Ministerial Review of PM_{10} Regulations in the Air Quality Standards

Tim Denne
September 2009

Benefits of Reductions in PM_{10} Emissions

Most studies of the benefits of air pollution control are dominated by reductions in the chronic mortality impacts of small particulates. Studies in New Zealand have estimated PM_{10} impacts in the form of numbers of premature deaths using robust techniques building on international best practice. However, very largely these studies show the impacts of current (or historical) elevated concentrations, rather than the effects of changing those concentrations. This is an important distinction. New Zealand studies have built on the international epidemiological studies but do not appear to have taken account of advances in the policy studies, especially those that have applied the epidemiology to decisions at the margin, ie the effects of changes in concentrations, as opposed to the effects of current concentrations.

We address two issues below: lag effects and monetary valuation.

Lag Effects

The mortality studies include[1]:

- Time series studies of acute exposure, ie the impacts of short term spikes in concentrations; and
- Cohort studies of chronic (long term) exposure that result in changes to age-specific death rates.

The impacts across a wide range of studies are dominated by the chronic effects. These studies show the impact on death rates, or more correctly life expectancy, of long term exposure to elevated levels of pollution. However, the results need to be interpreted with some caution.

The long and short term impacts can be explained using a two by two matrix (Table 1). Susceptibility to death may be increased because of air pollution or some other cause, eg illness, and the event of death may be triggered by air pollution or another cause. The long term studies that demonstrate a linkage between rates of death and long run exposure to pollution, do not separate out causes A, B and C.

---

[1] AEA Technology Environment (2005) . Methodology for the Cost-Benefit Analysis for CAFE: Volume 2: Health Impact Assessment. .Service Contract for Carrying out Cost-Benefit Analysis of Air Quality Related Issues, in particular in the Clean Air for Europe (CAFE) Programme. Methodology for the Cost-Benefit Analysis for CAFE: Volume 2: Health Impact Assessment.

Table 1 Long-term Frailty and Trigger of Death

Long-term frailty	Event of death	
	Related to air pollution	Not related to air pollution
Related to air pollution	A	B
Not related to air pollution	C	D

Source: Seethaler, RK, Künzli N, Sommer H, Chanel O, Herry M, Masson, S, Vergnaud J-C, Filliger P, Horak F Jr, Kaiser R, Medina S, Puybonnieux-Texier V, Quénel P, Schneider J, Studnicka M and Heldstab, J (2003) Economic Costs of Air Pollution Related Health Impacts: An Impact Assessment Project of Austria, France and Switzerland. Clean Air and Environmental Quality, 37/1: 35-43

While a reduction in emissions may reduce the number of deaths immediately related to air pollution (A and C), average levels of long term frailty in the population will change slowly over time.

However, despite this, the results of studies used to estimate current premature mortality owing to air pollution have been used to estimate marginal effects of reducing pollution levels, including as an input to the development of national environmental standards for air quality. [2] The approach used in New Zealand is consistent with numerous overseas studies but misleading as a measure of the expected effect, principally because it assumes that reductions in emissions or concentrations will have an immediate and proportional reduction in the number of premature deaths, but also because of the approach used to measure damage (as discussed below).

The cohort studies used to establish the chronic effect suggest that people are frail as a result of a lifetime living in elevated concentrations of pollutants. Given this, even if air pollution is cut to zero tomorrow, these people will still be frail and many will die prematurely because of this frailty. The reduction in emissions stops some additional frailty and would be expected to allow some repair if cut completely, however even if all pollution is eliminated, it will take many years without pollution and probably decades for the full benefits to be realised.

In correspondence with some of the international workers on these issues, all agreed with these concerns and the implications for analysis, eg Nino Künzli[3] agreed that the full mortality benefit will not result immediately but that the answer to when it results is not known;[4] Arden Pope[5] suggested that after cutting emissions, the pollution damage effects will persist for years or even decades.[6]

---

[2] Ministry for the Environment (2004) Proposed National Environmental Standards for Air Quality. Resource Management Act Section 32 Analysis of the costs and benefits.

[3] He was a member of the US National Academy of Sciences Committee on Estimating the Health-Risk-Reduction Benefits of Proposed Air Pollution Regulations as an expert in the integration and interpretation of the science needed to estimate the public health impact of air pollution. (http://yosemite.epa.gov/sab/SABPEOPLE.NSF/WebPeople/KuenzliNino?OpenDocument)

[4] Nino Künzli, personal communication

[5] Professor of Economics at Brigham Young University. According to his CV, he is one of the world's most widely cited and recognized experts on the health effects of air pollution. His cross-disciplinary research in environmental epidemiology resulted in seminal studies on the effects of air pollution on

These effects are beginning to be taken into account elsewhere for policy.

The US EPA and the Health Effects Subcommittee (HES) have noted the importance of this delay issue and initially have used a weighted 5-year time course of benefits in which 25% of the PM-related mortality benefits were assumed to occur in the first and second year, and 16.7% were assumed to occur in each of the remaining 3 years.[7] Spreading the effects over time in this way matters in cost benefit analysis with discounting. The EPA has been considering use of a range of lag structures from 0 to 20-30 years, with 10 or 15 years thought to be the mid-point value until more definitive information becomes available. The HES endorsed the consideration of these alternative approaches that took account of long lags.

Subsequently, the EPA stated that it intended to further analyse the cessation lag question, but in the interim, it intended to use a lag structure which assumes 20% of the incidence reduction occurs in the first year of a reduction in PM exposure, another 50% is evenly spread among years 2 through 5 (ie 12.5% each year), and the remaining 30 percent of the incidence reduction is evenly spread out among years 6 through 20 (ie 2% each year)[8]. The recent RIA of the 2008 National Ambient Air Quality Standards for Ground-Level Ozone has included a range of lag structures.

Work for the European Commission has examined the effects associated with a 1-year pulse change, ie a sudden reduction in pollution for one year, as a way to understand the marginal effects.[9] Here, in contrast to a 6% increase in mortality for a 10µg/m^3 increase in $PM_{2.5}$ concentrations, they assumed a 2.4% increase in year 1, followed by 0.36% increases in years 2 to 11, followed by reversion to the original mortality rate.

All of the researchers that are starting to take account of these effects are using assumptions in the absence of studies that have truly examined a marginal effect. However, they demonstrate that the assumptions of an instantaneous response to reductions in emissions greatly over-estimate the measured impact.

---

pulmonary and cardiovascular health. Over the last 20 years, he has conducted or collaborated on key studies of short- and long-term air pollution exposure which have influenced environmental public health policy and air pollution standards in the U.S., Europe, and elsewhere. (http://fhssfaculty.byu.edu/Faculty/cap3/)

6 Arden Pope, personal communication.

7 US EPA (2004) Advisory on Plans for Health Effects Analysis in the Analytical Plan for EPA's Second Prospective Analysis—Benefits and Costs of the Clean Air Act, 1990-2020. Advisory by the Health Effects Subcommittee of the Advisory Council on Clean Air Compliance Analysis. (www.epa.gov/sab/pdf/council_adv_04002.pdf)

8 www.epa.gov/sab/pdf/comments_on_council_adv_04001.pdf

9 AEA Technology Environment (2005) Methodology for the Cost-Benefit Analysis for CAFE: Volume 2: Health Impact Assessment. .Service Contract for Carrying out Cost-Benefit Analysis of Air Quality Related Issues, in particular in the Clean Air for Europe (CAFE) Programme. Methodology for the Cost-Benefit Analysis for CAFE: Volume 2: Health Impact Assessment.

Quantification of Value

The costs of morbidity effects are typically estimated using the costs of treatment and/or lost production and value added; there is little controversy about these. However, there are a number of issues that are not fully resolved related to the measurement of the valuation of chronic mortality impacts.

The previous CBA used a simple approach to analysis involving the following calculation:

annual death rate x population size x %increase per $\mu g/m^3$ PM_{10} x change in PM_{10}

This results in an estimated number of attributable deaths. These have then been multiplied by an estimate of the value of a statistical life (VSL). This simple approach is described by the AEAT team advising the European Commission as easy to do and to communicate but wrong![10] There are a number of issues of concern.

It is misleading to picture the impacts in terms of a number of premature deaths, as though they are discreet individuals. This is especially so when making marginal changes to concentrations, not eliminating pollution. The cited number of additional "premature" deaths is likely to be an outcome of the reduced lifespans of thousands of individuals so that deaths are squeezed into fewer years and the total annual death rate changes by this amount. When there is a reduction in concentrations, premature deaths are not avoided; rather lifespan is extended. People are still dying prematurely, but not as early as they would have done otherwise.

This suggests that reporting the effect as a number of premature deaths may not be an appropriate metric for total mortality.[11, 12] A more appropriate metric is the loss of life expectancy (LE). The European team notes the simplifications involved in approaches using premature deaths and VSL relative to an approach that uses life tables in which the impacts of extra deaths in one year affect the structure of the population in future years.

As no empirical data on VOLYs were available, the European ExternE team calculated the VOLY by assuming that VSL is the sum of discounted annual VOLY over 30 to 40 years,[13] ie they produced an annuity from a VSL. To illustrate the difference in result, AEAT provides the results using VSLs and VOLYs; they estimate that each premature

---

[10] AEA Technology Environment (2005) Methodology for the Cost-Benefit Analysis for CAFE: Volume 2: Health Impact Assessment. Service Contract for Carrying out Cost-Benefit Analysis of Air Quality Related Issues, in particular in the Clean Air for Europe (CAFE) Programme.

[11] Desaigues B, Rabl A, Ami D, Boun My K, Masson S, Salomon M-A and Santoni L (2004) Monetary Valuation of Air Pollution Mortality: Current Practice, Research Needs and Lessons from a Contingent Valuation (www.arirabl.com/papers/MortalVal-Desaigues%20et%20al04.pdf)

[12] Rabl A 2003. "Interpretation of Air Pollution Mortality: Number of Deaths or Years of Life Lost?" *J Air and Waste Management*, Vol.53(1), 41-50 (2003).

[13] Desaigues B, Rabl A, Ami D, Boun My K, Masson S, Salomon M-A and Santoni L (2004) Monetary Valuation of Air Pollution Mortality: Current Practice, Research Needs and Lessons from a Contingent Valuation (www.arirabl.com/papers/MortalVal-Desaigues%20et%20al04.pdf)

death represents a loss of one life year on average, ie people die one year earlier as a result of air pollution. The results are shown in Table 2 converted to New Zealand dollars. The VOLY results are significantly different and much lower.

Table 2 Values of Lives Lost from Air Pollution (NZ$)

	VSL	VOLY
Median	$1,960,000	$100,000
Mean	$4,000,000	$240,000

Source: AEA Technology Environment (2005) Service Contract for Carrying out Cost-Benefit Analysis of Air Quality Related Issues, in particular in the Clean Air for Europe (CAFE) Programme. Methodology for the Cost-Benefit Analysis for CAFE: Volume 2: Health Impact Assessment Converted to NZ$ at NZ$1:€0.5

The 2004 cost benefit analysis for the air quality strategy used a VSL approach and a value of $1.88million. This was derived from work by Transfund on the value of life for accidents, adjusted to reflect the older population likely to die from air pollution.[14] It would suggest that an appropriate VOLY for NZ would be approximately $96,000.[15]

However, even this VOLY is likely to be an over-estimate for the marginal effects because there is an assumption of divisibility of effect. The calculation assumes that extending life by one year is valued as 1/40th of saving a life of say a 40-year old from death by a motor accident. The studies that exist do not suggest this.

The first survey, to our knowledge, that asked explicitly about the valuation of a gain in life expectancy was by Swedish researchers Johannesson & Johansson. They administered a telephone survey and asked the following question "*The chance for a man/woman of your age to become at least 75 years old is x percent. On average, a 75-year old lives for another 10 years. Assume that if you survive to the age of 75 years you are given the possibility to undergo a medical treatment. The treatment is expected to increase your expected remaining length of life to 11 years. Would you choose to buy this treatment if it costs y and has to be paid for this year?*"[16] The resulting VOLY values are very low, in the range of NZ$1,000 to $2,000.

Implications

Morbidity and acute mortality effects appear to be well analysed and included appropriately in cost benefit analysis. However, cost benefit analyses have very significantly over-estimated the benefits of reductions in chronic mortality. They have done so by assuming that:

---

[14] Ministry for the Environment (2004) Proposed National Environmental Standards for Air Quality. Resource Management Act Section 32 Analysis of the costs and benefits.

[15] $1,880,000 ÷ $1,960,000 x $100,000

[16] Johannesson M & P-O Johansson 1997. "Quality of life and the WTP for an increased life expectancy at an advanced age". *J Public Economics*, 65, 219-228 in: Desaigues B, Rabl A, Ami D, Boun My K, Masson S, Salomon M-A and Santoni L (2004) Monetary Valuation of Air Pollution Mortality: Current Practice, Research Needs and Lessons from a Contingent Valuation (www.arirabl.com/papers/MortalVal-Desaigues%20et%20al04.pdf)

- the full benefits of lower PM_{10} concentrations are obtained immediately following a reduction in emissions;

- that changes in death rates can be characterised as premature deaths of discreet individuals;

- that the value of reducing death rates can be estimated from willingness to pay to avoid accidents of a person of average age.

None of these assumptions are correct. Rather:

- the full benefits occur if concentrations of small particulates are reduced to lower concentrations and maintained at these lower levels for a long time. We know for certain only that the full benefits are obtained when individuals have lived their whole lives at lower concentrations;

- the benefits from reduced chronic impacts are best characterised as extensions of life for numerous individuals;

- the limited studies that exist suggest that people place a relatively low value on these life extensions.

While these issues are still the subject of ongoing research, any cost benefit analysis should separate out the chronic mortality impacts and treat these values with considerable caution and with appropriate uncertainty.

…………………

Tim Denne
Director, Covec, Level 15, 191 Queen Street, Auckland 1010
tim.denne@covec.co.nz
(09) 916 1960

Tim Denne is an economist and a Director of Covec. He has been working on the economics of air pollution for over 15 years including advising the European Commission on non-monetary valuation techniques within the ExternE project and leading a CBA for the European Commission on the EC Large Combustion Plant Directive (LCPD). He has assessed particulate control benefits in NZ studies on the environmental impacts of thermal power generation and the benefits of biofuels supply. He advised the UK Royal Commission on Environmental Pollution on the appropriate use of CBA in environmental policy and was part of the group advising the UK government on its implementation of the LCPD. He was formerly Deputy Director of the Washington DC-based Center for Clean Air Policy where he led studies and chaired meetings including a USEPA Binational Toxics strategy meeting; he was formerly head of the climate change team at MfE and has represented both New Zealand and the European Commission in international negotiations. He holds a PhD from the University of London.