An ex post cost-benefit analysis of the nitrogen dioxide air pollution control program in Tokyo

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Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
The impact of nitrogen dioxide (NO2) control policy on the following was examined: the health of humans, animals and plants; productivity, in terms of the work time lost by human workers due to illness and damage to crops, livestock and buildings; and amenity, such as the pleasure derived by visiting a park or natural area for recreational purposes, or odour, noise and impaired visibility.

Type of intervention
Other: pollution control programme.

Economic study type
Cost-benefit analysis.

Study population
The study population comprised all inhabitants of the Tokyo area.

Setting
The setting was the community. The economic study was carried out in Tokyo, Japan.

Dates to which data relate
The effectiveness and resource use data were gathered from 1973 to 1994. The price year was 1994.

Source of effectiveness data
The effectiveness data were derived from pre-existing databases.

Modelling
All equations for calculating the costs and benefits were provided.

Outcomes assessed in the review
The outcomes assessed from pre-existing databases were:

- the number of trips each weekday into Tokyo from other prefectures and within Tokyo;
- the reported NO2 emissions in kg/year;
- the number of registered motor vehicles;
the number of stationary sources;
the incidence of phlegm and sputum in adults and workers;
the incidence of lower respiratory illness in children (colds going to chest, chronic wheeze and cough, bronchitis, chest cough with phlegm, and episodes of respiratory illness);
the duration of outpatient illness due to pollution in Tokyo;
the number of working mothers in Tokyo; and
the lost productivity from illness due to exposure to NO2 emissions.

These data were used to estimate the hypothetical net increases in NO2 concentrations in 1994 in the absence of controls. They were also used to estimate the excess incidences of respiratory illnesses and lost productivity.

**Study designs and other criteria for inclusion in the review**
Data were collected from the Tokyo Metropolitan Government (TMG), the Japan Environment Agency (JEA), and the US Environmental Protection Agency (EPA).

**Sources searched to identify primary studies**
Not stated.

**Criteria used to ensure the validity of primary studies**
Not stated.

**Methods used to judge relevance and validity, and for extracting data**
Not stated.

**Number of primary studies included**
The outcome data used in the effectiveness analysis were derived from three databases.

**Methods of combining primary studies**
Narrative methods were used.

**Investigation of differences between primary studies**
Not stated.

**Results of the review**
The total number of uncontrolled NO2 emissions was 96,364,000 kg/year in 1972 (actual figure) and 151,000,000 kg/year in 1994 (hypothetical figure). The total number of controlled NO2 emissions in 1994 was 55,300,000 kg/year. Consequently, the ratio of uncontrolled to controlled NO2 emissions was 2:7.

**Measure of benefits used in the economic analysis**
The benefit measure used in the economic analysis was the value of NO2 effects on human health and productivity, such as the hypothetical medical expenses and lost work time associated with the NO2 control programme. It was derived from the effectiveness analysis using published methodology. The cost of illness (COI) approach was followed.
Direct costs
The unit costs were reported separately from the quantities of resources used. The analysis of the costs included NO2 control for soot-and-smoke-emitting facilities, motor vehicles, and government agencies in Tokyo. The cost/resource boundary reflected that of the society, as the direct costs included in the analysis referred to three economic sectors. The sectors were private (capital and operating costs), government (national and local regulatory agency budgets), and society (opportunity cost, such as foregone income from other uses of a resource, which could not be realised because the resource was used in the context of environmental regulations). The direct costs were calculated as the annualised capital expenditures and one year's operating costs. Consequently, discounting was not carried out. The unit costs and resource use were estimated from actual data, derived from TMG, JEA, the Japan Ministry of Transportation and the US EPA. The authors made some assumptions when the data were unavailable. The price year was 1994.

Statistical analysis of costs
No statistical analysis of the costs was carried out, but the lower and upper bounds of the cost estimates were provided.

Indirect Costs
The indirect costs, such as productivity losses, were analysed as benefits since a cost-benefit analysis was carried out. Thus, see the 'Benefits' field.

Currency
Japanese yen (Y). Conversions into US dollars ($) were also reported.

Sensitivity analysis
The impact of several cost and benefit estimates and assumptions made in the analysis, was investigated using a one-way sensitivity analysis. This tested the uncertainty around the data, such as variations in the number of daily trips in Tokyo, or the use of different health end points. A detailed discussion of the use of other formulae and assumptions to calculate the costs and benefits was carried out.

Estimated benefits used in the economic analysis
The average estimate of the avoided medical costs in adults was Y730 billion (range: 680 - 770 billion). This corresponded to $6.08 billion.

The average estimate of the avoided medical costs in children was Y93 billion (range: 86 - 100 billion). This corresponded to $775 million.

The average estimate of the avoided costs of lost wages in workers was Y760 billion (range: 720 - 810 billion). This corresponded to $6.33 billion.

The average estimate of the avoided costs of lost wages in mothers caring for sick children was Y100 billion (range: 95 - 110 billion). This corresponded to $833 million.

Cost results
The mean costs were Y260,000 million (range: 240,000 - 280,000 million) for soot-and-smoke-emitting facilities, Y14,000 million (range: 13,000 - 15,000 million) for motor vehicles, and Y2,300 million for government agencies.

The total costs of the NO2 control programme in Tokyo in 1994 were Y280,000 million (range: 260,000 - 300,000 million). This corresponded to $2.33 billion.
Synthesis of costs and benefits
The costs and benefits of the pollution control programme were combined. The best net benefits-to-costs ratio was 6:1 (lower limit 0.3:1; upper limit 44:1). The factors that mostly affected the estimated benefit-cost ratio were data on mobile source emissions, the inclusion of specific health impacts, and assumptions on flue gas volume and fuel use.

Authors’ conclusions
The nitrogen dioxide (NO2) control programme carried out in Tokyo was effective, as approximately 6 Japanese yen of benefits were obtained from every 1 yen of costs in 1994.

CRD COMMENTARY - Selection of comparators
The choice of the comparator was justified. The pollution control programme was compared with no programme, as the aim of the analysis was to determine the economic effectiveness of the intervention in comparison with the prior practice of no intervention. You should assess whether no pollution control programme represents a valid comparator in your own setting.

Validity of estimate of measure of effectiveness
The effectiveness analysis used an ex-post retrospective study, carried out by combining the outcome data derived from pre-existing databases. The estimated data were then used to calculate the benefits of the intervention using published formulae. The authors also justified the selection of NO2 to determine urban pollution. The authors noted that some factors, such as the introduction of electronic fuel injection and electronic ignition in motor vehicle engines, may have represented potential biases. The sensitivity analyses, however, showed that such factors had little impact on the estimated benefits of the programme.

Validity of estimate of measure of benefit
The benefit measure used in the economic analysis was the economic impact of the pollution control programme on medical expenses and lost work time. It represents a common benefit measure in cost-benefit analysis. The authors noted that some limitations were associated with the COI approach, which was used instead of contingent valuation (the willingness to pay approach). These include the lack of valuation of pain, suffering or quality of life and risk aversion. It does not, however, seem likely that the inclusion of these would change any decision relating to this technology.

Validity of estimate of costs
The analysis of the costs was carried out from a societal perspective. It would appear that all the relevant categories of costs have been included in the study. The authors noted that, although the source of some costs was not robust, their estimates were similar to those reported in other studies. The potential biases in the cost estimation were appropriately reported. The costs were treated deterministically, but ranges of values were reported. Appropriate currency conversions were carried out.

Other issues
The authors compared their findings, and the cost and benefit estimates they used in the analysis, with those from other published studies. The issue of the generalisability of the study results to other settings was not explicitly addressed. However, sensitivity analyses were carried out and the unit costs were reported separately from the quantities of resources used. This enhanced the external validity of the analysis. The authors acknowledged that the assumptions made in the analysis may have represented a limitation of the study. However, the factors that mostly affected the study results were highlighted.

Implications of the study
The conclusion that the NO2 control programme in Tokyo was economically effective must be interpreted in the light of the limitations of the analysis. The authors suggested that future studies should take into account human health
benefits, ecosystem health and productivity effects, nonliving system effects, and benefits associated with ancillary reductions in other pollutants.

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