FOSSIL FUEL ENERGY IMPACTS ON HEALTH

Helena Ribeiro
Department of Environmental Health, Faculdade de Saúde Pública, Universidade de São Paulo, Brazil

Keywords: Fossil Fuel, Combustion, Air Pollution, Respiratory Diseases, Environmental Health.

Contents

Summary

The main effects of energy from fossil fuels on health are related to ambient air pollution resulting from combustion. Many professionals are involved in this complex field of studies. Scientific research has focused mainly on respiratory diseases because of the strong associations found during episodes of acute air pollution. Two approaches have been adopted: toxicologic and epidemiologic. The objectives have been to evaluate the short-term and the long-term effects of air pollution on health. A short bibliographic review gives an historical overview of these studies. Main health effects are summarized in Table 1 and explained in greater detail in Section 3. In conclusion, the main trends in the studies are pointed out.

1. Introduction

The main effects of fossil fuel energy use are related to changes in the composition of ambient air, called air pollution, and some of its side effects. Ambient air pollution resulting from the combustion of fossil fuels includes emissions from motor vehicle

engines (mobile sources), from power plants (stationary sources), and from area sources such as fireplaces and barbecues. These various sources generate predominantly different emissions, which have specific effects on human health that will be described in next sessions of this article.

Pollution from fossil fuel is an important topic of study in medicine and for public health. Thus many professionals have been involved in inquiries regarding its effects: clinicians who evaluate health of exposed individuals, toxicologists who define the injury resulting from the pollutant, and epidemiologists and medical geographers who identify and address the effects of exposed groups.

The main diverse effects on human health of atmospheric pollutants resulting from fossil fuel combustion are: opthalmic problems, skin injuries, gastro-intestinal, cardio-vascular and respiratory diseases, and some types of cancer. Effects on the nervous system have also been associated to high levels of carbon monoxide in the air. Indirect health effects may be related to climatic changes caused by air pollution.

An increase in air temperature has impacts on the distribution of fauna and flora, thus affecting the space distribution of some vector borne diseases. In addition, heat accumulation in urban centres, associated with the use of fossil fuels, has adverse health effects especially for old people.

Neverthless, most diseases are known to be multifactorial in aetiology; for this reason the task of evaluating health effects of pollutants is not an easy one. As well as this, some of these impacts have not been completely evaluated, so there is no scientific basis on which to quantify health risks associated with the use of fossil fuel energy. Scientific research on the impacts on health of fossil fuel energy use has focused mainly on respiratory diseases because the association in this case is more evident.

2. Air Pollution and Respiratory Diseases

2.1. First Studies

The existing literature about the relationship between air pollution and respiratory diseases is very wide. The first studies correlating respiratory diseases with air pollution date from the 1950s. Those pioneer studies and many others that followed them were undertaken mainly in cities and metropolitan areas with acute problems of air pollution, aggravated by unfavorable weather conditions: Los Angeles, London, Tokyo, and New York.

These enquiries were, in great part, motivated by acute episodes of air pollution that became famous for their intensity, duration, and negative impacts on the population. The most widely known are those that ocurred: in 1903 in the Meuse Valley in Belgium; in 1948 in Donora, Pensylvania, which lasted 5 days, affected 43% of its inhabitants, and caused 20 deaths; and the London episode, in 1952, that also lasted 5 days and caused 4000 deaths. In 1969, a widespread episode affected 20 states in the industrial zone of the United States, in an area from the Great Lakes to the Gulf of Mexico.

These early studies had an important role in promoting air quality control policies in those areas, and the levels of pollutants have decreased since then. As a consequence of the United States Clean Air Act of 1963, that established air quality standards for various pollutants, the mean annual average of particulate matter decreased from 90 $\mu g/m^3$ in 1960 to 60 $\mu g/m^3$ in 1978, and the level of SO_2 from 55 $\mu g/m^3$ in 1962 to 19 $\mu g/m^3$ in 1978.

England, already in 1956, had passed a Clean Air Act, restricting coal combustion for domestic use, without establishing air quality standards, but obtaining significant improvements in the London atmosphere. Already at that time, there was no question that high levels of atmospheric pollutants were deleterious to health in the short-term. But it was more difficult to detect whether, in the long run, even without transgressing maximum air quality standards, they have adverse health effects.

2.2. Conceptual Framework

Studies have adopted the conceptual framework of human exposure assessment. The exposure consists of contact at a boundary between a human and the environment at a specific environmental contaminant concentration for a specific interval of time (C x T). Presence of a pollutant in ambient air is presumptive evidence of human exposure. Personal exposure is the availability of a pollutant in the breathing zone of an individual.

Inhaled or potential dose is the product of the concentration of pollutant in ambient air and the volume of air inspired. Dose rate is the mass of pollutant inhaled per unit time. These concepts all have health implications. An individual's total personal exposure will depend on the time spent in different microenvironments and on activity patterns.

For example, vigorous exercise may lead to increased dose rate; also children may receive an increased delivered dose of outdoor pollutants compared to adults, because they have a higher per minute ventilaton per unit body mass than do adults, are generally more physically active, and spend more time outdoors than adults, as noted by the Committee of the Environmental and Occupational Health Assembly of the American Thoracic Society in 1996.

The various studies that have been undertaken have followed two approaches:

2.2.1. Toxicologic Studies

Undertaken in laboratories, toxicological studies can provide information about the level on which different air pollutants start to have acute health effects on animals and human beings. There are three main types:

- Animal bioassays provide a method to predict effects of air pollutants in humans. Even though extrapolation from animal models to humans have limitations, animal studies can use methods that would not be practical or ethical to apply on human subjects, including long-term studies, tissue collection, attempts to induce cancer, etc. For these reasons, animal studies have proven

useful in predicting human adverse responses to chemicals in the atmosphere and constitute the available data base on toxicity for risk assessment.

- In vitro studies include atmospheric chemistry and the chemical reaction of pollutants with substrates of interest and respiratory cells affected by inhaled, reactive toxicants, through biopsies and cell culture. Much useful informations on mechanisms of toxicant action can be obtained in these studies, even though data must be cautiously interpreted.
- Controlled human exposure studies are used to characterize the responses of normal children and adults, and of various disease subgroups (e.g. asthma, ischemic heart disease) to pollutants. They can only involve small and homogeneous groups of subjects who inhale pollutants through a mouthpiece or mask, or breathe naturally in an environmental chamber. This type of study produces evidence of acute health effects caused by specific components of a pollutant mixture. It also enables identification of sensitive human populations. These methods have limitations because it is quite difficult to reproduce in the laboratory all the ambient air conditions; only a restricted number of acute and subchronic exposure-response relations can be characterized; they are impracticable for long term studies; and they require considerable resources and facilities.

2.2.2. Epidemiologic Studies

These examine the association between exposure to different air pollution levels and health effects in the community setting. They have two objectives:

- To compare changes over time of ambient air conditions with fluctuations in mortality or morbidity data. In this case, the studies have focused mainly on short-term effects of pollution. In general, critical episodes have been correlated with hospital admissions, medical consultations, absences from work or school, or mortality data.
- To evaluate long-term effects, comparing morbidity and mortality data of areas with different pollution levels. These studies can be based on measurement of respiratory function, on X-rays or on questionnaires or interviews done with a selected group of the exposed population.

In spite of many conclusions arrived at by various research groups, the studies continue in search of a methodology that can eliminate all other possible factors that may cause or aggravate respiratory diseases, and which would interfere with their results: social differences, smoking habits, time of residence or permanence at the polluted area, individual susceptibility, psychological and emotional factors, and previous history of diseases, etc.

-
-
-

Bibliography

Bates D. V. (1972). Air Pollutants and the Human Lung. *American Review of Respiratory Disease* **105**, 1–13.

Committee of the Environmental and Occupational Health Assembly of the American Thoracic Society (1996). Health Effects of Outdoor Air Pollution. *American Journal of Respiratory and Critical Care Medicine* **153**, 3–50 and 477–498.

Dockery D. W. and Brunekreef B. P. (1996). Air Pollution Effects on Lung Function. *American Journal of Respiratory and Critical Care Medicine* **154**, S251–S256.

Ferris B. G. (1978). Epidemiology Standardization Project. *American Review of Respiratory Disease* **118**(6), 1-53.

Romieu I., Meneses F., Ruiz S., Sienra J. J., Huerta J., White M. C., and Etzel R. A. (1996). Effects of Air Pollution on the Respiratory Health of Asthmatic Children Living in Mexico City. *American Journal of Respiratory and Critical Care Medicine* **154**, 301–307.

Thurston G. D., Lippman M., Scott M. B., and Fine J. M. (1997). Summertime Haze Air Pollution and Children with Asthma. *American Journal of Respiratory and Critical Care Medicine* **155**, 655–660.

WHO and UNEP (1990). Indoor Environment: Health Aspects of Air Quality, Thermal Environment, Light and Noise, 127 pp. Geneva: WHO.

WHO (1974). *Chronic Respiratory Diseases in Children in Relation to Air Pollution*. Report of a Working Group.63 pp. Long Term Programme in Environmental Pollution Control in Europe. Dusseldorf: WHO.

WHO (1979). Sulphur Oxides and Suspended Particulate Matter: Environmental Health Criteria 8. 107 pp. Geneva: WHO.

Walsh M. (1995). *Global Trends in Diesel Particulate Control—A 1995 Update*, SAE Technical Paper Series # 950149, 15 pp. The Engineering Society for Advancing Mobility Land Sea Air and Space. Warrendale, PA, U.S.A.

Whittemore A. S. and Korn E. L. (1980) Asthma and Air Pollution in the Los Angeles Area. *American Journal of Public Health* **70**(7), 687–696.

Whittemore A. S. (1981). Air Pollution and Respiratory Disease. *Annual Review of Public Health* **2**, 397–429.

Biographical Sketch

Helena Ribeiro

Born in 1948 in S. Paulo, Brazil

Undergraduate course in Geography at Catholic University of Sao Paulo

Master of Arts in Geography by University of California – Berkeley

PhD in Physical Geography by University of Sao Paulo, Brazil

Post Doctorate in Public Health at the University of Sao Paulo, Brazil

Course in Environment and Development at International Academy of Environment in Geneva, Switzerland

Professor of the Catholic University of Sao Paulo

Professor of the Environmental Health Department of the School of Public Health of the University of Sao Paulo until present time

Environemntal Advisor to the Mayor of Sao Paulo, Brazil (1990-1992)

Since 1984 has been studying air pollution dynamics and related health effects in Sao Paulo Metropolitan area in a medical geography perspective

Has many publications in the field of urban environment.