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Recent results and updating of scientific and technical knowledge

Effects of Air Pollution on Health

Report by the Joint Task Force on the Health Aspects of Air Pollution[1]

I. Introduction

1. This report comprises the results of the discussion on health impacts of particulate matter (PM) and ozone and provides a summary of other workplan items discussed by the Task Force meeting, presented here in accordance with item 3.8 of the 2011 workplan for the implementation of the Convention (ECE/EB.AIR/106/Add.2) adopted by the Executive Body at its twenty-eight session in December 2010.

2. The fourteenth meeting of the Task Force on the Health Aspects of Air Pollution (TFH) was held in Bonn, Germany, on 12 and 13 May 2011. Altogether 44 experts from 30 Parties to the Convention attended the meeting chaired by a representative from the European Centre for Environment and Health (WHO/ECEH). A representative of the European Commission (Directorate General Environment) attended the meeting as well. The representative of the United States of America as well as two further experts from France attended a part of the discussion via electronic media. The meeting was chaired by M. Krzyzanowski (WHO/ECEH) and co-chaired by P. Straehl, Switzerland. Mr. T. Kyrklund acted as a rapporteur. Financial support of the Swiss and German governments to the meeting is acknowledged.

[1] The Joint Task Force on the Health Aspects of Air Pollution of the World Health Organization's European Centre for Environment and Health and the Convention on Long-range Transboundary Air Pollution's Executive Body.

II. Workplan items common to all Programmes

A. Monitoring and modelling of air pollution health effects

3. The European Topic Centre on Air Pollution and Climate Mitigation (ETC/ACM) of the European Environment Agency (EEA) maintains database of results of air quality monitoring performed by national monitoring networks in Europe. Though focussed on European Union's (EU) Member States, the database is open to other countries, allowing the most comprehensive evaluation of air quality, population exposure and their trends available in Europe. Additional information is collected by WHO and presented by ENHIS system. The most recent data available for analysis relate to 2009 and cover 34 European countries. A decrease of PM10 levels has been observed in 2007-2009 compared with the period 2000-2006 (for the countries with at least 3 years of data available). However, ca. 83% of urban population of Europe continues to live in cities where *WHO Air Quality Guidelines* level for annual mean PM10 are exceeded. Monitoring of fine PM (PM2.5) is expanding and is conducted in ca. 500 locations in Europe. Monitoring of PM10 and PM2.5 is very limited in the countries in Eastern Europe, the Caucasus and Central Asia (EECCA). Ozone levels tend to decrease in rural locations but increase in urban areas.

B. Contribution to ex post analysis

4. Following the TFH advice, the Centre for Integrated Assessment Modelling (CIAM) has implemented new method of estimating health impacts of particulate matter, using cause-of-death specific risk coefficients instead of the old method, based on the coefficient of risks for all-cause mortality. The new estimates show ca. 27% higher overall impact on health (expressed by the years of life lost) than the old estimates. The difference is especially high for the non-EU countries, with the new estimates exceeding the old ones by 54%. The estimated loss of life expectancy attributed to PM exposure estimated with the new approach amounts to 10.5 months on average in Europe, compared to 8.3 months calculated with the old method (9.9 vs. 8.6 for EU and 11.9 vs. 7.7 for non-EU, respectively). Most (87%) of the estimated impact is due to deaths from cardiovascular diseases.

5. The Task Force evaluated the new approach and agreed that it should give more precise estimate of burden of disease attributable to air pollution in countries with different structure of causes of death than that in the United States. However, the uncertainty of risk coefficients for cause-specific mortality is still relatively higher than that for all-cause mortality. Therefore, the Task Force recommended continuing the use of the old method as the main one in the cost-benefit analysis both in support of the revision of Gothenburg Protocol[2] and for the revision of the EU National Emission Ceiling Directive until the new results from cohort studies in Europe are available.

6. Further development of the health impact assessment modelling was presented by the APHEKOM project[3]. Using the data from 10 cities in Europe and assuming that the air pollution is contributing both to the development of chronic disease and to the episodes of exacerbation of these diseases, the project estimated that 15-30% of exacerbations of asthma in children, acute worsening of chronic obstructive pulmonary disease and acute chronic heart disease problems are attributable to air pollution. These estimates are substantially

[2] 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone

[3] Improving knowledge and communication for decision making on air pollution and health in Europe

larger than previous estimates assuming that only the exacerbation of disease are attributable to air pollution and ignoring that air pollution may cause the underlying disease as well.

7. The on-going project to estimate the Global Burden of Diseases, Injuries and Risk Factors (http://www.globalburden.org/), will produce the estimates for impacts of PM2.5 in all regions of the world in January 2012. It is based on exposure estimates calculated from satellite data (MODIS/MISR), chemical transport model (TM5) and ground level measurements. The concentration-response function used by the project is based on the combination of results of cohort studies on health effects of outdoor air pollution with studies of effects of PM from other combustion sources, including second-hand smoke and tobacco smoking. This approach is based conceptually on a joint analysis of the risks of mortality associated with the exposure to airborne fine PM and cigarette smoke which modelled the shape of exposure – response association with cardiovascular mortality and lung cancer at various, quite diverse, PM exposure levels. This approach allows the impacts of exposure to PM2.5 to be estimated in locations where PM levels exceed the relatively low concentrations of PM that have been studied in epidemiologic cohort studies performed in US and Canada.

III. Health Impacts of PM and Ozone

A. Progress in research on health effects

8. The on-going European Study of Cohorts for Air Pollution Effects (ESCAPE), conducted by 24 universities and research institutes spread over Europe, coordinated by the Utrecht University and funded by EU FP7 involves 30 existing cohorts, with ca. 645 000 children and adults. Exposure of the cohort members to air quality is estimated by the use of the existing AQ monitoring data, special monitoring performed by ESCAPE (including assessment of elemental composition of PM done by an associated study TRANSPHORM[4]) as well as by the land use regression models. The first results of the study are expected in 2012.

9. The Task Force discussed estimation of health burden of long term exposure to ozone. There is growing evidence for such effects. However, in view of existing uncertainties, the Task Force recommended to continue calculation of impacts based on short term effects, observed in time series studies, until new data from epidemiological studies are available.

10. The Task Force confirmed the need for further intensive research on health effects of air pollution and in particular on effects of individual pollutants (PM, ozone, NO2), their mixtures, chemical/physical characteristics of PM, specific (also genetic) vulnerabilities and mechanisms of effects. Investment in research infrastructure, such as establishment of new cohorts and long-term complex monitoring of air pollution, will be necessary to reduce the knowledge gaps and to better support policies.

[4] Transport related Air Pollution and Health impacts Integrated Methodologies for Assessing Particulate Matter – EU Project

B. Health effects of black carbon as a component of PM2.5

11. Following the Executive Body decision 2010/2 (ECE/EB.AIR/106/Add.1, para 8(b)(i)), the Task Force conducted an assessment of health effects of black carbon (BC) as a component of fine particulate matter (PM2.5). Based on the working papers prepared for the Task Force and comments received from external reviewers, the Task Force discussion focussed on formulation of conclusions presented below.

12. Black carbon (BC) is an operationally defined term which describes carbon as measured by light absorption. As such, it is not the same as elemental carbon (EC), which is usually monitored with thermal-optical methods. Current measurement methods of BC and EC need standardization to facilitate comparison between various study results. The main sources of BC are combustion engines (especially diesel), residential burning of wood and coal, power stations using heavy oil or coal, field burning of agricultural wastes, as well as vegetation and forest fires. Consequently, BC is a universal indicator of a variable mixture of particulate material from a large variety of combustion sources and, when measured in the atmosphere, BC is always associated with other substances from combustion sources, such as organic compounds. Spatial variation of BC is larger than that of PM2.5. Though, in general, ambient measurements or model estimates of BC reflect personal exposures reasonably well and with similar precision as it is the case for PM2.5, the differences in exposure assessment errors may vary between studies, possibly affecting risk estimates.

13. Systematic review of the available time-series studies as well as information from panel studies provide sufficient evidence of an association of short-term (daily) variations in BC concentrations with short term changes in health (all causes and cardiovascular mortality, cardio-pulmonary hospital admissions). Cohort studies provide sufficient evidence of associations of all cause and cardiopulmonary mortality with long-term average BC exposure.

14. Health outcomes associated with exposure to PM2.5 or thoracic particles (PM10) were usually also associated with BC (and vice versa) in the reviewed epidemiological studies. Effect estimates (both from short-term and long-term studies) were much higher for BC compared to PM10 and PM2.5 when the particulate measures were expressed per unit of mass concentration ($\mu g/m^3$). However, the effect estimates were generally similar per inter-quartile range in pollutant levels. Studies on short-term health effects showed that the associations with BC were more robust than those with PM2.5 or PM10, suggesting that BC is a better indicator of harmful particulate substances from combustion sources - especially traffic - than undifferentiated PM mass. In multi-pollutant models used in these studies, the BC effect estimates were robust to adjustment for PM mass whereas PM mass effect estimates decreased considerably after adjustment for BC. The evidence from long-term studies is inconclusive: in one of the two available cohort studies, using multi-pollutant models in the analysis, the effect estimates for BC were stronger than those for sulphates, but an opposite order in the strength of relationship was suggested in the other study.

15. Available clinical or toxicological studies are insufficient to allow of an evaluation of the qualitative differences between health effects of exposure to BC or to PM mass (e.g. different health outcomes), of quantitative comparison of the strength of the associations or of identification of any distinctive mechanism of BC effects. The review of the results of all available toxicological studies suggested that BC (measured as EC) may not be a major directly toxic component of fine PM, but it may operate as a universal carrier of a large variety of especially combustion-derived chemical constituents of varying toxicity to sensitive targets of the human body such as the lungs and its major defence cells, and possibly the systemic blood circulation.

16. The Task Force agreed that the reduction of exposure to PM2.5 containing BC and other combustion related PM material for which BC is an indirect indicator, should lead to reduction of the health effects associated with PM. The Task Force recommended continuing the use of PM2.5 as the primary metric in quantifying the human exposure to PM and its health effects, and for predicting the benefits of exposure reduction measures. In evaluation of local actions aimed at reduction of population exposure to combustion PM (e.g. from motorized traffic) the use of BC as an additional indicator may be useful.

IV. Review of Methods of Communication on Health Significance of Air Quality and Assessment of Feasibility for Harmonization of the Information

17. Following the recommendations of the 13th Task Force Meeting, the Task Force launched a project to evaluate the format, contents and interpretation of the data on air quality published by monitoring networks. In particular, the interpretation of health significance of the observed levels of air pollution was evaluated. A total of 26 web sites from 15 European countries, USA and Singapore, as well as two sites covering several countries of Europe were accessed and reviewed by a group of invited experts. The working paper summarizing the evaluation was distributed to the Task Force members in advance of the Task Force meeting, providing the background to discussion.

18. The review indicated that the principles used by the publishers of the information to define air quality vary substantially. Different sets of pollutants are addressed as the basis of the assessment, though PM, ozone and NO2 are used most often. Several sites combine air quality information to an index of pollution defined differently by various countries. The borders of categories and the adjectives used to describe air quality show large and unexplained differences. Health related information is available on half of the reviewed web sites but vary considerably between the sites, potentially sending contradictory messages.

19. In discussing the feasibility of international harmonization of the information presentation, the Task Force pointed to the possible reasons for the differences in messages. They may be due to the different climatic conditions, different target groups addressed by the publishers of the sites or due to the differences in basic assessment of the hazardousness of the pollution. The Task Force indicated that a common “scale” of the health effects appearing at various levels of air pollution, and related to various combinations of pollutants would be helpful in agreeing on more coherent messages. The scale should be expressed not only as increased risk of a serious effect (e.g. increase in risk of hospitalization or of premature death) routinely used in health impact assessment but also in terms of incidence of more common, but less severe, symptoms.

20. The discussion addressed also the role of the communication about air quality. The most common purpose of the web-based systems (originating in the “alert systems”) is informing the public about immediate risks to health and about measures to prevent occurrence of health effects of exposure to current air pollution in susceptible population groups (as people with pre-existing cardiovascular or respiratory diseases). The Task Force recommended exploring also educational aspects of the information, increasing understanding of the significance of long term exposure to relative low concentration of pollutants. Such understanding would increase acceptance for actions and policies contributing to reduction of longer term average air pollution.

V. Cross-cutting issues

21. The review of EU air quality policies planned for 2011-2013 will provide an opportunity for intensification of policy-related work on assessment of health aspects of air pollution. The Task Force will follow and, where appropriate, contribute to these assessments since they are highly correlated with the Task Force work supporting the Convention.