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LONG-RANGE TRANSBOUNDARY AIR POLLUTION

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SUMMARY OF HEALTH RISKS OF PARTICULATE MATTER FROM LONG-RANGE TRANSBOUNDARY AIR POLLUTION

Summary report prepared by the joint Task Force on the Health Aspects of Air Pollution of the World Health Organization/European Centre for Environment and Health and the Executive Body

I. PARTICULATE MATTER

1. The Task Force on Health conducted a multidisciplinary analysis aiming at the assessment of health impacts of suspended particulate matter. Special emphasis was placed on the fraction emitted by remote sources or formed from precursor gases in the atmosphere. This report summarizes the main results of this analysis.

2. The analysis indicated that particulate matter (PM), especially its fine fraction (PM2.5), affected the health of a majority of the population in Europe. There was a led to a wide range of acute and chronic health problems and an estimated decrease in life expectancy by about one year in the most polluted countries of Europe. The pollution from remote sources contributed significantly to the problem.

3. PM is an air pollutant consisting of solid and liquid particles suspended in the air. The particles vary in size, shape, chemical composition and origin. Their size, or aerodynamic diameter, is often used to characterize them. The size is associated with their origin, their transport in the atmosphere and their ability to penetrate into the respiratory system when inhaled. Particles smaller than 10µm (PM10) in diameter can enter upper parts of the airways and the lungs. Fine particles (<2.5 µm, PM2.5) can enter deep into the lungs and penetrate into the alveolar region. PM2.5 contains secondarily aerosols (formed via gas-to-particle conversion), combustion particles and re-condensed organic and metal vapours. The most important chemical species contributing to PM2.5 mass are usually secondary inorganic ions (nitrate, sulphate and ammonia), carbonaceous material (both organic and elemental carbon), water, crustal materials (including calcium, potassium, chloride, silicates, etc) and heavy metals. Coarse particles (diameter between 2.5 and 10 µg, i.e. the coarse fraction of PM10) usually contain earth crust materials and fugitive dust from roads and industries. PM2.5 can be transported over long distances in the atmosphere (from hundreds to thousands of kilometres). Coarse particles are more easily deposited and travel usually less than 10 km from their place of generation. However, dust storms may transport coarse mineral dust over more than 1000 km.

4. Exposure to PM in ambient air was linked to a number of different health outcomes. They ranged from modest transient changes in the respiratory tract and impaired pulmonary function, which increased the risk of symptoms requiring emergency room or hospital treatment, to increased risk of death from cardiovascular and respiratory diseases or lung cancer. This evidence stemmed from studies on both acute and chronic exposure. Toxicological experiments supported the evidence generated by epidemiological studies. PM2.5 was found more hazardous than the coarse particles. The primary, carbon-centred, combustion-derived particles were found to have considerable inflammatory potency. Nitrates, sulphates and chlorides showed lower toxic potency. However, despite these differences among PM constituents under laboratory conditions, it was not possible to quantify precisely the contributions of different components of PM, or PM from different sources, to health effects. While the long- and short-term changes of PM2.5 (or PM10) mass concentration levels were associated with changes in various health parameters, available evidence was still not sufficient to predict the health impacts of PM components. Based on review of the existing evidence, previous meetings of the Task Force on Health had recommended assuming that risk of death increased by 6% when long-term exposure to PM2.5 increased by 10 $\mu g/m^3$ (confidence interval 2–11%).

5. Health effects were observed at all levels of exposure. This indicated that in any large population there was a wide range of susceptibility and that some subjects were at risk even at the low concentrations observed. People with pre-existing heart and lung disease, asthmatics, socially disadvantaged and poorly educated people, as well as children, belonged to the more vulnerable groups. Despite the rapid expansion of the evidence, well-documented and generally accepted

mechanistic explanations of the observed effects were still missing and further studies were required. It was likely that the various attributes of PM (the inter-correlated mass, size, surface area and chemical composition) contributed to a different extent to numerous biological responses.

6. The population exposure to secondary aerosols was mostly determined by the long-range transport of PM. The long-range transport contributed less than local sources to primary PM exposure.

7. Ambient concentrations of PM were the best available indicators used to determine population exposure to PM. The availability of data on PM10 concentrations had increased rapidly in the last few years, mostly due to the requirements of the directives of the European Community (EC). Data on PM10 in 342 cities in 18 countries for the year 2002, relating to 100 million inhabitants, were reported to the AirBase system of the European Environment Agency. Measurements of PM10 concentrations in rural background were performed at 36 EMEP sites. The exceedances of EC PM10 limit values (40 $\mu g/m^3$ as an annual average) were widespread in urban areas in Europe. They were also exceeded in rural areas in some countries. The PM10 data at urban locations in Europe, where measurements started in the 1990s, showed a decreasing trend until 1999 and an upward one since then. PM10 concentrations in Europe followed the rural background concentrations (i.e. polluted mostly by remote sources) with local peaks related to traffic on busy roads.

8. Monitoring of PM2.5 was being performed at few locations only. Data from 30 stations were available in AirBase for 2002. PM2.5 was measured in parallel to PM10 at 19 EMEP sites. The PM2.5/PM10 ratios were around 0.65 (range from 0.42 to 0.82). The rural background sites seemed to have somewhat higher ratios than urban traffic sites.

9. The EMEP Eulerian model provided mean concentrations of PM2.5 from anthropogenic sources for different emission scenarios with assumed constant current meteorological conditions. Current methods and data did not allow modelling of secondary organic aerosols. Therefore, model outputs generally underestimated anthropogenic contributions to PM. The calculations indicated that the population exposure to PM2.5 would be reduced substantially in most of western and central parts of Europe if current emission reductions were implemented. Such improvements were estimated to be much smaller in the Eastern part of Europe.

10. Roughly one third of the primary PM10 emissions in the 15 European Union (EU) Member States originated from industrial processes and other non-combustion sources (e.g. agriculture). The transport sector contributed to a quarter of emissions. Combustion in the domestic/household sector (mainly wood fuel used in small stoves) was estimated to contribute to

less than 20% of the emissions. In the new EU Member States, the largest share of primary PM10 emissions was due to the combustion of coal, mainly in the domestic sector.

11. Primary PM10 and PM2.5 emissions decreased by 51% and 46% respectively in the period 1990–2000. The relative contribution of industry to PM10 and PM2.5 emissions decreased slightly and the contribution of transport increased. The decline of primary PM emissions was a consequence of the decreased consumption of solid fuels. This was mainly due to the economic restructuring in Central and Eastern Europe and to stricter emission control requirements for stationary and mobile sources.

12. The decline in primary PM emissions would be accompanied by reduced emissions of precursors of secondary particles. For the 25 EU Member States, the full implementation of present emission control legislation would reduce SO_2 emissions by 70% between 2000 and 2020 and NOx and VOC by 55%. Only small changes were anticipated for ammonia emissions. A clear exception was international shipping, where NOx and SO_2 emissions were predicted to increase by 28% and 52% respectively.

13. Current and future impacts of anthropogenic PM on life expectancy were calculated by the RAINS model of the Centre for Integrated Assessment Modelling, based on the advice of the World Health Organization and the Task Force on Health as well as on results from the EMEP Eulerian model. The impact of long-term exposure to PM on mortality, expressed as reduction of life expectancy, amounted to 8.6 months (confidence limit 7.7–9.6 months) in the 25 EU member States. Country-specific estimates ranged from 3.1 months (Finland) to 13.4 months (Belgium). These impacts should decline to 5.4 months by 2020 (averaged for 25 EU member States), when the impacts would still be highest for Belgium (8.8 months). The above figures apply to an average life expectancy of the whole country population, while only a fraction of deaths can be associated with air pollution. It was estimated that the latter group, i.e. individuals affected by the pollution, would lose on average about 10 years of expected life.

14. PM was expected to cause a wide range of acute diseases and symptoms in addition to mortality. For instance, about 51,000 hospital admissions per year were estimated to occur due to respiratory diseases. This number should fall to about 33,000 per year by 2020.

II. OZONE

15. The assessment of health impacts of ozone (O_3) from long-range transboundary air pollution started recently. The Task Force on Health has produced a first draft report. The analysis of data included estimates of health impacts of ozone exposure in the European population. More than 20,000 premature deaths per year could be currently attributed to ozone

exposure across Europe. Most impacts were expected in Italy, Germany, France, Spain, Poland and Spain. The estimates were based on the EMEP Eulerian model simulation and on the assumption that no effects occurred below 35 parts per billion (ppb) of maximum daily O_3 concentration.

16. Preliminary analysis indicated that most of the European population experienced some exposure over 35 ppb. The excess was less than 3 ppb for 70–80% of the population. The highest levels of exposure over 35 ppb (around 7 ppb) occurred in about 5% of the population.

17. Though the number and magnitude of ozone peak concentrations declined markedly during the last decade, mean ozone levels did not show significant changes. The exposure levels and their health impacts were not expected to change significantly in the immediate future.