying degrees, the conditions of deprivation experienced by the least privileged groups in the West. More-

Table 2.7 Temporal trends in age-specific cardiovascular mortality rates

	Males: 45–64		*Males: 65–74*		*Females: 45–64*		*Females: 65–74*	
	1960–76	*1974/76–1988/89*	*1960–76*	*1974/76–1988/89*	*1960–76*	*1974/76–1988/89*	*1960–76*	*1974/76–1988/89*
East[1]	+28.7	+20.4	+22.8	+2.3	-3.6	-2.2	-1.4	-8.7
West[2]	-19.5	-34.1	-15.0	-33.5	-43.3	-36.5	-33.0	-37.8

1. East: Poland, Hungary, Czechoslovakia.
2. West: Canada, United States, Sweden, Japan.
Source: Hertzman 1992 (a)

over, it must be assumed that these conditions occurred even though the centrally-planned economies provided good job security and relatively equitable distribution of income across a wide variety of white and blue collar occupations. The corollary is that improvements in socio-economic conditions will be the most effective means of reducing the life expectancy gap. Furthermore, health problems associated with poor lifestyle choices will not fall much with direct intervention until the socio-economic environment improves.

If the East-West life expectancy gap cannot be thoroughly explained by polluted environments, inadequate medical services, or lifestyle risk factors, and cannot be dismissed as historically inevitable, how can we explain it? Here we explore the hypothesis that factors associated with the social, political, and economic environment—social isolation, perception of powerlessness, relative declines in the economy, and increasing social class gradients in health status and well-being—are contributing to the life expectancy differential. Admittedly, there is little data from Central and Eastern Europe with which to test this hypothesis. Yet the hypothesis deserves adequate exposition because in many ways it explains international differences in health status better than any other approach.

The hypothesis, fully stated, is as follows: following impressive economic growth during the two decades following World War II, the countries of the East effectively reached the top of the national income/life expectancy curve (i.e. the point at which further increases in national per capita income would likely have only limited impact on national life expectancies). Thereafter, despite continuing economic growth, the authoritarian character of the countries of the East became an obstacle to further gains in health status, and the life expectancy gap began to emerge. As in other hierarchical societies, large social class differences in health and well-being emerged. In addition, the political climate in the East led to an increasing perception of isolation and powerlessness, particularly among politically disenfranchised groups in society. The concurrent decline in both the economic and social environments are now reflected in steep social class gradients in life expectancy and relatively high rates of mortality from cardiovascular disease in all social groups.

The discussion below follows the sequence of assertions in this hypothesis, presenting evidence from around the world to support the plausibility of each, and where possible, corroborating evidence from the East.

Preston, in *Mortality Patterns in National Populations* (1976), shows that until the 1930s, per capita national income was closely correlated with life expectancy around the world. Significantly, between the 1930s and the 1960s, the wealthiest countries in the world achieved a point at which differences in per capita national income no longer matched differences in life expectancy, even though there was a three-fold per capita income range among them. As mentioned earlier, several countries in the East had reached levels of life expectancy which were similar to those of the wealthiest Western countries by the early 1960s.

According to the latest available information, there is still no correlation between per capita national income and life expectancy among OECD countries. However, life expectancy differences among the OECD countries appear to be closely associated with *income distribution*. The OECD countries which have developed and maintained the most egalitarian income distributions have experienced the most rapid gains in life expectancy between the 1960s and the 1980s. Moreover, OECD countries with relatively egalitarian income distributions (i.e. Sweden *versus* Great Britain), also had high overall life expectancy and much smaller gradients of declining life expectancy across groups (i.e. the British classification of occupational class applied to both Sweden and Britain).

These observations suggest that the health impacts of a sense of relative deprivation, of being at a disadvantage in relation to those better off, extend beyond the impact of just relative income. Studies which have looked at the

Table 2.8 Infant mortality rates in Poland in relation to mother's maximum level of education attained, 1987

Mother's Education (maximum level attained)	*Infant Mortality Rate (per 1,000 live births)*
Did not complete primary	28.3
Completed primary	18.7
Basic vocational	14.1
Secondary or post-secondary	12.2
Higher (i.e. university)	10.6

impacts of a sense of "personal control" or "powerlessness" on health support this supposition. It is this latter interpretation of relative deprivation that would have to be invoked to explain the East-West life expectancy gap, since income distribution and and inequality in the East were not likely to be major factors. Indeed, according to the Welfare State Programme at the London School of Economics, Poland, Hungary, and the former Czechoslovakia had more equal income distribution than the United Kingdom, and, by extension, other OECD countries by the early 1980s.

Socio-economic gradients in life expectancy are society's best record of the health impact of relative deprivation. Gradients of life expectancy by occupational class, years of schooling completed, or quintile of income have been found in all industrial societies where analyses have been done looking for them.

Socio-economic gradients in health status have several important characteristics. First, they tend to show a monotonic pattern of decline in life expectancy with declining socioeconomic level, not a dichotomous separation of the "privileged" from the "underprivileged." Second, the gradients tend to be steeper among men than women. Third, the gradients have persisted for decades, even though the principal causes of death in society have changed fundamentally over those decades. In other words, the factors producing these gradients seem to operate through pathobiological mechanisms that are not unique to specific diseases but, rather, influence vitality through mechanisms fundamental to a wide range of life-threatening conditions.

Education level is likely to be the social status indicator most useful for comparisons between East and West. The alternatives, income and occupation, are both problematic. Differences in the level of monetary compensation for different occupations may make both household income and job title groupings mean quite different things in these very different societies.

Education level is strongly associated with infant mortality and adult mortality in Poland, Hungary, and the former Czechoslovakia, the three other countries in the East for which any data are available. In Poland in 1987, there was a nearly three-fold mortality gradient between the offspring of the most and least educated women. In most OECD countries the infant mortality gradient does not exceed a two-fold difference across educational levels.

Table 2.9 presents information on the potential influence of education on the health status of Czechoslovakians. The table shows age and sex specific mortality rates by years of schooling attained for people between the ages of 30 and 64. Mortality rates vary greatly between the most and least educated males in the former Czechoslovakia, regardless of age. The differences are greatest in the youngest age groups, with the gap declining steadily for older age groups. Mortality rates for females are also much higher among the least educated than the most educated. However, the trends are less consistent in the intermediate age groups than they are among males.

We have seen that differences in cardiovascular disease comprises most of the East-West differential in mortality. In order for the socio-economic approach to be credible, it must be able to explain the variations in cardiovascular mortality which depend principally on factors related to the quality of the social environment and not on individual lifestyle risk factors. There is evidence to suggest that three factors in the social environment may be important to health: socio-economic conditions in childhood, the quality of social support and cohesiveness in one's community, and conditions related to the work environment.

Table 2.9 Age-specific death rates (per 100,000) by level of education in the Czech Republic, 1979–1982

Age Group	*Education Level**				*Rate Ratio (1/4)*
	1	*2*	*3*	*4*	
Males					
30–34	438	151	89	77	5.7
35–39	579	244	155	117	4.9
40–44	814	380	238	206	4.0
45–49	1167	606	470	325	3.6
50–54	1662	1055	836	628	2.6
55–59	2247	1844	1548	1080	2.1
60–64	3399	3173	2614	2020	1.7
Females					
30–34	117	52	53	38	3.1
35–39	138	103	92	76	1.8
40–44	222	154	144	160	1.4
45–49	331	271	320	221	1.5
50–54	528	401	636	425	1.2
55–59	851	703	901	567	1.5
60–64	1523	1345	1369	1181	1.3

* Education levels:
1. Base education: 8–9 years of school attendance.
2. Secondary education without leaving examination.
3. High school without leaving examination.
4. University.

Source: Hertzman 1992 (a)

Several studies have demonstrated that children growing up in poverty in affluent societies are more likely to die from heart disease in adulthood than those who grow up in greater affluence. However it is still possible that nutritional and lifestyle differences are responsible for the increased mortality risk rather than the long-term impact of relative deprivation operating through novel biological pathways (for example, suppression of the immune system).

The best evidence available addressing this question comes from longitudinal studies of working populations in Britain and Sweden. The British study focuses on civil servants; a particulary good group to study because their work is generally not physically dangerous and the divisions between the occupational grades are quite rigid. This study found that persons in the lowest grade (manual), were three times more likely to die from heart disease than those in the highest grade (administrators), with the intermediate grades (professional and clerical) falling in between. *The crucial lesson from this study was that the gradient remained largely unchanged after account was taken of smoking, systolic blood pressure, and plasma cholesterol.* In other words, the risk of coronary heart disease mortality could not be explained away by parallel gradients in traditional coronary heart disease risk factors.

Karasek and Theorell (1990) looked at the relationship between job characteristics and the prevalence and incidence of coronary heart disease in Sweden. They found that workers who said their occupational environments were psychologically demanding and provided little latitude to make decisions were at greatest risk for developing heart disease. Lack of social support outside work increased the risk. A study which examined 7,219 working men over a period of nine years found that those who reported poor social support, excessive demands, and poor decision latitude at work were twice as likely to die from cardiovascular disease than others. These results are consistent with studies done in North America on relationships between social support and mortality and on relationships between personal control and health and illness. Not surprisingly, most of the jobs classified as "poor support/excessive demands/poor decision latitude" were associated with low socio-economic status.

The final element in this approach concerns the role of social support in protecting against heart disease mortality over time. There are many studies which demonstrate the role of social isolation, independent of working conditions, as a risk factor for premature mortality. Most relevant here are those that deal with the quality of social support networks in well-defined communities, and the best of these is the 50-year study of the population of Roseto, Pennsylvania, which tracked mortality from myocardial infarctions from 1935 to 1985—the basis of the "Roseto effect." Roseto was a homogeneous Italian-American community which had strikingly low mortality from myocardial infarction (heart attacks) relative to surrounding communities. Beginning in the 1960s, the pattern of low mortality broke down, primarily affecting men under the age of 65 and elderly women. This corresponded to a period of erosion of cohesive family and community relationships. Remarkably, during the 30-year period of relatively low mortality there was no evidence of differences between Roseto and the surrounding communities in terms of any conventional heart disease risk factors. In fact, it was during the period of increasing prevalence and accelerated death rate from heart disease that there was a striking reduction in the consumption of fats and oils by Rosetans. Social cohesiveness and social support are the protective factors which best help explain these remarkable trends.

Have the working and living conditions of Eastern Europe over the past three decades featured poorer social support, more demands, and less personal decision latitude than in the West? It is possible that they have. Lack of individual freedoms and liberties, overly centralized "command" economies, working environments infiltrated by police agents, and endless difficulties obtaining basic consumer goods may well have added up to more stress than faced by those with undesirable working conditions in the West. Yet, for the most part, we have no data to support this assertion, and, because of the political and economic changes taking place in Eastern Europe, it will become increasingly difficult to evaluate in retrospect.

A case study from Hungary illustrates this line of reasoning. Hungary is an interesting case because it has the worst health status in Central and Eastern Europe, yet does not have the severe pollution problems of Poland or the Czech Republic.

Interesting information on health inequalities within Hungary and other European countries has been presented in *Health Inequalities in European Countries* (Fox, 1989). In each country where it was looked for, there was a strong declining gradient of mortality with increasing educational level for males and females aged 35 to 54. A similar pattern was found for Hungarian males, although at each level of education the respective mortality rate in Hungary was higher than in the comparison countries. However, mortality for Hungarian women did not exhibit the same pattern. Beyond 12 years of schooling, mortality rates actually increased, and Hungarian women with university educations had a mortality experience much like those with less than 8 years of schooling. Mortality data for Czechoslovakian women presented earlier also exhibits this pattern, and is yet to be explained.

Within the city of Budapest, there are large differences in male life expectancy between the districts with the highest and lowest levels of educational attainment. When male life expectancy at birth by district is correlated with the proportion of each district's males over the age of 25 years having completed less than grade 8, the relationship between the two is very strong (correlation = –0.87). In addition, the areas with highest life expectancy are in the green belt, while those with lower life expectancy tend to be the most depressed neighborhoods downtown with many economic, social and pollution problems. These life expectancy differences are based primarily on mortality after the age of 30, and cut across almost all chronic diseases. In particular, mortality rates for men between the ages 40 and 45 are 3.3 times higher in District 7 (a depressed downtown area) than in District 2 (a green belt area). This pattern is apparent for other districts as well.

Districts 1, 2, and 12 are relatively privileged compared with the deteriorating downtown areas of Districts 6, 7, and 8, and suburbs with low educational attainment such as Districts 17 and 20. In the age group 40 to 59, the differences in mortality rates for cirrhosis of the liver, suicide and stomach cancer range from 2 to 10 fold across these districts.

There is evidence that the gradient between social class and infant mortality and suicide in Hungary is becoming steeper. For example, in 1965 there was a 1.8 fold difference in infant mortality between the offspring of women with the least *versus* the most education, but by 1980 this had grown to a 2.8 fold difference. In absolute terms, there was no improvement in the infant mortality rate for women with less than eight years of schooling, while for women with more than 13 years of schooling the mortality rate fell by 50 percent. The suicide rate follows a similar pattern. In 1960, the suicide rate for blue collar workers was twice as high as for white collar workers, but was three times as high by 1980. During this period, the overall suicide rate in Hungary doubled, and the mortality rate from cirrhosis of the liver quintupled, after remaining stable from the end of World War II until the Soviet invasion of 1956.

By 1980, there was evidence that paternalistic rule had left an imprint on people's sense of power and influence in society. According to a survey done in the late 1970s, about 50 percent of the adult population in the developed countries believed they could do something at the national level to protect their interests. Among Venezuelan and Turkish farmers, and Mexican non-agricultural workers in the developing world, this percentage varied between 20 and 38 percent. In Hungary in 1985, only 10 percent of the adult population surveyed believed that they could do something to protect their interests at the national level. Furthermore there are data showing a tendency towards distrust and social isolation in Hungary compared to Western European countries. The *European Value Systems Study,* which was carried out in Western Europe in 1982, was extended to Eastern Europe later in the decade. Compared to respondents from nine Western European nations, Hungarian respondents reported less willingness to sacrifice themselves for people outside their families, less willingness to sacrifice themselves for their children, less willingness to teach their children respect for other people, and less willingness to emphasize loyalty and faithfulness as child-rearing principles. These results raise the question of whether or not the "Roseto effect" might have been operating in reverse in Hungary.

A Reappraisal of the Determinants of Health in Central and Eastern Europe

As Thomas McKeown showed in his analysis of the origins of the decline in mortality from infectious disease in nineteenth and twentieth century Britain, we have shown that the traditional explanations for the life expectancy gap are not as important as had been thought. Still, we have not been able to demonstrate clearly the relative importance of the most important factors. For McKeown, it may have been sufficiently satisfying to create new lines of inquiry and research on the role of various determinants of health over time. For those seeking environmental policy advice, however, such an outcome may seem frustrating. But this would not be a correct assessment. We can reach conclusions that will help put into perspective the impact of environment on health in Central and Eastern Europe.

The idea that environmental pollution in Central and Eastern Europe is the principal cause of the life expectancy gap can be dismissed. Although this assertion has rarely been made directly, it has emerged as a meta-message through the juxtaposition of film and photographic images of polluted communities in the region with ominous health statistics. Instead, environmental pollution can be seen in context as one of a series of competing determinants of health.

Mortality is the only health status measure collected routinely under similar conditions in East and West. Therefore, despite its obvious limitations, mortality provides the only basis for large-scale comparisons of health status. It is significant that the relative impact of environmental pollution on life expectancy in heavily polluted areas of Central and Eastern Europe is likely to be of the same order of magnitude as excess mortality from medically avoidable deaths or lifestyle factors such as diet, smoking, and exercise. Spending resources to reduce pollution is no more (or less) justifiable than using resources for medical services reform or health promotion activities directed at lifestyle factors. On the other hand, reducing pollution will almost certainly reduce the burden of disease and morbidity, and will improve quality of life. Environmental action to protect human health can be readily justified on these grounds.

Finally, it is important to clarify that human health is not being proposed as a principal criteria for environmental intervention and policy setting because of any claim that environmental exposures are the principal determinant of health in the region. The claim is, rather, the reverse: among the wide-ranging impacts of environmental pollution, human health impacts are as significant, if not more significant, than any others.

Notes

1. All measurements of particulate matter have been converted to PM_{10} using conversion factors presented in Ostro and Hughes.
2. This result is obtained as follows. In the period 1970-74, the mortality rate difference from medically avoidable causes was 31.4 per 100,000 (101.0 – 69.6) and in 1985-87 it was 37.5 per 100,000 (72.5 – 35.0), an increase of 6.1 per 100,000. In 1970–74, the mortality rate difference from medically non-avoidable causes was 37.9 per 100,000 (336.1 – 298.2) and in 1985–87 it was 99.6 per 100,000 (351.6 – 252.0), an increase of 61.7 per 100,000. Thus, the total (relative) increase in mortality rate in the former Czechoslovakia compared to England and Wales is 67.8 per 100,000, of which only 6.1, or 9 percent, can be attributed to medically avoidable causes.

Chapter Three

Health and Environmental Pollution

This chapter analyzes the first two steps of a four-step process to reduce health damage from environmental pollution in Central and Eastern Europe. The four steps are:

i) Identifying human health problems associated with environmental pollution.
ii) Making generalizations about the principal types of environmental pollution affecting human health.
iii) Comprehensively identifying places where populations are exposed to these types and levels of pollution.
iv) Developing a remediation strategy for those places.

Information from countries in the region, while often incomplete or biased, has revealed the major health problems most likely to occur from exposure to environmental pollution. This has allowed a generalization about the principal types of environmental pollution affecting human health in the region and the types of exposure scenarios wherein human health will most likely be affected. In turn, this has made it possible to answer the question: *"What other places in the region are like the places where environmental pollution has been documented as having affected human health, but for which no human health evidence is available?"* This is a crucial question, because answering it allows the environmental action planning process to go from the second to the third step identified above, and comprehensively identify populations whose health may reasonably be expected to be affected by environmental pollution.

Below is a summary of the existing information showing locations where human health is likely being affected by exposure to pollutants, according to criteria described below in **Methods of Data Evaluation**:

a) In 37 locations in 7 countries, lead in the air, water, soil, and food was found at levels high enough to cause neurobehavioral deficits among children. *Evidence* of neurobehavioral deficits has been found in several of these places.
b) In 53 locations in 10 countries, acute respiratory and irritant conditions, such as sinusitis, pharyngitis, bronchitis, and conjunctivitis, were associated with airborne exposures to dusts, sulfur dioxide and other gases.
c) In 35 locations in 10 countries, chronic respiratory conditions, primarily chronic bronchitis and asthma, were associated with airborne exposures to dusts and gases in an epidemiologically credible manner.
d) In 8 locations in 3 countries there is evidence of excess mortality in relation to environmental pollution, particularly between lung cancer and air pollution, and infant mortality and air pollution. This is based on direct evidence.
e) In 19 locations in 7 countries there is evidence of abnormal physiological development associated with air pollution including abnormal pulmonary, hematologic, or immunologic development; growth retardation or congenital anomalies.
f) In 6 countries, there is evidence of widespread nitrate concentrations in drinking water high enough to require water replacement to protect newborns against methemoglobinemia, or where morbidity and mortality from methemoglobinemia is endemic.
g) Other, less frequently occurring problems, include exposure to arsenic in air and water, infectious disease outbreaks from microbiologically contaminated drinking water, increased incidence of thyroid cancers in some communities following the Chernobyl accident, incidences of fluorosis due to exposure to emissions from aluminum smelters, and diseases associated with exposures to chlorinated hydrocarbons and pesticides.

Annex 4 of this volume contains a complete list of localities in Central and Eastern Europe where these problems have been documented.

The pollutants having the greatest impact on human health status in Central and Eastern Europe are:

• *Lead in Air and Soil* from emissions from lead and zinc smelters and, in certain cities, emissions from transport due to the use of leaded fuels.

• *Airborne Dust* from coal burning in household furnaces, small-scale enterprises, power and heat plants, and metallurgical plants.

• *Sulfur Dioxide and other Gases* from power and industrial plants, and households burning high-sulfur coal or high-sulfur fuel oil.

The following pollutants have been defined as secondary because they are, on average, less prevalent and/or involve claims of causation that are less certain than the ones above.

• *Nitrates in Drinking Water* from inadequately maintained/designed or improperly located rural septic tanks, feed lots and agricultural enterprises, and inappropriate fertilizer application.

• *Contaminants in Food* from the inappropriate handling or disposal of lead dust, heavy metals, pesticides, polycyclic aromatic hydrocarbons, and chlorinated organics such as PCBs. Many of these substances have well-documented toxic properties, yet the human health significance of ingestion at largely unknown doses is uncertain.

• *Other Contaminants in Water* from the inappropriate handling or disposal of water contaminated with arsenic, viruses/bacteria, pesticides, radionuclides, and chlorinated organics. Waterborne arsenic and viruses/bacteria have been directly implicated in a number of episodes of human disease in the region. The other contaminants, like their counterparts in food, represent risks of unknown prevalence, magnitude, and certainty.

Three issues are likely to be sources of concern for some observers. These relate to (1) the relative importance of dust *versus* sulfur dioxide and other gases; (2) the relative importance of air *versus* water pollution in terms of current impacts on human health; and (3) the level of precision and coherence of the priority pollutant categories, from a toxicological perspective.

DUST *VERSUS* GASES. New knowledge is rapidly emerging about the impact of air pollution on human health. The role of certain gases and vapors (especially sulfur dioxide, oxides of nitrogen, ozone, and hydrocarbons) in precipitating acute respiratory episodes and exacerbating chronic bronchitis and asthma is being elucidated. At the same time, the impact of respirable dust on mortality (in addition to its role in respiratory morbidity) is being recognized from studies of a variety of major urban centers in the West where ambient dust concentrations are much lower than in many places in Central and Eastern Europe. In practice, the list of places in the region with human health problems associated with air pollution include many where the primary problem is dust; some where it is one or more gases or vapors; and many where the problem is a combination of the two.

AIR *VERSUS* WATER. Airborne pollution is almost certainly a greater threat to human health than waterborne pollution in Central and Eastern Europe. Polluted air is harder to avoid than polluted water. Thus, any country which has zones where ambient air quality could affect human health tends to have evidence that is *has* affected health, and the more people who live in the zone, the greater the public health significance of poor air quality. For water pollution, larger settlements tend to have more resources available to replace polluted surface water with deep ground water and to treat microbiologically contaminated sources with coagulation and chlorination. The situation in rural areas is somewhat different. In the countryside the only alternative to surface water will usually be shallow ground water, which seems to be vulnerable to nitrate contamination.

COHERENCE OF POLLUTANT CATEGORIES. Some of the exposure categories which have been used here may seem very broad, at least from the perspective of exposure assessment and epidemiologic toxicology. This is because they represent a compromise between a desire to come to terms with the rich knowledge base of environmental health, on the one hand, and the necessity of using exposure categories which are practical from the perspective of remediation, on the other. For instance "dust," though it has an inhalation toxicology of its own, can have very different health impacts depending on its physical and chemical character. Thus, a remediation strategy which targets "dust" might seem frustratingly heterogeneous to a professional exposure assessor. Yet if dust defines a category which is efficient for intervention, such concerns ought to be met with indifference, both from the investment community and within the broad field of public health.

Methods of Data Evaluation

Despite problems with the quality of epidemiology and exposure assessment in Central and Eastern Europe (see Annex 1), there is extensive evidence that environmental pollution has had an impact on the health status of the population. Because the quality of the available evidence varies so much from location to location, it has been necessary to develop a special set of criteria to distinguish between those exposure situations which have affected human health from those which have not.

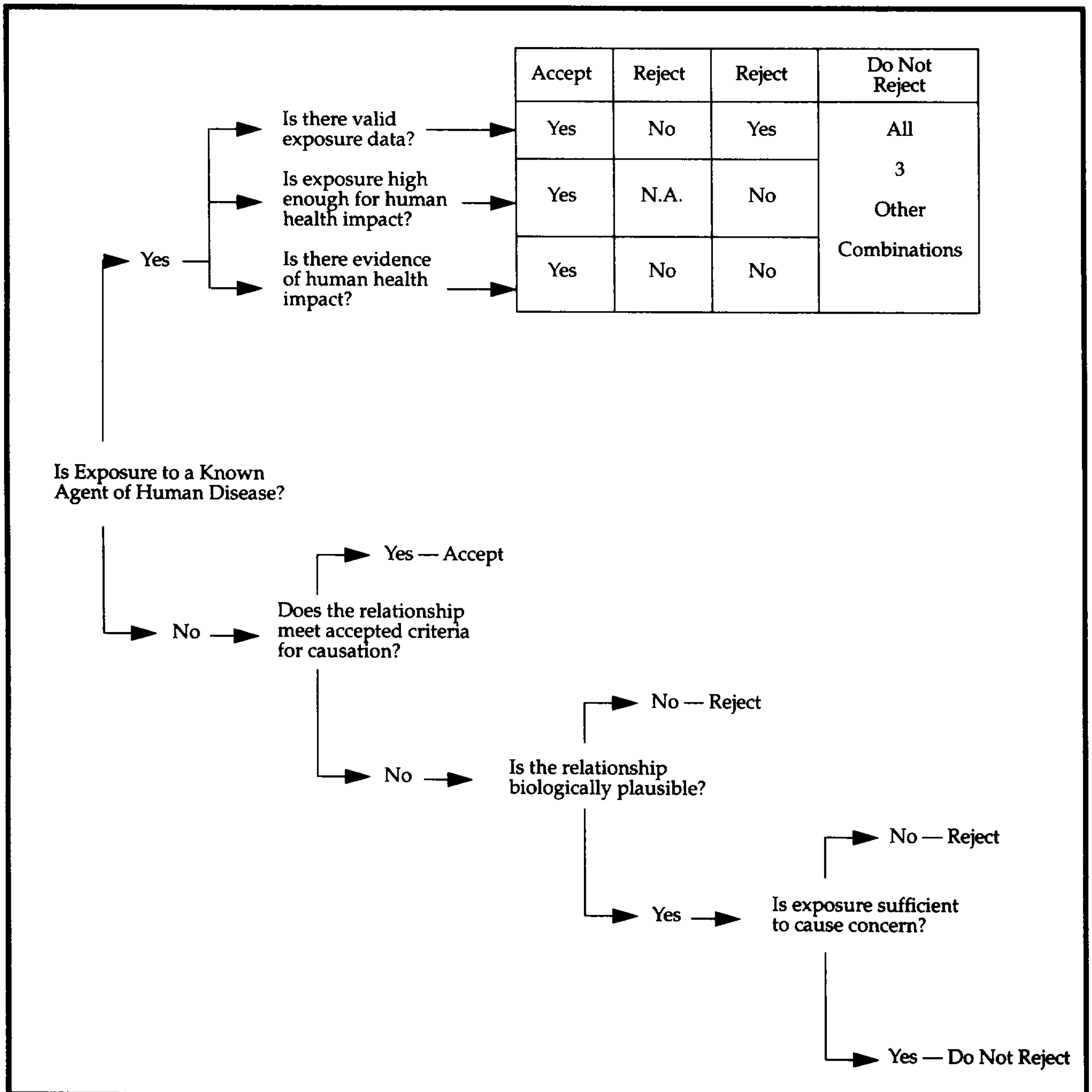
The criteria begin with a distinction between situations where an exposure is associated with a human health problem in a manner consistent with the results of well-designed epidemiologic studies conducted elsewhere in the world, and other situations in which the observed association has not been adequately studied elsewhere. In the former situations, three further questions need to be asked:

1) Are there valid exposure data?
2) Are the exposure levels high enough to lead to impacts on human health?
3) Is there direct evidence of an effect on human health in the location under study?

If the answer to each of these questions is "yes" we can conclude that human health has been affected. If the answer is "no" we can conclude that it has not. Similarly, when the answer to the first question is "yes" and the answer to the second and third is "no" it is concluded that human health has not been affected. The other contingencies fall somewhere between an unequivocal "yes" or "no" and require careful scrutiny on a case by case basis. For the purposes of identifying priorities for clean-up, uncertain cases have usually been resolved by "not rejecting" them, that is, by provisionally concluding that human health has been affected.

Where there is concern that human health has been affected by pollution in a way which has not been demonstrated by previous research around the world, the evaluation is more difficult. The first step is to ask whether or not sufficient evidence exists regarding the specific claim in the location of interest to meet traditional epidemiologic criteria for causation. So far this has not occurred, not least because it is difficult to sustain a claim of causation without consistent evidence from several places, rather than from just one. The next step is to ask whether or not the claim is plausible on the basis of what we know about human biology and pathology. If it is not, then the claim can be rejected. If it is plausible, then the final step is to ask whether the exposure is sufficiently intense and unusual by Western standards to have escaped detection in those countries where the epidemiologic study of the effects of industrial pollution is more advanced than in Central and Eastern Europe. If the answer to this latter question is "yes" then the claim is provisionally accepted.

This decision algorithm is illustrated below.



The Geography of Environmental Health Conditions in the Region

At the outset of our investigations in Central and Eastern Europe, it seemed as though environmental health problems were concentrated in large areas of ecological disaster which were called, somewhat loosely, hot spots. The model for this was the Katowice region of Poland, and the mining districts of northern Bohemia. From the standpoint of environmental action the most important characteristic of these large areas was the fact that air quality problems were not localized or easily attributable to a small number of polluting plants. Instead, the air shed was being influenced, more or less uniformly throughout the region, by hundreds of point and non-point (primarily energy and metallurgical) sources in the area. This would imply that any strategy for improving regional air quality would have to tackle whole sectors of the economies of Poland and the Czech Republic in order to have a significant impact.

As investigations proceeded though the rest of Central and Eastern Europe, it turned out that the hot spot model was not necessarily applicable to other places. Instead, we found smaller areas like Borsod County in Hungary or Copsa Mica region in Romania which are reminiscent of "rust belt" areas in America. These are old industrial areas where the nearby population is exposed to emissions from a confluence of point sources whose influences on air and water can largely be distinguished from one another. This suggests that an action plan which targets specific sources will have some chance of improving both environmental quality and human health.

Finally, some of the most dramatic environmental health problems have emerged in locations where "bad town planning" has augmented the impact of emissions from a single point source. Bad town planning simply means that housing or farms are located right next to a polluting plant with no *cordon sanitaire* to protect them. In such cases an effective environmental action strategy may be to close the plant, eliminate the emissions, or abandon the housing/farms. An example of each of these types of locations is given below.

A Regional Hot Spot—The Mining Districts of Northern Bohemia, Czech Republic

Life expectancy over the past 30 years for males and females in northern Bohemia has lagged behind the rest of the country. The districts of northern Bohemia are heavily represented among those with the highest mortality rates in the Czech Republic for lung cancer (as well as "all cancer"), cardiovascular diseases, suicides, infant mortality, respiratory disease, and "external" causes.

The physical and chemical environment of northern Bohemia is uniquely hostile. Anyone who visits the mining districts of Teplice, Usti nad Labem, Most, Decin, and Chomutov will witness the incremental effects of decades of open-pit mining and effluents from a variety of polluting industries with old technology and poor environmental controls. When emissions from home heating are combined with industrial emissions in these mountain valleys during temperature inversions, high ambient concentrations of sulfur dioxide commonly occur. Concentrations of greater than 1,000 micrograms per cubic meter can be sustained, on average, for 24 hours at a time or longer. High ambient concentrations of dust also frequently occur. Both rain water and dust in the area have been found to contain complex mixtures of metals, organics, and polycyclic aromatic hydrocarbons.

Several types of human health problems have been associated with the environmental conditions in the area. For example:

- Mortality from respiratory causes among newborns 1–12 months old is five to eight times higher in the areas of highest ambient dust and sulfur dioxide levels compared with places where air quality meets standards.
- Rates of low birth weight and congenital anomalies are suspected of being increased among newborns.
- Allergies and respiratory diseases are more prevalent among school children than in the rest of the Czech Republic.
- Children temporarily removed from the area to attend "nature school" in an unpolluted area have shown evidence of improved hematologic function, which reverses when they return home.
- All-cause mortality and mortality from lung cancer is higher among both men and women compared with the Czech Republic as a whole.

A Town at the Confluence of Point Sources of Pollution—Copsa Mica, Romania

Copsa Mica is home to several poorly maintained industrial facilities, among them two of the region's most notorious lead smelters. Health problems of particular interest in the community include respiratory problems from exposure to dusts and gases and neurobehavioral problems due to exposure to lead. One study examining pulmonary function in 371 Copsa Mica children ages 7–11 showed that of the exposed children, 30.2 percent had reduced peak expiratory flow rates and 18.1 percent had reduced forced expiratory capacity compared with 10 percent of children not exposed.

The same group of children, along with a group of 12-year old exposed children, were given a variety of psychometric tests to determine whether or not lead was damaging health. Children exposed to low levels of lead may suffer neurobehavioral damage, including lower I.Q.s, shortened attention spans, hyperactivity, aggressive behavior, reading disabilities, and behavioral problems. Much higher percentages than expected tested weak or very weak on among the exposed children. While approximately 30 percent of children were expected to test "weak or very weak," meaning below the first standard deviation of the "normal" distribution, 73 percent scored at this level on the I.Q. test, 58 percent on the concentration test, 52 percent on the learning test, and 60 percent on the memory test.

"Bad Town Planning"—Dimitrovgrad, Bulgaria

In Dimitrovgrad, thick, acrid effluent containing hydrogen fluoride and hydrogen sulfide comes from a single smoke stack at a fertilizer plant. High-rise apartments and other settlements are located at the plant gate, their occupants exposed to high levels of these emissions. A greater than expected number of children in Dimitrovgrad have below normal physical development and pulmonary function.

Health Problems Associated with the Principal Environmental Exposures in the Region

This section presents the evidence which supports the conclusion that human health has been affected by environmental pollution in Central and Eastern Europe. It is organized according to the principal exposure categories described previously.

Exposures to Lead

Exposure to even low doses of lead can cause subtle brain damage and learning problems including lower IQ's, impaired attention, speech and language deficits, and behavior disorders. These deficits are significant because they may have long-term effects on children's educational attainment, employability, and ability to cope with the stresses of life. Evidence of neurobehavioral deficits among exposed children has been found near industrial point sources of lead (especially smelters) and in urban areas with heavy traffic flows.

Average blood lead levels among exposed children in Central and Eastern Europe are often greater than 15 micrograms per deciliter and sometimes exceed 40 micrograms per deciliter. Levels like this were not uncommon in the West until twenty years ago, but are very high by today's standards. For instance, the highest average blood lead level in a local community in Canada in recent years, measured in a smelter town with particularly unfavorable meteorological conditions, was 13.8 micrograms per deciliter among a complete census of the town's 3–6 year olds. In Vancouver, a city of 1.5 million with no leaded gasoline for sale and virtually no other point sources of lead, the average blood lead level among 2–3 year olds was 5.3 micrograms per deciliter.

In studies in the West, it has been shown that soil and house dust are important sources of lead exposure to children, especially among those young enough to be playing on the ground, mouthing their toys, and licking their dirty hands. Soil lead concentrations in certain areas of Central and Eastern Europe may be well above acceptable levels for residential areas. In one area of Katowice, soil lead levels exceed 19,000 parts per million and near Pribram, Czechoslovakia they exceed 5,000 parts per million.

In several areas of Central and Eastern Europe, these sources of exposure have been augmented by high levels of lead in food. For instance, in the smelter town of Pribram in the Czech Republic, it was estimated that exclusive use of home grown fruits and vegetables would provide 1,042 percent of the acceptable weekly intake of lead for children. A similar problem likely exists in the Plovdiv-Kuklen-Asenovgrad area of Bulgaria where lead smelting is taking place in the middle of some of the richest farmland in the country. Studies among adolescents in certain parts of Silesia have shown dietary lead intakes as much as seven times above acceptable weekly intakes for those in the highest decile of intake.

POLAND. The Institute of Rural Medicine has studied soil contamination across Poland attributable to airborne point sources of metals and the "liming" of acidified soils. There have been dramatic and unfortunate impacts of using industrial waste to "lime" acidified soils. The metals content of the material used for liming, which came from several large industrial concerns, often exceeded recognized norms, (such as the West German soil cultivation standards for four target metals), by a hundred fold or more. This is illustrated in the table below. In major industrial areas, it would be difficult to separate the effects of liming from those of long-term airborne deposition of toxic materials originating from similar point sources.

The cumulative impact of airborne deposition and liming of soils with industrial waste may be seen with reference to heavy metal pollution in allotment gardens near large cities. Once again, the concentrations of these various metals can be seen to exceed cultivation standards by 5 to 120 fold.

The Institute of Hygiene, the principal agency looking at metal contents of food and studying total dietary metal intake among children, has carried out useful studies on the dietary intakes of heavy metals. One study has involved taking samples, usually over a 10-day period, of the food provided to children living full-time in institutional surroundings. The sample shown in the table below, while not representative of the entire country, shows that in many regions children are ingesting metals at levels far above international norms. Walbrzyskie is particularly striking in this regard.

Samples of crops taken at the farm have often contained unacceptable concentrations of heavy metals. Average concentrations of lead and cadmium in potatoes from various places within Katowice, as well as Walbrzyskie, Kieleckie, and Bydgoskie can exceed WHO guidelines for lead (see Annex 5, Table A5.1). In the other regions, the

Table 3.1 Metal content of materials used for liming soils in Poland

	Metals Content (parts per million)			
	Lead	*Cadmium*	*Arsenic*	*Chromium*
West German soil cultivation standards	100	3	20	100
Bolesaw	30,250	474	1,130	1,984
Miasteczko	4,563	..	1,250	1,600
Orzet Bialy	3,700	..	..	..
Huta Sendzimira smelting works	..	..	..	13,000

Source: Marchwinska and Kucharski 1983

Table 3.2 Allotment gardens near point sources of metals, Poland

		Parts per million	
Near industrial complex-	Bolesaw	12,750	lead
Near arterial road-	Bytom	161	cadmium
	Lublin	158	cadmium
Various allotments near industrial complexes/arterial roads		100	arsenic
Near leather tannery		3,047	chromium

Source: Marchwinska and Kucharski 1983

problems do not seem to be as acute. However, information on samples taken at the point of exposure do not necessarily reflect the dietary experience of the population.

Total Exposure and Health Outcomes of Lead in Katowice. The best studied environmental health issue in Katowice Province is lead pollution and its effects on children. This is not surprising because exposure to lead is significant from all major sources. First, consider airborne exposure: data (presented in Annex 6, Table A6.1) show that as recently as 1987, when industrial production in Katowice had not yet begun to decline, airborne lead concentrations were so high they would constitute special exposure conditions in North America.

A large proportion of the garden plots in Katowice are adjacent to industrial areas which have been contaminated both by airborne deposition and the practice of liming the soil with inorganic industrial waste. Annex 5, Table A5.2, shows that garden plots in Katowice are heavily contaminated with lead as well as cadmium. This would serve as one significant source of lead exposure among children.

Two extremely dedicated scientists at the local Environmental Pollution Abatement Center have carried out a pain-staking evaluation of the soil quality in virtually every farm and garden plot in the most heavily polluted parts of Katowice. Less than 40 percent of the places that they tested were found fit for unrestricted cultivation of edible plants because of heavy metal contamination. A full 50 percent of farms and gardens were found to be appropriate only for species of edible plants which do not concentrate heavy metals, while 10 percent were found suitable for decorative plants only. Because heavy metals persist in soils, pollution abatement will not be sufficient to resolve the problem. This is a major concern since, 70 percent of the food consumed in Katowice is grown in the province, and 50 percent of the land in the area is used for agriculture.

Soil lead levels in the most contaminated residential areas of Katowice are virtually outside the experience of much of the Western world. A standard for lead in residential soil in several jurisdictions is 500 parts per million. Table 3.4 shows that average soil lead levels in three contaminated areas in Katowice are much higher than acceptable standards.

Soil lead levels have been demonstrated to be a principal source of high blood lead in children who are not exposed to lead-based paints. This is because young children (under the age of 5) tend to passively ingest soil by direct contact or contact with house dust contaminated with lead. Thus, in addition to airborne exposure, children in Katowice are potentially exposed to lead both from food and soil. It is no surprise that the blood lead levels among all regions of Katowice are very high among chil-

Table 3.3 Daily metal intake from food in Polish adolescents, 1983
(micrograms per cubic meter)

	Lead		Cadmium	
	mean	90th percentile	mean	90th percentile
WHO daily intake maximum	428		57–71	
Bialystock	104	305	22	58
Krakow	431	609	111	184
Lublin	154	411	26	67
Plock	51	161	81	83
Sieradz	46	171	82	246
Slupsk	248	1040	11	49
Walbrzyskie	783	2643	..	..

Source: Zawadzka 1986

Table 3.4 Soil lead levels in three contaminated areas in Katowice

	Mean	Range
Area 1	6449	753 - 19,750
Area 2	2124	82 - 6,775
Area 3	1025	447 - 1,550

Source: Hertzman 1990 (d)

Table 3.5 Blood lead in children and mothers in various places within the Katowice region, 1989
(micrograms per deciliter)

	Children		Mothers	
	Mean	Percent > 35 µg/dl	Mean	Percent > 35 µg/dl
Szopiencice	26.7	18	21.1	12
Miasteczko Sl	24.7	17	21.6	15
Zyglin	26.1	22	20.1	10
Lubowice	12.7	0	10.6	0
Zabrze	18.9	3	15.9	4
Toszek	17.9	13	13.1	5
Bytom	15.2	10	15.5	5
Bojszow	12.3	0	11.5	0
Brzeziny Sl	22.4	13	17.6	7
Brzozowice	23.4	8	16.8	5

Source: Hertzman 1990 (d)

dren and mothers except in Lubowice and Bojszow, which are relatively remote areas.

For comparison, the Center for Disease Control (CDC) in the United States considers 10 micrograms of lead per deciliter of blood to be the maximum level before damage occurs. Levels above 25 micrograms per deciliter call for medical investigation. In five of the regions listed in Table 3.5, mean lead levels among the children were at or near this critical level and all were above the threshold level. These data from Katowice are likely to be conservatively biased since several children with acute symptoms were excluded from the Katowice sample. These children had blood levels between 35 and 87 micrograms per deciliter.

Children living near the Miasteczko lead and zinc smelter in the early 1980s also had very high blood lead levels, as a study carried out by the Academy of Medicine in Zabrze shows. Table 3.6 presents data on age-specific blood lead levels among these children.

One reason policymakers are so concerned about lead poisoning is that it can affect intellectual development. Data suggest that exposure to lead is affecting intellectual capabilities among children in Katowice. Table 3.7 indicates a 13 point IQ gradient between children with the highest and lowest blood lead levels among children participating in this study. The children suffering from lead poisoning may have reduced prospects throughout their adult lives.

The 231 children from the polluted areas in Katowice also suffered from a variety of other significant health problems which may be related to chronic and acute lead exposure: 66 percent were anemic, 33 percent had digestive tract systems, 78 percent had electroencephalogram changes (11 of whom had a history of "epileptic symptoms"), three had peripheral nervous system pathology, and virtually all had chromosome abnormalities in samples of white blood cells.

There is some evidence that anemia is a widespread problem throughout Katowice Province, possibly due to exposure to lead. One study shows that from the mid-1970s to the mid-1980s, the average hemoglobin level among children and mothers in the province was approximately 12.5 grams per deciliter. This is 2.5 to 3 grams per deciliter below the expected level and below the average for Poland. While anemia is associated with exposure to lead, it would be very difficult to attribute such a widespread phenomenon to this single source. Local investigators speculated that anemia might be a result of interactive effects of exposures to several metals and other environmental toxins, perhaps mediated through acidification of soils and loss of bio-availability of nutrients, but in ways which are very poorly understood.

HUNGARY. Blood lead levels among children in cities in Hungary can also be very high. Table 3.8 shows blood lead

Table 3.6 Blood lead levels among children in Zabrze, Katowice
(micrograms per deciliter)

Age	Mean	Percent > 30 µg/dl
1–3	17.3	7
4–6	20.1	7
7–10	25.8	21
11–15	19.3	3

Source: Hertzman 1990 (d)

Table 3.7 I.Q.s of children with different blood lead levels, Katowice

Blood lead level (g/dl)	Number	IQ
< 20	94	111
20–25	59	105
26–30	53	105
> 30	25	98

Source: Hertzman 1990 (d)

Table 3.8 Blood lead levels among children in Hungary
(micrograms per deciliter)

	Mean	Range	Percent > 20 µg/dl
Budapest:			
Inner city	24.8	3.5–57.5	57.1
Outskirts	7.6	2.5–20.9	1.7
Romhany	14.0	. .	17.9
Szolnok	18.0	. .	37.6

Source: Rudnai (undated)

levels among children for three localities in Hungary which participated in a study on lead neurotoxicity coordinated by the World Health Organization. Inner Budapest and Szolnok were selected because of their large and moderate sizes respectively and their relatively heavy traffic flows. The town of Romhany was selected for study because it has a single industrial point source of lead but low traffic flows.

In Inner Budapest, where the primary source of lead pollution is from transport sources, the mean airborne lead concentrations actually exceed those of Katowice. For comparison, the towns of Trail and South Riverdale in Canada with major point sources of lead have airborne lead levels only 8–34 percent of those found in inner Budapest (see Annex 6, Table A6.1).

Further evidence of the important role of motor vehicles in airborne lead levels is demonstrated by comparisons of regions of high and low traffic flow in Budapest: the range of airborne lead levels runs from 5.4 micrograms per cubic meter in high flow areas to a low of 0.4 in a parkland area. That this may have a significant public health impact is illustrated in Table 3.8. In the inner city, the mean blood lead level is more than 3 times as high as it is in the outskirts. Moreover, the proportion of children with blood lead levels above 20 micrograms per deciliter (a level of exposure at which one would expect evidence of neurobehavioral problems), is 57.1 percent, compared with a proportion of 1.7 percent on the outskirts, an enormous difference.

Although the town of Szolnok in Hungary is much smaller than Budapest, with a population of approximately 70,000, airborne lead levels there can be as high as areas of Katowice. As in Budapest, motor vehicles are the main sources of lead.

The study on lead neurotoxicity in Hungary also evaluated a wide variety of parameters related to neurobehavioral function among participating children. In Romhany, a clear gradient of I.Q. with blood lead level was found: children with blood lead levels above 25 micrograms per deciliter had I.Q.s, on average, 10 points below those whose blood leads were less than 10 micrograms per deciliter. However in Szolnok the gradient was only 3.5 I.Q. points, and in Budapest there was no statistically significant trend at all. At first glance, this would appear to be contradictory, since the range of blood lead levels in Budapest was higher than in Szolnok which was, in turn, higher than in Romhany. One would expect greater toxicity to be evident in the places with a higher range of blood lead. However, as settlements get larger, the degree of heterogeneity in socio-economic status increases. Because this is a powerful predictor of neurobehavioral function, it can easily confound the relationship between I.Q. and lead exposure. While the investigators attempted to take these factors into consideration, it is likely that the gradient in Budapest was obscured by residual confounding effects which were not adequately controlled.

CZECH REPUBLIC. The evidence for significant lead exposures in the area of the Pribram smelter is impressive. Soil lead levels near the smelter can exceed 5,000 parts per million, and even these values may be underestimates.[1] Locally grown food may be a significant source of lead intake for adults and children. Measurements of lead in fruit and vegetables grown near the smelter show that a diet made up exclusively of local produce would provide more than ten times the allowable weekly intake of lead, and excessive quantities of cadmium and mercury (see Annex 5, Table A5.3).

A small battery of three psychometric tests was administered to the study children from the Pribram area. These revealed deficits for both boys and girls for at least one of the three test variables. This result is consistent with other studies of children exposed to lead and supports the validity of the high blood lead values reported from testing in Central Bohemia, rather than lower results from retests done in Belgium.

ROMANIA. A World Health Organization study done among children in a Bucharest community adjacent to a lead smelter in 1985–86 showed that among 323 children, 184 (57 percent) had blood lead levels between 17–25 micrograms per deciliter and 44 (13 percent) had levels between 26–35 micrograms per deciliter. Data available from the WHO study on the relationship between performance on six neurobehavioral test batteries and blood lead levels show a strong correlation between increasing blood lead levels and decreasing performance after adjusting for age, sex, and parental occupation. The proportion of the variance explained by blood lead level varied from a low of 14.3 percent for a general performance test to a high of 32.1 percent for a test of visual-motor coordination skills, with those for tests of I.Q., verbal and number skills falling in between. Teachers in the local area have indicated that children with blood lead levels greater than 25 micrograms per deciliter were more likely to have unstable attention, lack of perseverance, and greater impulsiveness than children with lower blood lead levels. A similar study done with children from the smelter town of Copsa Mica has been discussed earlier.

BULGARIA. There is evidence of exposure to excessive lead in some cities in Bulgaria. One study, conducted from 1986 and 1989, showed that children below kindergarten age in residential institutions in Sofia, Plovdiv, Varna, Veliko-Turnovo, Stara Zagora, and Pleven were receiving excess levels of lead in food. These children were ingesting between 0.06–0.25 milligrams per day of lead in diet, far above the Food and Agriculture Organization (FAO) permissible total daily lead intakes for children of 0.046 milligrams per day. The food contained high concentrations of lead in all seasons of the year and lead levels had increased over each of years of the study, according to the Institute of Gastroenterology and Nutrition.

Unfortunately, data are not systematically collected from farms and processing plants, so we do not know whether the problem with the food supply is a general one or related to specific problem sources. In fact, it was claimed that the results of routine monitoring food are not retained, even in a non-computer-readable form. There has, however, been one study on the lead content of instant baby food cereals processed in Romania's single factory. This factory, in Svishtov, gets its raw material from all over the country. Of 66 food samples taken between 1986 and 1989, 62 had lead concentrations above the lead standard of 0.1 milligram per kilogram. Lead concentrations in food samples ranged from 0.08–0.93 milligram per kilogram; most samples contained lead in excess of 0.33 milligram per kilogram.

In the Plovdiv/Asenovgrad area, a principal concern is lead in soil, since a large lead and zinc smelter is situated in the middle of a valley of prime agricultural land. Land adjacent to the lead and zinc smelter is cultivated without zones of protection or apparently any local or national regulation. Measured lead concentrations in agricultural soil ranged from 12–1035 parts per million. More than 36 percent of the samples taken in the mid-1980s contained lead above the cultivation standard, after adjustment for soil acidity. Lead levels of several hundred to 1,000 parts per million in crop growing areas are very high. There is reason to believe that food grown in the area contains high levels of lead. Annex 5, Table A5.4, shows that crops grown in the area contain lead above the maximum allowable concentrations.

Moreover, atmospheric conditions in the valley may facilitate the airborne spread of lead-contaminated dust exposing settlements in the valley (particularly Kuklen) to high ambient concentrations of lead. The average airborne lead level in the Kuklen area in 1989–90 was 2.6 micrograms per cubic meter, which is comparable to the highest levels in Katowice, Poland. Table 3.9 below shows that nearly all the children tested in Kuklen had blood lead levels above 10 micrograms per deciliter and the majority had concentrations above the dangerous level of 25 micrograms per deciliter. Indeed, the average blood lead level in children in Kuklen is 33.5 micrograms per deciliter. No studies are available which help distinguish the relative contributions of food, soil, house dust, and other sources to blood lead levels in children.

The correlation of airborne lead levels with rates of anemia among children is strong (r=0.75). There is also correlation between toenail lead levels in 108 children and performance on the Weschler Verbal Intelligence Test (r=0.26, p=.008). This indicator of neurobehavioral dysfunction among children, conducted according to the WHO protocol, provides evidence that the sustained high lead exposures may be deleteriously influencing the development of children in the area.

BALTIC COUNTRIES. Unlike other countries in the region, the Baltic countries have not routinely measured blood lead. Therefore the lead exposure situation in the Baltic countries must be pieced together from hair lead data, which is difficult to interpret, and occasional blood lead sample studies. Annex 5, Table A5.5, shows that the average hair lead levels in the four cities of the industrial northeast are 2–2.5 times higher than in Tartu. The only blood lead survey among children in the northeast, in Saka, shows an average blood lead level of 10.5 micrograms per deciliter. This is not especially high compared with the most polluted Central and Eastern European towns and cities. Still, average blood lead levels of greater than 10 micrograms per deciliter among children is a concern, since this is the level at which neurobehavioral damage might occur.

UKRAINE. Konstantinovka is a town with 108,000 inhabitants in Donetsk Oblast, approximately 50 kilometers north of the city of Donetsk, in the eastern part of Ukraine. In the center of the town, in a valley that is approximately 70–80 meters deep and 6–7 kilometers wide, are located a lead and zinc smelter (with a 180 meter smokestack), a chemical plant, and a metallurgical plant. The smelter accounts for 33 percent of the air pollutants in the town; the chemical plant, 15 percent; and the metallurgical plant, 15 percent. The lead and zinc smelter, built in 1930, currently produces about 50,000 metric tons of lead per year despite a shortage of raw materials. Despite its heavy production, no investment for modernization or repair has been made at the smelter for the past 20 years. Staff of the sanitary epidemiology station estimate that about 15,000 people live within 1 kilometer of the industrial zone.

Between 1982 and 1991, mean airborne lead levels within one kilometer of the plant ranged from 2.7 to 5.4 micrograms per cubic meter and maximum levels reached 10 micrograms per cubic meter, higher than in Katowice or urban Budapest. Unfortunately we have no blood lead or

Table 3.9 Children's blood lead levels in the area of Plovdiv and Asenovgrad, Bulgaria
(percentages in each category)

	Blood Lead Levels (micrograms per deciliter)				
	< 10	*10.1–15*	*15.1–20*	*20.1–25*	*> 25*
Kuklen	1	1	16	20	61
Average of other settlements	3	16	31	25	24

Source: Hertzman 1991

neurobehavioral data on exposed children in the area. Reported soil lead levels are exceedingly low for these exposure conditions, calling into question the methods of measurement of lead in soil.

Although at least three studies of lead exposure to children living near point sources in Ukraine have been carried out, they are not of sufficiently high quality to provide a picture of conditions in the region. They do not identify the specific point sources of exposure, even by region, and they measure hair and tooth lead rather than blood lead. While one study does provide neurobehavioral data on both children and adults, it has limited usefulness because it fails to link health outcomes to exposure conditions.

Respiratory Conditions and Other Problems Associated with Air Pollution

Respiratory disease due to air pollution is the most commonly reported environmental health problem in Central and Eastern Europe. This is not surprising because high ambient levels of dust, sulfur dioxide, and other gases are common in populated areas of the region. The first of the following three sub-sections provides data on ambient air quality in the region. These are presented in non-standardized forms because each data set differed from the others in its original presentation. The second sub-section presents evidence of respiratory and developmental problems in specific locations in the region associated with airborne pollution. The third sub-section deals with excess mortality associated with airborne pollution.

Ambient Air Quality. Many towns and cities throughout Central and Eastern Europe suffer from high ambient concentrations of suspended particulate matter and sulfur dioxide due to the use of high-sulfur coal and fuel oil in power stations and households.

POLAND. Many communities throughout Poland experience high concentrations of sulfur dioxide and suspended particulate matter. Table 3.10 below shows sulfur dioxide concentrations in Polish cities for 1988 in comparison with levels in OECD cities for which data were available for various years in the late 1980s. The distribution of means in Poland is much higher than in the OECD cities, with the highest in Poland being more than 10 times that of the OECD cities.

The problem in Poland is not isolated to a few polluted communities. As Annex 6, Table A6.2 shows, in many Polish communities, sulfur dioxide levels exceeded those in the OECD cities. In addition, dust concentrations above 100 micrograms per cubic meter were common in Polish communities.

Katowice and Krakow are two of the largest industrial centers in Poland. According to available data, (Annex 6, Table A6.1), Katowice suffers from very high annual concentrations of suspended particulate matter: in 1987, concentrations were 3 to 30 times the levels found in cities in Canada, France, the United States, and Sweden in the late 1980s. The data also suggest that nitrogen oxide levels in Katowice are higher than in OECD cities. This is surprising because a major source of nitrogen oxide emissions is motorized transport, which is relatively undeveloped in Central and Eastern Europe compared to the West. On the other hand, sulfur dioxide concentrations appear moderate compared with other cities in Poland and elsewhere in Central and Eastern Europe. However, data for Katowice was provided by a different agency than the one providing data for the rest of Poland, so the values may not be strictly comparable.

Krakow is home to numerous emission sources, including the huge Nowa Huta Steelworks, an aluminum plant, several chemical concerns, and a variety of coal-fired electricity generating plants, as well as individual and neighborhood furnaces and heat plants. The data show that Krakow has high concentrations of sulfur dioxide compared with other cities in Poland, but not of airborne dust and nitrogen oxides.

HUNGARY. In Hungary, general environmental pollution does not appear to be severe enough to be having a significant impact on the health of the population as a whole. Even during the heating season (when coal burning is at its greatest) sulfur dioxide levels rarely exceed an average of 140 micrograms per cubic meter across monitored settlements in the various counties of Hungary.

As in many areas with traditional smokestack industries, dust is a major problem in the rust belt area of Borsod County. Unfortunately, Hungarians have not systematically measured suspended dust, but only sedimenting dust. This measure cannot be precisely correlated with the more common measures of suspended or respirable dust, so we have no way of knowing how severe the dust problem is in Hungary compared with other countries. All we can say for certain is that annual average sedimenting dust levels show a fourfold variation across the 5 sampling areas in Borsod County in the late 1980s. The dust has been high in cadmium, copper, zinc, and lead. In recent years, the installation of an electrostatic participator and changes in the open hearth technology at the steel mill in Miskolc, along with the economic slowdown, have helped to reduce sedimenting dust levels.

The industrial area of Nagyteteny of Budapest also has high air pollution. In the area there are 8 major industrial sources including Metallochemia, a source of lead and other heavy metals, sulfur dioxide, carbon monoxide, and

Table 3.10 Sulfur dioxide levels in OECD and Polish cities
(average annual micrograms per cubic meter)

	Range of means
OECD cities (late 1980s)	7–56
Poland (1988)	3–636

Source: Hertzman 1990 (d) and OECD 1991 (b) nitrogen oxides, and the Chinoin chemical plant. During the heating season, the ambient sulfur dioxide levels can reach 440 micrograms per cubic meter.

CZECH AND SLOVAK REPUBLICS. The period of relative decline in Czechoslovakian health status has occurred at a time of marked decline in the quality of the physical environment. The table below traces the changes in average annual sulfur dioxide concentrations in 6 regions of the country from 1970 to 1985. In the industrial and mining regions of northern Bohemia, sulfur dioxide levels more than doubled over the 15-year period. Increases were also seen in Prague and the Ostrava region, though not so obviously in Bratislava. This table also illustrates the dramatic difference in the historic trend of ambient sulfur dioxide levels between CEE and OECD cities. In 1970, sulfur dioxide levels were much higher in OECD cities from which data were available than they were in the industrial regions of the Czech and Slovak Republics. By the mid 1970s, these differences had disappeared and by the mid 1980s, sulfur dioxide levels in the OECD cities had dropped to a fraction of those in the Czech and Slovak Republics.

By the 1980s, sulfur dioxide levels in measured locations throughout the Czech Republic were all relatively high. Annex 6, Table A6.1 shows that annual average sulfur dioxide levels in northern Bohemia were much higher in the 1980s than in OECD cities. Moreover, under extreme inversion conditions, such as occurred on January 14, 1982, sulfur dioxide levels can exceed 2500 micrograms per cubic meter in Prague and in areas of northern Bohemia.

BULGARIA. In 1989–90, average annual sulfur dioxide levels varied between 28 and 485 micrograms per cubic meter and suspended dust levels varied between 160 and 530 micrograms per cubic meter in eight communities in Bulgaria with one or more point sources of pollution. The data presented in Annex 6, Table A6.1 show that ambient sulfur dioxide and suspended dust levels in Bulgaria are high even in comparison with the most polluted areas of northern Bohemia and Katowice.

ESTONIA. In general, air quality in Estonia is not as unfavorable to human health as it is in the most heavily industrialized and urbanized areas of Central Europe. This seems to be due to three factors. The country is not heavily industrialized and nowhere are there large numbers of highly polluting industries clustered close together. Tallinn is the largest city and while there are concerns about traffic emissions, the city is too small to generate the degree of traffic pollution found in a place like Budapest. Finally, strong winds often blow across northern Estonia which help disperse pollution. This process is no doubt assisted by the tall stacks on the two large oil shale fired power plants in northeastern Estonia.

Data presented in Annex 6, Table A6.1 show that sulfur dioxide levels in Tallinn and Narva are considerably lower than in the most polluted places in Central Europe. However, if the data are accurate, dust concentrations in Narva are very high. Narva is home to the Baltic and Estonia Power Plants, which emit prodigious quantities of sulfur dioxide and dust. These power plants are the only ones in the world using oil shale as a fuel. Oil shale is an inefficient energy source and is high in sulfur, but it is mined locally in an extensive network of open pit and underground operations.

Also in the local area is the city of Kohtla-Jarve, where the chemical plant Slantsechim emits large quantities of several toxic substances, including a variety of hydrocarbons. Slantsechim relies on oil shale as a feedstock. Nearby is the town of Sillamae, home to chemical and metallurgical industries which use radioactive materials such as tantalum oxide, niobium oxide, and thorium as inputs. There is also rumored to be a uranium dump site there, but information is not public. It is not surprising that the Narva-Sillamae-Kohtla-Jarve area is considered to be the main area of environmental concern in the country.

The other source of air pollution in the region is the Eesti Tsement plant in Kunda, in the region of Laane-Viru east of Tallinn. A photograph of the town of Kunda was featured in a National Geographic article on the Baltic countries showing houses in the vicinity covered with a thick layer of cement dust, like a permanent snow cover. This impression is borne out on visiting the town. Also unmistakable is the enormous quantity of dust emerging from the plant's several stacks. About 13.5 percent of the 75,000 tons of dust emitted from the plant per year consists of silica (which has toxic effects on the respiratory system beyond simple dust deposition); the dust also con-

Table 3.11 Historic changes in average annual sulfur dioxide concentrations in the Czech and Slovak Republics
(micrograms per cubic meter)

	1970	*1975*	*1980*	*1985*
OECD cities	151[1]	76[2]	59[2]	37[2]
Czech cities				
Chomutov region	53	71	94	126
Most region	57	80	102	132
Teplice region	51	77	93	110
Ostrava region	36	36	46	55
Prague (Karlov)	100	100	128	155
Slovak cities				
Bratislava	49	67	55	60

1. Based on data from 6 cities
2. Based on data from 18 cities
Source: OECD 1991 (b) and Czechoslovakia Department of the Environment 1990

tains greater than trace amounts of several toxic metals, including arsenic, lead, thorium, and uranium. It is remarkable that no routine or special air quality data exists for Kunda and that the regional San-epi station has taken no interest in human health issues associated with dust emissions there.

LITHUANIA. There are no large areas in Lithuania as polluted as the worst areas in Central Europe. However, there are small areas within certain urban areas where ambient concentrations of pollutants do reach high levels. Annex 6, Table A6.1 identifies Kaunas, Siauliai, and Kedainiai as the dustiest locations in the country.

There are approximately 150 significant industrial emission sources in Kaunas, (about 25 percent of Lithuania's industry), so it is not surprising that air quality is poor here. About 98,000 people live in areas where average dust levels exceed the daily Soviet maximum allowable concentration (MAC) of 150 micrograms per cubic meter by 1–4 fold and a further 28,600 live in areas where dust exceeds the MAC by more than 4 fold.

Data regarding benzo(a)pyrene identifies Siauliai as a place with high airborne concentrations of this known carcinogen. This is surprising because motorized transport is relatively light in Siauliai in comparison with Vilnius or Kaunas. It is possible that overflights from the Soviet air base nearby are a significant source of ambient benzo(a)pyrene in Siauliai. This impression is reinforced by data showing that ambient concentrations of formaldehyde, carbon monoxide and lead can be elevated in Siauliai.

In Jonava, the local fertilizer factory is emitting high levels of a variety of toxic chemicals (see Annex 6, Table A6.3). Of particular interest is hydrogen fluoride, a irritant to the respiratory system. Reductions in respiratory function have been documented among children living near this kind of fertilizer plant in other locations in Central and Eastern Europe.

LATVIA. With the exception of nitrogen dioxide from motor vehicles in Riga and formaldehyde in the port city of Ventspils, there are no areas in Latvia with sustained air quality problems—at least, not of an intensity which would lead to regional concerns about human health. However, there are local areas with air quality concerns of potential human health significance that are not reflected in the routine monitoring data. In general, these are poorly quantified. They include:

- Liepaja: phenol arising from military sources and benzo(a)pyrene from motor vehicle traffic.
- Olaine: ammonia, phenol, and benzol arising from the pharmaceutical plants and their waste water treatment facilities.
- Riga: phenol and benzol arising from thermal plants, transportation sources, and other specific point sources, such as the chemical industry.
- Valmiera: phenol arising from local industrial sources.
- Ventspils: benzo(a)pyrene arising from motor vehicle and energetic sources.

BELARUS. Annex 6, Table A6.1 gives average ambient air pollution levels in the major cities of Belarus. These data show that the principal airborne pollutant in Belarus is dust.

UKRAINE. The large industrial cities of Zaporozhye, Makeevka, Mariupol, and Konstantinovka in the Donbass region often have high levels of air pollution. The major industrial emitters in this region are metallurgical plants, coke-chemical plants, and underground coal mines.

Heavy industrial plants are commonly located within or near to urban residential areas. Efforts to keep people from living in so-called "sanitary zones" around these plants have not been successful. For example, in Makeevka, approximately 32,000 people live in the "sanitary zone" that lies within 2 kilometers of the metallurgical and two coke-chemical plants. Systematic measurements over many years have documented high levels of hazardous air pollutants in these residential areas. In Zaporozhye over 10,000 people living within 1 kilometer of a huge industrial area are exposed to hazardous levels of air pollution (see Annex 6, Table A6.4).

Respiratory and Developmental Problems. This section provides examples of respiratory and developmental studies done in several of the countries in Central and Eastern Europe. In the case of respiratory problems, the results described here are consistent with those of well-designed studies done elsewhere. This is less the case for problems described as abnormal physiological development. Developmental problems have not been studied extensively, at least not in relation to environmental etiology. The examples given here are illustrative rather than exhaustive.

POLAND. One study associating sulfur dioxide exposures with respiratory disease is available which is of sufficient quality to help understand the effects of sustained exposure to sulfur dioxide across the country. This study uses information from medical examinations for 575,000 19–year old males being inducted into the army between 1979 and 1982. Since all Polish males were required to submit to the examination, there should not be significant selection bias in this sample. The inductees were evaluated for chronic bronchitis and asthma according to diagnostic criteria which were, unfortunately, not stated. These examinations took place at 241 centers across the country. The centers were then divided by mean annual ambient sulfur dioxide levels as measured by the nearest monitoring stations. Since the inductees, as a rule, were evaluated at the centers nearest their homes, these served as surrogate measures of the sulfur dioxide exposure that the men experienced. Because of the large number of centers associated with each level of ambient sulfur dioxide, it is hard to imagine that a diagnostic bias would have applied systematically across all of them. The data revealed that the chronic bronchitis rates were more than three times higher in the recruitment centers in areas of high ambient sulfur dioxide than in areas of low concentrations. Similarly, the prevalence of asthma was a four times as high in the worst polluted areas as in the least. Unfortunately, no smoking data were provided.

Another study, summarized in Annex 7, Table A7.1, examines the relationship between air pollution and chronic bronchitis by comparing prevalence rates among people living near Krakow with prevalence among people living in smaller villages. The investigators were careful to divide the sample by males and females and to account separately for smokers and non-smokers. The study showed that risks of chronic bronchitis, using non-smoking villagers as a baseline, are higher for villagers who smoke, and for both non-smoking and smoking suburbanites, as we would expect. Another investigation compared respiratory function of a sample of children aged 7–15 and non-occupationally exposed adults aged 50–88 from the protected zone around the Huta Sendzimira steel works with that of an age comparable sample from the village of Tokarnia. This study found that mean values of airways resistance in inhabitants of the zone were 50–100 percent higher than those in inhabitants of Tokarnia village.

Two, higher quality studies have found associations between respiratory health and air quality in Krakow. One found relationships between (i) elevated nitrogen oxide levels and increased medical visits for circulatory system diseases; and (ii) elevated concentrations of suspended dust and sulfur dioxide and increased visits for respiratory complaints. The second, a 13-year longitudinal follow-up study of respiratory function in a sample of Krakow residents carried out to Western standards, found an association between air pollution and respiratory function. Three areas of the city with various levels of sulfate and sulfur transformation ratio (STR) in the urban air were defined. The study showed that males who lived in the most polluted area had lower FEV_1 (forced expiratory volume) levels by about 151 milliliters than did the residents of the other areas, equivalent to the effect of smoking. For females, the pattern was generally the same. In men, the FEV_1 decline rate, in milliliters per year, over the 13 year period was significantly faster by about 11 milliliters per year in the areas with higher and intermediate STR, which was again equivalent to the effect of smoking. In females, the prevalence of symptoms was correlated the level of sulfur dioxide and dust in the air; however, lung function deterioration was correlated more strongly with STR.

A pathologist from the Academy of Medicine in Krakow described a study of placentas of 1,000 non-smoking mothers from Krakow, Silesia, and other polluted areas. Virtually all of the placentas from central Krakow were subject to gross structural changes, which could, in theory, have contributed to intra-uterine growth retardation among the fetuses. Yet, other regions with fewer incidents of placental change, had higher infant mortality rates. If it could be established that the gross pathological changes in the placenta correlated with low birth weight, this would be an extremely important finding. Unfortunately, no one had the data available to follow this up.

HUNGARY. A study carried out under the auspices of the National Institute of Hygiene has found evidence that the air quality in the aluminum smelter town of Ajka has affected the respiratory health of children under age 12. The study uses information on respiratory morbidity among children provided by pediatricians in Ajka and the control community Papa. The average monthly rate reported for upper respiratory diseases, tonsillitis, acute bronchitis, sinusitis, laryngitis and asthma was more than twice as high in Ajka than in Papa for the 2-year period from July 1981 to June 1983. In addition, measurements of pulmonary function indicated that girls between the ages of 6 and 14 in Ajka were nearly 2.8 times more likely to show evidence of airways obstruction on spirometry than in Papa, while boys were 3.6 times more likely to. Moreover, monthly variations in the incidence of respiratory morbidity correlated strongly with fluctuations in sulfur dioxide, soot, fluoride, and dustfall. Interestingly, the correlation coefficient was 0.44 for the current month, but, when the exposures were lagged one month, the correlation increased to 0.76.

In Dorog, there had long been concerns about the effects of air pollution from the local power and heat station and coal mine on the respiratory health of children. When the government decided to put a waste incinerator in Dorog in 1984, it promised to conduct a health study to address these concerns. In Hungary, children with asthma and bronchitis register with the local authorities so they can receive free drugs for their conditions. This registry is a rich source of data concerning respiratory morbidity. Using this data source, investigators found that among children ages 0 to 14, the prevalence of "registered" chronic diseases—primarily respiratory, congenital malformations, or chronic urinary tract diseases—had increased from 5.8 percent to 10.7 percent from 1976 to 1985. Furthermore, the prevalence of asthma was approximately 3 times the national average. The monthly rate of new cases of bronchitis and cases of respiratory disease in general were highly correlated with the average ambient sulfur dioxide concentration for the 12-months between October 1986 to September 1987. The correlation coeffi-

Table 3.12 Sulfur dioxide concentrations and respiratory disease in Poland, 1979–82

Mean annual ambient SO_2 ($\mu g/m^3$)	*Number of centers*	*Chronic bronchitis[1] (per 1,000)*	*Asthma[2] (per 1,000)*
< 10	7	1.18	1.59
10–20	37	1.22	2.55
20–30	61	1.86	2.64
30–50	66	1.92	2.96
50–70	34	3.09	4.46
>70	36	3.83	6.23

1. r=0.37
2. r=0.35
Source: May 1988

cient was 0.81 for bronchitis morbidity and 0.78 for respiratory disease morbidity. For children ages 0 to 1 years, the correlation coefficients were 0.92 and 0.83, respectively.

CZECH AND SLOVAK REPUBLICS. Low birth weights were found to be more prevalent in the mining districts of northern Bohemia than in other parts of the Czech and Slovak Republics. Reported frequencies for Usti nad Labem, and Teplice in the mining districts of northern Bohemia over the period 1982–86 ranged between 7.5 - 9.2 percent of live births, compared with 4.3 - 5.5 percent for the non-mining districts.

Congenital anomalies also appeared with greater frequency in the mining than non-mining districts, varying between 7.8–8.7 percent in Teplice and between 8.7–11.1 percent in Usti between 1982 and 1986, while in Jablonec, they varied from 6.0–6.7 percent.

These data are both very intriguing and problematic. In any jurisdiction, the proportion of children with congenital anomalies is difficult to estimate. Some investigators include only serious congenital anomalies, while others include trivial ones, such as small birth marks. Some congenital anomalies show up at birth but others take months or years to express themselves. In addition, different physicians may record information about congenital anomalies differently, making it difficult for future researchers to know how comparable the data are. For a study in northern Bohemia, we were told that information about pregnancy outcomes was obtained from medical records at maternity hospitals and that the diagnosis of a congenital anomaly was verified at one year of age. But it is not clear how this was verified or whether biases may have affected the original recording of congenital anomalies. Recent reevaluations by the Northern Bohemia Regional Project Health Effects Research Collaboration have not corroborated the earlier data, so their validity remains in dispute.

Table 3.13 presents data on congenital anomalies in the district of Usti nad Labem between 1972 and 1981. The table shows that the proportion of babies born with congenital anomalies grew rapidly over the 10-year period. This corresponds with a period of rapidly increasing air pollution in the region. However, changes in patterns of reporting congenital anomalies must also be considered as a possible explanatory factor.

One of the most intriguing lines of inquiry into the effects of the environment on children's health involves the influence of attending nature school. Once or twice each winter, children from the mining districts of northern Bohemia and certain polluted areas of central Bohemia are sent to areas with better air quality for periods of 3–4 weeks. The influence of these nature school visits on hematologic, immune, and respiratory function have been studied using before-after designs. Annex 7, Table A7.2, presents results of three different investigations into changes in hematological function of children in northern Bohemia. In all three studies, the erythrocyte counts increased during the nature school visit. The hemoglobin counts also increased in the two studies where it was measured. Moreover, there is evidence that the improvements disappeared several weeks or months after the children returned home. Similarly, in Study 3, the proportion of immature lymphocytes dropped dramatically during the time at nature school, only to rebound thereafter. It is possible that these changes have nutritional as well as environmental influences. However, the pattern of widespread anemia is one which is also found in the Katowice area of Silesia in Poland, where environmental conditions are similar to those found in the mining districts of northern Bohemia. Thus, it is not unreasonable to suspect that early childhood exposures to high levels of environmental pollution from multiple sources may be having a chronic toxic effect on the blood forming organs.

Nature school has also been shown to have a beneficial effect on children from polluted parts of central Bohemia. Figure 3.1 shows improvements in hematologic, pulmonary, and immune function following a stay in nature school. The data on respiratory function (in particular FEV_1) are very useful because similar data were not available from northern Bohemia.

Several studies have looked at growth and bone maturation in northern Bohemia and polluted regions of the Federal Republic of Germany and the former German Democratic Republic. These studies found that, in the early 1970s, bone maturation was delayed in 32–54 percent of children in the polluted regions of each of the three countries. However, by the late 1970s this was no longer true in the Federal Republic of Germany. A descriptive study published in 1986 claimed that in northern Bohemia there had been no improvement between 1974 and 1984.

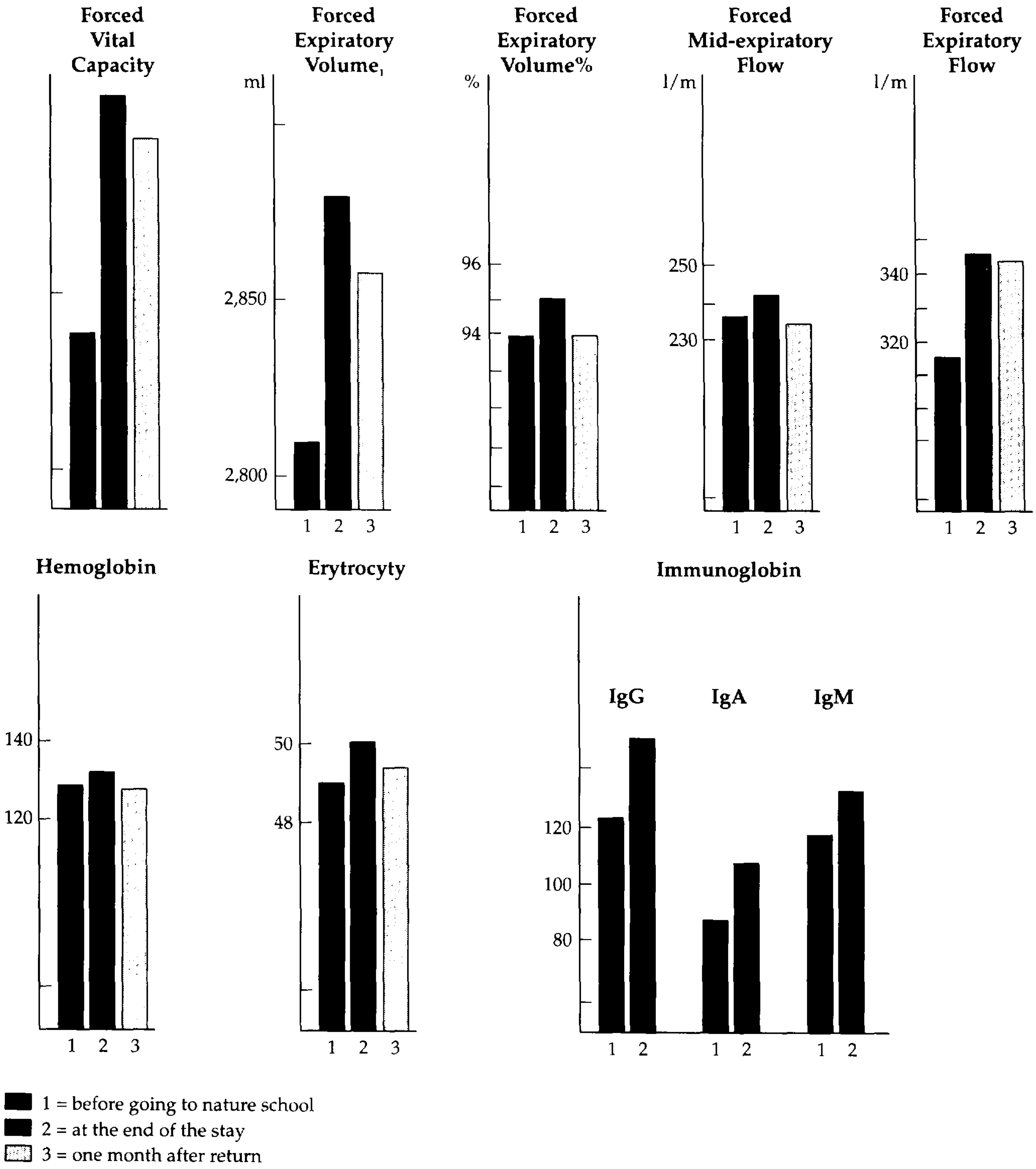
Several studies have found that a variety of chronic health problems, including kidney, lung, allergy, mental

Table 3.13 Incidence of congenital anomalies, Usti nad Labem, 1972–81

Year	*Number of live births*	*Percent congenital anomalies*
1972	1995	3.2
1973	2206	3.3
1974	2630	4.0
1975	2347	5.9
1976	2213	7.2
1977	2118	5.8
1978	2079	7.0
1979	2056	8.2
1980	1647	8.4
1981	1526	7.6

Source: Sram 1992

Figure 3.1 Effect of nature school on respiratory, immune, and hematological parameters among 36 children from polluted parts of central Bohemia



Source: Bubakava et al. 1987.

Table 3.14 Prevalence of respiratory conditions in Devnya, Bulgaria
(percent)

Condition	Devnya	Georgi Traikov
morning cough	30	12
cough: more than 3 months/year	15	6
cough: 3 successive years	8	4
sputum	20	6
sputum: 3 successive years	14	6
wheeze	14	6
chronic bronchitis	8	4
X-ray changes "characteristic of chronic bronchitis"	4	0.5

Source: Basmadjieva-Tancheva 1985

disorders and skin diseases are more prevalent among pre-school age children in the mining districts of northern Bohemia than among pre-school children in other parts of the Czech Republic. Information from compulsory medical examinations done from 1983–1987, shows a similar pattern among school age children (with a slightly different combination of problems). However, it is not clear how standardized these examinations are, or whether or not physicians in different parts of the country might be more or less careful to report problems depending upon their expectation of whether or not the children should be healthy. These are important factors to consider when evaluating routinely collected data such as this. Nonetheless, these data are useful for generating a hypothesis that environmental conditions in the mining areas of northern Bohemia may have affected multiple organ systems in children.

One well-designed study, carried out between 1982 and 1984, found a relationship between child illness and air pollution in the three Central Bohemia towns of Neratovice, Kralupy, and Benesov. In Neratovice, the environmental exposures included dust, sulfur dioxide, hydrogen sulfide, carbon disulfide, ammonia and chlorinated hydrocarbons. In Kralupy they included dustfall, sulfur dioxide, styrene, ethyl benzene, and acrylonitrile. Benesov served as the control town. The study was carried out in two parts. Researchers examined approximately 200 school age children in each town six times over three years. In addition, they collected information on the incidence of pediatric respiratory disease in the three study areas using pediatrician's reports. Because all children go to pediatricians for their health care, this can be construed as a population-based data source.

The cumulative incidence of acute respiratory disease among those ages 0 to 15, including pharyngitis, sinusitis, laryngitis, tonsillitis, bronchitis, asthma, flu, and pneumonia was higher in Neratovice than Benesov. The difference was greatest for sinusitis, which was 7 times more likely in Neratovice than in Benesov. In Kralupy, the overall incidence of respiratory disease was about 2.4 times higher than in Benesov. The gaps were largest for sinusitis and acute bronchitis, the latter being 3 times more frequent in Kralupy than Benesov. Bone growth measurements suggested that boys in Neratovice were 9.0 months behind boys in the control town while boys in Kralupy were 11.0 months behind. For girls, the delays were 5.6 and 5.9 months, respectively. On the other hand, the sample survey did not show statistically significant trends towards poorer spirometric and hematologic function in the industrial towns compared with the control towns.

BULGARIA. Devnya is the site of multiple industrial facilities including a fertilizer plant, a PVC plant, a power plant, and a facility described as a "carbide plant." The range of exposures in Devnya is very broad: dust, hydrogen sulfide, lead, ammonia, hydrogen fluoride, and sulfuric acid are all found in elevated levels in the ambient air. The prevalence of flu, chronic bronchitis, allergic "rash," conjunctivitis, and asthmatic bronchitis among children and adults were higher in Devnya compared with the control town of Georgi Traikov in a preliminary study using morbidity surveillance registry data. In the late 1980s these findings stimulated a more comprehensive study, which included a specially designed questionnaire, chest X-rays, and spirometry surveys of 2,350 people in Devnya and 1,000 people in Georgi Traikov who were carefully matched for age and smoking status. The study found that chronic bronchitis (and symptoms consistent with bronchitis) was more prevalent in Devnya (see Table 3.15). The spirometry evaluations strongly supported this finding, which showed that smokers in Devnya had higher proportions of obstructive bronchitis than smokers in the control town. Similarly, non-smokers in Devnya had higher rates of obstructive bronchitis than non-smokers in the control town. The big surprise was that non-smokers in

Table 3.15 Pulmonary function among children in Dimitrovgrad, Bulgaria
(average FEV_1 in milliliters)

	Boys				Girls			
Age	11	12	13	14	11	12	13	14
Dimitrovgrad	2020	2233	2344	2557	1709	1933	2050	2308
Controls	2360	2800	2967	3342	2082	2433	2525	3169

Source: Basmadjieva-Tancheva 1985

Table 3.16 Classification of children's developmental status in Dimitrovgrad, Bulgaria

	1	*2*	*3*	*4/5*	*Total*
Dimitrovgrad	18	37	45	0	100
Controls	72	20	8	0	100

1: normal development
2: slight changes
3: chronic, compensated disease
4/V: chronic disease with loss of function
Source: Basmadjieva-Tancheva 1985

Devnya actually had higher rates of obstructive bronchitis than smokers there. The study also showed a correlation between increasing length of residence in Devnya and increased risk of developing chronic bronchitis.

Vratsa is the site of several chemical industries. The air is polluted with high levels of dust, sulfur dioxide, hydrogen sulfide, lead, ammonia, and sulfuric acid. A study has been done looking at the daily variation in newly reported cases of seven respiratory, allergic, or irritant diseases in Vratsa in association with changes in the levels of sulfur dioxide, nitrogen oxides, and ammonia (controlling for temperature, humidity, and wind speed). The data show statistically significant correlations between daily variations in the air pollutants and variations in rates of medical visits on the same day (range of correlation coefficients: 0.37–0.69), the day after (range of correlation coefficients: 0.30–0.72), and two days after air pollution episodes (range of correlation coefficients: 0.52–0.68). In general, the correlations are stronger on the same day for acute conditions and stronger over the following two days for asthma and chronic bronchitis.

The town of Dimitrovgrad in Bulgaria—heavily polluted by emissions of dust, sulfur dioxide, hydrogen sulfide, lead, and hydrogen fluoride from fertilizer, cement, and power plants—is the site of one of the most interesting environmental health studies ever done in Bulgaria. A sample of 100 school children, ages 7 to 14 years, were matched with controls from Harmanly. Pulmonary function studies were carried out on children aged 11 to 14 within that group. The spirometry test, which measures how much air a child can exhale over one second, showed that both males and females had reduced levels of FEV_1 compared with the controls (Table 3.15). Furthermore, the data show the gap widening with age; by age 14, boys and girls in Dimitrovgrad had approximately 25 percent less FEV_1 than the controls. This widening gap between expected and actual pulmonary function raises the concern that the effects will be long term, especially for those who remain in polluted environments for long periods of their life.

In addition, a clinical evaluation was done to classify children according to their developmental stage between ages 7 and 14. Fifty percent of children from Dimitrovgrad had decreased height, weight, and chest expansion for their age. Table 3.16 shows that, although no children in Dimitrovgrad were in the worst developmental categories (4/5), only a small minority had totally normal development (1). Almost half the children in the study had some form of chronic condition, for which, fortunately, the children's biological reserve provided some compensation. The clinical evaluation also found increased rates of obstructive bronchitis, chronic tonsillitis and laryngitis, and several forms of dental pathology among children from Dimitrovgrad. An analysis of their blood revealed increased white blood cell counts, eosinophils, and immunoglobins, suggesting a chronically stimulated immune system. Overall, this constellation of findings among a young population is quite disturbing and raises questions about the long term consequences of such a large proportion of children being affected one way or another by chronic conditions.

ROMANIA. Copsa Mica and nearby Medeas are homes to lead smelters whose emissions were made famous by a photo study in National Geographic. Problems with lead exposures in these towns have been described earlier. A study comparing of morbidity in Copsa Mica and Medeas with the control town of Sibiu over the period 1983–87 found that rates of respiratory disease among adults were 1.6–7.0 times higher in Copsa Mica and Medeas than in Sibiu. Among children, bronchiolitis and pneumonia were more prevalent in the polluted towns. A time series correlation of morbidity and air pollution over five years showed a strong correlation (0.64) between variations in airborne dust levels and bronchitis among children. A 1990 study of health status of schoolchildren aged 7–12 in Copsa Mica and Medeas showed that over 63 percent had lower height and/or weight than expected and 30 percent of boys and 48 percent of girls had blood pressure above normal. Studies showing reduced pulmonary function in children were described earlier.

Baia Mare is the second of two lead smelter towns in the vicinity of Cluj with significant community exposures. In one study of 300 children ages 7–13, approximately 30 percent of both boys and girls were found to be below the fifth percentile for expected height. About 30–60 percent of children had above normal blood pressure.

In Turda, a town of 60,000 with a chemical plant and an asbestos cement plant, a 1990 study of respiratory health involving 302 children aged 7–11 showed a prevalence of chronic bronchitis of 11 percent. A spirometry test showed that almost 18 percent of children had forced and peak expiratory capacity of more than 20 percent below normal. The cement plant is likely an important source of workplace exposure: the average time from first employment to a diagnosis of silicosis is 12.5 years (1970–79) among those who develop the disease. A study of clinic records revealed that first medical encounters for asthmatic bronchitis were 43 percent more frequent among adults living near the cement plant than in a control community; encounters for chronic upper respiratory complaints were twice as frequent; encounters for chronic obstructive pulmonary disease were 20 percent more frequent; and encounters for contact dermatitis and eczema were 28 percent more frequent.

A 1988 study of respiratory health, carried out among school children 7–11 years old in Tarnaveni, where there is a non-ferrous metallurgical plant, and a control town showed evidence of decreased pulmonary function (i.e. vital capacity and forced expiratory flow rates) among certain age groups. However, although 16 percent of the children in Tarnaveni were registered as having had an episode of asthma, the symptom survey did not reveal an increased prevalence of wheeze or shortness of breath.

In 1988, the WHO standard respiratory questionnaire was used to assess the prevalence of symptoms among schoolchildren 7–11 years old who had lived in the industrial communities of Rimnia Vilcea and Navodari for at least 5 years. The study done in Rimnia Vilcea found 22–28 percent higher rates of chronic cough and wheeze of 22–28 percent among children living near the petrochemical plant and the chlorine plant. The study done in Navodari, home to a fertilizer and sulfuric acid plant, found respiratory symptoms 2–4 times more prevalent than in a control community.

ESTONIA. There have been several large sample studies in the industrial areas of northeastern Estonia which have produced findings linking environmental pollution to health. These include:

- A 2.3-fold increase in the prevalence of chronic bronchitis and asthma among adults in the oil shale area compared with those in unpolluted areas.
- A 2.5-fold increase in allergic sensitization to common allergens among adults in the oil shale area compared with those in unpolluted areas.
- An increased prevalence of allergic sensitization and allergic dermatitis among children in Narva/Kohtla-Jarve/Sillamae compared with those in Tartu.
- A strong correlation between changes in the frequency of medical visits for respiratory disease and fluctuations in air pollution levels in Narva and Kohtla-Jarve.
- An increased prevalence of respiratory morbidity and immune system dysfunction in a "clean" versus a "dirty" part of Kohtla-Jarve.

One study of 2317 children aged 3–14 in Tartu versus Narva/Kohtla-Jarve/Sillamae, indicated a much higher prevalence of anemia and overstimulated immune systems among children in the northeast (see Annex 7, Table A7.4). These findings are quite non-specific, and may be attributable to various combinations of chemical and microbiological exposures, or nutritional factors or both. The most characteristic finding consistent with exposure to air pollution is the 7–8 fold increase in the prevalence of eosinophilia among the children from northeast Estonia.

A health study was carried out on children in Kehra, where a pulp and paper mill contributes to ambient concentrations of sulfur dioxide, phenols, formaldehyde, and hydrogen sulfide, 5 to 9 times the Soviet maximum allowable concentrations. The study found that 77 percent of boys and 75 percent girls 5 years old had reduced lung capacity, while 29 percent of boys and 69 percent of girls 6 years old did.

UKRAINE. There is evidence of geographic correlation between various indices of morbidity and air pollution in Ukraine. One investigation compared the incidence of specific diseases in five cities (Severodonetsk, Rubezhnoye, Kremenchug, Cherkassy, and Kherson) with air concentrations of specific pollutants. The correlations were very strong. Bronchial asthma morbidity (per 10,000 population) was correlated with nitrogen dioxide levels (correlation coefficient = 0.94) which was also correlated with eye disease morbidity (0.99) and upper respiratory disease morbidity (0.99). There have also been a small number of more carefully controlled studies of air pollution and respiratory morbidity in several communities in Ukraine, although the choice of locations seems to be arbitrary, and not based on the places expected to have the most serious problems. In Vinnitsia Oblast, a medical record study was done of rural residents living near a chemical manufacturing plant emitting fluoride compounds, sulfur dioxide, and detergent aerosols, compared with a control group of residents from Yakuschyntsi village. The investigators found higher recorded proportions of chronic bronchitis (4.5 times controls), bronchial asthma (4.5 times), allergic conditions (4.0 times), and pneumonia (4.5 times) in the exposed community.

A study of air pollution in relation to respiratory health was carried out in Lviv. High, moderate and low pollution zones were defined according to ambient levels of pollutants associated with traffic (carbon monoxide, nitric oxide, and photo-oxidants). Medical chart review revealed that the rates of respiratory illness among children in the high pollution zone was 1.4–1.5 times greater than among children living in the low pollution zone. The general index of health improved with age, but was still 1.5–2.5 times worse among children living in the high pollution zone.

Perhaps more importantly, one study has been carried out on the effect of air pollutants on children's health in the highly industrialized center of the Donbass. Data for the study came from medical chart reviews of 6,500 children in three districts of the city of Luhansk with varying levels of air pollution. Pollution was rather bad in all the zones, with concentrations of sulfur dioxide and formaldehyde nitrogen dioxides, sulfurous gases, formaldehyde, hydrogen fluoride, and carbon dioxide exceeding the Soviet maximum acceptable concentrations in even the low pollution zones. Girls ages 5, 7, and 9 living in the more highly polluted districts had poorer physical development, as measured by weight, height, and chest circumference. Children under 7 years of age living in the more polluted areas had higher incidence of pneumonia, allergic reactions, chronic upper respiratory tract diseases and anemia. However, rickets was also more prevalent among children living in polluted zones, suggesting that socioeconomic factors may be contributing to poor health.

There are concerns about the relationship between air pollution and perinatal morbidity and mortality in several regions of the Ukraine. For instance, in the Proletarky region of Donetsk, where there are high levels of dust, nitrogen oxides and hydrogen sulfides, 48 percent of pregnant women were hospitalized with some form of complication of pregnancy. Children born to these mothers had 4 times greater mortality in the perinatal period than children of mothers residing in less polluted regions. A senior scientist at a research institute in Kiev has conducted studies on a possible relationship between ambient air pollution and congenital anomalies (see Annex 7, Table A7.5). The data show higher rates of spontaneous abortions, congenital anomalies detected in the six days after birth, multiple congenital anomalies, and dominant and X-linked congenital anomalies in the industrial cities with high airborne emissions compared with the control town.

Excess Mortality. The influence of the physical environment on excess mortality is not easy to evaluate. Unlike lead poisoning, none of the major causes of mortality is uniquely attributable to factors in the physical environment. Therefore, studies linking mortality by specific cause to variations in pollution levels are unsatisfactory for making causal inferences unless they take into consideration various lifestyle and social factors. This subsection presents evidence not discussed in Chapter 2 of this report on the East-West life expectancy gap.

POLAND. One study done to international standards examined lung cancer mortality in high and low air pollution districts around Krakow, using the case control methodology. The study demonstrated that, after adjusting for smoking and other confounders, males with lung cancer were 47 percent more likely than expected to have lived in a high rather than a low air pollution district, and women with lung cancer were 26 percent more likely to have. While the results for men were statistically significant, the results for women were not. This is an interesting outcome because it parallels very closely a study in Hamilton, Ontario where the size of the environmental effect was similar. In Hamilton, as in Krakow, there is a large steel mill with a coking facility which emits considerable air pollutants. In both cases, the lung carcinogens would likely be among the polycyclic aromatic hydrocarbons (or "polynuclear aromatic hydrocarbons" as the Poles call them) coming from the coke oven. And in both cases, the odds ratio for females was *not* statistically significant, because of the comparatively small number of female lung cancer cases.

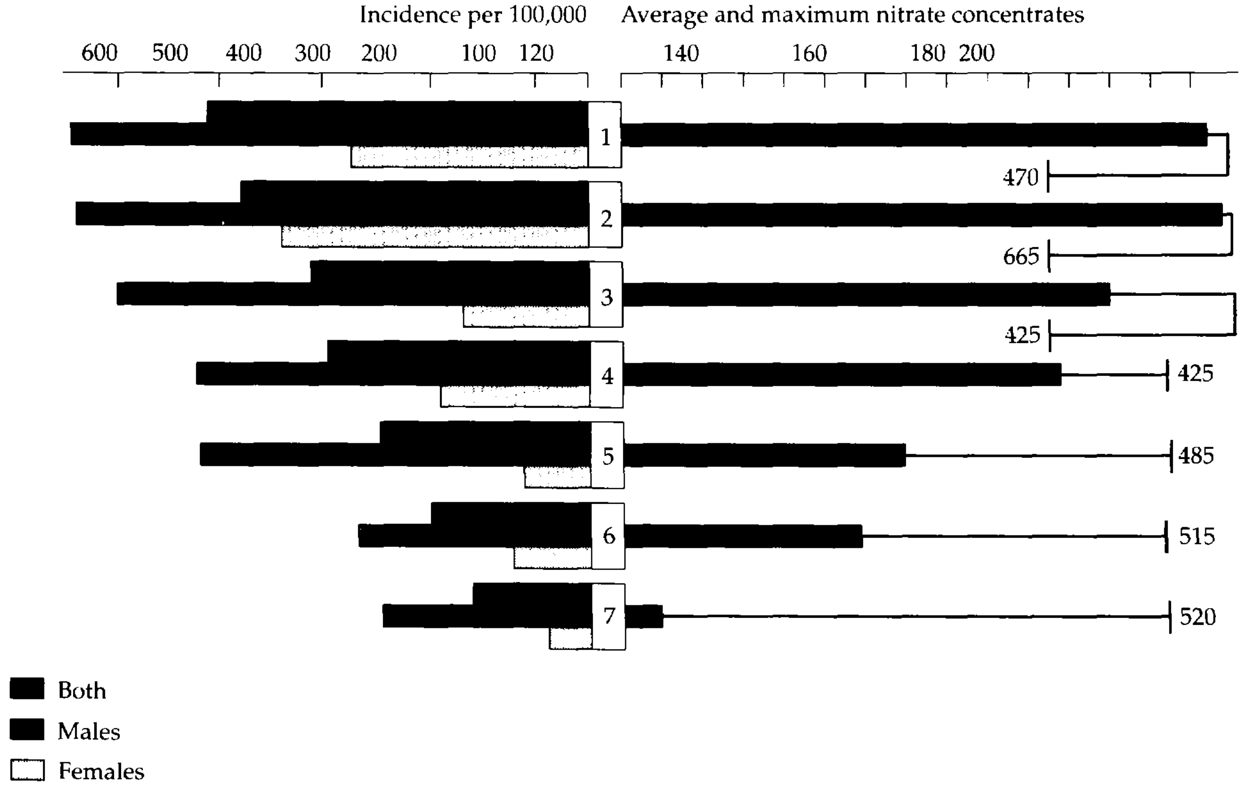
HUNGARY. In Borsod County, the incidence of digestive cancer is closely associated with nitrate levels in drinking water. The crude incidence of all digestive tract tumors excluding liver cancer (International Classification of Diseases 150–154) rises from approximately 250 cases per 100,000 population per year in a region with an average nitrate concentration of 90 milligrams per liter, to 500 cases per 100,000 people in two regions where the nitrate concentrations exceed 200 milligrams per liter (see Figure 3.2). While this relationship is biologically plausible (nitrates may be converted to carcinogenic compounds in the digestive tract), the study did not control for the age and sex distribution of population of the communities, and the results must be considered inconclusive.

A study, carried out over the period 1970–1981, compared adult mortality in Ajka, home of an aluminum smelter, with mortality in the control town of Papa. Mortality from chronic bronchitis, emphysema, and asthma were higher among men aged 40 to 59 in Ajka than in Papa. In addition, mortality rates for these causes were increasing more quickly in Ajka than in Papa for both men and women. Mortality from heart disease (except for men aged 40 to 59) was higher in all age groups in Ajka than in Papa. Mortality from cancer of all causes was higher among men aged 20 to 39 in Ajka. Finally, lung cancer mortality rates for women were increasing faster in Ajka than in Papa.

Data are also available showing dramatic increases in the numbers of new cases of digestive and respiratory cancer in four locations in Borsod County (Leninvaros, Kazincbarcika, Sajoszentpeter, and Miskolc). In each location, these increases were greater than six-fold for digestive cancers between 1980 and 1987 and greater than three fold for respiratory cancers over the same period. However, the studies did not take into account underlying age distribution of the population. And it is unclear whether the reporting of new cases was consistent over time. Local public health officials tended to attribute these increases to long-term accumulation of heavy metals, such as cadmium and lead, in the environment. However, increased mortality is more likely to be related to substances such as polycyclic aromatic hydrocarbons, chlorinated hydrocarbons, and nitrate derivatives than to cadmium and lead. Stomach cancer mortality rates have been found to be significantly above the national average in several rural counties in Hungary and have been associated with the use of nitrosable pesticides and high levels of nitrate in drinking water. One study compared a village with high pesticide use in Szabolcs-Szatmar county to another with moderate use. It revealed that mortality rates from stomach cancer in the high-use village was 65 percent higher than in the moderate-use village, after taking account of age, nitrates in drinking water, drug consumption, smoking and eating habits, and alcohol consumption. The age standardized mortality rate for stomach cancer was 3.2 times the national average in the high pesticide-use village, and above average in the moderate-use village.

There are concerns about cancer mortality in the Nagyteteny District of Budapest. Between 1979 and 1984, 26 percent of adult male and 23 percent of adult female deaths in the Nagyteteny District were attributed to cancer, compared with 22 percent and 19 percent for Budapest as a whole, after correcting for differences in age distribution. Three neighborhoods within the Nagyteteny District (Akkugyar, Gyufagyar, and Jatok u. Lakotolop) had particularly high cancer mortality rates especially from gastrointestinal tract cancer. What is causing this high rate of gastrointestinal tract cancer is not clear. This type of cancer is not usually associated with airborne industrial emissions (though it might be related to passive ingestion of contaminated soil). One hypothesis is that oil wastes stirred up from the bottom of the Danube River has con-

Figure 3.2 Incidence of digestive tract cancers in relation to nitrate in drinking water in seven areas of Borsod County, Hungary



1-7 = Areas in Borsod County

Source: Hertzman 1990 (b).

taminated local bank-filled wells. At present, the available data do not allow any definitive conclusions about the impact of environmental pollution on the health of adults in Nagyteteny District.

BALTIC COUNTRIES. One study compares "proportional mortality" in the village of Saka, (2–4 kilometers from Kohtla-Jarve), over the period 1979–88 with the rest of Estonia for 1980. Table 3.17 presents a version of that data, which has been corrected to take into account the difference in the all-cause mortality between Saka and Estonia as a whole.

The six-fold increase in respiratory mortality is very large and cannot be explained away by differences between the age structure of the local population and Estonia as a whole. The local air quality is not as poor as in many other parts of Central and Eastern Europe where similar statistical evaluations have not been done. It is possible that respiratory mortality is due to smoking or occupational exposure. However, if exposure to environmental pollution is the primary cause, this might mean that environmental contamination has had a larger impact on mortality than we estimated in the determinants of health chapter (Chapter 2) of this report.

Table 3.17 Mortality in Saka compared with Estonia as a whole, 1979–88

Cause of death	*Observed*	*Expected*	*O/E ratio*
Cardiovascular	45	37	1.22
Cancer	7	9	0.78
Injuries, poisonings, violence	8	7	1.14
Respiratory	12	2	6.00[1]
Other causes	1	5	0.20

1. Statisitcally significant difference.
Source: Hertzman 1992 (c)

Table 3.18 Districts with concordant high male-female site specific cancer rates, Bulgaria, 1985–87
(age standardized incidence rate [world standard] per 100,000)

Colon Cancer			
Males		*Females*	
Plovdiv	13.1	Sofia city	11.5
Gabrovo	12.7	Gabrovo	11.2
Ruse	12.3	Pernik	11.0
Pernik	11.7	Plovdiv	8.9
Silistra	10.8	Ruse	8.6
V. Turnovo	10.3	V. Turnovo	8.6
Varna	9.6	Burgas	7.4
Myeloid Leukemia			
Males		*Females*	
Silistra	2.7	Silistra	2.4
Plovdiv	2.2	Kyustendil	2.3
Smolyan	2.2	Yambol	2.2
Sofia city	1.9	Pazardjik	2.1
Kyustendil	1.8	Smolyan	1.9
Ruse	1.5	Ruse	1.6
Yambol	1.4	Plovdiv	1.6
Pazardjik	1.4		

Source: Hertzman 1991

Another study looked at the association of lung cancer with smoking habits and residence in polluted communities. After adjusting for age and smoking habit, the risk associated with residential exposure to pollution was 1.5 (95 percent confidence interval=1.04–2.3), which suggests that those living in polluted communities have a 50 percent greater risk of developing lung cancer than those living in environments considered "clean."

Kedainiai has received a lot of attention over the years because, during the 1970s, sulfur dioxide emissions from the fertilizer plant destroyed the local forests. The incidence of lung cancer in Kedainiai was the highest in the country between 1970–79. Furthermore, the ratio of affected males to females, about 8 to 1 in the rest of the country, was much lower in Kedainiai, suggesting the influence of a common risk factor such as the airborne contaminants. As of 1988–90, the lung cancer incidence rate in seven contiguous districts around Kedainiai remained the highest in the country.

BULGARIA. Using data supplied by the National Oncology Center for 1985–87, we have analyzed the age standardized cancer incidence rates looking for concordance between districts with high male and female rates. Table 3.18 presents data for colon cancer and for myeloid leukemia, for which there is considerable male-female concordance across districts. For colon cancer, 5 of the 7 districts with highest incidence rates are found in common between males and females: Plovdiv, Gabrovo, Ruse, Pernik, and V. Turnovo. For myeloid leukemia, all 7 of the districts with highest incidence rates among females are represented in the top 8 among males. This high level of concordance does deserve careful follow-up because cancers originating in the bone marrow can be caused by exposure to ionizing radiation and to benzene. Given the secrecy in Bulgaria regarding sources of and exposures to ionizing radiation and volatile organics, this remains an important outstanding concern.

Contaminants in soil, water, and food may cause stomach and colon cancer, so these diseases deserve special consideration in any survey of environmental health. However, environmental influences on stomach and colon cancer have not been well documented in epidemiologic studies in other parts of the world. Nonetheless the concordance of regions with high colon cancer rate between males and females deserves further attention. Plovdiv, a district with several industrial sources of soil and food pollution, appears to have high incidence rates for stomach cancer as well as for colon cancer for males and females. Gabrovo and V. Turnovo are also represented as areas of high stomach and colon cancer. Of course dietary and other factors may be influencing the prevalence of these cancers in these areas rather than environmental conditions. Further investigation of these relationships id needed.

Lung cancer is perhaps the most important cancer of environmental concern and, fortunately, is the cancer for which the most data are available. Data from the early 1980s, show that the districts with high lung cancer incidence rates were also those with industrial facilities, including areas with the greatest problems of air pollution and occupational exposures. In addition, the oil refining district of Burgas is represented as an area of high lung cancer incidence rate. It should be noted however, that there is little correspondence between the districts with a high rate of lung cancer for men and for women, suggesting occupational rather than environmental exposure may be important. A separate analysis of the 20 settlements with the highest age standardized lung cancer incidence rates between 1971 and 1980 shows that many are places with major industries. For instance, Pomorie, Sozopol, and Nesebar all cluster around Burgas. There is also a close geographic correspondence between many of the areas of soil pollution in southern Bulgaria and areas of high lung cancer incidence. This does not suggest, by any

Box 3.1 Chernobyl

There is widespread apprehension among populations exposed to radioactive fallout from Chernobyl about the increased risk of cancer which might result from radiation. Yet, based on the current best evidence, any increase in cancer deaths will almost certainly be epidemiologically undetectable against the normal high background level of fatal cancer (about 20% of all deaths), and will in most cases not show up for at least another 10 years. The following table shows the predicted frequency of radiation-induced cancer from *external radiation*, relative to normal cancer frequency, by distance of residence from Chernobyl. It can be seen that for those who were evacuated quickly—the residents of Pripyat for example—the average dose of whole-body gamma radiation was 3 Rem, which would be estimated to cause approximately 68 extra cancers during the lifetime of the 45,000 inhabitants. The risk can be seen to be higher for those who lived between 3 and 15 kilometers from Chernobyl since they were not evacuated as quickly, and may increase their lifetime cancer risk by more than 10%. However, even this level of risk is unlikely to become detectable through epidemiological studies.

Predicted Normal Cancers in Residents of Evacuated Zone, Plus Extra from *External* Radiation

Kilometers from Reactor	*Population (000s)*	*Predicted fatal cancers*	*Rem per head*	*Predicted extra cancers1*	*Total cancers*	*OBI/ESP "Relative risk"*
Prepay (3 km)	45	9,000	3	68	9,068	1.01
3–7	7	1,400	54	189	1,589	1.14
7–10	9	1,800	46	207	2,007	1.12
10–15	8.2	1,640	35	144	1,784	1.09
15–20	11.6	2,320	5	29	2,349	1.01
20–25	14.9	2,980	5	37	3,017	1.01
25–30	39.2	7,840	5	98	7,938	1.01
Total (0–30 km)	134.9	26,980	12	772	27,772	1.03

1. Extra cancers based on a rate of 5 per 10,000 person-Rem.
Source: Anderson 1992

The significant exception to this sanguine assessment is thyroid cancer. Exposures of hundreds and even thousands of Rem to children's thyroid glands from internally-emitting I131 were not uncommon during the first days and weeks after the accident. This concern has given rise to controversy. One study showed an increase in thyroid cancer incidence, starting in 1990, in three communities adjacent to the evacuation zone and within 80 kilometers of the plant. This study was based upon very small numbers (less than 10 cases) and there is concern that the increase may be an artifact based on increased surveillance after the accident.

The following data show the pattern of incidence of childhood thyroid cancer in Belarus before (1985–86) and after the Chernobyl disaster (1987–91).

Incidence of Thyroid Cancer in Children Up to 15 Years of Age

Oblast	*Year of Diagnosis*						
	1985	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*
Brest	1	..	..	1	1	6	5
6tebsk	1	.	..	..	..	1	3
Gomel	..	1	2	2	2	14	38
Grodno	..	1	..	2	2	..	7
Mogilev	..	..	..	..	..	2	1
Minsk	..	..	1	1	1	1	4
Minsk city	..	..	..	1	..	3	2
Belarus	2	2	3	7	6	27	55

Source: Annau 1992 (a)

If these data are valid (i.e. if they are not attributable to a massive case finding effort), they show a huge increase in the incidence of thyroid cancer among children in the region of Gomel which experienced the heaviest radioactive fallout. It has been claimed that these cancers spread rapidly to the lung, an unusual phenomenon, and do not respond well to traditional treatment. It is interesting to note that this increase occurred within four years of the disaster, a short latent period by the standards of adult cancers, but not implausible for thyroid cancer in children. On the other hand, a survey for thyroid nodules in a sample of 1060 people living around Chernobyl, and controls, did not reveal an elevated incidence of nodules in the heavily exposed group. On balance, the concern that there may be an epidemic of thyroid cancer in children developing as a result of fallout from Chernobyl cannot be rejected at this time.

Another major concern is that the radiation has resulted in increased birth defects. Yet there are several sets of statistics which do not support this concern. Ministry of Health data from 1970–1990 do not show an increase in the number of reported birth defects among newborns in Belarus after the Chernobyl disaster. Although the quality of routinely reported data such as this may be suspect, one would expect there to be a bias toward over-reporting after the accident. The fact that this was not seen is compelling negative evidence in itself. Moreover, data relating frequency of congenital malformations to maternal exposure to radiation from 1986 to 1988 do not reveal a dose-response gradient. Similarly, there is no correlation between birth defect frequency by region of the country and the average radiation dose by region for 1986 to 1988.

Finally, there is also concern about an apparent increase in the frequency of a wide variety of other diseases, all of which are being attributed to the effects of Chernobyl, despite overwhelming evidence from previous experience that cancer is the only late effect of radiation. A study in the fallout area, the International Chernobyl Project, found no detectable differences in the frequency of physical ill health between contaminated versus uncontaminated communities in Ukraine, Russia, and Belarus. However, this study found a high level of fear and general psychological distress, both in the contaminated and the uncontaminated settlements.

means, that soil pollution is a risk factor for lung cancer. It simply underlines the need for systematic evaluation of the relationships between environmental exposures from multiple sources and health outcomes in several regions of the country.

CZECH AND SLOVAK REPUBLICS. Map 3.1 depicts the districts of the Czech and Slovak Republics by the percentage of residents who live in areas with the worst or second worst air pollution levels. The band of districts along the northwest border of the Czech and Slovak Republics appears to be a heavily polluted area where the majority of residents are exposed to high levels of air pollution.

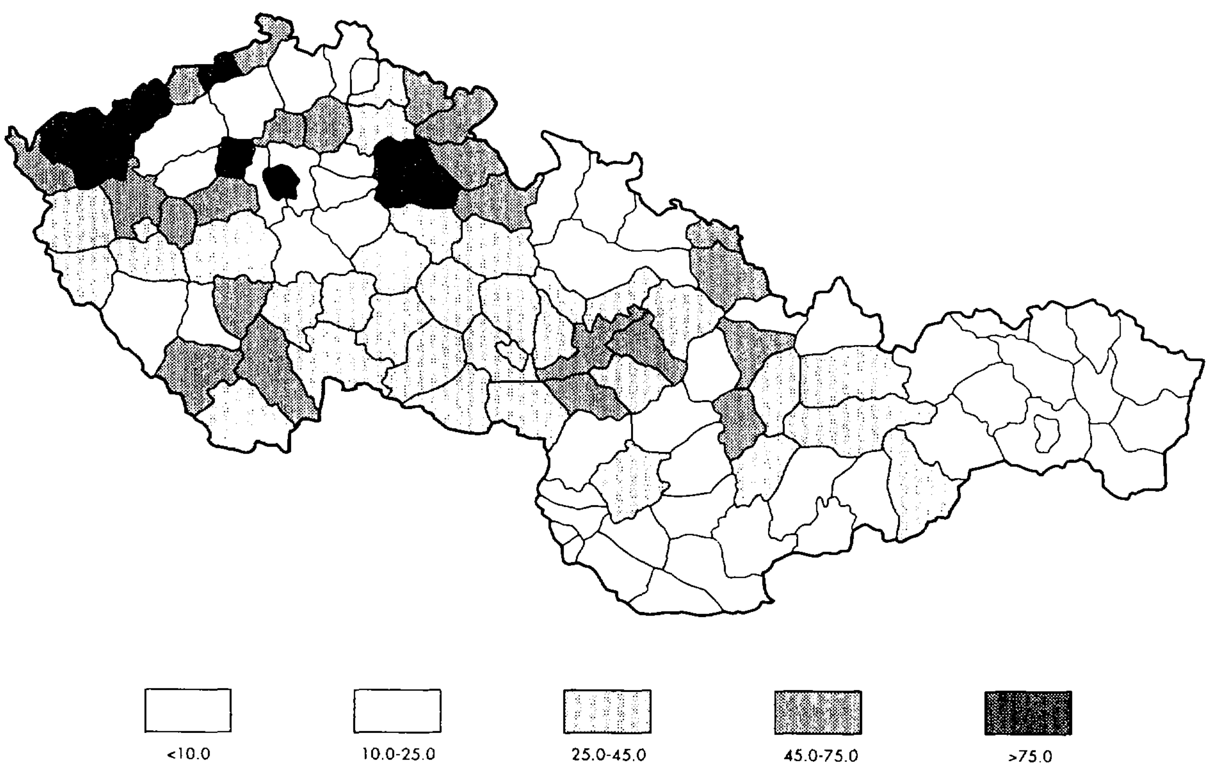
Map 3.2 presents life expectancy for females by district (male life-expectancy by district is similar). The regions with lowest female life-expectancies include many of the same districts in northern and western Bohemia identified as heavily polluted. However, the picture is not without inconsistencies. Certain areas in the Slovak Republic have low life expectancy despite their relatively favorable air quality. In contrast, east Bohemia would appear to be a region of relatively favorable life expectancy despite its poor air quality.

The conjunction of environmental and social factors is nowhere more difficult to handle analytically, and nowhere more important than in northern Bohemia. The districts of northern Bohemia are heavily represented among those with the highest cause-specific mortality rates in the Czech Republic. This does not apply merely to lung cancer and cardiovascular mortality, but also to problems such as suicides and accidents.

Figure 3.3 compares the mining and non-mining districts of northern Bohemia with respect to age standardized mortality ratios for each sex for all causes and all cancers. Mortality rates were consistently higher in the mining districts than in the non-mining districts over five consecutive years, regardless of age and sex, strong evidence of a non-random effect.

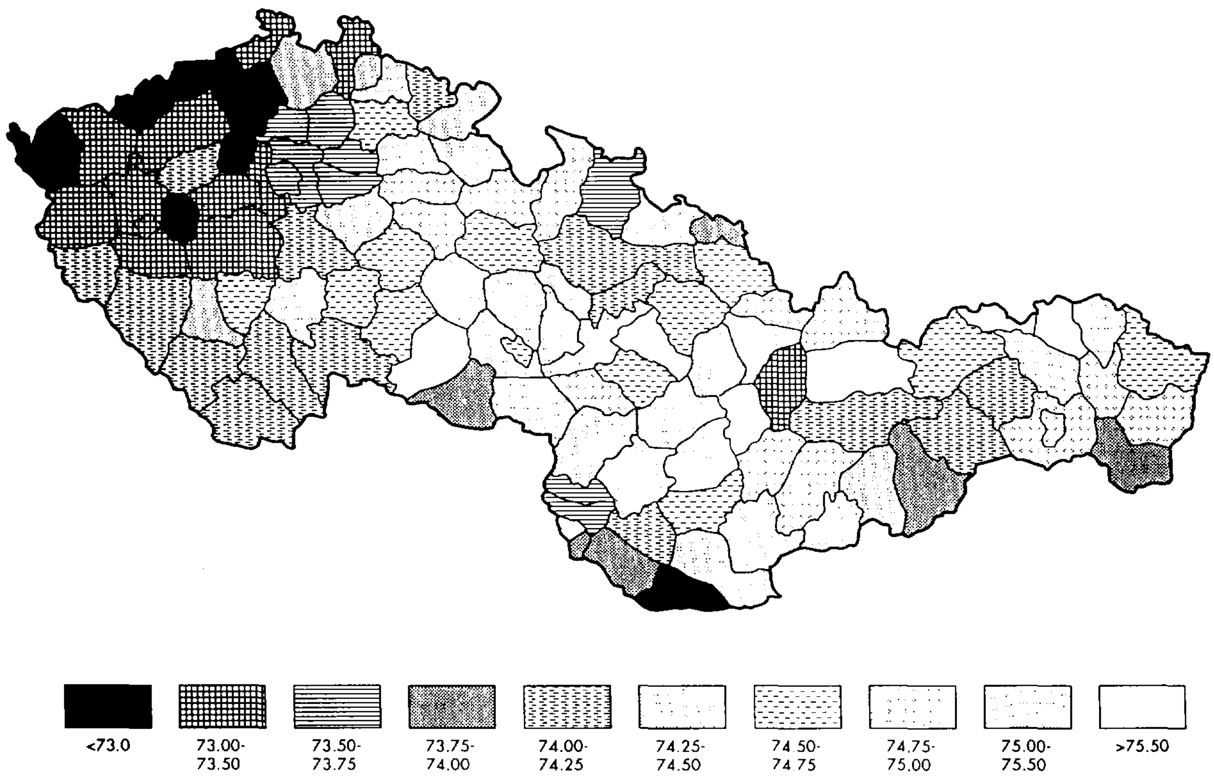
Are the data non-randomly distributed in a way which might be consistent with environmental influences? Table 3.19 gives standardized incidence ratios (SIRs) for lung, colon, and stomach cancer. (The SIR for the Czech Republic as a whole is 100, so that a value of 140 would be interpreted as 40 percent more than expected based on the age distribution of the population alone.) The incidence rate for all three cancers is higher in the mining districts than

Map 3.1 Districts of the former Czechoslovakia by the percentage of residents living in areas with the highest levels of air pollution



Source: Institute of Health Information and Statistics 1990

Map 3.2 Female life expectancy by district, 1981–85



Source: Institute of Health Information and Statistics 1990

in the country as a whole. However the SIRs for stomach and colon cancers, which are not known to be associated with air quality, deviate much less from the expected than does lung cancer.

Evidence of potential exposures to carcinogens in the mining districts is not hard to find. Concentrations of up to 800 nanograms per cubic meter of three carcinogenic polycyclic aromatic hydrocarbons (PAH) were found in dust samples in the vicinity of Teplice in 1988. High concentrations of pollutants have also been found in rainwater in Teplice (see Annex 6, Table A6.7). For example, polycyclic aromatic hydrocarbons were found in measurable quantities in 60 percent of the rainwater samples collected. It would not be unreasonable to assume that high levels of pollutants are found in varying degrees in many other local areas within the mining districts.

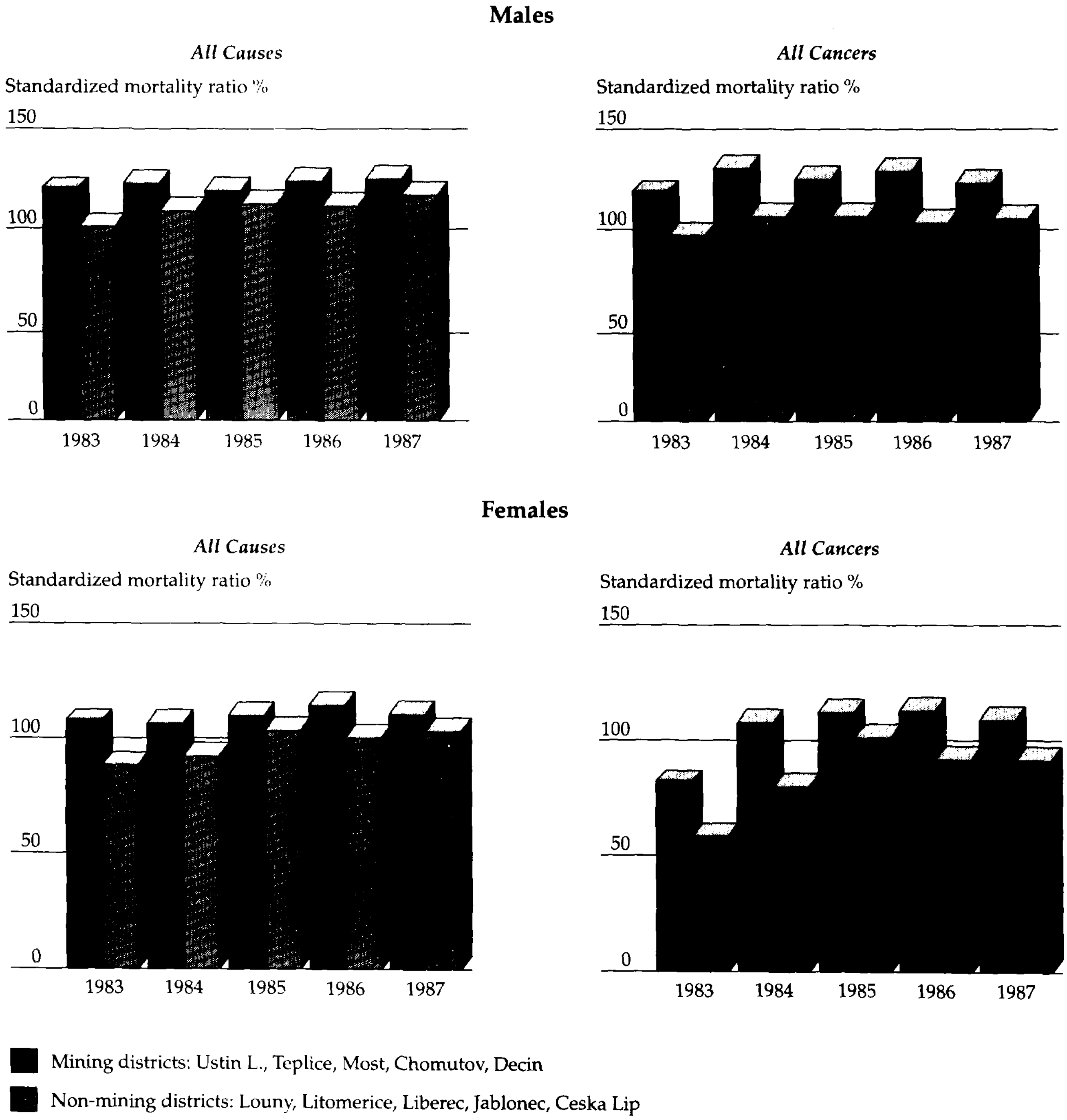
The adult mortality and cancer incidence data should be interpreted in light of the evidence presented earlier that infant mortality in the mining districts was also elevated and that social factors could not explain away the air pollution gradient of infant mortality. Together, these observations suggest that poor health which begins at or before birth in the mining districts of northern Bohemia continues throughout life. If factors in the chemical environment are responsible for these patterns, the mechanism might be either a latent effect, wherein cancers and other chronic diseases express themselves after long-term expo-

Table 3.19 Standardized incidence ratios for cancer in the Czech Republic
(SIR=100 for the Czech Republic as a whole)

	Males		*Females*	
Site of cancer	*Mining districts*	*Non-mining districts*	*Mining districts*	*Non-mining districts*
Lung/airways	140.8	113.9	153.2	93.4
Colon	113.8	95.5	122.3	86.3
Stomach	112.7	94.0	117.4	97.3

Source: Benes 1990

Figure 3.3 Mortality by Mining and Non-Mining Districts of Northern Bohemia, 1983-87



sures to specific chemicals or a long-term sequelae of chronic toxicity during childhood.

While general environmental conditions in central Bohemia are less extreme than in northern Bohemia, there are strong correlations between certain health status measures and the quality of the environment in which people live. For instance, the statistical correlation is strong between the proportion of infants born small for gestational age, by district, with the proportion of people living in areas rated as having poor environmental quality. In one analysis, 45 percent of the variance in "small for gestational age" was statistically explained by environmental quality. Age standardized all-cause mortality also correlates with environmental quality to a similar degree.

Central Bohemia is a region with much lower divorce rates and a much smaller gypsy population than northern Bohemia, two socio-demographic factors that may be related to poor health status. To understand the effect of these socio-demographic factors on health, we related the districts in terms of environmental quality with divorce rates and proportions of gypsies and calculated four correlations, as follows:

- Small for gestational age with percentage of gypsies: $r=0.76$, $p=.004$
- Small for gestation age with divorce rate: $r=0.84$, $p=.001$
- Standardized mortality ratio with percentage of gypsies: $r=.41$, $p=.18$
- Standardized mortality ratio with divorce rate: $r=.51$, $p=.09$.

The results suggest that these social variables may be stronger correlates of "small for gestational age" in central Bohemia than environmental quality but weaker correlates of the standardized mortality ratio. Unfortunately, the data do not allow us to create a multi-variable model to test whether or not there are independent effects of social and environmental factors.

Methemoglobinemia and Nitrates in Drinking Water. Nitrates in drinking water or breast milk can cause methemoglobinemia or "blue baby syndrome," a life-threatening condition. Methemoglobinemia is a form of chemical asphyxiation wherein the oxygen-carrying function of the blood is blocked by metabolites of nitrate which bind to hemoglobin in the red blood cells. There is evidence of mortality associated with high levels of nitrates in drinking water in Central and Eastern Europe.

HUNGARY. From 1976–1982, there were 1353 reported cases of methemoglobinemia in Hungary, including 21 deaths. One area of special concern is Borsod County. The average concentration of nitrates in water in Borsod County ranges from a low of approximately 90 milligrams per liter to a high of greater than 220 milligrams per liter. Levels above 45 milligrams per liter are considered potentially dangerous to health. There is evidence of a relationship between the incidence rate of methemoglobinemia in various regions within Borsod County and the average nitrate concentration in local water supplies. In the period 1975–77, the case-fatality rate for this disease in Borsod County area was 3.2 percent. The number of reported cases rose from 10 in 1975 to 44 in 1978, the peak year. In 1982, a program was initiated to dilute nitrate levels and, more importantly, to supply bags of drinking water to infants. Since that time all infants in areas with nitrate-contaminated drinking water have been supplied with two liters per day of nitrate-free water in polyethylene bags. This has resulted in a decline of methemoglobinemia to 1 to 3 cases per year. Potential sources of the high nitrates include fertilizer runoff, organic waste spread on soils, depositions of airborne nitrogen oxides, leachates from septic systems and cesspools placed too close to drinking water sources, and emissions from chemical plants.

SLOVAK REPUBLIC. Methemoglobinemia has been a problem in many areas of the Slovak Republic. Between 1971 and 1985, there were 2255 methemoglobinemia cases reported in the Slovak Republic, including 12 deaths. Between 1985 and 1990, there were 281 cases with only one death. Authorities attribute the apparent decline in methemoglobinemia to a public education program encouraging parents to supply nitrate-free bottled water to infants. Pediatricians and obstetricians and the local hygiene stations have been cooperating in the program by supplying information and analyzing home water supplies free of charge.

BULGARIA. Three of the 28 regions of the country—Turgoviste, Stara Zagora, and Burgas—have high levels of nitrates in drinking water. Ten year-average nitrate concentrations were 70 to 100 milligrams per liter, with excursions as high as 200 milligrams per liter (the Bulgarian standard is 50 milligrams per liter). In six other regions—Pazardzhik, Kurdzhaly, Yambol, Sliven, Varna, and Tolboulchin—the 10-year average levels were 50 to 70 milligrams per liter. More than 30 percent of the districts in nine regions have levels above the standard. In all nine regions, the general trend for nitrate concentrations is upward. In the former three regions, 70 percent to 80 percent of the population is exposed to drinking water containing nitrates above the standard. In the six other regions, (as well as two others), 35–45 percent of the people are exposed to levels above the nitrate standard. Finally, in eight other regions of the country, 2–30 percent of the population have excessive nitrate concentrations in their drinking water.

Unfortunately, there is very little data available on the incidence of methemoglobinemia. Public officials had contradictory accounts of the incidence of the disease. Furthermore, there was disagreement about whether or not bottled water was being supplied to pregnant women and newborns in areas with contaminated drinking water. One official claimed that such water was being provided, but we could find no confirmation of this. Overall, we found the lack of evidence of methemoglobinemia quite startling. This is because, in comparison to Hungary, nitrate pollution is much more widespread and the public health measures used to protect against it are much more limited.

Public health officials disagree about the sources of nitrate pollution. Although it is commonly thought that the nitrate pollution is primarily due to over-fertilization, one 20-year fertilization experiment in Stara Zagora found no correlation between nitrate fertilization and ground water nitrate levels in an area where the ground water nitrates ranged between 120 and 240 milligrams per liter. However, the investigators did find a correlation between fertilization and ground water nitrate levels in areas with sandy soils.

LITHUANIA. There are high levels of nitrates in drinking water in many parts of Lithuania, ranging up to 200 milligrams per liter. However there is very little data on either the sources or health impacts of the nitrates. While the primary sources of contamination are thought to be fertilizers and industry, this has not been subjected to critical investigation. There have been sporadic cases of methemoglobinemia diagnosed among newborns each year. Officials suggested that 1 to 3 cases were being found each year, that the situation had been "worse in the past," and that the condition was likely under-diagnosed. However, each of these assertions was based on hearsay and there did not seem to be any systematic reporting of methemoglobinemia in Lithuania.

Approximately one-third of Lithuania is covered by a program of water replacement for pregnant women. The local hygiene centers and medical clinics test the drinking water being used by newly pregnant patients and provide replacement drinking water during pregnancy where necessary. This program is quite unlike the one in Hungary which provides water to newborns and children, rather than to pregnant women. The difference in emphasis likely reflects a difference in the understanding of the etiology of methemoglobinemia, but does not seem to have been the subject of any discussion or consensus-building among public health officials in Central and Eastern Europe.

ROMANIA. Elevated nitrate levels are found in local water supplies in all but 2 of the 41 districts of the country. A 1990 survey of water supplies in 2,474 rural locations around the country showed that 7.1 percent had nitrate levels above 200 milligrams per liter, 10.1 percent had between 100 and 200 milligrams per liter, and a further 19.1 percent had between 45 and 100 milligrams per liter. In 14 districts, (Mehedinti, Dolj, Olt, Teleorman, Calarasi, Constanta and Bucuresti-SAT in the South; Tulcea, Braila, Galati, and Vaslui in the East; Botosani and Suceava in the northeast; and Satu Mare in the northwest) more than half of the water supplies had nitrate levels above the standard of 45 milligrams per liter. In these districts, up to 13 percent of the newborns were reported to develop methemoglobinemia annually. However reporting of deaths due to the disease is very incomplete around the country. Some insights into the health impacts of ingesting nitrate-polluted water may be gained from a special study of children in high nitrate areas in the Mehedinti/Dolj area. In 1989, 55 percent of the children in the study area had elevated methemoglobin in their blood. In 1991, there were 181 cases of methemoglobinemia, including 35 which were associated with diarrhea. In total, there were 9 deaths, for a case-fatality rate of 5 percent. This is a much higher rate than would be implied by routine reporting, since only 1 to 2 deaths from methemoglobinemia per year were routinely reported from Mehedinti and Dolj in the 2 years preceding the study. A case-fatality rate of 5 percent would potentially make a significant contribution to infant mortality in any district where methemoglobinemia was a common problem.

BELARUS. Nitrates in drinking water would appear to be a serious problem in parts of every oblast in Belarus, especially where shallow wells are used. Table 3.20 shows the maximum measured nitrate levels by oblast, between 1987 and 1990.

It is not clear what proportion of wells in each oblast has nitrate levels above the maximum permissible level of 45 milligrams per liter. In Brest Oblast, where the highest levels are found, approximately 50 percent of samples exceed this level. Despite high nitrate levels, no cases of methemoglobinemia have been officially reported in Belarus. This is hard to understand given the experience of other countries in the region.

Other Environmental Health Problems in the Region

In addition to the five groups of environmental health concerns identified above, there are many others which appear to be unique to specific local areas. These types of problems may be more widespread than indicated here, but simply not studied extensively. Several of these are identified below.

Arsenic in Drinking Water

BULGARIA. High arsenic concentrations in drinking water have been found in Pazardjik, downstream from the copper smelter in Srednogorie. Arsenic levels of 1,440, 389,

Table 3.20 Maximum measured nitrate levels, Belarus, 1987–1990

Oblast	*1987*	*1988*	*1989*	*1990*
Brest	..	..	..	1712
Gomel	420	440	420	530
Grodno	420	332	420	450
Vitebsk	..	..	..	341
Minsk	..	97	129	210
Mogilev	174	135	115	129

Source: Annau 1992 (a)

1,072 and 470 micrograms per liter have been measured in the tributaries of the Topolnitza River upriver from Pazardjik. The Bulgarian standard is 50 micrograms arsenic per liter in surface waters. In some wells near the Topolnitza reservoir, arsenic was measured at levels between 19 and 286 micrograms per liter. These water supplies had apparently been closed for human consumption, but there was conflicting information as to whether this water was still being used to irrigate crops.

A study done in 1985 revealed that 20 percent of the soils in the Pazardjik area had arsenic levels exceeding the standard of 25 parts per million. According to local experts, water contaminated with arsenic from the copper smelter is used to irrigate farms near Pazardjik. This is a rice growing area and the land is flooded for extensive periods of time. There is little information regarding the public health response to the arsenic problem in Pazardjik. It was claimed that since 1985, the smelter was emitting less arsenic than in the past, and that soil arsenic levels had been declining. However, we saw no quantitative information which validated this claim. Moreover, it was said that water from the Topolnitza River was being used less now in rice production than it had been before.

HUNGARY. Arsenic in drinking water is a widespread public health problem in Hungary, especially in Bekes County. A report from the Hungarian Academy of Sciences reports that 740 of 3,000 settlements in Hungary do not have potable water because of high nitrate and arsenic pollution; about 11 percent of the population lives in these settlements. In 1981, it was estimated that 450,000 inhabitants of 6 counties were drinking water contaminated with arsenic above the standard of 50 micrograms per liter. About 270,000 of these people were living in 31 settlements within Bekes County, and drinking water with arsenic levels 2 to 3 times above the standard.

A study was carried out in Bekes County between 1971 and 1987 to learn the health impacts of ingesting arsenic-contaminated water. The researchers surveyed 25,650 inhabitants of Bekes County who have used deep-well water contaminated with arsenic throughout their lives. A total of 20,800 inhabitants of the neighboring rural area with uncontaminated drinking water served as controls. The childhood sample included approximately 5,000 children exposed to arsenic in drinking water and 5,000 not exposed. Children with hair-arsenic levels greater than 1 milligram per kilogram had higher rates of bronchitis, tonsillitis, intestinal colic, arsenic melanosis, and arsenic keratosis than children with lower hair-arsenic levels. The rate of stillbirths was 7.68 per 1,000 live births in the areas with arsenic-contaminated water compared with 2.84 in the control area.

A study of adults, which covered the period 1978–88, concerned various aspects of mortality and morbidity associated with arsenic exposure. The rate of death from heart attacks (myocardial infarctions) among those aged 30 to 39 of both sexes was reported to be 20 percent higher in communities with high arsenic levels than in the control communities. The local authorities think this may be related to degeneration of the small arteries (arterioles), a pathology of acute arsenic poisoning.

One of the main public health responses to the problem of arsenic has been to supply water in plastic bags. In Bekes County, all children under the age of 14 years get two liters per day of bagged water if the arsenic level in their natural drinking water is two or more times the standard.

ROMANIA. An area of high naturally-occurring arsenic in ground water extends from Southeastern Hungary into the districts of Arad-Lipova-Ineu in Romania, where between 80,000 and 100,000 people live. Arsenic levels in water in this region can reach 2–3 times the standard of 50 micrograms per liter. The region also seems to have unusually high rates of skin cancer. However, no sample surveys of health status have yet been done in the area.

Infectious Disease and Microbiologically Contaminated Water

ESTONIA. Problems with water quality in Estonia has led to restrictions for recreational use and to replacement of certain polluted local drinking water supplies with more expensive, distant sources. In Estonia there are 24 public beach areas, of which 10 have been closed to swimming since 1989 due to microbiological pollution. The worst affected areas are coastal areas near Tallinn, Parnu, Haapsalu, and Kohtla-Jarve, two locations on the island of Saaremaa, and a lake in the Viljandi district. In each case the problem is attributed to untreated or inadequately treated sewage. Because swimming is forbidden, the health impacts due to the contaminated water have been minor. Only one person is believed to have become ill from swimming in the past three years. Public health authorities are concerned about beach closures because they believe that swimming is important for optimum development of the respiratory organs in children. Thus, they tend to view beach closures as a threat to health protection, similar to that caused by a shortage of vaccines against childhood diseases.

LITHUANIA. The public health significance of microbiological contamination of well water in Lithuania is unclear. There has been no evidence of large-scale waterborne outbreaks of infectious disease, but there is some concern that water may be contributing directly or indirectly (through contamination of food) to the 1000–2000 cases of salmonella, shigella, and hepatitis A in Lithuania each year, as well as to giardia, leptospirosis, and viral infections. However there is no evidence that a systematic study of this issue has ever been done. Several milk plants around the country have been closed due to unhygienic conditions, but we were unable to get any descriptions of infectious disease outbreaks due to contaminated water in milk plants. This is in contrast to Latvia, where such epidemics have been documented.

Sewage and industrial effluent contaminate the Neris-Nemunas River system, the Curonian Lagoon, and the Baltic Sea coastline, making these unfit for recreational use. The Nemunas River is contaminated at its origin in Belarus by untreated sewage, and receives industrial discharges of dyes, detergents, chrome compounds and other chemical substances along its course. The Neris River, carrying all the residential sewage (untreated) from Kaunas, joins the Nemunas downstream. Because of this high pollution load, beaches along the river system in Kaunas have been permanently closed. Downstream of Kaunas, the Nemunas River receives enormous amounts of industrial waste from two large, late nineteenth century pulp mills in the Kaliningrad Oblast. The river then flows into the Curonian Lagoon, where raw sewage from Klaipeda is dumped, along with 24 million cubic meters of effluent per year from a local pulp and paper mill and smaller amounts from a battery plant, including manganese and mercury.

Curiously, as of 1992, there were no restrictions on fishing in the Curonian Lagoon. Elevated arsenic levels have been found in two fish samples in the past three years, but no other significant metal concentrations. Officials from the Ministry of Environment tell anecdotes about fish with tumors, but persons from the Municipal Hygiene Center, who are responsible for inspecting fish, claim they have not detected diseases in fish. The biggest problems they perceive are massive fish kills in the summer due to blue-green algae blooms, due in large part to the organic wastes dumped into the lagoon.

The most noticeable impact of contamination of the Nemunas-Neris-Curonian water system so far has been beach closures. Between 43–54 percent of water samples taken from beaches near the outflow failed to meet the microbiological standards for bathing water. The three beaches closest to the outflow have been closed for the full season in recent years, preventing potentially serious outbreaks of waterborne infectious diseases. There was also one beach closure at Palanga, a popular tourist resort area several kilometers further north along the Baltic.

LATVIA. The best-documented human health problems from environmental pollution in Latvia are due to contaminated drinking water. More than most countries in the region, Latvia relies on surface waters for a large share of its drinking water. In recent years, there have been several outbreaks of waterborne infectious disease in the country.

In the winter of 1988/89, the city of Riga ran low on alum, an agent used in the coagulation and purification of drinking water. This was critical because approximately

Box 3.2 Environment and health in Russia

At present there seems to be a disconnection between the data and information flows which drive policy debates on the environment in Russia and the supply of environmental health evaluations which are of sufficient quality to inform these debates. At the level of policy-making, reliance is being placed upon routinely collected data, usually regarding mortality, which is aggregated over large, administratively convenient regions and not across geographic areas with common environmental pollution problems. These data reveal large differences in life expectancy among the oblasts and autonomous republics. For example, in 1989 there was a 5.3 year life expectancy difference for males across the 73 administrative regions with valid death certification. Certain indexes which reflect these differences, such as cause specific mortality rates and "person years of life lost before age 70" have been correlated with variations in "living conditions" and also with environmental quality across administrative regions. These analyses have revealed that the measures of living conditions are much stronger correlates of mortality than are the measures of average ambient air and water pollution.

There are obvious methodological problems with averaging measures of air and water pollution over areas with different pollution experiences, all of which would tend to strongly bias against detecting an environmental effect. We have come to realize that environmental impacts in Central and Eastern Europe are strongest in relation to morbidity and not mortality. Thus, these correlation analyses *are no test at all* of the impact of environmental pollution on health.

Nonetheless, in a country as diverse as Russia, where living conditions encompass a range from modern to primitive, the basic observation that life expectancy variations are primarily a function of living conditions is likely correct. But inserting it into the discussion about the impact of environmental pollution on human health has been most unhelpful. The policy corollary which has been drawn is of the form: socioeconomic conditions are more important to address than environmental conditions when it comes to health. The dichotomy is counterproductive. No-one seems to be asking the question: can environmental health problems be used to help set investment priorities in a way which could protect health at the same time as promoting economic development which will improve living conditions?

The other striking aspect of the current policy discussion is how unlike the public perception it is. Russia has been portrayed in the media, and in book length exposés, as a country with widespread health problems due to uncontrolled spread of ionizing radiations, untreated sewage, contamination of water and soil with pesticides and chlorinated organics, and air polluted with dust and organic substances. There does not seem to be any agency in Russia with general access to data and information which is evaluating these claims. Nor does there seem to be any agency with a mandate to do so. On past experience in Central and Eastern Europe it is likely true that some, but not by any means all, of the health claims have been exaggerated. Thus, the job of collating and critically appraising information linking environmental pollution to human health risk across the country is of top priority, both to address the gulf between public perception and policy analysis and to mobilize environmental health information for policy making purposes.

It is not clear whether or not the principal environmental health problems in Russia are the same as those in the rest of Central and Eastern Europe. Russia's size and tremendous diversity impose significant obstacles to generalization and the job of collating and analyzing existing information will be long and protracted. This task is made daunting by the fact that relevant information has, according to one estimate, been generated by more than 100 different institutes around the country. Judging from the experience in Moscow, these institutes are affiliated with a wide range of different government ministries and may have cross-affiliations to either the Academy of Science or the Academy of Medical Science.

Environmental health information in Russia includes an *ad hoc* mixture of analyses of routinely collected data and studies of specially identified populations. They cover a wide range of levels of geographic aggregation, from huge administrative regions to narrowly defined neighborhoods and communities. There is reason to believe that a significant amount of this information is useful.

In one summary, published in the English language journal *The Science of the Total Environment*, a variety of studies of lung cancer, respiratory disease, and child development in relation to environmental pollution were briefly described, although in too little detail one-half of Riga's drinking water comes from the Daugava River which is heavily polluted with multiple bacteria and viruses from upstream discharges of sewage. Because of the alum shortage, Riga's drinking water was incompletely treated, and a waterborne epidemic of hepatitis A broke out, lasting approximately 2 months. Between 500 and 2,000 people fell ill with the disease. Hepatitis A was not suspected and was not detected in the water until samples were sent to Moscow for examination by electron microscope. Subsequently, a "boil water" order was issued which helped end the epidemic. It is now the practice of the Republican Hygiene Center to test drinking water for hepatitis A, but since it takes several days to obtain results, an outbreak could occur before the contamination is detected. Because coagulants continue to be in short supply, this is a serious concern.

Contaminated surface waters have also contributed to foodborne infectious disease epidemics. One dramatic example concerns a milk plant in Jelgava, where technical water became mixed with drinking water, contaminating milk bottles. Sterilization did not correct this problem, since the pasteurization equipment was not functioning at the appropriate temperature. An epidemic of 5,000–6,000 cases of dysentery occurred as a result.

The above two episodes are the most well-known but may not be the only ones. Shortages of alum occur frequently in Latvia, and sporadic waterborne cases of hepatitis A and typhus are suspected. In addition, leptospirosis has become endemic in Latvia, a serious concern because 18 to 25 percent of cases are fatal. Although leptospirosis is usually spread directly by rodents, two recent cases among bathers were traced to leptospira in a small tributary of the Leilupe River near Iecava.

Contamination of the Daugava and Lielupe Rivers from sewage and industrial emissions have also led to beach closures in Jurmala, which is one of the prime summer recreation areas on the Baltic Sea coast. During the pre-independence period, "stop swimming" orders were rarely issued. Water samples were not frequently taken at the beaches, and public health officials were reluctant to take actions which

Box 3.2 (continued)

to evaluate their validity. During a short visit to Moscow, some useful work on kidney disease in relation to cadmium exposure in children could be identified, and several important investigations of occupational disease found. Taken together, these investigations have not been part of a coordinated strategy for the identification, evaluation, and control of threats to human health from environmental pollution. The result is that, at this time, it is difficult to make any general statements about which sources of pollution have had the greatest impact on human health or to estimate what the magnitude of the impact might be. This means that the criterion of human health protection cannot be effectively used for priority setting by environmental agencies until the environment and health infrastructure has been further developed.

Several *ad hoc* lists of locations thought to have significant environmental health problems in European Russia have been made available to us by individuals and groups in the country. Two of these lists use the categories of health problems, found in Annex 4 of this report, which have been used for the rest of Central and Eastern Europe. The categories seem to be relevant to Russia because large numbers of communities were found to fit each of them. However, it would appear that the lists were not compiled on the basis of systematically evaluated information about health status. For the most part, they seem to be based upon inferences drawn from ambient air pollution and emission data and are inconsistent with one another. During the World Bank mission to Russia, no individual or agency with access to sufficient information could be found to evaluate these lists and resolve the contradictions. Thus their credibility is low in comparison with other information which went into compiling the lists of affected locations found in Annex 4.

Notwithstanding the serious reservations described above, the following impressions are defensible on the basis of current information.

1 *Respiratory problems*, both chronic and acute, are prevalent in association with air pollution in urban and industrial locations in European Russia. Compared to the rest of Central and Eastern Europe, the profile of air pollution sources of greatest concern would appear to be more like Bulgaria than like Poland or the Czech Republic, in that sulfur dioxide from coal burning is relatively insignificant, while specific point sources of organic vapors and irritant gases from chemical plants and polycyclic aromatic hydrocarbons from petroleum industries appear to be more significant. Dust is a significant air pollution concern in Russia, as it is across the rest of Central and Eastern Europe.

2 *Overexposure to lead* in children has been documented (using measurements of lead in hair) in the vicinity of several large industrial facilities, including a lead smelter, lead-cadmium battery plant, and a storage battery factory. It is unclear whether or not transportation sources are a significant source of lead overexposure in children. More generally, there is reason to believe that health status in a large proportion of communities adjacent to facilities emitting metals, organic chemicals, and petroleum products is being affected by these emissions.

3 There is particular concern about *exposures to ionizing radiation* in communities adjacent to military-industrial facilities in Russia and risks of cancer mortality and adverse reproductive outcome. At present, these concerns are very difficult to evaluate. The experience at Chernobyl so far has been that careful dose assessment and epidemiological investigation has helped to put strict upper bounds on the health concerns there. A similar approach is needed in the communities of concern in Russia.

4 Several well-designed studies of cohorts of workers in Russia exposed to known *industrial toxins* have shown patterns of excess mortality characteristic of those substances. Studies of exposure to cadmium at work have shown prodigiously high levels of long-term overexposure. These studies suggest that working conditions in many Russian work places were significant sources of overexposure to their workers before the recent economic collapse. It is not clear how the patterns of exposure have changed over the last several years of economic change.

5 There is reason to believe that *nitrates in drinking water* are a prevalent concern in Russia. Arsenic, pesticides, and petroleum products in drinking water are also significant concerns, but may be less prevalent.

Table 3.21 Water supplies not meeting microbiological and chemical standards, Lithuania
(percent)

	Microbiological Standards		*Chemical Standards*	
	1989	*1990*	*1989*	*1990*
Drinking water:				
Centralized	7	7	..	..
Well	41	30	42	39
Recreational:				
Rivers/lakes	40	41	25	17
Sea	27	25	46	63

Source: Hertzman 1992 (c)

might affect the summer vacations of those who went to Jurmala. However, during the 1989–91 summers, such orders have become common in Jurmala, lasting the whole 1991 bathing season. Cases of skin rash have been reported among some of those who have ignored the stop swimming orders. Bathing has also been frequently prohibited in the Venta River (Ventspils region and Kuldiga), the Daugava River (Jekabpils and Plaunas) and the Guuja River (Cesis region).

BELARUS. A study by the Sanitary and Hygiene Research Institute of the Ministry of Health found that 48 percent of the rural population was supplied with substandard drinking water. Thirty-five percent of shallow wells did not meet the bacteriological standard of 3 E-coli per liter. Not surprisingly, rural populations suffer acute intestinal infections at rates higher than urban populations. Regression analyses relating variations in water quality (measured as the percent of wells below standard over 5 years) with frequency of intestinal infections, have shown water quality to be a highly statistically significant risk factor for intestinal infections in all oblasts.

Problems Unique to Specific Locations

ESTONIA. Since the late 1980s, 2–8 percent of children in Sillamae have had problems with baldness which, in many cases, disappeared when the children left the area. In Narva the prevalence ranged from 2.3–4 percent and in Kohtla-Jarve, from 0.6–4.7 percent. In Tartu, the comparator community, the prevalence of baldness was 0.8 percent. Therefore, this has been variously described as a problem of Sillamae or as a problem of the whole area. Because the Sillamae area had been under direct Moscow control for at least a decade, local public health officials were not certain about the patterns of environmental exposure and the cause of the problem remains a mystery.

LATVIA. Leipaja is a seaport on the Baltic Coast with a population of about 114,000. It was a commercial port until 1966 but was made a closed city by the Soviet military from 1966–76. The military base occupies two thousand hectares of town and housed approximately 15,000 personnel and 25,000 family members in early 1992. The base dumps raw sewage into the artificial harbor, contaminating the beaches on the north side of town. Health authorities in Leipaja consider the principal environmental health concern to be the effects of electromagnetic radiation from the radar stations along the "Tallinn line" and at the air bases at Skrunda and Vainode. Until three years ago the Soviet military controlled all data and information on electromagnetic fields in the area, so public investigations are only two years old. In November 1990 the hygiene center took measurements of the electromagnetic fields at a school in the Ezerkrasts neighborhood located within 200 meters of a point source. The field intensity was reported to be 8 times the Soviet standard (the Soviet standard is similar to the European standard). At two houses which were both approximately 2,500 meters from the same point source, the field intensity was reported to be three times the standard. During the summer of 1991 the military built a fence between the point source and the Ezerkrasts neighborhood which reduced the field intensity at the school to twice the standard.

Investigations and observations of health problems among people living and working in the Ezerkrasts neighborhood and other areas near major radar facilities are as follows:

- A study involving 180 children who had lived for at least 3 years in Ezerkrasts or another exposed neighborhood found that 60 percent had enlarged thymus glands (an organ important for the body's immune function). In addition, 60 percent of a sub-sample of 34 children had increased lymphocyte counts in blood and other "non-specific" evidence of increased immunological activity. Among the full sample of 180 children, problems with headaches, nervousness, and lassitude were reported much more frequently than expected by examining physicians.
- Routine investigation of all "well babies" less than 1 year old in Leipaja revealed that those living on the military bases had a prevalence of thymomegaly 20–30 percent higher than those living off the base.
- The Institute of Oncology examined 481 blind adults who worked at a sheltered workshop in Ezerkrasts, within 500 meters of the radar facility. Of the study subjects, 107 had evidence of anemia and leukopenia (reduced numbers of white blood cells) and a further 4 had lymphadenitis (inflammation of the lymph glands).
- Investigators at the Institute of Oncology report that there is a cluster of leukemia among teenagers at school near the military airbase in Vainode.

Further investigation and more careful documentation are needed to determine how environmental exposures are damaging health in this region.

One large point source of air pollutants in Leipaja is the Leipaja Metal Worker. This steel mill is 109 years old and still uses open hearth furnaces (most recently installed in 1965, long after basic oxygen technology had been perfected). In addition, its casting process uses silica sand and waste oils for binding which give off carcinogenic products during pyrrolysis (non-oxygen burning). Workers in the plant are exposed to numerous toxins and carginogens. At present, the plant has 76 workers on pension for permanent disability. Some of these disabilities are due to trauma, but others involve dust-related chronic bronchitis, silicosis from the casting operation (which they say is under-diagnosed due to poor X-ray quality), and lung cancer, likely due to exposure to the above-mentioned pyrrolysis products. The community impact of emissions from this plant has not been fully evaluated. The major emissions are sulfur dioxide and dust, containing relatively low concentrations of metals. Three years ago radioactive dust was discovered on the site. The plant, which is largely a recycling facility, was melting down Soviet military equipment. The plant is no longer doing this, but the waste materials on the site may still be posing a threat to the health of the local population.

A unique problem exists at the beaches of Liepaja on the Baltic. The heavily used beaches on the south side of Leipaja are littered with pieces of phosphorus wastes, washed up from sites to the south used by the Soviet military for bombing practice. Small children in particular often mistake the pieces of phosphorus for colorful rocks, and place them in their pockets. These bits of phosphorous can spontaneously ignite and badly burn the children. Local pediatricians reported approximately 13 incidences in which children received third degree burns to their legs and groins in 1991 from this cause.

The main concern in the Baltic port city of Ventspils is the potential for an explosion at a facility which stores ammonium, methanol and acrylonitrile on site and manufactures liquid fertilizer from phosphoric acid and ammonium. Rail cars carrying raw materials sit on tracks across the street from residences. Next to the facility is oil tank farm and a few hundred meters away is a Soviet army munitions dump. This juxtaposition of facilities was approved directly from Moscow, over-riding local permitting procedures, in the 1970s.

In 1991, a quantitative risk assessment was conducted at the ammonium storage facility and fertilizer plant to assess the potential for an explosion there and to see how much the risk could be reduced by instituting a series of technical and procedural controls. The initial risk was determined to be very high (i.e. a 1 in 10 chance per year of an explosion involving at least one fatality), but it was estimated that a well-designed and implemented control program involving engineering and administrative changes at the plant could reduce the risk 1,000-fold.

There is some concern however as to whether such an extreme decrease in risk is really possible. For instance, it is not clear that the plan takes into account the explosion hazards represented by the nearby oil tank farm and the munitions dump.

Ironically, one benefit of the explosion hazard is that Ventspils has attracted the attention of the United Nations Inter-agency Group on Risk Assessment and Human Health. The Dutch government is sponsoring a project in which physicians, chemists, architects, sanitation experts, and a lawyer work with Dutch experts to develop an environmental strategy for Ventspils, to extend the risk assessment and management process to all firms in town, to develop further preventive strategies, and to create an overall town plan.

SLOVAK REPUBLIC. Several epidemiological studies have been done among workers in aluminum smelter operations who may be exposed to polycyclic aromatic hydrocarbons used in the manufacture of aluminum. These studies have consistently demonstrated an increased risk of bladder cancer among the workers. We are not aware of similar evaluations of workers at Ziar nad Hronom in the Slovak Republic. However, a map of bladder cancer incidence rates by district, published by the Slovakian Cancer Registry of the Institute of Experimental Oncology, shows that there was a high rate of bladder cancer among males (although not among females) for the period 1975–84 in Ziar nad Hronom. These maps help demonstrate the potential usefulness of an ongoing cancer incidence reporting system for detecting potential environmental health problems which deserve further investigation.

Another example of the usefulness of a cancer incidence reporting system concerns the coal-fired power plant at Horna Nitra, which is an important source of arsenic emissions. Data from the Slovakian cancer registry, 1975–84, show that the population living in the districts around and downwind of the power plant has unusually high incidence rates of non-melanoma skin cancer. Epidemiological studies done elsewhere have shown an association between exposure to arsenic and skin cancer. Increased levels of the disease appears in both males and females in the contiguous districts of Martin and Prievidza.

Lung cancer and neurological diseases have also sometimes been associated with exposure to arsenic in epidemiological studies done elsewhere. We have no data on the incidences of these problems in the region near Horna Nitra. However, in 1977 one Slovak investigator published an extremely interesting paper which showed hearing loss among children living near the power plant. In this case, the noise frequencies were 125, 250 and 8,000 Hz, not the frequencies usually associated with noise-induced hearing loss. The authors suggest that the results may be due to central neurological damage to the ear.

From 1956 to 1984, PCBs were produced by a plant in the Michalovce area for the Czechoslovak and Soviet markets. During that time no special measures were taken for protection of the environment. Liquid waste was regularly spilled into the River Laborec. Solid wastes were put into a local landfill without treatment. In 1977, the local hygiene station found increasing levels of PCBs, formaldehyde, and nitrates in water in the Laborec River and the Sirava reservoir (which is a recreational lake). In 1978, nitrate levels were in the range of 44–120 milligrams per liter in these waters. By 1980, formaldehyde was found at a concentration of 0.9 milligrams per liter in drinking water, which was three times the standard. PCBs in the Laborec River reached 15.5 microgram per liter and ranged from 1.5 to 2.9 micrograms per liter in the Sirava reservoir. In the Michalovce water supply, the concentrations of PCBs ranged from 2.3 to 6.4 milligrams per liter.

In 1980, a pathologist in Michalovce noted that there was a very high incidence of Potter's Syndrome among infants born in the town, a condition of congenital underdevelopment or non-development of kidneys which has been associated with PCB exposure in scientific research. Twenty cases of Potter's Syndrome had occurred in

Michalovce between 1975 and 1980, nine of them in 1980 alone. The overall rate of occurrence of Potter's Syndrome was 12 times higher than expected. As a result of this finding, the local drinking water source was closed and water was supplied from other sources. In January 1984, the plant stopped producing PCBs. However, 90 tons of PCB waste products were burned in the local cement plant between 1984 and 1988, which may have contributed to airborne exposures. As of October, 1990, there was still another 2,500 tons waiting for adequate disposal.

By the late 1980s, PCB-levels in the local water sources had dropped to negligible levels. However, PCBs have persisted in the breast milk of women in the area as well as in the fat tissue of hospital patients who have been tested. The average levels have ranged from 4 to 9 milligrams per kilogram and the maximum measured values have ranged from 10 to 27 milligrams per kilogram. Background levels would be less than 1 milligram per kilogram.

Environmental Conditions of Special Concern to Human Health, but for which no Health Data Exist

POLAND. In Silesia, as in northern Bohemia and other areas with multiple point and non-point sources of air pollution, the mixture of dusts and gases in ambient air is very complex. In addition to the commonly measured substances identified previously in the section on air quality, there are a variety of other substances found in high concentrations in the air (see Annex 6, Table A6.5). Of greatest interest is benzo(a)pyrene, which is the best documented carcinogen among the polycyclic aromatic hydrocarbon family.

Exposures to polycyclic aromatic hydrocarbons and other carcinogens may have affected health in Katowice Province. One study, which used a battery of biological markers to measure molecular and genetic damage in blood samples from residents of Gliwice in Katowice and from persons living in a rural, less polluted area of Poland, found that exposure to polycyclic aromatic hydrocarbons was associated with significant increases in "carcinogen-DNA adducts" (i.e. polycyclic aromatic hydrocarbons linked directly to genetic material in the blood cells). These increases in carcinogen-DNA adducts, in turn, were significantly correlated with three measures of chromosomal mutation, providing a molecular link between environmental exposure and a genetic alteration relevant to cancer and reproductive risk.

A study conducted in two heavily industrialized areas of Katowice province found that urine samples taken from children living in areas with high airborne concentrations of benzo(a)pyrene were more likely to be mutagenic in one or another form of the Ames mutagenicity assay (see Table 3.22). Mutagenic urine is an indicator of exposure to biologically significant doses of carcinogenic substances. Mutagenic urine is rare among people without a defined source of exposure in North America. Benzo(a)pyrene which is not necessarily the only carcinogen in the air, but is likely a covariate of the total airborne carcinogen load. By including a (relatively) unexposed control group, statistically significant increases in the proportion of mutagenic samples can be seen. Concentrations of benzo(a)pyrene the soil of garden plots in Katowice Province can also be very high, up to 1,000 parts per billion in some places. Therefore, soil and foodborne exposures may contribute to the mutagenic load.

HUNGARY. Data show that in Ajka as of the early 1980s, where the aluminum smelter was a significant source of benzo(a)pyrene emissions, ambient concentrations were 4.8 nanograms per cubic meter, approximately five times higher than in the control town of Papa. Monitoring data reveals a marked seasonal variation in the mutagenicity of airborne particulates, with high levels of mutagenic activity occurring in the winter and lower levels in the summer. Also, the character of the mutagenic response in bioassay systems changes with the seasons, suggesting a different mixture of chemicals contributing to the mutagenic load in summer and winter.

There are high levels of volatile aromatics in the air in the city of Vac, although Vac is a comparatively small settlement with motor vehicle traffic flows well below those of Budapest (see Annex 6, Table A6.6). Ambient benzene levels at five monitoring locations in Vac exceeded the measured concentrations in four major Canadian cities during the late 1980s. The range of concentrations for toluene and xylene were also higher than in Canada. Since volatile organics have a wide variety of toxic effects, particularly upon the nervous system, finding unexpectedly high concentrations in the air in a city with no obvious source is a cause of concern.

ROMANIA. Carcinogenic substances in concentrations exceeding the Romanian standards have been measured in water samples from 32 of 41 districts in the country and in air samples in 26 of 41 districts in the country and in "menu samples" of food in 23 of 41 districts in the country.

Chlorinated pesticides (which include linden, HCH, aldrin, dieldrin, and DDT and its breakdown products) have been detected in 100 tap water samples in the districts of the southeastern portion of the country supplied with drinking water from surface and shallow ground water

Table 3.22 Mutagenic urine among children in Katowice Province, 1987
(percent mutagenic in Amass assay)

Ambient Benzo(a)pyrene levels (ng/m³)	*Test Bacteria Type 1*		*Test Bacteria Type 2*	
	Direct acting	*Indirect acting*	*Direct acting*	*Indirect acting*
100–228	22	28	16	25
50–228	20	39	13	29
< 50	4	5	8	10

Source: Dutkiewicz *et al.* 1988

sources. Although DDT has been banned for use in Romania since 1974, it is still produced in the country for export (one plant is in Rimnicu Vilcea on the Olt River, a tributary of the Danube) and there may also be a black market for it. Drinking water in 73 percent of the sampled towns had total chlorinated pesticide levels above the Romanian (and European Community) standard of 0.1 micrograms per liter; 13 percent had concentrations above 10 micrograms per liter. Samples taken from towns along the Danube were among the most contaminated.

Samples of mother's milk taken according to a WHO protocol in 1984/85 showed DDT levels of 2–8 parts per million and HCH levels of 11–12 parts per million. Adipose tissue levels of DDT in several samples taken from adults were 8–34 parts per million, compared to levels in the West which rarely exceed 1 part per million.

Drinking water samples taken from three towns along the Prut River in 1988–89 had high levels of total chlorinated pesticides, ranging from 12 percent to 480 percent of the standard.

Chlorinated pesticides in drinking water were also a serious problem in Timosoara. Total chlorinated pesticide levels in the Bega River ranged from 0.3–1.0 micrograms per liter at five sampling locations and average 0.5–0.6 micrograms per liter in tap water samples in Timosoara.

ESTONIA. Contamination of groundwater, mainly with oil products, has made it necessary to supply many towns and cities in Estonia with drinking water from alternative sources. Rakvere, Tapa and Kuressaare, Tamsalu and some small settlements near Tartu all rely on water trucked in from distant sources because of groundwater contamination. Drinking water for Kotla-Jarve is piped in from the Narva River because groundwater in the area is contaminated. In Kivioli, an industrial settlement near Kohtla-Jarve, hydrocarbons have contaminated the soil and the groundwater.

The waste pile at Slantsechim in Kohtla-Jarve is a serious source of water pollution. Leachate from the pile contaminates the Purtse River with phenols to levels 300–1500 times the standard of 0.001 milligrams per liter. This discharge has killed all the fish in the Purtse River and in the Kohtla River into which it feeds, as far as the Gulf of Finland.

The Baltic and Estonian Power Plants are also sources of water pollution. Both plants discharge cooling water into the Narva River. In addition, highly alkaline runoff from slag heaps (pH of 12–13), contaminates the river.

The Maardu chemical plant on the outskirts of Tallinn discharges phosphite and sulfate into the Baltic Sea (phosphite concentrations can be as high as 2,000 milligrams per liter in the receiving waters). It is suspected that the chemical and metallurgical works in Sillamae discharge radioactive substances into the Baltic. There is also concern in Estonia about water pollution due to fertilizer runoff and runoff from animal feedlots.

LITHUANIA. The port city of Klaipeda has several sources of air and water pollution of concern for human health. The pulp mill is a source of ammonia and sulfur dioxide emissions. The battery plant and meat packing plant both emit pollutants. The ship repair facility pollutes the air and water with dust and paint residues, including arsenic, and is the likely source of arsenic occasionally detected in fish. Finally, there is the potential for a catastrophic explosion due to the unsafe handling of chemicals and grain (whose gases can also be explosive) being loaded and unloaded at the port and being transported through the town.

LATVIA. The careless handling of materials has resulted in surface water contamination in recent years. A major accident occurred in November, 1990 when a factory in Belarus accidentally released 8 tons of cyanide into the Daugava River upstream of Daugavpils. No warning was given to downstream users, but a large fish kill was reported to authorities in Daugavpils in time to close the water supply for a few days. One person was hospitalized after eating a fish he found dead, presumably from cyanide poisoning. Untreated chemical wastes entered the Daugava River from Belarus in two other incidents, in November 1991 and January 1992. Fortunately, no one was hurt from the incidents.

CZECH AND SLOVAK REPUBLICS. Metal concentrations in drinking water samples taken in the Czech Republic between 1984 and 1986 varied by as much as ten-fold for many of the metals. In some areas, drinking water samples also contained mutagenic substances. Between 59 and 77 percent of drinking water samples from various industrial areas showed mutagenic activity in the Ames Assay, an indication of the presence of carcinogens. Other data showed a high level of mutagenic activity in river water near the waste outlet from a chemical plant continuing downstream for several hundred meters. Such high metal concentrations and mutagenic activity in drinking water and other surface waters may be harming health.

UKRAINE. High concentrations of benzo(a) pyrene have been found in the ambient air of several large Ukrainian cities. Near main automobile routes in Kiev, concentrations range from 1.3 to 10.6 nanograms per cubic meter. Near urban point sources, concentrations ranged from 2.6 to 9.1 nanograms per cubic meter. A relatively high percentage of mutagenic activity has been found in air pollutants in industrial cities in Ukraine. As Table 3.23 shows, higher levels of mutagenic activity have been found in air in cities which have metallurgic and chemical industries than in control cities.

Contaminants in Food

Data on contaminants in food were available from two countries in Central and Eastern Europe: Lithuania and the Slovak Republic.

LITHUANIA. Table 3.24 provides a summary of available information on contamination of food in Lithuania. The table shows that 0.5–10.2 percent of sampled items have levels of pesticides, metals, and nitrates exceeding the standard. While this information is insufficient to make inferences about human risk, it is a useful indicator of the degree of food contamination for comparisons over time. Public health officials do not think that pesticide contamination in food and water is currently a major problem, but they are concerned that pesticide use will increase when

Table 3.23 Mutagenic activity of chemical pollutants in the ambient air, Ukraine
(range of percent positivity, Ames test)

Cities	*Range*
Metallurgical[1]	12–19
Chemical	4–17
Control	2–7

1. Includes Mariupol, Zaporozhye, Donetsk, Krivoi Rog, and Makeevka.
Source: Levy 1992

agriculture is privatized. At present, the country does not have a compulsory declaration system for pesticides.

However, the most serious problem with food contamination at present is microbiological contamination in processing plants. For example, about 36 percent of reported acute dysentery in 1990 was transmitted by contaminated milk. The Head of the Hygiene Department in the Ministry of Health estimates that approximately 37 percent of shigella infections are due to contaminated food, although what proportion is due to food industry hygiene conditions, as opposed to food-handler carelessness, is not clear.

SLOVAK REPUBLIC. High levels of polychlorinated biphenyls (PCBs) were found in food in many places in the Slovak Republic between 1987 through 1990 (see map, Annex 8). In addition, hexachlorobenzene has been found throughout the food chain as recently as 1983, although it has not been used in agriculture in the former Czechoslovakia since 1980. Taken together these observations indicate significant local variations in exposure to classes of chlorinated hydrocarbons which are stored in human fat and are potential cancer risks. It is not surprising to find that when PCB measurements have been done on human fat samples, the levels measured have been highest near point sources of emission (such as Bratislava and Trencin). The extent to which this is due to air, dust, or diet, is not clear.

A special concern is the presence of PCBs in breast milk. In Michalovce in 1988 and 1989, breast milk PCBs averaged approximately 4.0 to 4.4 milligrams per kilogram of fat. In Trabisov they ranged from 2.5 to 3.4 milligrams per kilogram of fat. In some samples samples, concentrations exceeded 20 milligrams per kilogram of fat. The presence of PCBs in breast milk is widespread throughout the Slovak Republic because of a past practice of using PCBs in animal feed. There is some disagreement between different agencies as to how complete the process of identifying and impounding foods contaminated with PCBs really is. While there is a consensus that contaminated butter is being kept off the market, there is disagreement about whether the sale of contaminated meat is being controlled.

Note

1. A nitric acid digestion method was used to measure lead in soil, which consistently gives lower results than hydrochloric acid digestion.

Table 3.24 Food quality in Lithuania

Food item	*Percent of samples above standard*			
	pesticides	*nitrates*	*cadmium*	*lead*
fish (1988)	1.3	..	..	..
milk (1988)	3–9	..	3–9	3–9
vegetables (1988)	3–4	..	..	..
vegetables (1990)	..	10.2	..	..
all food tested (1990)	1.6	..	1.2	0.5

Source: Hertzman 1992 (c)

Chapter Four

Human Health and the Environmental Action Programme for Central and Eastern Europe

The most commonly occurring human health problems associated with environmental pollution in Central and Eastern Europe appear to be: overexposure to lead among children, acute respiratory and irritant conditions, chronic respiratory conditions, excess infant mortality and lung cancer mortality, abnormal physiological development among children, and methemoglobinemia. In addition, there are other, less frequently occurring problems, such as air and waterborne arsenic over-exposures, infectious disease outbreaks from microbiologically contaminated drinking water and water, increased incidence of thyroid cancers in some communities following the Chernobyl accident, fluorosis near aluminum smelters, and a high probability of disease associated with exposures to chlorinated hydrocarbons and pesticides.

The locations known to be affected by these problems have been listed in Annex 4. However, this is not yet a comprehensive list of the places where similar environmental health problems are likely to have occurred. Not all places with similar environmental pollution problems have been investigated for health risks. And those that have been carried out have not always been conducted on the basis of accepted scientific methodologies. In some cases health claims have been overstated to fulfill a political agenda. In others, very real problems have been discounted. Many problems have been insufficiently investigated because of shortages of resources, lack of epidemiological expertise, or lack of concern for the health impact of environmental pollution.

The next step in developing environmental action plans to protect human health must be to identify all the places in Central and Eastern Europe where populations are exposed to environmental conditions likely to be harming health. Locations have come to our attention for a variety of reasons: because of health claims, ambient air or water pollution data suggesting overexposure to human populations, or because of the presence of known pollution sources in a local area. It is unlikely that significant locations would be missed by all three approaches. However, there is a danger that some locations would be unfairly removed from consideration because epidemiological data was either missing or lacked credibility.

To overcome this potential bias we have made some generalizations about the types of environmental conditions characterizing communities with well-documented environmental health problems. Using these generalizations, we have identified other communities with similar environmental profiles. Following this methodology, we have identified the principal types of environmental pollution which have affected health status in Central and Eastern Europe:

- *Lead in air and soil* from lead and zinc smelters and, in certain cities, from transport due to the use of leaded fuels.
- *Airborne dust* from coal burning in households, small-scale enterprises, and in power and heating plants without or with poorly operating dust filters and metallurgical and other large industrial plants.
- *Sulfur dioxide and other gases* from power and industrial plants and households using high-sulfur coal or high-sulfur fuel oil.

The following types of environmental pollution have been defined as secondary with respect to human health because they are, on average, less prevalent or because it is less certain how they are affecting human health:

- *Nitrates in drinking water* from inadequately maintained/designed or improperly located rural septic tanks, feed lots and agricultural enterprises, and inappropriate fertilizer applications.
- *Contaminants in food* from the inappropriate handling or disposal of lead dust, heavy metals, pesticides, polycyclic aromatic hydrocarbons, and chlorinated organics such as PCBs. Many of these substances have well-documented toxic properties, yet the human health significance of ingestion at largely unknown doses is uncertain.
- *Other contaminants in drinking water* from the inappropriate handling or disposal of water contaminated with arsenic, viruses or bacteria, pesticides, radionuclides, and chlorinated organics. Waterborne arsenic and viruses

or bacteria have been directly implicated in a small number of episodes of human disease in the region. Exposures to these contaminants in water, as their counterparts in food, represent risks of unknown prevalence, magnitude, and certainty.

Using these generalizations we have used ambient air, water, and food quality data to identify other places in the region which have exposure profiles like places for which we have epidemiological data, and have produced a supplementary list of sites where environmental exposures might be harming health. These locations are listed in Annex 9.

Economic Transformation and Environmental Health

The level, composition, and resource requirements of economic activity in Central and Eastern Europe are changing rapidly, and will continue to change, as a consequence of the economic transformation that is taking place. From a strategic standpoint, it would seem most beneficial to focus interventions on those environmental health problems which will persist after the economic and structural changes have been completed. To identify how environmental conditions might change in response to economic transformation, scenarios of future economic activity in the countries of Central and Eastern Europe have been prepared, based on a careful analysis of a large number of structural, institutional and microeconomic changes that are expected to occur over the next two decades.

It is expected that economic change will bring about a permanent drop in the demand for the output of heavy industry relative to national income. The economies of the region should be able to produce more final output for the same volume of resource and other inputs, thereby reducing the volumes of residuals (in the form of solid, liquid or gaseous waste) that are generated. Finally, much of the oldest capital equipment will be scrapped as a result of the decline in industrial output and the process of industrial restructuring. Even if old capital equipment were simply

Box 4.1 Airborne Dust or Gases—Which is More Important?

The work described in this report has come at a time in which new knowledge is rapidly emerging about the impact of air pollution on human health. Of particular interest is the role of certain gases and vapors (especially sulfur dioxide, oxides of nitrogen, ozone, and hydrocarbons) in precipitating acute respiratory episodes and exacerbating chronic bronchitis and asthma. At the same time, the impact of respirable dust on mortality (in addition to its role in respiratory morbidity) is being recognized from studies of a variety of large cities in the West with concentrations of ambient dust which are much lower than in many places in Central and Eastern Europe. The most recent study, by Dockery *et al.* (1993), which followed 8,111 adults in six U.S. cities for 14–16 years and which adjusted for age, sex, smoking, education level, and occupational health risks, found that the city with the worst fine particulate air pollution had a 26% higher mortality rate than the city with the least pollution of this kind.

Thus, from a health perspective, it is difficult to come up with a strong theoretical rationale to concentrate on either dust or gases to the exclusion of the other. In practice, the list of places in the region where airborne pollution threatens human health include some where the primary exposure is to dust; some where the primary exposure is to one or more gas or vapor; and many where the problem is a combination of the two. This same pattern holds true for regional hot spots, areas with a confluence of point sources, and areas where the "bad town planning" model best applies.

Knowledge of the relative importance of the health impacts of dusts and gases does not give a basis to set environmental action priorities which would target one and neglect the other. However, even if the health impacts of dusts and gases is similar, the cost of controlling the former is typically much lower. Strategies aimed at controlling dust while incidentally reducing gaseous emissions are therefore potentially the most cost-effective.

The following table shows typical costs of controlling particulates, SO_2 and NO_X emissions from coal-fired plant in the power and district heating sectors using pollution abatement devices. The results highlight the relatively low cost of controlling particulates compared with either SO_2 or NO_X emissions.

Typical Costs of controlling emissions from the power and district heating sectors

Pollutant	*Abatement technology*	*Removal efficiency %*	*Abatement cost ($ per annual tonne emission avoided)*
Particulates	Electrostatic Precipitators (ESP)	97 - 98	15 - 65
	High efficiency ESP	99 - 99.9	20 - 90
	Baghouse	99 - 99.9	15 - 65
	Mechanical Collector	50 - 90	10 - 70
SO_2	Dry sorbet	50 - 80	400 - 3,500
	Semi-dry FGD	80 - 95	600 - 4,000
	Wet FGD	96 - 98	800 - 5,000
NO_X	Low-NO_X burners	30 - 70	750 - 7,000
	SCR	80 - 90	5,000 - 45,000

Priority should be given to:

- fitting particulate control devices to plants that currently have no such facilities installed; and
- repairing or upgrading existing facilities that are currently not working to design capacity.

scrapped at rates typical of market economies, more than half of the existing stock will be replaced by more modern, more efficient and less polluting technologies within ten years.

However, different countries in the region will have different degrees of success in transforming their economies, with different results for the environment, in both the short and long run. In some countries, old plants may continue to operate, but without major investments in new capital or maintenance. These plants will not likely improve their environmental performance, and may even do worse. If countries export their cleaner fuels, such as low-sulfur oil, and use poorer quality coal instead, particulate emissions may increase rather than fall. The decentralization of government responsibilities might encourage local authorities to make concessions to polluters that would be easier for centralized agencies to resist. Moreover, increased car ownership and consumption of consumer goods will add to problems of traffic pollution and municipal waste.

Allowing energy prices to rise to market levels is expected to have two principal effects on air pollution by promoting energy conservation and by shifting the composition of fuel use away from coal and towards gas and oil. Both of these should have the effect of reducing emissions of most air pollutants, including those of significance to human health. Projections of how much emissions of major air pollutants are likely to fall have been made for (relatively) high and low emission countries in the region, based on alternative reform scenarios. In almost all cases, the initial declines in emissions due to reduced levels of industrial activity after economic liberalization are followed by further declines until after the year 2000: the result of the combined impact of higher energy prices, industrial restructuring and new investment. Total emissions of particulates and sulfur dioxide are expected to decline by 70 percent or more of their pre-reform level by 2005 in many countries despite recovery of Gross Domestic Product to pre-reform levels or higher in all cases. Declines of 50 percent or more in other air pollutants such as nitrogen oxides and airborne lead are likely.

Sustaining these declines over time, and achieving them in certain "high range" countries will involve investment and regulation strategies that must be actively pursued, and do not simply depend on passively reaping the benefits of economic change. The following sections discuss the priority investments needed to achieve sustained declines in emissions of significance to human health.

Priority Investments and Health

Because resources for environmental improvement are scarce in Central and Eastern Europe, it is necessary to set priorities which reflect the urgency and importance of environmental concerns. The damage to human health due to exposure to environmental pollution is the first environmental concern in the region. Evidence from selected OECD countries suggests that the costs of damage to health due to poor environmental quality almost certainly outweigh the costs of damage to physical or natural capital.

Investments, policies, and institutional actions which will effectively reduce or eliminate specific environmental exposures will have a positive impact on human health. Furthermore, the potential benefits of reducing health problems such as neurobehavioral dysfunction due to lead overexposure and acute and chronic respiratory problems associated with dusts and gases will likely have positive economic impacts in addition to meeting social and humanitarian objectives.

In view of the most prevalent environmental health problems in Central and Eastern Europe, the following remediation objectives appear likely to have significant benefits for human health:

- Control of lead emissions from all significant industrial and transportation sources.
- Control of dust from all significant industrial point sources.
- Control of dust and gas emissions from the burning of coal.
- Reduction of nitrate levels in rural water supplies.

The investments and actions below will lead to immediate improvement in environmental conditions at a low cost.

1. The installation of dust collection systems and filters to non-ferrous metal smelters which are located within 5 km upwind of significant centers of population. Priority should, in particular, be given to lead, zinc, copper and aluminum plants. In the longer term, pollution abatement strategies should be developed to reduce lead emissions from transport sources.
2. The installation of equipment to reduce emissions of dust, smoke and soot, and carbon monoxide from iron and steel plants, especially those relying upon open hearth furnaces.
3. Investments either to replace coal by gas or to permit the burning of smokeless solid fuels in district heating plants, commercial premises and households in those towns and cities where the average ambient concentration of particulates during the winter months exceeds 150 micrograms per cubic meter.
4. Assistance to facilitate the proper installation of domestic septic tanks and the appropriate disposal of manure from intensive livestock operations in rural areas where levels of nitrates in drinking water drawn from shallow wells typically exceed 10 milligrams of nitrate-N per liter.[1]

LEAD EMISSIONS FROM NON-FERROUS METAL SMELTERS. Highest priority should be given to eliminating the bulk of dust emissions from lead, lead-zinc and copper smelters where there are towns or cities that are located within the dispersion zone around the plants. Examples of such smelters can be found in most countries but those near Plovdiv in Bulgaria, which causes elevated blood lead levels for a population of over half a million people, and Copsa Mica in Romania have been particularly bad (see Box 4.2).

The costs of damage to human health caused by such emissions can be large, especially if they affect a substantial population. Children are the primary victims of exposure to lead. Lead exposure interferes with neurobehavioral development and may affect health, well-being, and competence throughout the life cycle. Thus, the costs of lead overexposure in childhood will be incurred over a long period of time and it is important to deal with the problem as soon as possible in order to prevent damage to those born in the next few years.

Since exposure to lead may occur through numerous pathways, reducing the risk of exposure will require a variety of measures. To reduce airborne lead dust, lead and copper smelters must install dust control equipment. At the same time, to avoid exposure to lead in food or water, it will be important to maintain a *cordon sanitaire* around smelters to prevent soils which are already contaminated with high levels of heavy metals from being used to grow crops or for grazing.

Significant reductions in the damage caused by nonferrous smelters can be achieved by focusing on plant management and hygiene. Even a cursory inspection may reveal very simple measures that can be taken to reduce wind-blown dust, energy losses and other fugitive emissions. A common problem is the poor handling and storage of metal ores which results in large quantities of dust being distributed around the surrounding area. Investment in water sprays, partial (or complete) enclosure of stockpiles and conveyors, and careful attention to cleaning roadways are clear examples of "win-win" measures related to good housekeeping.

CONTROL OF LEAD FROM TRANSPORTATION SOURCES. High blood lead levels have been recorded in several cities in Central and Eastern Europe, making the reduction of lead emissions from transport sources a priority for human health. In North America, large-scale population reductions in average blood lead levels over the past 20 years have strongly correlated with policies reducing or eliminating lead from gasoline. There is good reason to believe that an analogous set of policies would be similarly effective in Central and Eastern Europe.

PARTICULATE AND SULFUR EMISSIONS FROM IRON AND STEEL PLANTS. Every country in Central and Eastern Europe, other than Hungary, has two or more large urban areas whose air quality is badly polluted by iron and steel plants which belch out particulates, sulfur dioxide, carbon monoxide and miscellaneous hydrocarbons. Much of the iron and steel industry in Central and Eastern Europe relies upon out-dated and inefficient technology which results in poor environmental performance. For instance, open hearth furnaces account for almost half of crude steel production. The installation of better environmental controls should be an absolute requirement for any plant that receives investment for modernization.

Towns and cities with old steel plants have always been among the dirtiest areas in any country, whether in market or formerly centrally planned economies. Ambient levels of particulates are especially high, which can lead to excesses of both acute and chronic respiratory disease as well as a variety of heart and other conditions. The damage done by particulates may be exacerbated by relatively high ambient levels of sulfur dioxide and carbon monoxide. Eliminating the pollution from steel plants should alleviate many of these heath conditions, even for long-

Box 4.2 Environmental improvements in the nonferrous metals industry—Plovdiv and Copsa Mica

The main environmental problem concerns emissions of dust containing lead which can contaminate soils and affect children in a wide radius around a plant. In the plants recently studied—Plovdiv (Bulgaria) and Copsa Mica (Romania)—the main sources of dust emissions were: (a) dust creation in handling the metal concentrates including unloading trucks or railway wagons, mixing and crushing operations, and transferring it to the sinter plant; (b) windblown losses of concentrates from stockpiles; and (c) fume and dust emissions from the sinter plant, blast furnace and other refining operations. The worst problems at both plants seem to be associated with handling the concentrates and losses from stockpiles. Drastic reductions in output since 1989 have reduced emissions from both plants more than proportionately because concentrates are handled more carefully and dust control systems are not expected to operate far beyond their design capacity. However, it is probable that neither plant is economically viable in the long run at current levels of output, unless the size of their work force is drastically cut, since they are operating at less than half the scale of equivalent plants in market economies.

The immediate priorities are measures to deal with dust from concentrate reception, stockpiles and handling. At Copsa Mica, a simple system of water sprays to damp down the stockpiles—at a cost of less than US$100,000—would have a big effect, provided that the water drained from the stockpiles is properly treated. Completion or installation of perimeter walls (or even complete enclosure) plus other measures to prevent spillage—costing less than US$2 million at each plant—would greatly reduce the dispersion of dust that has contaminated the areas around the plants. These should be "win-win" investments since lower concentrate losses should cover most or all of the costs involved. Similar "good housekeeping" measures could also reduce other emissions to both air and water at a very small cost.

At Plovdiv the dust collection system within the plant has been substantially upgraded in the last two years with the installation of new hoods, baghouse filters and upgrading of the old equipment. The plant's management expect to be able to meet the new emission standards which came into effect in January 1993. Similar measures are the second priority at Copsa Mica. A sum of US$2 million should be sufficient to repair and modernize existing controls and to install additional hoods and filters.

The sulfuric acid plants at both Plovdiv and Copsa Mica are in a bad state of repair. Most of the sulfur dioxide produced in the sintering and roasting operations and in the blast furnace is emitted to the air rather than being recovered. New acid plants could not be justified economically, but repairs and upgrading to process more of the sinter plants gases could reduce SO2 emissions substantially. The cost would be of the order of US$3–4 million for Copsa Mica and US$6–8 for Plovdiv, part of which could be defrayed by the higher sulfuric acid yield from the plants.

Box 4.3 Cost-effective ways to control emissions from transportation sources

Cost-effective measures to control lead emissions may include (a) taxing fuels differentially according to lead content, and (b) reformulating the leaded grade of motor fuel. Vehicles using a leaded grade of gasoline would not be using catalytic converters, and will thus have much higher lead emissions than the (mostly catalyst-equipped) vehicles using unleaded gasoline. Since the vehicle stock in CEE is, on average, old (in Hungary, 42% of passenger cars are over 10 years old, and 62% are over 7 years old), poorly maintained, and includes a high proportion of cars with highly polluting two-stroke engines (in Hungary, two-stroke engines comprise nearly one-third of the vehicle fleet), cost-effective strategies may involve targeting these vehicles. Possible measures may include an ownership tax which rises as the vehicle ages and an ownership tax on vehicles with two-stroke engines. Alternatively, governments may offer subsidies for vehicle scrappage or incentives (such as tax breaks) for the acquisition and use of "clean" cars.

Because of their intensive use, the amount of pollution emitted by buses, trucks, and taxis is very high in relation to their proportion in the vehicle fleet. Therefore focusing on high-use vehicles may be a cost-effective approach for many urban areas. A recent study comparing mobile sources emission control options for Budapest concluded that the least expensive way to reduce mobile source pollution is to replace standard diesel bus engines with "clean" engines (which are also more fuel efficient than standard engines). Another study showed that retrofitting high-use vehicles such as trucks to operate on "clean" fuels such as liquid petroleum gas or compressed natural gas may be cost-effective for some cities. Finally, it may be cost-effective to target taxis for emission controls.

standing sufferers. The benefit of investing in better environmental controls for steel plants are typically large because of the size of the population affected and the health gains that can be achieved in a reasonable period of time.

COAL BURNING IN HOUSEHOLDS AND SMALL BOILERS. Although the volume of coal burnt in power stations and large industrial plants is generally several times that used in households and small scale boilers, it is the latter which are responsible for a large portion of the local concentra-

Box 4.4 Environmental investments in the iron and steel industry

The main sources of particulate emissions from iron and steel plants are materials handling and storage, coke ovens, the sinter plant, blast furnaces and steel converters. Most plants have reasonable facilities for primary gas collection and cleaning for coke ovens, sinter plants, blast furnaces and oxygen converters, especially where the exhaust gases are used to fuel other stages of the operation. Thus, attention must focus on secondary collection of fugitive emissions including those from charging and discharging steel converters. These emissions may be high because of poor maintenance or careless operating practices in the past and dealing with them will involve the installation of ventilation hoods, fans and filters or precipitators whose costs will be highly plant-specific.

At Krivoi Rog in Ukraine dust generated by the nearby iron ore beneficiation/pelletization plant is the most serious environmental problem, while better arrangements for dust suppression are also required at Kosice in Slovakia. Water sprays, partial enclosure of conveyor belts and other simple measures can reduce dust emissions, especially that generated by handling fine ores in dry and windy weather. The investment cost would amount to US$1–2 per tonne of steel-making capacity or up to US$25 million at Krivoi Rog and up to US$10 million at Kosice.

At Kosice, all four units of the sinter plant have cyclones, while two have also had electrostatic precipitators fitted to the sinter breaker and screening areas but not to the sinter furnace. As a result, the emissions from the stacks at Kosice are dirty, and will almost certainly contain relatively large amounts of fine iron oxide dust. The solution to the problem, which is expensive, will involve changes in operating practice to improve the sinter quality, and the replacement of the ignition and filtration systems. The total cost of these measures applied to two of the units (two are expected to be closed) is estimated at US$12–18 million. The sinter plant at Krivoi Rog has a very bad dust problem, partly because it uses low quality waste and sludge from the iron beneficiation plant. A combination of better housekeeping, installation of fans with sufficient capacity to capture and clean waste gas prior to stack discharge and the use either of iron ore pellets or of higher grade fines could achieve large reductions in emissions. The plant management would like to invest in a new sinter preparation plant, but more limited investment of up to US$50 million to improve the existing unit would probably be justified.

Controlling particulate releases from coking ovens is largely a matter of good operation and maintenance. For example, adherence to a regular charging and discharging schedule and effective control of oven heating can assist in minimizing brickwork damage and hence gas leakage. Where plants have been poorly operated and maintained, significant repairs may be needed to affect a reduction in emissions. The coke ovens at Kosice and at Krivoi Rog display signs of age, misuse and the need for urgent repair. Most of the doors were leaking and there was a constant haze emanating from the top of the ovens. Detailed studies of the coke ovens would be needed to determine the precise measures needed to reduce the emission levels but replacement or major rehabilitation of many of the coke batteries may be necessary in the medium term. This would be expensive with a cost of US$100 million or more for Kosice.

Improvement of primary particulate controls plus installation of secondary fume collection and cleaning for basic oxygen converters in existing basic oxygen converters may cost up to US$10 per tonne of steel-making capacity. For example, the electrostatic precipitator on one of the Basic Oxygen System (BOS) units at Kosice was ineffective—the stack was emitting a thick plume which deposited red dust around the surrounding area—and may need repair or replacement at a cost of up to US$8 million. It is unlikely to be worth investing significant sums in open hearth plants whose economic life should be very limited.

tions of particulates and sulfur dioxide in the majority of the most polluted urban areas in Central and Eastern Europe. In Poland it has been estimated that the population living in those urban centers worst affected by particulates amounts to about 6 million people out of an urban population of 24 million. The prospective health benefits to such people of remediating these emissions are similar to those described previously for people living near iron and steel plants.

RURAL WASTE WATER TREATMENT. A program of rural waste water treatment which effectively reduces excessive nitrate levels in shallow wells and other drinking water sources should eliminate the problem of methemoglobinemia in newborns, which is widespread in the rural areas of many countries in Central and Eastern Europe.

As with many diffuse environmental problems, tackling high nitrate concentrations involves a large number of small measures designed to reduce discharges of nitrates and to ensure that groundwater sources used for drinking are protected from the infiltration of nitrates resulting from the careless disposal of human and animal wastes. These measures involve a large component of agricultural extension and public education as well as programs to finance the relatively small individual expenditures required to install septic tanks or simple systems to collect and treat wastewater in larger villages and small towns. The major issue is proper legislation followed up by effective enforcement to ensure that the design, construction and operation of septic tanks are in accordance with design standards. If this is not achieved, septic tanks are nothing more than point sources for groundwater pollution.

A short term program to reduce the incidence of methemoglobinemia among infants should concentrate on monitoring nitrate levels in the affected areas combined with public education and the provision of bottled water for families at risk. Since breast-feeding will likely reduce exposure to waterborne nitrates among newborns, this information should be included in any health education package being contemplated. Health education and the provision of bottled water amount to a strictly palliative approach, but they are necessary interim steps because other measures to reduce levels of nitrates will take a considerable period to have an impact on exposure levels. Once the population is being provided with better protection from existing problems, the focus of public policy should turn to reducing the flow of nitrates into groundwater, especially from intensive animal husbandry and improperly maintained and/or located rural septic tanks.

The immediate priority for public investment should be to ensure that the manure from feedlots, dairy and pig farms, and poultry units is properly managed, so that highly concentrated effluent is not allowed to seep into the ground and is not discharged into neighboring streams or Rivers. Quite apart from the contribution such activities make to levels of nitrates in groundwater, they can have a devastating impact on river quality and aquatic life if the untreated liquors from manure heaps are simply piped into nearby surface waters. In areas where there are several enterprises, it may be sensible to invest in collective treatment and disposal arrangements with effluent being transported to the central facility. Projects which provide finance and technical assistance for such facilities may be excellent candidates for support from the donor community.

Other Strategic Considerations

DEALING WITH OLD INDUSTRIAL PLANTS. Whether to invest in pollution control in large old industrial plants depends on tradeoffs between social benefits and economic factors. The choices are (1) to close down such plants as rapidly as possible on both economic and environmental grounds; (2) to permit them to continue to operate for a limited period as in the past; and (3) to permit them to continue to operate provided that environmental improvements are implemented. In a considerable number of cases modest environmental investments could generate a good return within 2 to 3 years. In such cases, there is no basis to allow them to operate as in the past. If the government (or the enterprise) is unwilling to finance modest improvements, then this amounts to a decision that the social benefits of keeping the plant open do not outweigh

Box 4.5 Investments to control emissions from coal burning

For large boilers it is possible, at modest cost, to install electrostatic precipitators or other dust filters to eliminate 98 percent or more of the particulate emissions. In any case, most such emissions are dispersed over a relatively wide area because of the height to the chimneys concerned as well as the relatively high emission velocities. By contrast, the emissions from burning coal on a small scale are neither dispersed nor can they easily be controlled. Thus, there is a need to tackle excessive exposure to particulates linked to the use of coal in households, small commercial and industrial premises, and small district heating units.

This does not mean that emissions from power stations and similar large sources can be neglected, but rather that the solution is clear—install and maintain appropriate electrostatic precipitators.

There are three ways of eliminating or, at least, drastically reducing the emission of particulates from small scale sources. The first is to require that all users burn smokeless solid fuel rather than ordinary coal or coal briquettes, the second is to substitute some alternative fuel—normally gas—for coal. An appropriate strategy would be to provide the resources required to accelerate the substitution of gas for coal in large, heavily polluted urban areas. In parallel, governments could adopt a policy of requiring the use of smokeless fuels in smaller towns whose average levels of particulate exposure during the heating season exceed some critical value—probably 150 micrograms per cubic meter. In some cases, a third option is to develop district heat systems which distribute heat to households and small industries and where the central generating plant can be more efficiently fitted with the necessary pollution control equipment.

the costs, and the plant should be closed. In other words, the strategic choice is between (1) and (3) above.

Where modest improvements are not feasible or will not be effective, then the government should set an absolute maximum term for the continued operation of the plant under choice (2) above. This period should be substantially less than the payback period for potential environmental investments.

This approach provides clear guidelines for action which allow governments to make their own choices about the trade-off between the social costs of unemployment and of continuing environmental damage. It suggests, further, that all public enterprises should be subject to a gradual tightening of environmental conditions for continued operation under which managers are held accountable for making progressive improvements in environmental performance.

NON-INVESTMENT STRATEGIES. Capital investment is only one part of the story and may not even be the most important part. There are numerous low-cost measures, many of which pay for themselves through reduced wastage and reduced emissions. For example, properly maintaining plant and equipment, making sure that environmental controls operate according to specification, and dealing promptly with leaks and spills will go far to reduce plant emissions. In part this is a matter of commitment to and pride in achieving a better environmental record. Thus, trivial but symbolic steps such as publicizing the achievement of plants or work groups which make significant environmental improvements can produce surprisingly large benefits. It follows that investments must be reinforced by expenditures on management and worker training and other programs to ensure they bring the best possible returns in terms of improvements in environmental quality.

Community health promotion strategies may also prove to be beneficial. Breast feeding has already been mentioned as a palliative for methemoglobinemia, and the prevalence of breast feeding may be increased by community or clinic based efforts to promote it. Furthermore, communities contaminated by lead will require ongoing efforts to remove high-lead dust from homes and reduce contact with contaminated soils, even after emission sources are controlled. The former may require home vacuuming programs and the latter may involve campaigns to improve grass-cover or to cover contaminated soil with new, uncontaminated soil. On the basis of experience elsewhere, such efforts are best organized locally.

The Need for Remediation-oriented Health Data

The ultimate test of effectiveness of the investments and policies described above will be reflected in the answers to the following questions:

- Have ambient levels of exposure to lead, dust, sulfur dioxide and waterborne nitrates been reduced as a result of these policies and investments?
- Has morbidity related to these exposures been reduced at the same time?

Getting adequate answers to these questions requires that appropriate baseline and follow-up data be systematically collected. There is a need for both ambient and health outcome monitoring which is specific to each pollutant and health outcome under consideration. Fortunately, the exposure-outcome combinations are few in number and relatively simple to measure. Three groups of data-gathering strategies should be developed to evaluate the effectiveness of (a) reducing exposures to lead; (b) reducing threats to respiratory health, and (c) controlling morbidity and mortality from nitrates in drinking water.

LEAD. Sample locations should be selected from among those where lead from industrial or transport sources will be subject to remediation. Thorough baseline surveys of ambient airborne, house dust, and superficial/labile soil lead levels should be carried out, in conjunction with blood lead measurements on a sample of children under the age of six. The environmental samples should be repeated in the same locations after investments are made, or periodically during the introduction of policies to control emissions from transport sources. Because blood lead levels change systematically with age, a repeat cross-section of children under six should be evaluated for blood lead levels, not a longitudinal follow-up sample. It would not be necessary to do neurobehavioral testing in this context, because declining blood lead levels can be taken as surrogate evidence of effectiveness in protecting children against lead-related neurobehavioral risks. It will be difficult to include control communities in the evaluation, because there are not likely to be communities willing to delay any attempts at lead abatement until other communities remediated their lead problem and were evaluated.

There will be a need to supplement the large-scale investment and policy strategies with simple local measures, such as thorough vacuuming of houses near smelters where lead emissions have been reduced. Such initiatives, as well as the efforts to design and carry out the evaluation, will require a strong local public health presence with access to epidemiological and environmental measurements, and health promotion skills. These latter will likely need to be supplied from a national pool of skilled personnel, which in turn presumes that a national or regional training strategy is in place.

THREATS TO RESPIRATORY HEALTH. Evaluating the effectiveness of measures to reduce exposures to particulates and sulfur dioxide will require data on both ambient conditions and health outcomes. Health outcomes can be evaluated most efficiently by administering childhood respiratory questionnaires and spirometry to samples of pre-adolescents. These methods are well validated, and also have some capacity to predict adult respiratory health status. It is not necessary to study adults in the same way, since children's respiratory health status is more sensitive to air pollution than adults' (other than those suffering certain chronic diseases) and because of the powerful confounding effect of cigarette smoking. To that end, information on exposure to second-hand smoke would need to be collected on participants in the study. A case could also be made for recruiting control children from "clean" communities who are exposed to second-hand smoke.

In addition to sample surveys, it may be feasible to use data from emergency room visits for respiratory conditions as a surveillance tool. In conjunction with high quality, routinely collected data on the specific air pollutants of interest, it should be possible to identify whether a correlation between fluctuations in air pollution and emergency room visits for respiratory conditions disappears as the average pollutant level declines. Such a strategy presumes that air monitoring resources will be concentrated in communities of special concern and that the population-based health data systems which were a relative strength of the former Central and Eastern European systems will be maintained and improved during current health care reforms.

NITRATES IN DRINKING WATER. There will need to be two forms of outcome evaluation in communities where waterborne nitrates are associated with endemic methemoglobinemia. The first would simply involve evidence of declines in morbidity and mortality from methemoglobinemia as a result of short term interventions which did not affect the nitrate content of local drinking water (i.e. public education and provision of bottled water). This would involve a rigorous case definition of methemoglobinemia-related morbidity which could be determined in an inexpensive and unbiased fashion by rural health care practitioners and transmitted in standardized form to local public health authorities. The second form of evaluation would involve evidence that using a "remediated" water supply was associated with no return of endemic methemoglobinemia. This would involve maintaining a case surveillance program before and after pregnant and lactating women were advised to use their local drinking water supply again. Measurement of waterborne nitrate levels would need to be available at baseline, periodically during the remediation period, at the time the water was declared safe, and for a follow-up period of at least two years.

Once again, this approach presumes a strong local public health presence and access to skilled epidemiologic personnel. The case for a core national resource in environmental epidemiology is not based solely on the need to evaluate current initiatives. There is also a need to complete high quality epidemiologic studies of the wide variety of environmental health concerns that are inadequately evaluated at present and to develop and maintain data systems to detect patterns of morbidity and mortality in the future which might have an environmental etiology.

Note

1. The proposed threshold is based on the standard WHO guideline, which is identical to the US guidelines for the quality of public drinking water. The threshold allows a considerable margin of safety so that a less strict threshold of 20 mg/l of nitrate-N would prevent almost all cases of methemoglobinemia. The EC drinking water standard specifies that nitrates should not exceed 50 mg/l of NO_3 which is equivalent to 11 mg/l of nitrate-N.

Annexes

Annex One

Separating Fact from Fiction: Collecting and Evaluating Environmental Health Information

This section provides a description of the methods which were used to collect and evaluate available epidemiological and exposure information in countries of Central and Eastern Europe. The knowledge base is largely composed of studies done under conditions which were not technically or ideologically favorable to epidemiologic investigation or exposure assessment.

As much as possible, the idiosyncrasies of each country's investigation have been preserved in the text so that the readers can judge for themselves the sorts of limitations under which data collection took place.

Methods of Data Collection

The principal method of data collection for this investigation was a form of "epidemiologic tourism" through Central and Eastern Europe. From the autumn of 1989 to the summer of 1992, multi-disciplinary missions of environmental specialists from the World Bank visited ten countries in the region: Poland, Hungary, Czechoslovakia, Bulgaria, Romania, Latvia, Lithuania, Estonia, Belarus, and Ukraine. The role of the environmental epidemiologist on the team was to collect all information possible which might identify human health effects from environmental pollution. We collected information personally in eight of these countries and received reports from colleagues who visited two others (Belarus and Ukraine).

The country visits were a challenge. They were not long, lasting up to three weeks in large, populous countries like Poland and only a week in each of the smaller Baltic Countries. At the outset of each visit a contact in the leading government agency responsible for environmental health was assigned to me, and a skeleton plan for meetings and site visits prepared on the basis of preliminary World Bank investigations. Our challenge was to quickly overcome the language barrier, establish a reasonable level of trust, and identify the key agencies and investigators who *actually* knew something about human health and the environment. When this process was successful, we ended up spending our time collecting the highest quality information available rather than wasting it in inconclusive, non-technical discussions.

A typical successful session would be a series of one-on-one discussions with front-line investigators from an agency or institute who would explain their research/data to me and give me the opportunity to ask questions critically appraising it. Usually, the outcome of such sessions was simply our handwritten notes. But whenever possible we accepted their written documentation. Usually the investigators were willing to help translate key tables, figures and abstracts which made the documents usable.

Much of our time was taken up trying to confirm rumors and sweeping statements about the state of environment and health in a particular country. Often, it turned out that supporting data which were thought to exist, in fact did not, or else showed the opposite of what it was claimed to show. Frequently, studies which were being relied upon at the policy level turned out to be so flawed as to contain no usable information at all. On the other hand we did find some reasonably valid and reliable information in every country we visited. Often it had been generated in agencies and by investigators not sought out in environmental policy development.

The proximate outcome of our visits was a series of country reports based upon the material we had personally collected, supplemented by relevant information from the international health literature. We were very selective in what we included, discarding virtually all information which lacked basic credibility. In some cases, stories of bad data were included to explain why we disbelieved a commonly-heard health claim which had followed us to the country, or to make the case for a technical assistance program.

These country reports were largely responsible for creating the impression that it would be possible to base an efficient environmental action plan for the region on human health concerns.

The Structure of Environmental Health Data Collection in Central and Eastern Europe

This section describes the activities of the principal agencies responsible for collection of environmental health data in several of the countries of Central and Eastern Europe. The review does not include all countries because the data collection structures and problems are similar among them. Seven countries are presented below, but not in a strictly parallel way. The attempt here is to highlight different issues by reference to examples which have occurred in particular countries, but which are not confined to them.

During our visits, it was important to repeatedly emphasize the fact that the data most pertinent to human health was not necessarily the data of greatest interest to Ministries of Environment. For instance, ambient air quality data is more relevant than emission data for assessing human health risks, while the reverse may be true for characterizing particular sources of pollution. Ministries of Environment in Central and Eastern Europe were generally most concerned with emission data, while Institutes of Hygiene, under the auspices of Ministries of Health, often had more extensive information on ambient air quality. Moreover, the principal agencies often had only a minority of the relevant information at their disposal. Sometimes allied agencies, such as a particularly active cancer registry, would have information yielding the most useful insights. Activities of a selected sample of these allied agencies are highlighted in the section following this one.

Poland—Until the political changes in 1989, the two most important agencies in the environmental health field had been the sanitary epidemiology stations, which are supervised by a central Institute of Hygiene of the Ministry of Health, and the State Environmental Inspectorate of the Ministry of Environmental Protection and Natural Resources, which is closely associated with the Institute for Environmental Protection.

In general, the activities of the sanitary epidemiology stations (herein known as san-epi stations) are like North American health departments, but in regions with significant environmental pollution problems they have a strong environmental health component to their activities. This is focused on the human experience of exposure to environmental pollution. They are concerned with ambient air quality, drinking water quality, and food contamination. They also are responsible for monitoring air quality in the workplace. In contrast, the environmental inspectorate is oriented towards the control of sources of exposure. Thus, their monitoring activities generally concern pollution emission rates from sources of exposure and not ambient conditions. In theory, this is an extremely rational distinction to make, but in practice, there has been a great deal of overlap in the agencies' activities. For example, in zones of "special environmental protection," which are nationally-designated because of their particular ecological significance, the environmental inspectorate does studies of food contamination. These studies, by design, sample food in a geographic cluster at its source. The san-epi stations sample the "food basket" as it is found in the market place; which represents the food supply as its is delivered to the people rather than as it leaves a region which might be polluted.

Both the san-epi stations and the environmental inspectorate have collected ambient air pollution data in the zones of special protection, but san-epi has had a much more extensive network of monitoring stations and been able to sample a larger number of substances. Their routine measurements include dust sedimentation, airborne particulate concentrations, sulfur dioxide, and oxides of nitrogen, while carbon monoxide, phenols, formaldehyde, heavy metals, and benzo(a)pyrene are sampled on a nearly routine basis. San-epi has 49 district stations with 328 subsidiary field stations and approximately 560 points around the country where routine environmental data are collected. The Institute of Hygiene serves as a warehouse for all data produced by the sanitary epidemiology stations and also all emission data generated by the Institute for Environmental Protection.

Hungary—Unlike in Poland, it has been difficult to get an adequate overview of the institutional linkages dealing with the public health aspects of environmental pollution in Hungary. From interviews and discussions in Budapest, it was clear that the National Institute of Hygiene, which exists under the auspices of the Ministry of Health, was the principle agency responsible doing research into the health status of Hungarians. Under its auspices come the monitoring of 79 settlements for sulfur dioxide, oxides of nitrogen, and soot, and 99 settlements for sedimenting dust. Also, five disease registries are maintained by institutes within the NIH, which relate to mortality, cancer, congenital abnormalities, chronic pulmonary diseases, and acute respiratory morbidity among children.

There seems to be great variation in the degree to which the different institutes of the NIH actually pursue environmental causes of ill-health. For instance, the Center for Congenital Anomaly Control has a very active program of environmental surveillance for anomalies related to workplace and environmental conditions. On the other hand, the National Institute of Oncology has made few efforts in the area of occupational and environmental causation. Therefore, there is no adequate surveillance system for occupational cancer or any regional cancer mapping as would be common in Western Europe or North America.

In the regional centers, the sanitary epidemiology stations have responsibility for the public health aspects of environmental exposures. However, the degree to which this mandate is carried out seems to vary greatly from region to region. In Miskolc, an area with significant environmental concerns, the san-epi station seemed to be actively involved in data collection, research, and the public health response to local issues, often in collaboration with the central institutes in Budapest. In other parts of the country the san-epi stations seemed less relevant. There was also a widespread sense of distrust throughout the country regarding data which were produced by the Institutes in Budapest. In Miskolc, where the san-epi station was active, there was distrust expressed about the quality and veracity of the data which they were producing. This distrust, and sometimes rivalry, extended into inter-institutional relationships as well. For instance, in Poland the Institute of Occupational Medicine and the Institute of Hygiene cooperated closely with the san-epi stations in collecting and evaluating occupational exposure data. In Hungary, it would appear that the Institute of Occupational Health has, until recently, been cut off from the agencies which deal with environmental health conditions. The difficulties here go as far as to include an episode in which quality control samples sent to Hungary from abroad to standardize the work of various laboratories of the National Institute of Hygiene were taken by one institute (not the one which ordered them) and not passed on to others.

Czechoslovakia—Even before dissolution of the federation, the principal agencies responsible for investigating human health aspects of environmental pollution in Czechoslovakia were separate for the Czech and Slovak Republics. In the Czech Republic the Institute of Hygiene and Epidemiology was the lead agency, serving as the central resource for the san-epi stations, much as the Institute of Hygiene did in Poland. The san-epi stations were organized by region, and regions with many environmental pollution problems, such as northern and central Bohemia, had active environmental health investigation programs of their own. In the Czech Republic it was easier than anywhere else to find individuals in academia and the Central Statistical agencies who were making useful contributions in the field of environmental health. Unfortunately, some of these efforts were going on unnoticed by the Institute of Hygiene and Epidemiology.

In the Slovak Republic, the lead agency for our purposes seemed to be the Research Institute of Preventive Medicine. As its name suggests, this agency had a much stronger "original" research role but a weaker "service" research role than the Institute of Hygiene and Epidemiology. Thus, it was difficult to obtain from them routine monitoring data and other information of unambiguous relevance to public health. We were able to obtain some useful information on contaminated land and food pollution from the Institute of Food. In addition, the Slovakian Cancer Registry was the first of several we visited in the region which had case finding systems of international caliber.

Bulgaria—By the time we reached Bulgaria, we were able to anticipate the agencies which were taking the lead in investigating the human health aspects of environmental pollution. The Institute of Hygiene and Occupational Diseases served as the central resource for the district hygiene and epidemiology stations, which are roughly analogous to san-epi stations elsewhere in the region. The district hygiene and epidemiology stations have responsibility for collecting air, water, and soil data relevant to industrial exposures as well as having a role in inspecting industrial work places and in food hygiene. They were organized on a regional basis according to 28 districts which map neatly onto the 9 larger regions that are used for other administrative purposes in the Ministry of Health system. Unfortunately the 28 health districts were not the same as the 16 Ministry of Environment districts, making integration of Ministry of Environment and Ministry of Health data somewhat awkward.

The Institute of Hygiene and Occupational Diseases has 3 broad functions in support of the work of the district hygiene and epidemiology stations: to conduct special studies into problems requiring special expertise; to establish exposures standards and norms; and to develop laboratory methods. The Institute also has a role in collecting and organizing data from the 28 stations. The general computer center of the Bulgarian Academy of Medicine is found on the same premises as the Institute of Hygiene and Occupational Diseases. It is responsible for the maintenance of 16 disease registries, based on routinely collected data throughout the health care system of Bulgaria. This core resource supports regional centers for information technology in each of the 28 districts of Bulgaria. The general flow of information is from the districts to the center, often with increasingly summarized and distilled information available by the time it reaches Sofia.

The Ministry of Health role in air quality is confined to monitoring of ambient levels, not controlling emissions per se. The Ministry maintains a network of 89 stations for sample-taking in strategic locations around the country. Data from the 89 stations are collected under the auspices of the hygiene stations and forwarded to the Institute of Hygiene and Occupational Diseases. The data are subsequently sent on to the Ministry of Environment for publication in their quarterly reports. The Ministry of Environment also receives data from the Institute of Meteorology and Hydrology, which has several ambient air monitoring stations, as well as from its own network of 30 stations around the country.

The general impression created was that the Ministry of Health and Ministry of Environment did not have close cooperation in the area of monitoring ambient air quality or in responding to air quality problems. The primary concerns of the Ministry of Environment were in the area of air pollution due to emissions from power stations and the problems of coal burning in houses. By contrast, the Ministry of Health was particularly concerned with hot spots where multiple airborne exposures of the population occurred as a result of emissions from particular local factories.

Estonia—Despite its small size Estonia had a rather elaborate and uncoordinated network of agencies interested in the public health impact of environmental pollution. These agencies include the san-epi stations, the Institute of Preventive Medicine, the Institute of Experimental and Clinical Medicine, the Institute of Hydrometeorology, the Ministry of Environment, and the local environmental committees.

The Ministry of Environment is the lead agency in environmental protection in Estonia. Its current priorities are to protect the forests; to find less polluting ways to burn oil shale so that Estonia can maintain energy self-sufficiency; to decrease emissions from the chemical industries which use oil shale; to upgrade the Eesti Tsement plant, which is a major source of dust pollution; to upgrade wastewater treatment throughout the country to comply with the Baltic Sea convention; and to decrease SO_2 emissions by 30 percent and NO_x emissions by 70 percent in compliance with international conventions.

At present, the Ministry is in a relatively weak position to fulfill its leading role in the environmental field. Aside from being strapped for cash, the Ministry does not have its own air and water measurement capabilities and has had no control of the environmental monitoring program in the past. The vast majority of air and water quality monitoring is done by the Institute of Hydrometeorology, which has operated according to a sampling strategy laid down by Moscow authorities 15-20 years ago and not changed substantially thereafter. This has meant that there has been little input from the Ministry of Environment, local environmental committees or Ministry of Health regarding what, when, and where to monitor.

In the regions where there are significant environmental health problems, such as Narva and Kohtla-Jarve in the northeast, the san-epi stations have been active in the field. For instance, in Narva the san-epi station has participated in large-scale health studies of pollution and health, collected some air and drinking water quality data, and has kept track of occupational health problems. The head of the san-epi station works closely with the head of the local environmental committee; the san-epi laboratory does work for the environmental committee and the two agencies carry out joint inspections of industrial facilities. Nonetheless, the relative weakness of the san-epi station in environmental health was demonstrated by the fact that they had only one full-time staff member devoted to the field.

The Institute of Preventive Medicine has operated under the auspices of the Ministry of Health, and serves, in part, as a service research center for environmental health problems throughout the country. It has a department of hygiene with four subunits: the laboratory of children's health protection, laboratory of atmospheric air toxicology, laboratory of food toxicology, and chemical sanitary laboratory, each of which carries out some investigations in "human ecology." Most of the usable environmental health information in the country has emerged from this Institute, although, conversely, only a small fraction of what they produce under the rubric of "human ecology" is helpful for the purposes of evaluating the impact of the chemical environment on human disease.

In addition to facing problems which are similar to those in Central Europe (such as lack of computerization and up-to-date analytical equipment), the Institute of Preventive Medicine has faced two other important obstacles to its work, one of which is in the process of being solved while the other is likely getting worse.

The first problem is the long tradition of secrecy associated with birth and death statistics, and attendant concerns about poor quality control and outright falsification of these data. Until last year, they were controlled by a central statistical agency in Moscow which was resistant to the Institute's special needs for vital statistics. In 1991 the data were taken over by Estonia, and there is confidence that the problems with secrecy and quality control can now be solved.

The second problem, a much more intractable one, is that the Institute of Preventive Medicine and the san-epi stations are seen as remnants of the old order by some Estonians working in environmental health. The main reason for this is that, until recently, there was no public health training in Estonian medical schools. All the public health specialists were trained in Russian in St.Petersburg, and tended therefore to be ethnic Russians. This has led to an atmosphere in which Estonian-dominated agencies, such as the Ministry of Environment, are reluctant to accept the professional credentials of public health staff, trust their work, or recognize a legitimate role for them in environmental health regulation.

Lithuania—In Lithuania, the Ministry of Health is more dominant in the field of environmental health than in Estonia but has managed to create an organizational structure that tends to separate the process of identifying and evaluating human health issues related to environmental pollution from the day-to-day activities of public health regulation. Starting at the level of the Minister of Health two separate branches of authority diverge: one for regulation and another for investigation. It is the investigative arm which is relevant here.

The investigative branch of the Ministry of Health begins with a committee comprised of the Minister, Deputy Minister, and a board of medical specialists who decide on the priorities for environmental and other public health investigation. There is no representation from the Department of Hygiene or the Republican Hygiene Center, which are the regulatory agencies, on this committee. The agency which receives instruction from the committee is the Institute of Hygiene, which carries out most of the environmental health investigations in the country. Their general mandate is in the area of ecology and health, with special concerns for air, water, food, and soil. Their investigative priority is the health of people in the residential areas of polluted places. They have access to polyclinic records and the right to do environmental sampling. Until one year ago they kept their monitoring data separate, but now are sending it to the Environmental Protection Department for collation with data collected from other agencies. From time to time they involve municipal hygiene centers in their work, but they do not ask the regulatory agencies for input into what to investigate or how to investigate it. As a result, the Institute of Hygiene has only initiated one study at the request of local authorities. In effect, this system splits the regulatory and investigative roles which in most other Central and Eastern European countries are found in a single agency.

In Lithuania, as in Latvia, there is no ministry of environment as such, but a fully staffed quasi-ministry which functions as a committee of parliament and reports directly to it. In Lithuania this agency is called the Environmental Protection Department, and its head enjoys ex-officio status in cabinet. The quasi-ministerial structure seems to reflect the politically charged nature of environmental concerns on the one hand, and on the other, the fact that a distinct environmental agency, as opposed to one simply concerned with nature conservation or forestry, is a new feature of political life.

Central collection and collation of environmental data in the Environmental Protection Department seems to be the principal act of coordination between the Ministry of Health and Environmental Protection. At the local level there did not seem to be a high level of interaction between the two agencies and their representatives tended to view local problems quite differently. The principal exception to this is in Kaunas, where the municipal council has taken the lead in coordinating environmental protection management. The system, which was developed as an initiative of WHO Europe's "Healthy Cities" program, has regional environment and municipal hygiene officials reporting to an Ecological Board of the City Council and an Environmental Protection Division of the municipal administration, which, in turn, report to a coordinating body of the Healthy Cities program. Under this structure, Kaunas has been able to organize its information and set priorities better than elsewhere in the country and create an environmental improvement plan for 1991-1995.

Latvia—The leading environmental agency in Latvia is the Environmental Protection Committee, which operates under the auspices of the environmental protection committee of parliament. Unlike Lithuania, the Committee does not have a direct voice in parliament, but speaks only at the request of the Deputies. At the time of our visit, everything was in transition, and parliament was in the process of creating reporting requirements and sorting out levels of responsibility. Sometimes former environmental regulations have been voided without being adequately replaced, leaving the Committee vulnerable to being undermined.

Public health services are in an even greater state of transition at present than environmental services. After the failed coup attempt in August, 1992, the Ministry of Public Health was downgraded to a Department within a ministry of social services, labor and health. The current structure, which will be changed in the near future, is as follows. Agencies relevant to environmental health which report to the Department are the Republican Center of Hygiene and Epidemiology, the Latvian Occupational Diseases Center of the Academy of Medicine, the Medical Statistics Bureau of Vital Statistics, and the Republican Oncological Diseases Department. The local hygiene centers report to the Republican Center and, also, cooperate with local occupational disease centers (which are part of the Academy of Medicine structure), giving them workplace inspection data useful for diagnosing and treating occupational disease.

The public health system in Latvia has been almost exclusively devoted to infectious disease control, at the expense of environmental health in particular and chronic disease control in general. Few of the local medical officers have knowledge and training in the chemical disease paradigm, but in some districts they have gotten involved in the field through exposure to occupational health issues. Also, there were no smoking data available for the country (not even data on per capita tobacco sales), no participating centers in WHO studies such as the MONICA program, and a cancer registry which was not yet fully usable for epidemiologic purposes.

Two clinical physicians (who were also members of the Green Party) had been seconded for a period of two months to propose a reorganization of public health services which would strengthen its efforts in environmental health and chronic disease control. Their proposed reorganization would see routine infectious disease control operating through a Branch of Hygiene which would report directly to parliament through the National Control Service, not through the Department of Health. Within the Department of Health a new Institute of Human Ecology and Public Health would be created for handling all issues associated with chronic and environmental disease control. The country's main clinical specialists would report to it, helping to identify important issues for investigation. The Institute would create a network of epidemiologists, both in the local areas and centrally, to carry out investigations on disease clusters and environmental exposure situations and to study other determinants of health status. The Institute would come under a Deputy Director & Chief of Human Ecology & Public Health, to which the Department of Medical Statistics would also report.

The rationale for this reorganization was to integrate all those activities which are directly related to preventive aspects of health. The statistical division would help identify significant health trends, such as temporal increases or regional variations in disease rates. The main specialists would report patterns of clinical disease which might be amenable to preventive action. The team of epidemiologists would be delegated to investigate, using rigorous methods, those problems deserving further study. Furthermore, the Institute of Human Ecology and Public Health would be mandated to evaluate and upgrade existing health data bases, work out computerization plans, and identify needs for new data sources.

Special Agency Initiatives

In several countries in Central and Eastern Europe health agencies outside the mainstream of environmental health have contributed to understanding environment and health relationships. Two such agencies are highlighted below.

The Center for Congenital Anomaly Control in Hungary has the most highly evolved program for evaluating environmental causes of congenital anomalies in Central and Eastern Europe. The Center is part of the Department of Human Genetics and Teratology of the National Institute of Hygiene. It has an epidemiological unit with separate descriptive, analytical, and experimental activities. One notable feature of the Hungarian system is that physicians are required by law to maintain prenatal log books on all pregnant women. Copies of 95% of these log books find their way to the congenital malformation registry, which allows epidemiologic researchers to get complete histories of previous prenatal experience, drug usage during pregnancy, and medical conditions of the mother. In order to survey for environmental causes of congenital disease, the center has established a program of "sentinel conditions" which are designed to serve as early indicators of potential excesses of congenital disease. At present, the center is doing several environmental studies based on these sentinel conditions. Since 1980, a case control surveillance system has been in place in which approximately 2,000 major congenital anomalies are identified each year through the registry and direct contact is made with the parents within one month of notification. For each child with a congenital anomaly, three control children are identified. The parents are asked questions regarding drug taking, maternal health problems, and their occupational history.

One of the most encouraging experiences we had was with the National Oncological Center in Bulgaria. The

Center serves both as a referral center for the clinical treatment of individual cancer cases and as a site for data collection and research regarding risk factors for cancer. The National Oncological Center is the focus of a network of 13 regional centers. When new cases of cancer are identified, local physicians are required to notify the regional centers, which report annually to the epidemiology department at the National Oncological Center, and to complete a cancer reporting form which is the basis of the reporting system. The information found on this form could be of tremendous use in surveillance for environmental influences on cancer. The reporting form differentiates between an initial diagnosis, a confirmed diagnosis, and a case identified first on death certificate or autopsy. This is very useful information for validity and quality control purposes. In addition, the form records specific residence information which could allow detailed cancer mapping if the technology were available. Also, there is information on occupation, place of work, marital status, and social group: all important in the analysis of cancers with multiple risk factors. At present, efforts are being made to cross check the mortality file with the cancer incidence file for consistency. This is a very important step because information on the death certificates follows a separate paper flow from the cancer incidence reporting system. In addition, it was claimed to me that 65% of individuals with a suspected diagnosis of cancer have an autopsy. This is a much higher rate than in North America and probably makes for more valid data than some of that which goes into North American cancer registries.

Limitations in the Quality of the Available Information

One of the principal impediments to understanding environment-health relationships in the Region is the generally poor quality of data regarding exposures to environmental agents and, also, the assessment of human health outcomes.

The Central and Eastern European tradition of epidemiology is firmly rooted in infectious disease control. In the West, the modern era of epidemiology was ushered in by the landmark studies of cigarette smoking and lung cancer in the 1950s in the United States and Britain. The methods developed then were applied to a wide variety of chronic diseases and helped to bring about a revolution in the contribution of epidemiology and biostatistics to the study of health and health care. During the 1960s, the reformation of the Food and Drug Act in the United States brought pressure to bear to demonstrate empirically the effectiveness of prescription pharmaceuticals. The research methods used to address these concerns derived from the principles of chronic disease epidemiology. Postgraduate training in epidemiology, biostatistics, and public health throughout the English speaking world has been oriented this way for the last two decades. It has proved to be an approach which is well suited to the study of cancer, reproductive problems, or chronic respiratory diseases which may be caused by or contributed to by occupational or environmental exposures.

It would appear that none of the Central and Eastern European countries have followed this trend. There are only a handful of investigators with graduate degrees in chronic disease epidemiology and biostatistics in each country. The efforts of these individuals are quite noticeable where they have occurred, but the lack of epidemiologic consciousness is seen acutely throughout the system. In general, the assessment of human health outcomes has taken place without due regard for epidemiologic principles which help ensure the validity of results. In particular, few of the health studies from the region allow us to simultaneously assess the impact of environment, lifestyle, and social factors on disease causation. These methodologic problems make it difficult to be unequivocal about what we believe to be true about environmental health in Eastern Europe.

The barriers to effective exposure assessment in the Region are varied and complex, relating to poor equipment, slow turnaround times, agency rivalries, and nonexistent quality control programs. As a result, embarrassing inconsistencies are often found when more than one agency has collected exposure data at the same place and time. These inconsistencies are often identified by outsiders and not by the agencies concerned. The complexity of the problems can best be understood by a few examples.

Example 1: Food Surveillance in Bulgaria

Food surveillance in the country appears to be in a totally chaotic state. There are no less than 12 agencies engaged in some monitoring and regulatory activity in relation to the domestic food supply. Nonetheless, very little useful information has been retained on the nature and extent of food contamination. The agencies do not collaborate with one another and do not use Ministry of Environment information on soil pollution as a guide to how and where to strategically sample the food supply. Moreover, most of the analytical procedures used to evaluate food have long turn-around times, so that most food is sold before the results of analysis are available. This is a particularly important problem for sampling under the auspices of the Ministry of Health, since it is mostly confined to foods found at the market place ready for sale rather than at the farm gate.

For reasons of ease of analysis, virtually all agencies measure nitrates in food. One investigator circulated a cucumber sample, blind, to several of laboratories and found variations in its measured nitrate concentration from 40 to 1150 milligrams per kilogram. This was attributable, in part, to different laboratory methods and, in part, to the fact that there is no national quality control or laboratory accreditation process for these labs. There is also no equipment available which could be considered to be of reference laboratory quality.

There was a general consensus among officials that more than 47,000 hectares of agriculture land in the country were contaminated by toxic chemicals. Yet it would appear that systematic evaluation of agriculture soil for organics has not taken place. It was difficult to get a precise interpretation of the figure of 47,000 hectares. It was never clearly stated whether this figure represented land which was totally contaminated or if it was the total area of all the plots on which there was at least some contamination in one location or another.

Example 2: Air Monitoring in Poland

Officials at the Institute of Hygiene admit that there are problems maintaining quality assurance at their extensive network of stations; partly because of poor quality pumps, partly due to insensitive detectors, and partly due to the sheer logistics of such a mammoth quality control program. The equipment problems appear to be a direct result of Poland's economic collapse. Monitors, detectors, and pumps bought from the West during the prosperous mid-1970's had not been replaced with updated technology when all the government's hard currency reserves were going to debt servicing. While the know-how is said to be adequate in the country to manufacture equipment there, there was not enough hard currency available in official sources to purchase the manufacturing licenses necessary to do so.

The problems faced by the Institute of Hygiene were also acknowledged by the Institute of Environmental Protection. However, this Institute had begun to take steps to establish a national quality assurance program which, they hoped, would include the san-epi stations as well. For instance, the Institute had catalogued 23 different methods which were being used to measure oxides of nitrogen in Poland. Next, they identified a sub-set of methods which were acceptable and which could be standardized. They intended to bring their monitoring stations into conformity with these methods by the early 1990s.

The need for national quality control was made clear when airborne data from the Institute of Environmental Protection and the san-epi stations were compared for the same times and places. In general, the level of agreement was inadequate. In the worst cases, the separate estimates of the average annual concentration of sulfur dioxide differed by 10 to 80 fold in a given region. For oxides of nitrogen, all comparisons fell within a 2 fold range, but still represented different ambient conditions from a regulatory standpoint.

The obstacles to developing an effective quality control program had the same source as the quality control problems themselves. There was only one mass spectrometer in the entire data collection system which could validate regional data. In order to achieve a "gold standard" against which monitoring stations could be judged, it would have been necessary to increase the number of mass spectrometers; but this would have involved hard currency purchases from the West. There had also been a problem obtaining automatic continuous monitors which make long-term sampling more feasible since there were no Polish producers. The system is also short of atomic absorption spectrophotometers (important for identifying metals), methods to measure acid aerosols, and peak flow meters. At the local monitoring stations, much of the equipment is out of date and poorly functioning. Also, few if any studies of chlorinated organics (e.g. PCB's, dioxins, solvents) have been undertaken because of the expense, both in labor and equipment, which this would entail.

Example 3: Air Monitoring in Estonia

The Institute has two stations for monitoring transboundary air pollution, six air monitoring stations in Tallinn, four in Kohtla-Jarve, and two in Narva. Their measurement capabilities include dust, carbon monoxide, sulfur dioxide, sulfate, phenols, oxides of nitrogen, ammonia, formaldehyde, and hydrogen fluoride. They have no capability of measuring airborne lead. The choice of what to monitor at each station is based on the nature of the local emission sources. All stations measure dust and sulfur dioxide but only one station, in Tallinn, measures all compounds.

The air monitoring system is based on grab samples taken during three one-hour periods each day. Only one continuous, on-line monitoring apparatus exists in the country, at Kohtla-Jarve. There have been quality control problems with the system, the most serious of which concerns the measurement of sulfur dioxide. In 1991, the method of measurement was changed to one which would involve less cross-contamination with other sulfur-based compounds. As a result, measured sulfur dioxide levels appeared to have declined approximately 10-fold.

In addition, there has not been any routine air monitoring capability in several other important locations, such as Kunda (site of a heavily polluting cement plant), Sillamae (site of a chemical facility of strategic importance under the old Soviet regime), and Kehra (site of a pulp mill with significant airborne effluents). Because the Institute has tended to operate autonomously from the Ministries responsible for regulating environmental pollution there have been few special collaborative efforts involving air monitoring. The only example we could document took place in the town of Saka, near Kohtla-Jarve, in collaboration with the Institute of Preventive Medicine.

Example 4: Blood Lead in Central Bohemia

This example concerns lead exposures to children near the smelter in Pribram. The problems in Pribram are no doubt compounded by the fact that the plant is 200 years old. During the 1960s it was emitting approximately 600 tons of lead per year into the environment, although by the 1970s this had declined to 250 tons per year. A study of lead exposures in children during the 1970s demonstrated very high blood lead levels at 2 schools within 10 kilometers of the plant. This helped to drive a modernization program, such that by 1982 emissions had declined to less than 25 tons per year. Between 1986 and 1988, a second study of child lead exposures was initiated. It was similar in design to the first one, involving 200 children from two schools within 10 kilometers of the plant and 100 controls from the town of Mnichovice. The children were aged 10 to 13.

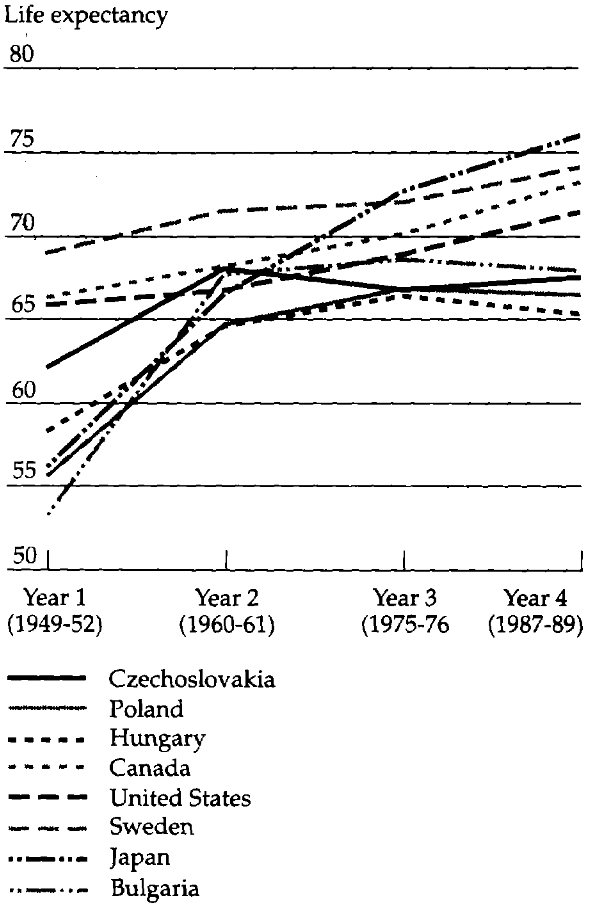
The average measured blood lead levels in boys and girls from the two schools in the Pribram area was above 30 micrograms per deciliter in both schools. Even in the control town of Mnichovice, the average blood lead level exceeded 20 micrograms per deciliter. In North America, children in a high blood lead area might have an average level of 15 micrograms per deciliter and any value exceeding 25 micrograms per deciliter would be considered a basis for individual medical intervention. Thus, average blood lead values in excess of 20 micrograms per deciliter, including in a control community, should be a major cause for concern.

Because of the importance of these data, it was disconcerting to find out that, when the blood lead samples were retested in a Belgian laboratory, the results were approximately 2.5 times lower than the original measurements. This fact alone makes the data impossible to interpret. It also raises questions about the full range of quality control issues which the public health system faces when dealing with laboratory analysis. For instance, the most likely explanation for the discrepancy in blood lead values between the Central Bohemian and Belgian labs would have to do with whether or not the sample collection tubes were adequately "heparinized." If they were not, blood clots forming in the samples might trap lead, so that analyses performed on blood which had sat around would give lower results than on fresh samples. However, this is only one problem. Adequate blood lead analysis requires a high quality atomic absorption spectrophotometer linked to a graphite furnace. Such equipment is in extremely short supply in the country. At the time there was one at the Institute of Hygiene and Epidemiology, but it was already being heavily used.

Annex Two

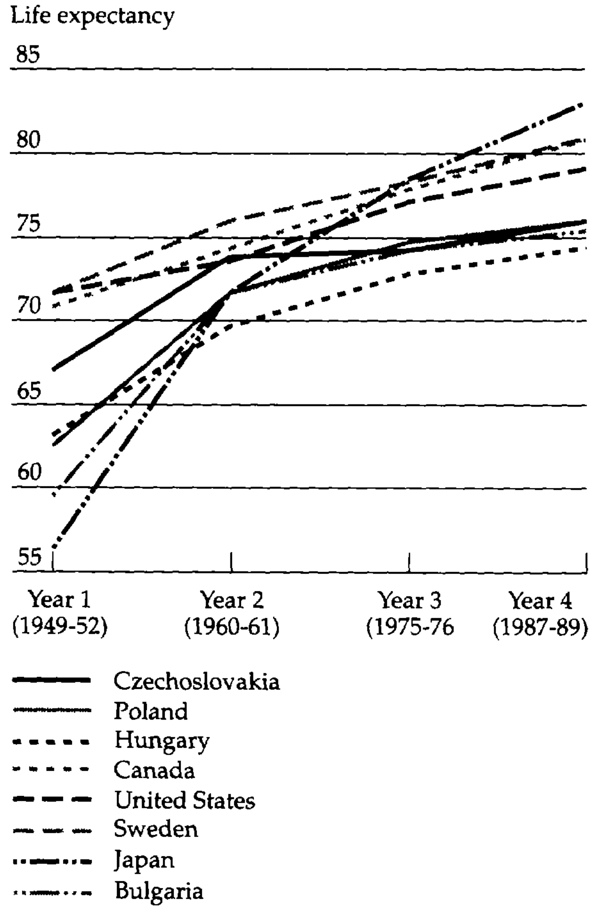
Temporal Trends in Life Expectancy

Figure A2.1 Temporal Trends in Life Expectancy - Males



Source: United Nations and World Health Organization, various years.

Figure A2.2 Temporal Trends in Life Expectancy - Females

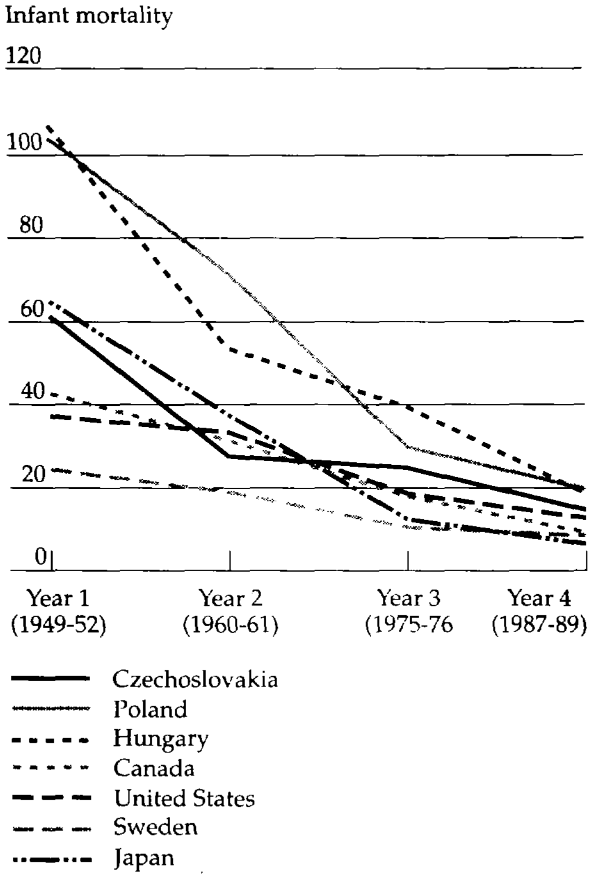


Source: United Nations and World Health Organization, various years.

Annex Three

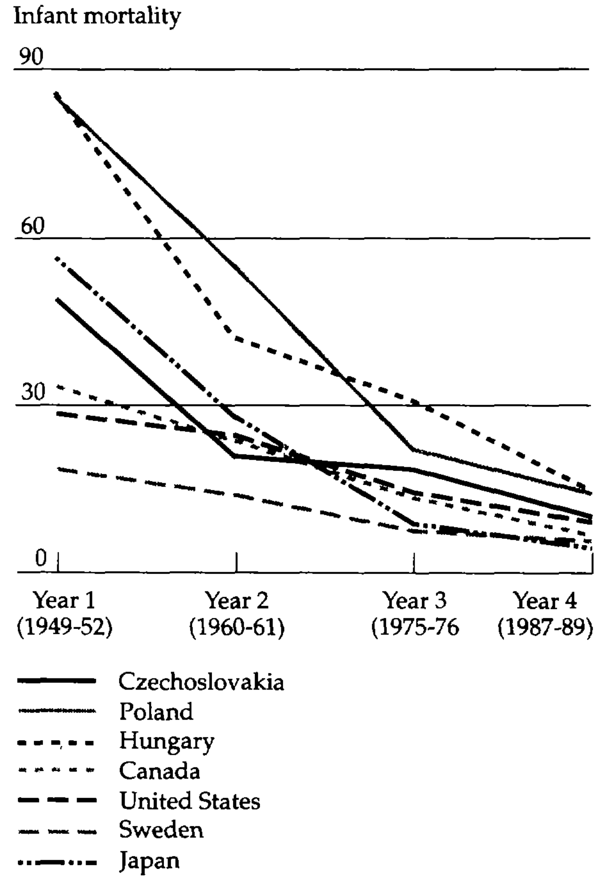
Temporal Trends in Infant Mortality

Figure A3.1 Temporal Trends in Infant Mortality - Males



Source: United Nations and World Health Organization, various years.

Figure A3.2 Temporal Trends in Infant Mortality - Females



Source: United Nations and World Health Organization, various years.

Annex Four

Summary of Human Health Problems and Major Industrial Plants Located in Pollution "Hot-Spots" in Bulgaria, Czech and Slovak Republics, Hungary, Poland, Romania; Latvia, Lithuania, Estonia, Belarus, Ukraine, and European Russia

This summary outlines those environmental health problems in Central and Eastern Europe for which reasonably credible epidemiologic data are available. It is meant to be a comprehensive summary, but there are obstacles to achieving this goal. Health outcomes in the various regions with similar chemical exposure problems have not necessarily been investigated to an equal degree, and different methodologies of varying credibility have been used. This is particularly a problem for chronic and multifactorial diseases which require advanced epidemiologic methods that are not commonly understood in Eastern Europe. Thus, the following summary draws attention to those chemical exposure problems which have been adequately studied, but does not mean to imply that other, well recognized episodes of environmental pollution or degradation have not led to human health problems.

The problems described here are primarily the result of exposures to lead in air and soil, airborne dust, sulfur dioxide and other gases,[1] and nitrate in water.

1. **Places where there is a problem with *overexposure to lead among children*** (37 locations in 7 countries):

   This problem is important because it may lead to neurobehavioral deficits which will have long term effects on children's educational attainment. Evidence of neurobehavioral deficits among exposed children has been found in several of the following places:

   a) **Poland.** Katowice Wojewodship—Szopienice, Miasteczko, Zyglin, Lubowice, Zabrza, Toszek, Bytom, Bojszow, Brzeziny, and Brzozowice.
   Legnica-Glogow area—near copper smelters (note: quality control problems with blood lead data).
   b) **Czech Republic.** Central Bohemia—Pribram (note: quality control problems with blood lead data).
   c) **Hungary.** Inner Budapest, Romhany, Szolnok.
   d) **Bulgaria.** Plovdiv, Asenovgrad, Kuklen, Kurdzhali (results of lead studies of adults in Voden, Kremikovtsi, Jana and Pernik imply that there are probably overexposures to children, too).
   e) **Romania.** Bucharest, Copsa Mica, Baia Mare (probable).
   f) **Russia (European).**[2] St. Petersburg, Berezniki, Podolsk, Yaroslavl, Samara, Nizhnyy Novgorod, Ulyanovsk, Rostov-na-Dony, Kursk, Astrakhan.
   g) **Ukraine.** Kostiantynivka (probable).

2. **Places where there are documented associations between *acute respiratory diseases* (sinusitis, pharyngitis, bronchitis and laryngitis) and air pollution** (46 locations in 10 countries):

   a) **Poland.** Kraków.
   b) **Slovakia.** Bratislava.
   c) **Czech Republic.** Central Bohemia— Neratovice, Kralupy.
   Northern Bohemia— Usti nad Labem, Teplice, Most, Chomutov, Decin.
   d) **Hungary.** Dorog, Ajka.
   e) **Bulgaria.** Ruse, Vratsa, Devnya, Srednogorie, Krekikovtsi, Asenovgrad, Shvistov, Dimitrovgrad, Sofia, Gabrovo, Varna, Kameno, Burgas.
   f) **Estonia.** Narva/Kohtla-Jarve/Sillamae area, Kunda.
   g) **Lithuania.** Jonava, Kaunas.
   h) **Latvia.** Olaine.
   i) **Romania.** Slatina, Baia Mare, Tasca, Sendreni-Galati, Savinest, Suceava, Hunedoara, Mintia, Otelul Rosu, Navodari, Remicu-Vilcea.
   j) **Russia (European).** Arkhangelsk, Berezniki, Voskresensk, Cheboksary, St. Petersburg.
   k) **Ukraine.** Zaporizhzhia.

3. **Places where there are documented associations between *chronic respiratory diseases* (chronic bronchitis/emphysema and asthma) and air pollution** (29 locations in 9 countries):

   a) Poland. Regional association between SO2 levels and chronic bronchitis and asthma rates throughout the country; also found specifically within Kraków.

b) **Czech Republic.** Northern Bohemia—Usti nad Labem, Teplice, Most, Chomutov, Decin.

c) **Hungary.** Dorog, Ajka, Nagyteteny (in District 22 of Budapest), Borsod County (especially Karincbarcika and Miskolc).

d) **Bulgaria.** Ruse, Razlog, Vratsa, Devnya, Srednogorie, Plovdiv, Asenovgrad, Kremikovtsi, Pernik.

e) **Estonia.** Narva/Kohtla-Jarve/Sillamae area, Kunda.

f) **Lithuania.** Jonava, Kaunas.

g) **Latvia.** Olaine.

h) **Russia (European).** Sterlitamak, Ufa, Chaykovskiy (Perm oblast).

i) **Romania.** Turda, Copsa Mica.

4. **Places where there is reasonably strong evidence of a connection between excess infant and lung cancer *mortality* and air pollution** (8 locations in 3 countries):

a) **Poland.** Katowice—infant mortality in areas with the highest dust levels.
Kraków—Lung cancer in relation to community exposures to steel mill emissions.

b) Czech Republic. Infant mortality (especially postneonatal respiratory mortality) in regions with the highest dust and SO2 levels.

c) **Russia (European).** Berezniki, Nizhnyy Novgorod, Dzerzhinsk, St. Petersburg, Lipetsk.

NB:Other places where correlations between air pollution and adult mortality and/or cancer incidence are likely valid, but require further investigation, include the mining districts of northern Bohemia (lung cancer, all cancer, total mortality), the most polluted districts of Central Bohemia (total mortality), Ziar nad Hronom region of Slovakia (total mortality), Lódz (total mortality) and the mining district of southern Bulgaria (lung cancer).

5. **Places where there are documented associations between *abnormal physiological development* and air pollution** (18 locations in 7 countries):

a) **Poland.** Krak_w—reduced pulmonary function among adult males exposed to acid rain emissions.
Katowice—average hemoglobin levels among mothers and children reduced by about 20% below normal.

b) Czech Republic. Rates of low birth weight are increased in the regions with the highest levels of dust and SO2.
Central Bohemia
—increased rates of "small for gestational age" babies in the regions with worst environmental quality.
—reduced pulmonary, hematological, and immune function in children from most air polluted areas.
Mining Districts of Bohemia
—reduced hematological and immune function in children.
—delayed bone maturation in children.
Teplice and Usti nad Labem, Northern Bohemia
— increased rates of congenital anomalies.

c) **Hungary.** Nagyteteny—anemia among children.
Ajka—reduced pulmonary function among children.

d) **Bulgaria.** Dimitrovgrad—reduced pulmonary function and reduced growth rates among children.

e) **Estonia.** Narva/Kohtla-Jarve/Sillamae area—reduced hematological and immune function in children.
Kehra—reduced pulmonary function among children.

f) **Romania.** Slatina, Copsa Mica, Turda—reduced pulmonary function among children.
Copsa Mica, Baia Mare—growth retardation.

g) **Ukraine.** Mariiupil, Zaporizhzhia—increased rates of congenital anomalies.

6.**Places where *nitrates in drinking water* are widespread, requiring water replacement to protect newborns against *methemoglobinemia*** (Widespread in 6 countries):

Methemoglobinemia is a form of chemical asphyxia wherein the oxygen carrying capacity of the blood is chemically inhibited by nitrates:

a) **Slovakia.** Widespread problem.

b) **Hungary.** Borsod County—widespread problem.

c) **Bulgaria.** Districts of Haskovo, Burgas, Varna, Razgrad and Lovech—widespread problem. Also in Stara Zagora, Pazardgik Targovichte.

d) **Belarus.** Brest, Gomel, Grodno, Vitebsk, Minsk, Mogibv oblasts.

e) **Lithuania.** One-third of country covered by water replacement program for pregnant women.

f) **Romania.** Widespread problem throughout the country.

7. **Places with problems with *arsenic*:**

a) **Slovakia.** Ziar nad Hronom—increased rates of non-melanoma skin cancer and hearing loss in children downwind of the aluminum plant.

b) **Hungary.** Békés County—high levels of arsenic in the water supply, with evidence of arsenic-related skin conditions and intestinal colic among children, as well as a possibility of increased rates of stillbirths and spontaneous abortions.

c) **Bulgaria.** Srednogorie—increased levels of arsenic in surface water and in the soil.

d) **Romania.** Arad-Lipora-Ineu districts—area is contiguous with Bekes County, Hungary. High rates of skin cancer have been found here.

e) **Russia (European).** Cherepovets, Kamensk-Shakhtinskiy (Rostov oblast), Tyrnaua (Kabardino-Balkariya), Vladikavkaz.

8. **Other Health Effects of *Contaminated Drinking Water Supplies*:**

   a) **Latvia.** Riga—large waterborne hepatitis A outbreak
   Jelgava—large milk-borne dysentery outbreak based on contaminated water supply.
   b) **Romania.** —carcinogenic substances exceeding standards have been measured in water samples from 32 of 41 districts in the country.
   —chlorinated pesticides found in many water supplies around the country.
   c) **Russia (European).** St Petersburg, Murmansk, Volograd, Kurgan, Novgorod oblast, Mordovian Republic.

9. **Places with *other problems*:**

   a) **Poland.** Kraków—ongoing problems with fluorosis near an aluminum smelter.
   Turow, Silesia—high prevalence of methemoglobinemia near lignite power plant.
   b) **Slovakia.** Michalovce—PCB exposures, with mini-epidemic of Potter's Syndrome (congenital agenesis of kidneys) in the late 1970s.
   c) **Belarus.** Gomel oblast—thyroid cancer in children following Chernobyl.
   d) **Estonia.** Widespread beach closures to protect against the spread of infectious disease.
   e) **Latvia.** Water supply in Daugavpils closed twice in the last two years to protect against chemical spills upstream on the Daugava River in Belarus.
   Brocenai—large-scale community asbestos exposure.
   Liepaja—multiple concerns from electromagnetic radiation from radar stations.
   Olaine—disordered immune function in adults.
   f) **Romania.** Several towns/cities with high airborne asbestos levels.
   Suceava—neurological symptoms in children exposed to carbon disulfide.
   g) **Russia (European).** Kalingrad, Novgorod, Lepetsk, Syktyrkar, Kandalaksha, Cherepovets—high airborne benzo(a)pyrene levels.
   Dzerzhinsk, Serpukhov—High levels of polychlorobiphenyls in air, soil, water, vegetation, and breast milk.
   Ufa, Shchelkovo, Chapayevsk, Dzerzhinsk, Moscow, Murmansk—high concentrations of dioxin in the soil on grounds of industrial plants and in the ashes of waste incinerators.
   h) **Ukraine.** Thyroid cancer in 3 contaminated areas of Ukraine following the Chernobyl accident.

The information collected and evaluated from nine CEE countries provides the following overall picture:

Poland

The predominant environmental health threat in Poland is the regional hot spot in the Katowice-Krakéw area. Threats to human health are mostly due to airborne exposures, and secondarily to deposition of metals (especially lead) in soil. Widespread water pollution has not been shown to be a significant risk to health at this time, presumably because there is a tradition of not using tap water for drinking.

Czech Republic

Air pollution in the mining districts of northern Bohemia forms a regional hot spot, which is the primary source of environmental health problems. There are smaller areas of concern in industrial areas of Central Bohemia and Moravia, as well as in Prague. As in Poland, water pollution is not a major current concern with respect to human disease.

Slovak Republic

The pattern in the Slovak Republic is different from Poland and the Czech Republic, in that nitrates in drinking water in rural areas appear to be a significant problem. In addition, there are human health problems associated with air pollution from specific plants in a handful of specific locations.

Hungary

In Hungary, areas with human health problems in relation to the environment tend to be old industrial areas with a confluence of airborne pollution sources, such as Borsod County and the industrial areas of Budapest, or areas with a single major point source, such as Ajka. Waterborne exposures to nitrates are important as well in Borsod County, and there are problems with naturally-occurring arsenic in water in Békés County.

Bulgaria

The pattern in Bulgaria is similar to Hungary with a mixture of single and multiple point sources of air pollution predominating. However, the number of areas with documented associations between air pollution and human health outcomes is much larger in Bulgaria than in Hungary. Nitrate pollution of water is a widespread problem, affecting drinking water supplies in rural areas throughout the Western part of the country.

Romania

Most of the air pollution related problems in Romania are due to intense exposures from single point sources. These tend to be clustered in certain parts of the country, especially in the area of Transylvania near Cluj. Nitrate pollution is common in 38 of 41 districts of the country.

Baltic Countries

Aside from prodigious dust emissions from a cement plant in Kunda, Estonia, and a small number of other local concerns, air pollution problems in the Baltic Countries tend to have less health significance than in other parts of Central and Eastern Europe. Instead, problems with water pollution have come to the fore. Rural Lithuania has problems with nitrates which are of human health significance. Riga has had an epidemic of waterborne hepatitis A as a result of a temporary lack of coagulant to treat drinking water from the Daugava River. All three countries have had to close beaches in recent years to prevent the spread of infectious diseases due to inadequate sewage treatment in adjacent settlements.

Russia

It is not clear whether or not the principal environmental health problems in Russia are the same as those in the rest of Central and Eastern Europe. Russia's size and tremendous diversity impose significant obstacles to generalization. The task is made more difficult by the fact that relevant information has, according to one estimate, been generated by more than 100 different institutes around the country.

A preliminary assessment suggests that industrial facilities are the most important sources air pollution causing respiratory and developmental problems in urban and industrial locations in European Russia. Chief among these are chemical plants, which emit organic vapors and irritant gases, and petroleum refineries, which emit polycyclic aromatic hydrocarbons. As in other parts of Eastern and Central Europe, emissions of lead from lead smelters, lead-cadmium battery plants, and storage battery factories have been linked with high blood levels in children living in the vicinity of the plants. Suspended particulate matter is a concern in many urban areas. Finally, there is concern about exposures to ionizing radiation in communities adjacent to military-industrial facilities.

As in other countries in the region, it appears that elevated nitrate levels in drinking water may be a widespread problem. Arsenic, pesticides, and petroleum products may also be contaminating drinking water in some places.

Note

1. There is a need to carefully review the places with environmental health problems due to airborne exposures to evaluate the relative importance of gaseous exposures in the absence of dust.

2. This and the following information on European Russia is preliminary and subject to verification.

Table A4.1 Major industrial plants located in pollution "hot-spots"

Country	Location	Pop'n ('000)	Nature of environmental problems: Epidemio-logical links (see Key)	Nature of environmental problems: High levels of dust, SO_2 or both	Nature of environmental problems: High levels of lead	Number of plants: Power and district heating	Number of plants: Iron and steel	Number of plants: Non-ferrous metals	Number of plants: Refining and petrochem.	Number of plants: Organic chemicals	Number of plants: Inorganic chemicals	Number of plants: Pulp
Bulgaria	Dimimtrovgrad	56.2	A, P	●		2					1	
	Srednogorie	25.0	A, C	●								
	Devnya	30.0	A, C	●		1				1	1	
	Panagiurishte			●								
	Kurdzhali	58.0	Pb	●				1				
	Sofia	1,221.4	A	●		1		1				1
	Ruse	210.2	A, C	●					1			
	Plovdiv	374.0	Pb, C	●				1				
	Stara Zagora	186.7		●							1	
	Asenvgrad		Pb, A, C	●								
	Pernik	97.2	Pb, C	●		1	2					
	Vratsa	80.5	A, C	●							1	
	Kuklen		Pb									
	Voden		Pb									
	Kremikovtsi		Pb, A, C			1	1					
	Jana		Pb									
	Shvistov		A									

(Table continues on the following page)

Table A4.1 (continued)

			Nature of environmental problems			Number of plants						
Country	**Location**	**Pop'n ('000)**	**Epidemio-logical links (see Key)**	**High levels of dust, SO_2 or both**	**High levels of lead**	**Power and district heating**	**Iron and steel**	**Non-ferrous metals**	**Refining and petrochem.**	**Organic chemicals**	**Inorganic chemicals**	**Pulp**
	Shvistov		A									
	Gabrovo		A									
	Varna		A			1						
	Kameno		A									
	Burgas		A			1	1		1	1		
	Razlog		C									1
	Other					2	-	3	1	-	1	4
Czech Republic	Northern Bohemia:											
	Usti nad Labem	106.4	A, C	●						1		
	Litvinov	29.9		●					1	1	1	
	Decin	56.1	A, C	●								
	Most	70.8	A, C	●					1			
	Teplice	55.5	A, C	●								
	Chomutov	56.2	A, C	●								
	Central Bohemia:											
	Beroun	24.1		●								
	Prague	1,215.6		●					1			
	Kladno	73.3		●			1					

Table A4.1

			Nature of environmental problems			Number of plants						
Country	**Location**	**Pop'n ('000)**	**Epidemio-logical links (see Key)**	**High levels of dust, SO_2 or both**	**High levels of lead**	**Power and district heating**	**Iron and steel**	**Non-ferrous metals**	**Refining and petrochem.**	**Organic chemicals**	**Inorganic chemicals**	**Pulp**
	Melnik	19.7		●	●	3						
	Pribram		Pb					1				
	Neratovice		A							1	1	
	Kralupy		A						1	1		
	Southern Bohemia:											
	Sokolov	28.5		●							1	
	Plzen	174.7		●		1	1	1				
	Ostrava	331.5				1	2		2		1	
	Brno	392.2				1						
	Other					31	2	4	3	-	4	6
Slovakia	Bratislava	442.9	A	●		3			1	1	1	
	Ziar nad Hronom	21.4		●				1				
	Other					8	1	2	2	2	3	6
Hungary	Borsod-Abauj-Zemplen industrial zone:											
	Izsofalva			●								
	Miskolc		C	●								
	Karincbarcika		C							1	1	
	Ozd			●			1					

(*Table continues on the following page*)

Table A4.1 (continued)

			Nature of environmental problems			Number of plants						
Country	**Location**	**Pop'n ('000)**	**Epidemio -logical links (see Key)**	**High levels of dust, SO_2 or both**	**High levels of lead**	**Power and district heating**	**Iron and steel**	**Non-ferrous metals**	**Refining and petrochem.**	**Organic chemicals**	**Inorganic chemicals**	**Pulp**
	Sajoszentpeter			●								
	Budapest		C, P	●	●		1				1	1
	Northern Transdanubian region:											
	Dorog	13.0	Pb	●		1						
	Esztergom	29.8		●								
	Komarom	19.6		●					1			
	Tata	24.8		●								
	Tatabanya	73.8		●		1		1				
	Central Transdanubian region:											
	Ajka		Pb	●		1		1				
	Baranya County:											
	Pecs			●		1						
	Szaszvar			●								
	Szolnok			●	●						1	
	Romhany		Pb									
	Other					24	2	2	4	2	3	1
Poland	Katowickie:											
	Dgbrowg Górnicza	139.2	M	●	●		2					
	Chorzów	131.5	M	●	●	1	2					

Table A4.1

			Nature of environmental problems			Number of plants						
Country	Location	Pop'n ('000)	Epidemio -logical links (see Key)	High levels of dust, SO_2 or both	High levels of lead	Power and district heating	Iron and steel	Non-ferrous metals	Refining and petrochem.	Organic chemicals	Inorganic chemicals	Pulp
	Mystowice	94.6	M	•								
	Świętochowice	60.6	M	•	•		1					
	Katowice	366.9	M, P	•	•	1	1					1
	Puda Śląska	171.6	M	•	•							
	Chrzanów	42.8	M	•								
	Tarnowskie Góry	74.4	M	•	•				1			
	Zawiercie	57.1		•			1					
	Wodzistaw Śląski	112.2		•								
	Rybnik	144.8		•		1						
	Gliwice	215.7		•								
	Pilica	< 10		•								
	Toszek	< 10	Pb	•								
	Bytom	323.2	Pb	•	•		2					
	Zabrze	205.8	Pb	•								
	Szopienice		Pb					1				
	Miasteczko		Pb									
	Zyglin		Pb									
	Lubowice		Pb									
	Bajszow		Pb									

(*Table continues on the following page*)

Table A4.1 (continued)

			Nature of environmental problems			Number of plants						
Country	**Location**	**Pop'n ('000)**	**Epidemio-logical links (see Key)**	**High levels of dust, SO_2 or both**	**High levels of lead**	**Power and district heating**	**Iron and steel**	**Non-ferrous metals**	**Refining and petrochem.**	**Organic chemicals**	**Inorganic chemicals**	**Pulp**
	Brzozowice		Pb									
	Jeleniogórskie:											
	Kemienna Góra	23.5		•								
	Bolkow			•								
	Lubawka			•								
	Zgorzelec	36.5		•								
	Krakowskie:											
	Kraków	751.3	A, C, M, P	•		1	1				1	
	Legnickie:											
	Legnica	106.1	Pb					1				
	Gtogow	73.9	Pb					2				
	Chojnów	14.8		•								
	Piotrkowskie:											
	Tomaszów Mazowiecki	69.9		•								
	Poznańskie:											
	Gniezno	70.6		•								
	Toruńskie:											
	Torun	202.0		•		1					1	

Table A4.1

			Nature of environmental problems			Number of plants						
Country	Location	Pop'n ('000)	Epidemio-logical links (see Key)	High levels of dust, SO_2, or both	High levels of lead	Power and district heating	Iron and steel	Non-ferrous metals	Refining and petrochem.	Organic chemicals	Inorganic chemicals	Pulp
	Wałbrzyskie:											
	Zarow			•								
	Świebodzice	24.8		•								
	Jaworzyna Sl.			•								
	Strzegom	17.3		•								
	Świdnica	63.8		•								
	Lazdec			•								
	Wałbrzych	141.2		•								
	Dlugopole Zdrój			•								
	Polanica			•								
	Wrocławskie:											
	Wrocław	643.6		•		1					1	
	Other					64	6	5	10	5	13	17
Romania	Bucharest	2,325.0		•	•	4						
	Piatra Neamt	117.3		•							1	2
	Zlatna	9.3		•	•			2				
	Brobeta Turnu Severin	108.0		•		1						
	Galati	305.0		•		1	1					
	Craiova	297.5		•		2					1	

(*Table continues on the following page*)

Table A4.1 (continued)

			Nature of environmental problems			Number of plants						
Country	**Location**	**Pop'n ('000)**	**Epidemio -logical links (see Key)**	**High levels of dust, SO_2 or both**	**High levels of lead**	**Power and district heating**	**Iron and steel**	**Non-ferrous metals**	**Refining and petrochem.**	**Organic chemicals**	**Inorganic chemicals**	**Pulp**
	Tirgu Jiu			•								
	Tirgu Mures	166.0		•							1	
	Slatina	74.0	A, P	•	•			1				
	Medias	72.6		•								
	Satu mare	137.9		•								
	Hunedoara		A	•			1					
	Isalnita			•								
	Copsa Mica		Pb, P					1				
	Baia Mare		Pb, A					2				
	Tasca		A									
	Savinest		A									
	Suceava		A			1						1
	Mintia		A			1						
	Otelul Rosu		A				1					
	Navodari		A			1			1		1	
	Remicu-Vilcea		A							1	1	
	Turda		C, P							1	1	
	Other					20	5	3	12	7	10	11
Estonia	Narva	82.3	A, C, P	•		2						

Table A4.1

			Nature of environmental problems			Number of plants						
Country	**Location**	**Pop'n ('000)**	**Epidemio -logical links (see Key)**	**High levels of dust, SO_2 or both**	**High levels of lead**	**Power and district heating**	**Iron and steel**	**Non-ferrous metals**	**Refining and petrochem.**	**Organic chemicals**	**Inorganic chemicals**	**Pulp**
	Tallinn	484.4		●		2						1
	Kunda		A, C									
	Kohtla-Jarve		A, C, P			2					1	
	Sillamae		A, C, P									
	Kehra		P									1
	Other					5					-	-
Latvia	Ventspils	50.4		●							1	
	Daugaupils			●								
	Liepaja			●			2					
	Riga			●		7					1	
	Olaine		A, C	●								
	Other					-	-				-	1
Lithuania	Kaunas		A,C	●		2						
	Siauliai			●		1						
	Kedainai			●		1					1	
	Vilnius			●		3						
	Klaipeda			●		1						1
	Jonava		A, C	●		1					1	
	Other					11			1		-	1

(Table continues on the following page)

Table A4.1 (continued)

			Nature of environmental problems			Number of plants						
Country	**Location**	**Pop'n ('000)**	**Epidemio -logical links (see Key)**	**High levels of dust, SO_2 or both**	**High levels of lead**	**Power and district heating**	**Iron and steel**	**Non-ferrous metals**	**Refining and petrochem.**	**Organic chemicals**	**Inorganic chemicals**	**Pulp**
Belarus	Orsha			•								
	Vitebsk			•								
	Polotsk			•					1			
	Magilev			•		1						
	Grodno			•		1					1	
	Gomel			•		1					1	
	Minsk			•		2						
	Novopolotsk			•		1				1		
	Brest			•								
	Other			•		4	1		1	-	1	1
Western Russia	Volsk (Saratov oblast)			•								
	Lipetsk			•			2		1			
	Makachkala			•								
	Novgorod		Pb, M	•							1	
	Kaluga			•								
	Smolensk			•							1	
	Rostov-na-Dony		Pb	•								
	Shakhly (Rostov oblast)			•								
	Zheleznodorozhnyy (Moscow oblast)			•								

Table A4.1

			Nature of environmental problems			Number of plants						
Country	**Location**	**Pop'n ('000)**	**Epidemio-logical links (see Key)**	**High levels of dust, SO_2 or both**	**High levels of lead**	**Power and district heating**	**Iron and steel**	**Non-ferrous metals**	**Refining and petrochem.**	**Organic chemicals**	**Inorganic chemicals**	**Pulp**
	Kashira (Moscow oblast)			•		1						
	Nizhnckamsk (Tatariya)			•					1	1		
	Segezha (Karelea)			•								1
	Taganrog (Rostov oblast)			•								
	Krasnodar			•					1		1	
	Ulanovak		Pb	•								
	Novorossiyak (Kransnodar kray)			•								
	Balakovo (Saratov oblast)			•							1	
	Gubakha (Perm oblast)			•					1			
	Podolsk (Moscow oblast)		Pb	•								
	Volgodonsk (Rostov oblast)			•								
	Onega (Arkhangelsk oblast)		A	•								
	Dzerzhinsk (Nizhegorod oblast)		M	•						1	1	
	Saratov			•		1			1			
	Astrakhan Stepnoy		Pb	•								1
	Novokuybyshevak (Samara oblast)			•						1		
	Kirovo-Chepetsk (Kirov oblast)			•					1			
	Novocherkassk (Rostov oblast)			•		1						
	Zapolyamyy (Murmansk oblast)			•								

(Table continues on the following page)

Table A4.1 (continued)

			Nature of environmental problems			Number of plants						
Country	**Location**	**Pop'n ('000)**	**Epidemio-logical links (see Key)**	**High levels of dust, SO_2 or both**	**High levels of lead**	**Power and district heating**	**Iron and steel**	**Non-ferrous metals**	**Refining and petrochem.**	**Organic chemicals**	**Inorganic chemicals**	**Pulp**
	Syzran (Samara oblast)			•					1			
	Tolyatti (Samara oblast)			•							1	
	Saint-Petersburg		Pb, A, M			1		2			1	
	Berezniki		Pb, A, M								1	
	Yaroslavl		Pb								1	
	Samara		Pb						1			
	Nizhnyy		Pb, M						1			
	Kursk		Pb									
	Voskresensk		A								1	
	Chehoksary		A									
	Sterlitamak		C									
	Ufa		C						3			
	Chaykouskiy (Perm oblast)		C									
	Other					20	9	10	20	15	7	23
Ukraine	Donetsk	1,110.0		•		2	1		1	1		
	Krivoi Rog	713.0		•		1	1		1			
	Odessa	1,115.0		•					1		1	
	Zaporozhe	884.0	A,P	•		1	2	1	1			
	Dneprodzerzhinsk	300.0		•			1		1	1	1	

Table A4.1

			Nature of environmental problems			Number of plants						
Country	**Location**	**Pop'n ('000)**	**Epidemio-logical links (see Key)**	**High levels of dust, SO_2 or both**	**High levels of lead**	**Power and district heating**	**Iron and steel**	**Non-ferrous metals**	**Refining and petrochem.**	**Organic chemicals**	**Inorganic chemicals**	**Pulp**
	Dnepropertrovk	1,179.0		•		1	2		1			
	Marioupol	517.0	P	•			2					
	Makeeva			•			1		1			
	Kiev	2,602.0		•				1				
	Konstantinovka		Pb				1	1				
	Other					7	4	2	16	5	8	5

Key:
A = places where there are documented associations between acute respiratory diseases and air pollution.
C = places where there are documented associations between chronic respiratory diseases and air pollution.
M = places where there is reasonably strong evidence of a connection between mortality and air pollution.
P = places where there are documented associations between abnormal physiological development and air pollution.
Pb = places where there is a problem with over exposure to lead among children.

Annex Five

Heavy Metal Contamination: Selected Data

Table A5.1: Lead and cadmium in potatoes in selected localities in Poland
(average concentrations in parts per million)

	Lead	Cadmium
WHO Guideline	0.4	0.06
Katowice Province	0.91	0.17
Zyglin	2.17	0.22
Zabkowice Bedzinskie	1.47	0.20
Chorzow	0.17	0.15
Walbrzyskie	0.19	0.05
Kieleckie	0.38	0.05
Bydgoskie	0.28	0.09

Source: Marchwinska *et al.* 1983

Table A5.2: Lead and cadmium in garden plots in Katowice
(parts per million)

	Lead	Cadmium
Cutivation standard	100	3
Mode	200-500	10-12
Peak	8,000	140

Source: Hertzman 1990 (d)

Table A5.3: Metal contamination of food in the Czech and Slovak Republics: Pribram and Mnichovice
(parts per million)

	Lead		Cadmium		Mercury	
	Pribram	Mnichovice	Pribram	Mnichovice	Pribram	Mnichovice
Potatoes	13.72	0.25	0.975	0.088	0.099	0.0014
Fruit	10.21	0.7	0.546	0.034	0.001	0.0007
Vegetables	13.28	0.09	0.045	0.007	0.017	0.0009
Total	37.2	0.41	1.566	0.129	0.117	0.003
Difference in contribution to allowable weekly intake	36.79		1.437		0.1139	
Estimates of allowable weekly intake based on home produ-ce only (percent)	1042	13-15	31	25-30	14	2

Source: Kodl and Kriz 1987

Table A5.4: Lead contamination of food grown in Plovdiv/Asenovgrad, Bulgaria, 1990/91
(parts per million)

Maximum Allowable Concentration: 0.5	*Average Concentration*
Tomatoes	0.76
Potatoes	0.92
Maximum Allowable Concentration: 0.4	*Range of Concentrations*
Apples	0.78-0.80
Grapes	0.75-1.47
Cherries	0.66-1.10
Strawberries	0.94-1.00

Source: Hertzman 1991

Table A5.5: Lead concentrations in hair and blood in Estonia

	Hair Lead	*Blood Lead (micrograms per deciliter)*	
Location	*Children (1.0=Tartu)*	*Children*	*Adults*
Tartu	1.0	..	..
Kohtla-Jarve	2.5	..	17.1
Saka	2.3	10.5	..
Narva	2.1	..	..
Sillamae	2.0	..	..
Tallinn	..	..	8.3

Source: Viitak *et al.* 1991

Annex Six

Ambient Air and Water Quality: Selected Data

Table A6.1: Ambient air quality in selected localities in Central and Eastern Europe
(annual averages in micrograms per cubic meter)

Country/City	TSP	SO_2	Lead	NOx
Belarus (1991)				
Orsha	395	8		66
Vitebsk	166	11		23
Polotsk	135	19		62
Mogilev	133	14		104
Grodno	111	8		37
Gomel	103	9		27
Minsk	101	4		33
Novopolotsk	86	10		35
Brest	64	13		30
Bulgaria (1989-90)				
Dimitrovgrad	530	119	0.7	10
Srednogorie	400	440		
Devnya	350	28	0.3	9
Panagiurishte	320	350	0.5	
Kurdzhali	310	103	1.5	
Sofia	303	67	0.4	48
Ruse	300	32	0.4	29
Plovdiv	280	306	1.0	31
Stara Zagora	275	120		
Asenovgrad	270	485	2.6	15
Pernik	245	469	0.5	
Vratsa	160	59	0.3	23

(Table continues on the following page.)

Table A6.1 (*continued*)

Country/City	*TSP*	*SO_2*		*Lead*	*NOx*
Czechoslovakia (range of annual averages, 1981-88)					
N. Bohemia: (average, region)	63-223	43-184		.27-.40	12-153
Usti nad Labem	94-223	70-98			34-120
Litvinov	70-161	59-184			43-107
Decin	91-150	60-126			56-114
Most	75-127	55-176		.18-.43	51-153
Teplice	63-111	87-141		.15	28-111
Chomutov	66-106	58-120			35-75
C. Bohemia:					
Beroun	85-134	9-34			15-34
Prague	77-107	26-117			52-71
Kladno	64-98	30-72			20-33
Melnik	52-85	46-72		0.8-1.6	
S. Bohemia:					
Sokolov	74-129	24-50			34-62
Plzen	47-118	16-113			22-205
Other:					
Ostrava	102-139	47-77			
Ziar nad Hronom	>100				
Brno	63-86	23-55			31-70
Estonia (1990)					
Narva	200	50			
Tallinn	100	90			
Hungary		Winter	Annual		
B-A-Z industrial zone					
Izsofalva		133	72		17
Miskolc		48	27		29
Ozd		61	34		34
Sajoszentpeter		55	30		24
Budapest					
(site 1)		20	13	5.3	25
(site 2)				2.9	
N. Transdanubian:					
Dorog		114	94		39
Esztergom		100	57		30
Komarom		90	52		31
Tata		146	84		43
Tatabanya		101	62		22
C. Transdanubian:					
Ajka		42	28		
Baranya County:					
Pecs		32	22		53
Szaszvar		51	29		20
Szolnok				2.0	
Latvia (1989)					
Ventspils	100	20			
Daugavpils	100	< 10			
Liepaja	100	< 10			
Riga	100	10			
Olaine	100	< 10			
Lithuania (1990)					
Kaunas	300	10			
Siauliai	300	10			
Kedainai	200	10			
Vilnius	100	10			
Klaipeda	100	10			
Jonava	100	10			

Country/City	TSP	SO_2	Lead	NOx
Poland (TSP data for 1987, SO_2 data for 1987 or 1988)				
Katowice:				
Dabrowa Gorn.	477	36		110
Chorzow	440	70		94
Myslowice	342	42		108
Swietochlowice	336	67		95
Katowice	311-327	29-75	0.5-2.6	100
Ruda	318	55		116
Chrzanow	315	128		109
Tarn. Gory	314	112		126
Zawiercie	297	51		80
Wodzislaw	288	75		175
Rybnik	276	45		95
Gliwice	267	42		92
Pilica	225	29		77
Tosek	209	107		89
Bytom	279	48		131
Zabrze	174	49		78
Jelenia Gora:				
Kamienna Gora		129		
Bolkow		112		
Lubawka		99		
Zgorzelec		82		
Krakow:				
Krakow	138	105		
Legnica:				
Chojnow		115		
Piotrkow:				
Tomaszow Maz.		88		
Poznan:				
Gniezno		96		
Torun:				
Torun		149-584		
Walbrzych:				
Zarow		289		
Swiebodzice		280		
Jaworzyna Sl.		277		
Strzegom		271		
Swidnica		197		
Lazdec		193		
Walbrzych		57-187		
Dlugopole Zdroj		183		
Polanica		179		
Wroclaw:				
Wroclaw	105	70		50
Romania (1990)				
Bucharest	14-285	1-8	1-9.6	
Piatra Neamt	250	33		
Zlatna	204	128	2.3	
Drobeta Turnu Severin	188			
Galati	166	34		
Craiova	75-140	6-7		
Tirgu Jiu	120	16		
Tirgu Mures	116			
Slatina	113	15	.84	
Medias	107			
Satu Mare	107			
Hunedoara	99	11		
Isalnita	84	4		

(Table continues on the following page.)

Table A6.1 *(continued)*

Country/City	*TSP*	SO_2	*Lead*	*NOx*
Ukraine (1990)				
Donetsk	500	40		
Krivoi Rog	400	30		
Odessa	300	50		
Zaporozhe	300	20		
Dneprodzerzhinsk	300	10		
Dnepropetrosk	200	10		
Marioupol	200	20		
Makeeva	160-200	84-250		
Kiev	100	100		
United States (city average)	63	20	< 0.4	66
Canada (city average)	55	13	< 0.2	43
Canadian "hot spots"			0.4-1.0	
France (city average)	38	34		44
Sweden (city average)	10	18		36

Table A6.2 Distributions of towns in Poland (not including Katowice) according to ambient air quality
(percentage in each category)

	Ambient Air Concentrations (micrograms per cubic meter)					
	< 20	*21-40*	*41-60*	*61-80*	*81-100*	*> 101*
Dust	5	16	26	21	3	29
Sulfur dioxide	24	26	13	11	13	13
NOx	20	30	30	10	0	5

Source: Institute of Hygiene 1989

Table A6.3 Air quality within 5 kilometers of fertilizer plant, Jonava, Lithuania
(micrograms per cubic meter)

	Short-term Maximum Allowable Concentration	*1986*		*1987*	
		Min	*Max*	*Min*	*Max*
Ammonia	200	50	890	150	440
Formaldehyde	35	31	1400	140	160
Sulfur dioxide	500	230	520	30	670
Nitrogen oxide	85	50	410	150	30
Hydrogen fluoride	20	20	67	50	90

Source: Hertzman 1992 (c)

Table A6.4 Median concentration of air pollutants by distance from perimeter of industrial zone in Zaporozhye, Ukraine

		Distance from zone (kilometers)			
	MAC	*1*	*2*	*3*	*4*
Dust	500	1330	1400	1100	700
Sulfur dioxide	500	810	820	720	430
Nitrogen oxides	10	130	140	120	90
Hydrogen chloride	200	240	150	150	. .
Carbon monoxide	5000	9000	8400	6300	10,500

Source: Levy 1992 (c)

Table A6.5 Average annual ambient concentrations of pollutants in Katowice Province, Poland, 1987

	Fluoride (μg/m^3)	*Formaldehyde* (μg/m^3)	*Lead* (μg/m^3)	*Cadmium* (ng/m^3)	*Chromium* (ng/m^3)	*Benzo(a) pyrene* (ng/m^3)
Katowice	1.2	42	0.47	13	23	130
Bytom	1.6	13	0.60	17	26	162
Chorzow	1.3	8	0.83	26	36	258
Dabrowa Gorn.	6.3	39	0.75	30	31	138
Gliwice	1.5	11	0.30	8	13	66
Ruda	1.5	8	0.40	10	18	95
Rybnik	3.6	11	0.35	8	14	72
Swietochlowice	2.1	19	0.40	11	14	128
Tarn. Gory	2.0	16	2.60	77	15	96
Wodislaw	4.8	28	0.20	4	15	95
Zabrze	1.9	12	0.31	8	18	117

Source: Hertzman 1990 (d)

Table A6.6 Indicator volatile aromatics in the air: Vac, Hungary, compared with selected Canadian cities

City/Location	*Benzene*	*Toluene*	*m/p-Xylene*
Vac (1990)			
1	41.0	76.9	57.6
2	38.0	83.4	59.5
3	51.2	106.5	87.8
4	45.6	93.0	62.0
5	30.3	76.6	44.6
Vancouver (1987-88)			
1	21.2	40.8	17.4
2	21.0	76.9	28.8
3	27.4	50.1	27.5
Windsor (1987-88)	8.1	30.0	15.3
Toronto (1987)	20.7	99.4	40.7
Montreal (1986-88)	20.3	32.0	..

Source: Hertzman 1990 (b)

Table A6.7 Pollutants in rainwater, Teplice, Czech Republic, 1989

Pollutant	*Mean concentration (per liter)*	*Range*			*Deposition per hectare*
pH	4.64	3.78	-	6.10	..
Hardness	0.25 mmol	0.1	-	1.0	..
NO_3	5.13 mg	1.26	-	12.92	26 kg
SO_4	19.05 mg	2.4	-	153.7	78 kg
ChSKMn	7.07 mg O_2	2.96	-	15.6	36.8 kg
Cl	3.23 mg	0.9	-	16.0	32.6 kg
Ca	6.47 mg	2.0	-	30.1	28.9 kg
Mg	2.84 mg	0	-	6.1	10.8 kg
Fe	0.08 mg	0.01	-	0.59	323 g
F	0.84 mg	0.17	-	5.60	1.1 kg
Pb	19.45 g	3.4	-	83.0	107 g
Cd	0.812 g	0.2	-	2.7	3.03 g
Zn	361.89 g	71	-	1994	1.5 kg
PAH*	43.7 ng	3	-	119	153 g

* Measured in 60 percent of samples
Source: Benes 1990

Table A6.8 Metal concentrations in drinking water, Czech Republic, 1984-86

	Percent of Samples Above the Standard
Aluminum	9.6
Arsenic	0.1
Barium	0.2
Cadmium	0.2
Chromium	0
Copper	0.3
Mercury	3.0
Lead	0.6
Selenium	0.2
Silver	3.7

Source: Hertzman 1990 (a)

Annex Seven

Health Status in Relation to Environmental Pollution: Selected Data

Table A7.1 Relative prevalence of chronic bronchitis in Kraków, Poland

	Males	*Females*
Non-smoking villagers	1.0	1.0
Smoking villagers	2.0	2.0
Non-smoking suburbanites	1.6	1.4
Smoking suburbanites	3.0	1.7

Source: Nikodemowica 1983

Table A7.2 Nature school and hematological function in children from northern Bohemia, Czech Republic

		Before Nature School	*After Nature School*
Study I	Erythrocytes	4.6	4.9
	Hemoglobin	123.1	128.4
Study II	Erythrocytes	4.5	4.7

		One day before	*End of stay*	*One month after*	*Two months after*	*Three months after*
Study III	Erythrocytes	4.2	4.3	4.2	..	..
	(% < 1 SD below norm)	36.0	14.0	..	..	..
	Hemoglobin	113.5	117.6	117.3	..	113.8
	(% < 1 SD below norm)	42.0	15.0	..	..	..
	Lymphocytes with active nucleoli (%)	11.9	4.8	6.1	7.1	..

Source: Pelech 1985 and Hertzman 1990 (a)

Table A7.3 Prevalence of health problems among children: Czech Republic compared with mining districts
(percent)

	Pre-School Age		*School Age*	
	Czech Republic	*5 mining districts*	*Czech Republic*	*5 mining districts*
Chronic kidney/urinary tract diseases	0.9	1.1	1.4	1.7
Nonspecific lung/airways diseases	0.5	2.9	0.5	1.4
Allergies	1.7	2.9	2.0	4.0
Mental illnesses and "defects"	0.5	1.1	..	..
Skin diseases	0.7	1.3	0.7	1.1
Endocrine disorders	..	..	1.2	1.5
Other chronic problems	..	..	0.9	1.8

Source: Benes 1990

Table A7.4 Prevalence of anemia in Estonia: industrial cities compared with Tartu
(percent in each category)

	Red Blood Cells < 3.5 million	*Hemoglobin < 11.5 g/dl*	*Eosinophils > 400*	*Monocytes > 700*
Tartu	0.3	0	2.6	0.8
Kohtla-Jarva	1.8	7.0	18.2	6.9
Narva	10.3	26.7	18.2	10.9
Sillamae	4.3	5.0	20.7	13.1

Source: Teoste *et al* 1991

Table A7.5 Air pollution and abnormal pregnancy in Ukraine: two industrial cities compared with Simferopol, 1981-88

	Mean annual emissions of air pollutants (000 tons) 1982-87	*Mean annual rate of spontaneous abortions (per 1000)*	*Mean annual rate of congenital anomalies in first 6 days of life (per 1000)*	*Rate of multiple congenial anomalies*	*Rate of dominant and X-linked congenital anomalies*	*Rate of recessive congenital anomalies*
Mariupol	920	24	11.7	4.2	2.2	0.6
Zaporozhye	415	19	8.8	3.4	1.0	0.5
Simferopol	128	11	3.8	1.6	0.7	0.3

Source: Levy 1992

Table A7.6 PCBs in fat tissue in autopsy samples from the Slovak Republic
(micrograms PCB per kilogram fat)*

	Male		*Female*	
Bratislava	n=16	4105	n=9	2243
Martin	n=15	1045	n=7	920
Trencin	n=10	3142	n=4	2622

* Background levels < 1000 micrograms per kilogram
Source: Hertzman 1990 (a)

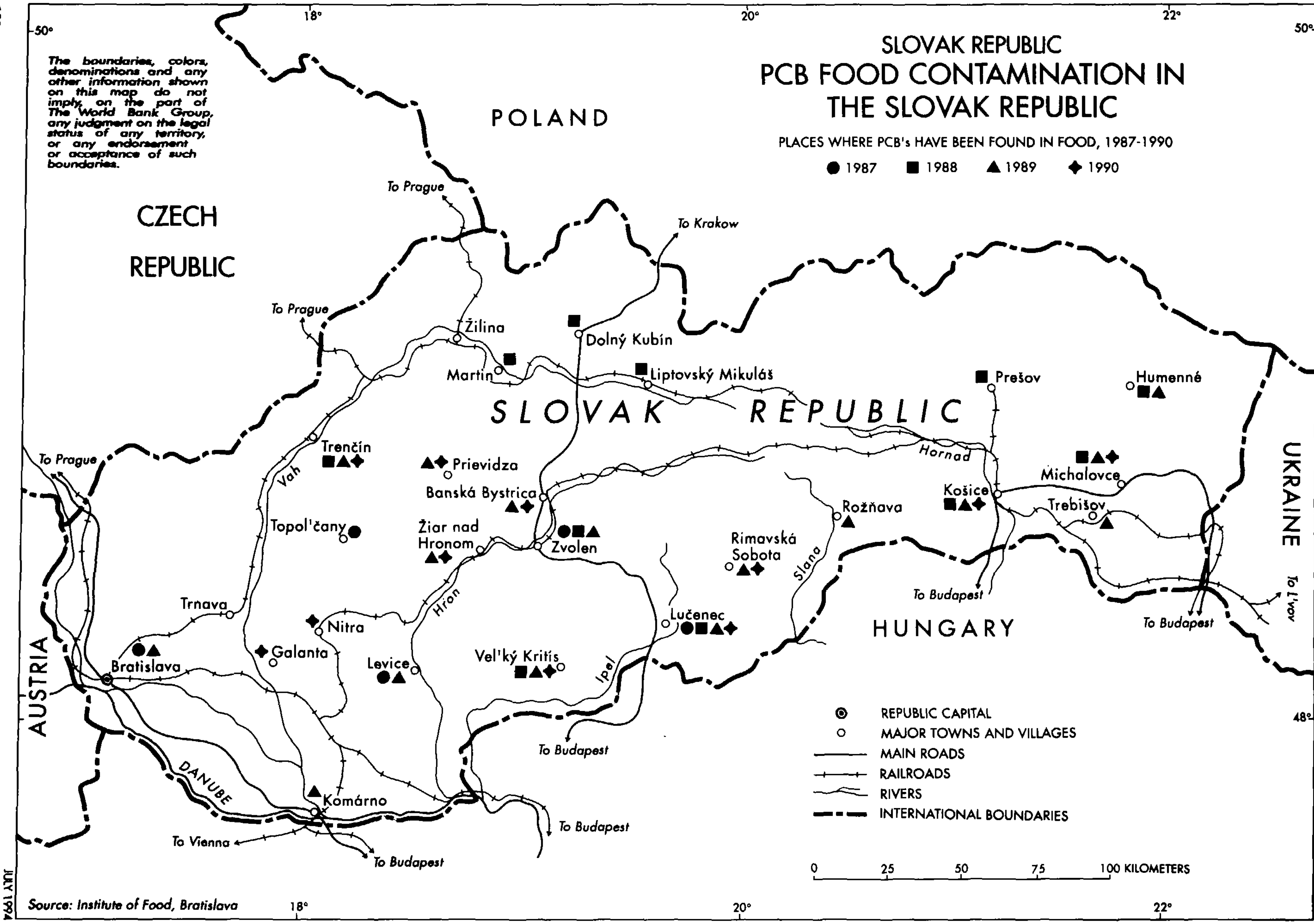
Table A7.7 Estimated number of workers exposed to toxic agents at work at levels above the maximum allowable concentrations

	Numbers (000s)
Noise	372
Dust	210
Vibration	49
Welding fumes	28
Solvents	12
Pesticides	10
Polycyclic aromatic hydrocarbons	10
Carbon monoxide	8.6
Manganese and other organics	7.7
NOx	7.4
Lead	6.0
Iron oxide	5.3

Source: Hertzman 1990 (c)

Annex Eight

PCB Food Contamination in the Slovak Republic


SLOVAK REPUBLIC
PCB FOOD CONTAMINATION IN THE SLOVAK REPUBLIC
PLACES WHERE PCB's HAVE BEEN FOUND IN FOOD, 1987-1990
● 1987 ■ 1988 ▲ 1989 ◆ 1990
The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of The World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries.
POLAND
CZECH REPUBLIC
SLOVAK REPUBLIC
UKRAINE
HUNGARY
AUSTRIA
To Prague
To Prague
To Prague
To Krakow
To Vienna
To Budapest
To Budapest
To Budapest
To Budapest
To Budapest
To L'vov
Žilina
Dolný Kubín
Martin
Liptovský Mikuláš
Prešov
Humenné
Trenčín
Prievidza
Banská Bystrica
Michalovce
Košice
Trebišov
Rožňava
Topoľčany
Žiar nad Hronom
Zvolen
Rimavská Sobota
Trnava
Nitra
Lučenec
Galanta
Levice
Veľký Krtíš
Bratislava
Komárno
Vah
Hron
Ipeľ
Slana
Hornad
DANUBE
REPUBLIC CAPITAL
MAJOR TOWNS AND VILLAGES
MAIN ROADS
RAILROADS
RIVERS
INTERNATIONAL BOUNDARIES
0 25 50 75 100 KILOMETERS
50°
48°
18°
20°
22°
Source: Institute of Food, Bratislava
IBRD 24466R

Annex Nine

Places Where More Information is Needed

Places in Central and Eastern Europe Where Populations Are Living under Environmental Conditions like Those Found at the Locations Listed in Annex IV

A. Places where ambient air quality is like other places listed in Annex IV

1. Czech Republic—Prague, Pilsen, Ostrava, Sokolow, Beroun, Kladno, Melnick
2. Bulgaria—Panagiurishte, Stara Zagora
3. Romania—Zlatna, Isalnita
4. Poland—Walbrzyskie
5. Belarus—Minsk, Polotsk/Novopolotsk, Mogilev
6. Ukraine—Maruipol, Donetsk, Kiev
7. *Russia—currently incomplete*

B. Locations for which further information is necessary

1. Czech Republic—Brno, Kosice, Prievidza
2. Bulgaria—Pleven
3. Romania—Drobeta Turnu Severin, Tirgu Jiu, Turgu Mures, Satu Mare, Ploesti, Piatra Neamt, Brasov, Onesti-Bacau-Borszesti region
4. Poland—Jeleniogorski region, Torun region
5. Belarus—Bobruysk, Grodno, Orsha, Svetlogorsk, Vitebsk
6. Hungary—Tata, Tatabanya, Esztergom, Komarom
7. Ukraine—Obuhov, Drogobych
8. *Russia—currently incomplete*

Annex Ten

Occupational Health

There is a high degree of overlap between the locations of environmental health concern and the areas of industrial concentration in Central and Eastern Europe. This is not surprising since three of the principal environmental health threats are dust, toxic gases, and lead: all of which are emitted in large degree from industrial sources. To the extent that these polluting industries affect both the health of the communities in which they are located and, also, the workers who work there, a remediation strategy which targets environmental health problems will also be effective in capturing workplaces with significant occupational health problems. The best example of this is lead smelters, where significant community exposures to children and in-plant exposures to workers seem to coexist everywhere they have been measured in tandem in Central and Eastern Europe. However, there are some important exceptions to this general pattern which need to be carefully considered in the development of an environmental action program. These include two types of locations: those where environmental health problems exist in the absence of occupational health problems and, conversely, those where occupational health problems exist in the absence of environmental health problems.

In many locations in Central and Eastern Europe stack emissions from industrial sources are prodigious but in-plant exposures are trivial, or, at least, no worse than would be expected in comparable facilities in the West. This would appear to be true for many coal-fired power and heating stations as well as certain cement plants, such as the one in Kunda, Estonia. But the phenomenon is not confined to these sorts of facilities. In general, the environment inside industrial facilities, except in Romania, seems to be relatively closer to Western norms than conditions in the adjacent communities, despite a widespread lack of basic safety equipment and exceedingly lax enforcement of health and safety regulations. A good example of this is the Huta Sendzimira steel works near Krakow. The facility has historically been a principal source of air pollution for Krakow and was represented to us as a dangerous place to work, since only 13 percent of the workers were said to retire without a disability. However, our visit to the facility revealed that this statistic distorted the realities of working conditions in the plant, which were no more threatening than an average North American steel plant. It turned out that the high rate of disability could best be explained as a response to the exceedingly generous disability pension benefits that existed for workers in heavy industry in Poland, rather than the workers' experience of disability per se.

Routinely reported data on worker absenteeism and occupational disease across Central and Eastern Europe reveal a pattern which supports these perceptions. Absenteeism rates tend to be high (probably reflecting benefit-driven behavior), while occupational disease rates tend to be no higher than in Western countries. This latter statement, however, must be taken with three important qualifications. First, certain occupational diseases are underdiagnosed and under-recognized in Central and Eastern Europe. Most important among this group are occupational cancers, which have received no recognition at all as occupational diseases and very little investigation has been done of them. Second is the problem of political interference in the reporting of occupational disease. In Czechoslovakia, a political decision was made in the early 1980s to suppress data on silicosis cases at the national level. In Romania, financial incentives were exerted on plant physicians to keep the number of reported cases of occupational disease below a targeted value on an annual basis. Anecdotes about less systematic forms of misreporting came out in other countries. Finally, the prevalence of the "traditional" occupational chest diseases, silicosis and silicotuberculosis, certainly is higher among Central and Eastern European workers in exposed occupations than among their counterparts in the West.

This third qualification of the occupational disease statistics points directly to the nature of many of those places where there are severe occupational health problems in the absence of environmental health problems. These tend to be places with heavy workplace dust exposures in the absence of large scale emissions into the community, in other words, in mines. This generalization would seem to apply to many underground coal and uranium mines in

Central and Eastern Europe. A good example is found in Pecs, Hungary, where a uranium mine and a coal mine were both in production until recently. There is currently a mini-epidemic of lung cancer which began among the miners from the (now defunct) uranium mine, while, at the same time, the coal mine (still operating) has been producing 100-120 new silicosis cases per year among a workforce of 4100. Nonetheless, community air quality is not of particular public health concern. Similarly, epidemiologic data for uranium miners in Czechoslovakia suggest an ongoing lung cancer risk there. To be sure, there are examples of especially dangerous workplaces, other than mines, in Central and Eastern Europe which do not coexist with significant community exposures. But, when countries other than Romania are considered, it is fair to say that a large proportion of the dangerous workplaces that do not lead to community exposures are in the energy sector, and should become targets of closure or reinvestment as part of a program of reform in that economic sector.

Romania. As has been hinted at above, Romania is an exception to these general rules. The former regime there pursued a policy of industrialization despite the human cost. It provided stunningly generous danger pay to workers in mines, mills, and smelters which were based on ambient in-plant air quality measurements done periodically by the Centers for Medical Prevention. The scale of perversity of this incentive cannot be overstated. In many locations throughout Romania workers have been militantly demanding that dangerous working conditions be maintained in order to support danger pay which can drive their wage rates to several times the national average. In this context there appear to be many locations throughout the country with severe occupational health problems.

- National data indicate that there are approximately 500-600 new cases of silicosis per year produced in mines and foundries around the country, of which 10 percent have silicotuberculosis. The average time from first exposure to disease is short, 15.5 years in the mines around Suceava during the 1980s and 18.4 years in large foundries around the country over the same time period. The large copper mine near Suceava has a particularly striking history of silicosis. Of 2700 miners retired with permanent disability between 1953 and 1982, 61.5 percent had silicosis. The average age of retirement was less than 40 and 69 percent of these men had less than 10 years of exposure. Tuberculosis complicates 24 percent of cases. So far, 23 percent of the deaths among this sample of pensioners has been from silicosis and the average time from retirement to death has been approximately 7 years.
- In 1990 there were 246 confirmed cases of one-time exposures to ionizing radiation of more than 400 millirem in uranium mines and other workplaces.
- Between 1986 and 1990 approximately 3.6 percent of the workforce, or 51,809 workers, were exposed to carcinogens in the normal course of their work. In six districts, Olt, Giurgiu, Bacau, Vaslui, Prahova, and Salaj, more than 10 percent of the workforce are exposed to carcinogens. The most prevalent exposures, in descending order, are tars/mineral oils/carbon black; polycyclic aromatic hydrocarbons; hexavalent chromium; benzene; asbestos; vinyl chloride; arsenic; naphthylamine and benzidine; nickel; and epichlorhydrin.
- Several workplaces in the vicinity of Bucharest report high levels of chemical disease. These include the Acumulatorul factory in Bucharest, which experiences 30-45 cases of lead intoxication per year; the UREMOAS plant in Bucharest, which produces 15-25 new cases of silicosis per year; the friction materials factory in Rimnicu Sarat, which produced 30 new cases of asbestosis in 1990; and the synthetic fibers factory in Braila, which produces 30-50 cases of carbon disulfide and sulfuric acid toxicity per year.
- Lead related problems have been studied among workers at the IMN plant in Copsa Mica, which is said to be cleaner than the other plant there. Between 1984 and 1989 there have been 61-103 cases of acute lead poisoning per year (from a workforce of approximately 3,000), based on clinical symptoms of severe gastric pain. In addition, there have been 113-120 cases of chronic lead poisoning, based on symptoms of neurasthenia, constipation, anemia, anorexia, and moderate gastric pain. Urinary lead samples taken in 1989 showed the following:

Table A10.1 Urinary lead levels at the IMN plant, Copsa Mica, Romania, 1989

Urinary lead level (g/dl)	*Number of workers*	*Percentage*
< 80 (normal)	404	13.6
80-150	998	33.6
150-250	1290	43.4
> 250	280	9.4

Not only are these numbers extremely high, but the categories underestimate the problem because even the category defined here as acceptable would be considered dangerous in the West.

- The town of Baia Mare is heavily polluted with lead and other metals due to two lead smelters in the area. In the Phenix plant there, approximately 25 of 3,000 workers per year are removed from work and chelated to reduce dangerously high body burdens of lead. There are currently 17 cases of lung fibrosis at the plant, primarily among maintenance workers. It is interesting to note that the official number was three cases until the December 1989 revolution, when it became possible to report the other fourteen cases. There are fifteen workers still in the plant who have arsenic-related polyneuropathies, and twenty others have recently retired with this condition. The most prevalent complaints are respiratory; with approximately 100 new cases of acute bronchitis, twenty-five new cases of chronic bronchitis, and six new cases of asthma per year.
- In Dej, a four year follow up study was done of workers exposed to carbon disulfide in a plant where the airborne levels ranged from 5-304 milligrams per cubic meter. Of the workers, 85.7 percent were found to have vegetative symptoms consistent with carbon disulfide poisoning; 70 percent had neurological symptoms; 45 percent had digestive symptoms; and 67 percent had cardiovascular symptoms. Studies were also carried out among workers at the

artificial fibers plant in Suceava. In 1985, 43 percent were found to have neurological findings consistent with carbon disulfide exposure, 22 percent with alcohol intolerance, 82 percent with nerve conduction abnormalities, 48 percent with personality disorders, 4 percent with chromosomal aberrations, and 6 percent of births to female workers between 1983 to 1987 ended with a congenitally malformed offspring.

- At the "Bicaz" asbestos cement plant, a special chest x-ray survey of the workers showed that 15% had evidence of asbestosis.
- At the vinyl chloride plant in Borzesti, a follow-up study of workers from 1977-87 showed increasing frequencies of Reynauds phenomenon and acro-osteolysis, which are characteristic of vinyl chloride exposure. There have also been increases in hepato-biliary symptoms and changes in liver function tests consistent with vinyl chloride related pathology.
- In a pesticide manufacturing plant in Borzesti there have been problems with exposure to simazine/atrazine and carbamates. In 1991, 149 relatively young workers exposed to the azide pesticides were evaluated. Eighty-eight were found to be suffering medically significant conditions: 60 percent were experiencing allergies, 38 percent had endocrine conditions, 22 percent had digestive conditions, 15 percent had cardiovascular conditions, 10 percent had respiratory conditions, and 5 percent had reno-genital conditions. Approximately 25 percent had hematological changes which were deemed to be "pre-leukemic" by a hematologist. On two different types of chromosomal evaluation, 13 percent and 8 percent of exposed workers and 1 percent and 1 percent of controls, respectively, showed a pattern of damage. Among the workers exposed to carbamates, a positive correlation was found between the prevalence of nerve conduction disorders on electromyography and the concentration of the urinary metabolite DDC-Na. Chromosome damage was found in 15 percent and 8 percent of their samples on the same two tests mentioned above.
- In the galvanizing area of the Electrobanat plant in Timosoara, a study of pulmonary function showed that 24 percent of the workers had forced vital capacity less than 80 percent of predicted (compared with 5 percent of controls) and 20 percent had forced expiratory volumes less than 80 percent of predicted (compared with 8 percent of controls).

Poland. National statistics are available for compensable occupational diseases. The table below details the five major causes of occupational disease among the 9604 individuals (6031 males and 3573 females) who received new compensation claims in 1988. It should be noted that the leading causes of compensable disease in Poland are not dissimilar to what is seen in North America. For instance, if we exclude problems with joints, which seem to be handled as "injuries" in Poland and "diseases" in North America, then skin diseases, pneumoconioses, upper respiratory problems, hearing loss, and infectious diseases are all among the top ten in this part of the world, too. On the other hand, the overall compensation rate of 77 workers per 100,000 per year would appear to be somewhat lower than the North American experience.

Table A10.2 Annual incidence rate of occupational diseases in Poland, 1988
(per 100,000)

Disease	*Rate*
Hearing loss	20.5
Infectious disease	14.7
Throat/voice problems	9.5
Pneumoconiosis	8.2
Skin diseases	6.4

Hungary. In Hungary, attention has been focused on occupational health problems in the city of Pecs, at the Mecseki Uranium Mine and at the Anthracite Mine at Mecseki Mountain. Workers began mining uranium at Mecseki in the late 1950s until the mine was closed in 1990. Under normal operating conditions the mine employed 50,000 people (although at its peak, the mine employed nearly 78,000 workers): by 1990, 10,450 had cumulative lifetime exposures of more than 25 working level months of ionizing radiation. The three main health problems in this mine, aside from accidents, are noise-related hearing loss, silicosis, and lung cancer. When the mine first opened, 3-5 percent of the workers were developing noise related hearing problems per year, whereas in the late 1980s, this had declined to approximately 0.5 percent per year. In the early years of the mine's operation, it took an average of seven years for an underground miner to develop silicosis from exposure to silicate materials. It is reported that by the late 1980s the average time from first employment to the development of silicosis had increased to approximately twenty years. It was also reported that there had been 103 new lung cancer cases since 1981 among the 10,450 people with greater than twenty-five working level months of exposure.

The silicosis and lung cancer statistics, when taken together, are quite ominous. The silicosis rates should be interpreted as a surrogate indicator of the dustiness of working conditions in the mine. If it is true that silicosis developed within seven years of first exposure in the early years of operation, then the dust exposure conditions must have been very severe since this is a very short period in which to accumulate enough silica in the lungs to cause disease. This is significant not only because of silicosis morbidity, but also because of what it might mean for lung cancer patterns in the future. It is well known that occupational cancers usually develop after a latent interval of 20 years or more from the time of first exposure to an occupational carcinogen. In practice, one often has to wait 30 or 40 years from the time that a new carcinogen is introduced into a workplace until its epidemiological effects can be detected.

In the case of uranium mining, radon gas is a known lung carcinogen. Thus it is not surprising that the authorities at the mine identified lung cancer cases starting in 1981, approximately 25 years after the mine opened. What is ominous is that the working conditions in the early years of the mine will largely determine the extent of the subsequent lung cancer epidemic. Since the carcinogenic alpha particles associated with radon gas will absorb to silica aerosols, the number of lung cancer cases which might show up over the next two decades will likely be directly related to the intensity of the exposure to silica in the early years of the operation of the mine. It is impossible to predict how many new lung cancer cases might occur, but it would not be surprising if it exceeded 1,000. If this prediction is correct, it will create a particularly difficult health-social crisis in a community facing the prospect of mass unemployment with the potential shutdown of its two largest industries.

Silicosis was also a major problem among the underground miners in the anthracite mine due to the silicates in the rock in which the coal is found. In recent years, an average workforce of 4100 miners have worked underground. These miners are allowed to do a maximum of 4,000 shifts before compulsory retirement from underground mining; which works out to be approximately 20 years of experience. Despite this maximum, the mine is producing 100 to 120 new silicosis cases per year. This implies that the average worker has approximately a 50 percent chance developing silicosis during his working life time.

Czechoslovakia. In Czechoslovakia, as in Hungary and Poland, routinely collected data on occupational diseases do not clearly indicate working conditions which are qualitatively worse than in Western countries. In large measure, this may be the true state of affairs. But as well, it is due to the fact that guidelines on compensability of disease are determined politically rather than scientifically; so direct comparison of compensation statistics from one country to another will be distorted by policy influences. Therefore, compensation data are interesting mostly for identifying specific unusual phenomena rather than for making broad population comparisons.

In reviewing the compensation data for Czechoslovakia for the period 1978-88, two items stand out. One is the persistence of several dozen cases of silicotuberculosis being compensated per year. This is in addition to approximately equal number of cases of non-silicotic type tuberculosis which, presumably, come from the health care sector. These data likely reflect the fact that tuberculosis is still endemic in Czechoslovakia, whereas in most Western countries it is sporadic. The second pertinent finding is that approximately 100 cases of lung cancer related to exposure to ionization radiation are being compensated each year. This is an extremely important outcome because it represents an element of the public health consequences of exploiting nuclear energy as a substitute for coal.

There have been studies of six groups of miners who work in uranium, iron, and shale clay mines and are exposed to radon gas, using world-class cohort methodology and statistical analysis. The study groups include one sub-cohort whose exposure began before 1950, three which began in the 1950s, one in 1968, and the latest one in 1973. The results are particularly useful in estimating an "attributable risk" per unit of exposure; which is given as 20 to 30 lung cancers per million per year per working level month of exposure. From these data, it is possible to make rough estimations of the ongoing risks of continuing to mine uranium and other substances found in rock with high radon levels. If the dose-response relationships reported in the research today still apply to the mining conditions of the early 1990s, then a great deal of improvement in the working conditions will need to made before the risks are in any sense "acceptable," even in a country which must make difficult trade-offs in order to obtain energy.

As good as the work on radon exposed workers is, it is incomplete. It would be very important for studies to evaluate leukemia and other cancers which might be attributable to ionizing radiation exposures. These studies would be necessary in order to more comprehensively determine the health impacts of obtaining energy from radioactive sources.

Table A10.3 Occupational variations in the proportion of reported congenital anomalies in mining districts of northern Bohemia

Occupational Group	*Mothers*		
	Number of live births	*Percent with congenital anomalies*	*Percent excess compared with Jablonec*
Non-exposed	13,069	8.8	
Printing	16	25.0	+184
Hair-dressing	61	11.5	+31
Gas-production	63	11.1	+26
Agriculture	353	11.0	+25
Chemical production	279	10.4	+18
Hospitals	504	9.3	+11
	Fathers		
	Number of live births	*Percent with congenital anomalies*	*Percent excess compared with Jablonec*
Non-exposed	12,111	8.4	
Printing	18	33.3	+296
Gas-production	91	14.3	+70
Chemical production	349	11.7	+39
Machine production	504	10.3	+23
Mining	1111	9.5	+13
Medical doctors	190	7.4	-12

The following tables provide some information regarding occupational variations in the proportion of reported congenital anomalies among workers in two cities among the mining districts of northern Bohemia compared with the town of Jablonec in the non-mining district of northern Bohemia. The former table shows three-fold variations in the proportion of children with congenital anomalies among women in six occupational groups where significant chemical exposures might occur. However, because the number of children produced by these women was relatively small during the course of the study, the estimates of the proportion of congenital anomalies may be somewhat unstable. Thus, from a statistical standpoint, it is possible that these results could be explained by chance alone. Similar patterns are seen in the latter table in relation to the proportion of congenital anomalies by paternal occupation. Once again, the highest rates of congenital anomalies are found in the occupations where the smallest number of children have been born (i.e. among printers). However, this methodological problem should not be taken to mean that the data are wrong, only that they are of an exploratory rather than an hypothesis testing character.

Lithuania. The Republican Hygiene Centre estimated that, based on industrial hygiene monitoring, approximately 175,514 workers in 1989 were working in establishments where there is an ongoing concern about exposure to gases and vapors, dust, vibration, or noise. The most hazardous industries are considered to be textiles, machinery and building materials.

In 1990, 373 cases of occupational disease were registered in Lithuania, up from 240 in 1989. Sixty-seven percent of these involved vibration (primarily vibration-related back injury from tractors), 10 percent involved noise (primarily hearing loss in the textile, furniture, and lumber industries), and 7 percent involved the respiratory system. As a result of vibration problems with poorly maintained tractors, half of all reported occupational diseases occur in agriculture. Other recognized problems include skin allergies among health care workers using inadequately sterilized syringes; asthma among painters, workers producing building materials, and workers at the cement plant in Akmene; and silicosis among molders in steel foundries.

Officials at the Republican Hygiene Centre have reason to believe that occupational disease is underreported in the country. For instance, no occupational diseases are reported from pulp and paper mills or fertilizer plants; no record is kept of Hepatitis B cases among medical staff; and no lead surveillance is carried out in electrotechnical industries where soldering is done. There is little specialized diagnostic equipment in the country for occupational health purposes, especially as regards early diagnosis of insidious conditions. Variability due to medical diagnostic factors is best illustrated by the fact that, when a new specialist who was interested in vibration-related disease began work three years ago, the number of compensated cases of vibration-related disease across the country doubled! As another example, only 1-2 acute pesticide poisonings are recorded each year, but these tend to be acute emergencies. No one knows how many less acute cases occur. Finally, there is no organized insurance fund for workers' compensation. The legislated benefits are quite generous, but they must be paid directly by the employer. Therefore workers are pressured to not report occupational health problems. The Republican Hygiene Centre considers establishing a compensation fund to be a priority.

Latvia. There is reason to believe that the most significant environmental chemical exposures in Latvia occur at work, rather than in the community. A study carried out in 1975 showed that the odds of a lung cancer case having had a significant workplace exposure were 11.6 times higher than controls who did not have lung cancer. Unfortunately, this work was done in 1975, and has not been repeated since. Nor have there been any more detailed investigations of cancer or other chronic diseases in the workplace in Latvia.

The Latvian Occupational Diseases Centre has estimated that 166,000 workers, 12.3 percent of the workforce, are working under poor conditions. It is not clear how this estimate was made. More concretely, 56 percent of 2255 monitored enterprises in Latvia do not meet current exposure standards. Despite these estimates, there were only 240 occupational diseases reported in 1990. The following data gives the distribution of these diseases.

Table A10.4 Most commonly reported occupational diseases in Latvia, 1990

Disease	*Percentage of cases*
Lung and bronchial illnesses	23.2
Cochlear neuritides	33.1
Musculoskeletal & peripheral nervous system	18.2
Vibration-induced diseases	9.8
Allergic disorders	9.8

The number of reported lung and bronchial diseases has been increasing in recent years, occurring most frequently among workers in the building material industry, mechanical engineering industry and glass and china industry. In 1990 there were fourteen cases of pneumoconiosis (e.g. silicosis, asbestosis) diagnosed, mostly from the electrotechnical industry. These figures are likely to be gross underestimates. For example in Broceni, polyclinic records show that more than 400 asbestos cement workers are suffering from obstructive lung disease, yet no more than a handful of them have found their way into the national statistics. Like Lithuania, the individual workplace must pay some, though not all, of the compensation to disabled workers. We are not sure to what extent this disincentive has reduced occupational disease reporting and to what extent underdiagnosis and political manipulation have been contributing factors.

Broceni is the site of the 'Slates' asbestos cement plant which has high levels of ambient asbestos in the workroom air. Data show periodic exposures to asbestos and asbestos-laden dust ranging from 2.2 to 336.6 milligrams per cubic meter. These data are somewhat difficult to compare to Western norms, which are often expessed in asbestos fibers per unit volume, or as weight per volume of eletron microscopically confirmed fibers. Yet it would be reasonable to assume these measured concentrations are as much as one to two orders of magnitude above levels accepted in the West.

Data from the local polyclinic, reveals that a very high proportion of the workers in the plant are diagnosed as having obstructive lung disease. In Latvia, this diagnosis is a catch-all, which includes what we would normally call obstructive lung disease, but would also include dust deposit diseases such as asbestosis. This is because many of the screening X-rays done for chest disease in Latvia are not of high enough quality to make the diagnosis of a dust deposit disease. Therefore, all diseases involving chronic cough and breathlessness tend to be lumped together. During the five years 1987-91, the average prevalence of Chronic obstructive lung disease (COPD) was approximately 40 percent and nine respiratory cancers were diagnosed. Since the plant is only 20 years old and the minimum latent period for respiratory cancer due to asbestos is 10-20 years, it is possible that this is the beginning of an epidemic curve.

It is important to realize that, despite the very high dust levels in the plant and associated respiratory morbidity, this plant was not identified to us as a principal concern by environment or health authorities in Latvia. Data were obtained by purely informal means and do not seem to be in the possession of any officials in Riga. Perhaps environmental officials were not concerned because the plant only emits 5,000 tons of dust per year into the general environment. In general, concerns about asbestos exposures in the region are not as high as they deserve to be on the basis of the human health impact of asbestos and the exposure conditions which exist in plants like Broceni.

Olaine is the centre of the Latvian pharmaceutical industry. It has two large facilities, known as Biolar and Latbiofarm, which are of environmental health interest because both are within a few hundred meters of town. It is also of occupational health concern because of the complex chemistry of their production processes. Latbiofarm is a large facility with a wide range of products, including anti-cancer agents which are themselves carcinogenic. In one special investigation of workroom air, the MAC was exceeded in 17-21 percent of measurements for ethanol, isopropanol, butanol, benzene, benzaldehyde, chloroform, dichloride, or acetone. At a distance of 1200-1300 meters, 9 percent of short-term air samples exceeded the MAC for isopropanol, ammonia, aliphatic amines, nitrogen oxides, hydrogen chloride, or formaldehyde in 1986-88. In another air monitoring exercise, eight substances (hydrogen chloride, formaldehyde, isopropanol, phenol, acetone, nitrous oxide, sulfuric acid and methanol) were measured at five locations in the area, three months a year for three years. It was reported that 41 percent of the samples exceeded the MAC.

The water effluent includes toluene, formic acid derivatives, various alcohols, and certain carcinogenic substances such as benzene and anti-cancer agents. Thus, the waste water is both toxic and mutagenic. It is treated at the plant's facility which is 500 meters from town. City sewage and waste from Biolar also go into the facility. The facility has technical problems with the complex mixtures of sewage, domestic detergent, and industrial chemicals it must treat. There are problems with creating new toxic agents through chlorination, airborne discharges of volatile hydrocarbons, and contamination of groundwater with toxic sludge. In addition, the plant has been burying solid waste in 1200 meter deep dolomite deposits. It is suspected that these have contaminated the groundwater, but there does not seem to be reliable data on this matter.

The pharmaceutical workers and the town's inhabitants have been the subject of health concern for several years. The most impressive of these involved workers from Biolar, residents of Olaine, and controls from Aizkraukle. Results are shown in the table below. They show that the workers and, to a lesser extent, the residents of Olaine, differ from the controls on four important immunological measures. Also, it was demonstrated that residents and workers had higher rates of bronchitis and allergic rhinitis than controls. The workers, but not the residents, also had higher rates of chronic hepatitis and allergic dermatitis than the controls. These results are reasonably credible because they are specific to the toxic properties of the exposures from the plants.

Bulgaria. The following data shows the distribution of compensated occupational diseases in Bulgaria for the latest available year, 1989.

While the proportional distribution of the compensable diseases is credible enough, the total number of new cases (200-400 per year) is approximately ten times lower than we would have expected for a country of 8 million people.

Table A10.5 Allergic and immunological observations in Olaine, Latvia: persons working at chemical factories, residents, and controls
(percentage)

Variable	*Workers (n=560)*	*Residents (n=200)*	*Controls (n=200)*
Sensitization to chemical allergens	41[1]	18[1]	0
Immunosuppression of local immunity	53[1] 33[2]		20
Interference with humoral immunity	32[1] 26[2]		20
Interference with cell-mediated immumity	30[1]	24[2]	18

1. $p < 0.05$
2. $p < 0.01$

Table A10.6 Distribution of compensated occupational diseases in Bulgaria, 1989

Disease	*Percentage of cases*
1. Repetition Strain Injuries	49
2. Hearing Loss	12
3. Vibration Syndromes	11
4. Lung Diseases	11
5. Poisonings	8
6. Allergies-Skin	4
7. Biological factors-infection	3

When confronted with this observation, there seemed to be general agreement that, indeed, there was large scale undercounting of occupational diseases in the country. A number of reasons were advanced for this problem. In order for an occupational disease to be compensated, it must be acknowledged by an expert diagnostic commission. These commissions, made up of occupational pathologists, internists, hygienists, and other specialists, exist in 30 locations around the country. Workers must apply to these commissions in order to get a disease compensated. It is thought that many physicians do not refer people to them who have legitimate occupational disease (e.g. noise induced hearing loss) and the network of commissions does not have any method to find individuals who are not being referred by their physicians. If a worker is deemed by the commission to have an occupational disease, he or she still has to take the company to court in order to get compensation. This is a surprising obstacle not found in other Eastern European countries or in North America. When compensation comes, the payment is usually much lower than what the worker would make if he or she were still at work. It would appear that there is no provision made that would allow a worker to continue to work while collecting a disability pension.

In addition to an extended discussion on the problems on workers compensation statistics, We were given general descriptions of several investigations being carried out by the Clinic of Occupational Diseases. Most of this work does not contribute a great deal to our understanding of the environmental health situation in Bulgaria because it deals with special surveillance and screening programs for workers, rather than health outcomes per se. We received one useful set of data from occupational surveillance which provided average blood lead levels on workers from several plants in 1979 and 1990. It shows that the average blood lead levels were at or above the critical range of 40 to 60 micrograms per deciliter for adults. Because these values are averages and not peak values, we must assume that a large fraction of the workers in these facilities are being grossly overexposed to lead. This was the only data set available to me which helped demonstrate the potential scale for occupational disease in Bulgarian industry. It stands in marked contrast to the message implicit in the compensation statistics.

Ukraine. Like several other countries in the Region, there appears to be significant under-reporting of occupational disease in Ukraine. For example, in the industrial city of Mariupol, with a 1990 population of approximately 550,000, there were only 119 reported cases of all occupational diseases over the period 1980-91. The reasons for this are similar to other countries as well. Under the previous regime, physicians and plant managers were discouraged from diagnosing and reporting occupational diseases. The list of compensable occupational diseases is limited, primarily to: chronic dust bronchitis, pneumoconiosis, vibration-associated disorders, noise-induced hearing loss, and certain back and joint conditions. There is a lack of appropriate screening and diagnostic tests.

Despite extensive exposure to lead in the workplace, there are few facilities for testing for blood lead. For instance, at the lead and zinc smelter in Konstantinovka, only 15 cases of lead poisoning were reported between 1985 and 1990 among a workforce of approximately 1600. Although annual physical examinations are done on the workers, no proper blood samples are drawn for analysis. Airborne lead levels in the smelter are exceedingly high. Between 1989 and 1992 the range of mean airborne lead levels in various work stations was 80-750 micrograms per cubic meter (the Ukrainian MAC is 10 micrograms per cubic meter and the American Permissible Exposure Limit is 50 micrograms per cubic meter). Based on the experience of airborne exposures like this in other locations, it must be inferred that there is massive under-diagnosis of acute and chronic lead poisoning in the smelter.

Notwithstanding these problems, some significant occupational health problems can be identified through routinely collected data. There are an estimated 35,000 prevalent cases of coal workers' pneumoconiosis and chronic dust bronchitis in Donetsk Oblast, which is home to approximately 300,000 underground coal miners. There are other, more direct indications that the coal mines may be specially hostile working environments. Underground coal miners who work strenuously in a hot environment have increased rates of acute myocardial infarction (heart attack), which has been attributed by researchers to hot microclimates in the mines (often with temperatures at 35 degrees Celsius) and arduous physical work. The rate of sudden death among coal miners in Donetsk Oblast is 170 per 100,000 per year (a total of 510 sudden deaths a year among coal miners in the oblast), as compared with a rate of 120 per 100,000 per year among the rest of the population.

In Ukraine, many coal mines have vertical shafts. Rates of occupational disease and injury are higher in mines with vertical shafts than those with horizontal shafts. Coal dust levels are said to average 90-150 milligrams per cubic meter in the horizontal shafts and about 400-500 milligrams per cubic meter in the vertical shafts. The rate of vibration-associated disorders is more than fifteen times higher in mines with vertical shafts than those with horizontal shafts. In addition, there have been documented instances of chemicals such as chlorobenzene, formaldehyde, and cyanides directly leaking into mines with vertical shafts from factories that sit atop or near the top of the mine shafts. In one incident, three deaths occurred when chlorobenzene had been allowed to leak into a vertical mine shaft over at least several weeks, despite warnings, from a factory that was located at the top of the mine.

Belarus. Further evidence of under-reporting of occupational disease comes from Belarus, where, in the most recent year for which data are available, only 247 cases were identified in a republic of 10.8 million people. A close examination of this low number of cases revealed that this number represented only what may be better defined as "occupational disability" cases and that in fact the number of workers with occupational diseases must be much larger, but is currently inestimable. Like in Romania, wages among workers rise with the dangerousness of the job. Thus, workers are reluctant to move to a less hazardous position or complain of ill health because of the fear of losing precious income, particularly during difficult times. Like in Bulgaria, industry opposes identifying occupational disability because management has to compensate the worker. In other words, there is no "no fault" system. Also like in Bulgaria the worker is required to undergo a series of medical examinations before (s)he is classified as occupationally disabled. The first one is done at the plant by a physician paid for by management, the second is done by an oblast committee, and the final one is done by a committee at the Republican Centre at Minsk. There is a lack of appropriate diagnostic equipment at all levels and so it is difficult to verify many conditions.

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The World Bank

Headquarters	Telephone:	+1 (202) 477-1234
1818 H Street, NW	Facsimile:	+1 (202) 477-6391
Washington, DC 20433	Telex:	MCI 248423 WORLDBANK
USA		MCI 64145 WORLDBANK
	Cable:	INTBAFRAD WASHINGTONDC
	Internet:	books.worldbank.org
	EMAIL:	URL:http:\\www.worldbank.org\\
European Office	Telephone:	+33 (1) 40.69.30.00
66, avenue d'Iéna	Facsimile:	+33 (1) 40.69.30.66
F-75116 Paris, France	Telex:	640651
Tokyo Office	Telephone:	+81 (3) 3214-5001
Kokusai Building	Facsimile:	+81 (3) 3214-3657
1-1, Marunouchi 3-chome	Telex:	26838
Chiyoda-ku, Tokyo 100, Japan		

Life expectancies have been stagnating or declining in many countries of Central and Eastern Europe over the last few decades. Some observers have suggested that high levels of air and water pollution are at least partly to blame for life expectancies that are far below those in Western Europe, North America, and Japan.

This report shows that environmental contamination is one of many factors contributing to low life expectancies in Eastern and Central Europe and may not be the most important. Still, in many places high levels of lead, dust, and sulfur dioxide in the air are causing learning and behavioral problems in children, respiratory diseases, and premature mortality. This report summarizes current knowledge about locations in Central and Eastern Europe where environmental pollution has influenced human health, identifies the principal pollutants damaging health, and suggests a remediation strategy for achieving the greatest health benefits for the limited resources available.

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