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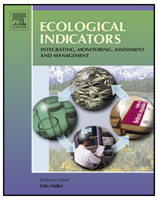

Original Articles

Co-benefits of climate mitigation: Counting statistical lives or life-years?

Mikael Skou Andersen

Dept. of Environmental Science, Aarhus University, Nordre Ringgade 1, 8000 Aarhus C., Denmark

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ABSTRACT

Making up for air pollution related mortality and accounting for the number of deaths has become an important environmental indicator in its own right, but differences across the Atlantic over how to account for these are making it difficult to find common ground in climate policy appraisals, where co-benefits from reducing air pollution of fossil fuels is to be factored in. This article revisits established quantification methodologies for air pollution related mortality applied by government agencies in USA and EU. Demographic lifetables are applied to explore uncertainties over latency periods and the number of affected victims. These lifetable simulations are based on WHO consensus estimates for the mortality risk ratio related to long-term exposures and suggest an average loss of life expectancy of 9–11 years for an annual air pollution exposure increase of 10 $\text{ug}PM_{2.5}/m^3$. With a common OECD base value approach the air pollution costs related to fossil fuels are found to be about 3 times lower with EU versus US methodology.

1. Introduction

Recent years has seen increased interest in including the co-benefits of reduced air pollution from fossil fuels in appraisals of climate and energy policies (OECD, 2014; World Bank and IHME, 2016). For emerging economies, with levels of air pollution from fossil fuels subject to less stringent regulations, recent studies for Mexico, South Africa and India underline that energy transitions providing deep reductions in conventional air pollutants are offering substantial health and welfare benefits against the costs of climate mitigation policy (Barker et al., 2010; Eto et al., 2013; Thambiran and Diab, 2011). China probably represents the most compelling case, as has been pointed out by many (World Bank, 2007). The benefits from improved air quality could well offset the greater part of mitigation costs, with 75–85% for Europe as a lower bound conservative estimate (cf. Schucht et al., 2015).

There are considerable challenges in accounting appropriately for the lives lost from air pollution and in monetizing benefits from reductions in fossil fuels. While the potential significance was highlighted over 20 years ago by IPCC (1995:215), an international consensus on the underlying health science has been accomplished only recently (WHO, 2013). Bringing this knowledge base to good use is nevertheless complicated by government agencies in USA and EU having adopted different methodologies. Many energy transition studies and even studies directly addressing air pollution, that are making use of cost estimates as indicators, pay scant attention to the issues involved (Pascal et al., 2013).

The objective here is to analyze and explore the different approaches and rationales in USA and EU in view of present knowledge on air pollution related mortality, more specifically the numbers, age profiles and years of life lost by air pollution victims. The analysis places methodological differences with regard to co-benefits in perspective and should be of interest to all readers and users of studies with air pollution deaths included. It also aims to inform international institutions looking for common ground in accounting for air pollution deaths from fossil fuels.

2. A harvesting effect of air pollution and its implications

Cost-benefit analysis in USA relating to air pollution proceeds from a standard approach whereby abatement measures preventing premature mortality are considered according to the number of statistical fatalities avoided, which are appreciated according to the value of statistical life (VSL) (presently USD 7.4 million) (IEc, 2010).

In contrast, and following recommendations from the UK working group on *Economic Appraisal of the Health Effects of Air Pollution* (EAHEAP, 1999), focus in Europe has been on the possible changes in average life expectancy resulting from air pollution. The point of

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E-mail address: msa@envs.au.dk

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departure has been indications from air pollution episodes that victims are mainly elderly citizens in poor health (e.g. Schimmel and Murawski, 1976:318). Chilton (2004) provides the following non-technical explanation of the phenomenon; "for some people in their 70's and 80's with existing heart or lung disease, the unusually high level of pollution on a bad air day can put so much extra stress on their breathing, that their heart fails and they cannot be revived. Often these people are not expected to live very much longer anyway, but a bad air day can bring their death forward. If the bad air day had not occurred, they could have lived a few weeks or months longer, although this time would have been spent in their existing poor state of health".

Consequently government agencies in Europe, including the European Commission, apply a methodology for costing of air pollution that is based on accounting for lost life years, rather than for entire statistical lives as is otherwise customary in economic appraisals in Europe. Whereas the average traffic victim, for instance, is mid-aged and likely to lose about 35–40 years of life expectancy, pollution victims are believed to suffer significantly smaller losses of perhaps only one or a few years (EAHEAP, 1999:64; Friedrich and Bickel, 2001). To avoid overstating the benefits of air pollution control, these are treated as proportional to the number of life years lost.

The quintessence of these assumptions is the hypothesis of a harvesting effect from air pollution (first proposed by Schimmel and Murawski, 1976:317), according to which "the increased mortality associated with higher pollution levels is restricted to very frail persons for whom life expectancy is short in the absence of pollution" (Zeger et al., 1999:171). The harvesting hypothesis has been disputed by analysis showing that, at least for the immediate months following an air pollution episode, there is no netting out of mortality rates, while being unable to account for any longer term displacement (Schwartz, 2000, 2001; Zeger et al., 1999).

In Europe the specific number of life years lost as a result of changes in air pollution exposures are estimated based on lifetable methodology (see Section 3 on Materials and methods), and monetized with Value-Of-Life-Year (VOLY) unit estimates (Holland et al., 1999; Leksell and Rabl, 2001). The theoretical basis is a life-time consumption model according to which the preferences for risk reduction will reflect expected utility of consumption for remaining life years (Hammitt, 2007; OECD, 2006:204).

Where the European Commission in sensitivity calculations has considered the number of statistical fatalities, the air pollution specific VSL applied is reduced by 30% to reflect the value of avoiding merely 'deaths brought forward' among seniors (based on a panel recommendation (European Commission, 2001) and studies suggesting that the willingness-to-pay for risk reductions peaks at mid-age (Aldy and Viscusi, 2007)). In USA proposals from the Office of Management and Budget (OMB) for a comparable approach with reductions for elderly led to a public outcry against the use of a 'senior death discount' and the passing of a resolution in Congress abolishing application by federal agencies (WP, 2003). Concerns are underpinned by economists maintaining that life is a more precious good at older age (Krupnick, 2007; Krupnick et al., 2005). The Science Advisory Board of the US-EPA has concluded that the existing economics literature does not provide clear theoretical or empirical support for using different values for mortality risk reductions for differently-aged adults, nor does it support a constant value of a statistical life year (cf. US-EPA, 2007; NCEE, 2010:12).

Air pollution costs, as a result of these conventions, are appreciated entirely differently across the Atlantic.

In Europe VOLY values have been deducted from a traffic-related VSL under the assumption that a mid-aged traffic victim loses approximately 35–40 years of life-expectancy. The much lower VSL values customary in Europe (presently €2.2 million) add decisively to the differences. Chilton (2004) was the first study to elicit directly the willingness-to-pay expressed in VOLY's in an air pollution context. The results from this and other studies with wider geographical coverage (Alberini et al., 2006; Desaigues et al., 2011; Markandya et al., 2004) have been interpreted to suggest that VOLY estimates correspond relatively well to estimates derived from a European traffic-related VSL (OECD, 2006:206), when VSL is considered to represent the discounted[1] stream of values relating to life years lost by traffic victims.

In Europe it is frequently stated that lifetable methodology cannot predict the number of air pollution victims, precluding a fatality/VSL approach (Desaigues et al., 2011; Rabl, 2005, 2006). Still, some sources provide figures for the number of lost life years per individual whereby victim frequencies are implicit (Hollander and Melse, 2005; Watkiss et al., 2005).

Death is always sudden, but the timescale of exposures triggering the event may differ. While air pollution episodes with peak concentrations (e.g. the 1952 'London fog') have been confirmed to trigger acute mortality, supposedly among vulnerable and elderly individuals, it is less clear to which extent a possible 'harvesting effect' applies to mortality related to longer term exposures to elevated air pollution concentrations. It is often referred to as 'chronic mortality', not to be confused with chronic diseases, due to the permanency of exposures. Schwartz (1989:310) defines chronic exposure as "the average of the exposure measurements taken in the previous 365 days", while Chilton (2004) provides the following non-technical explanation "some chemicals in the air may cause wear and tear on our bodies, so that people living in areas with more pollution may age faster and die younger than people in low pollution areas". It follows that chronic exposure will often be linked with latency, involving a mortality time lag.

Previous research addressing the harvesting effect is based on inspection of time-series on mortality and was published before chronic mortality findings based on large cohort studies had been verified, indicating that acute deaths are only the tip of an iceberg of more profound premature mortality impacts from long-term air pollution exposures (Pope et al., 1995, 2002). More recent investigations by WHO and others have fallen short of providing specific estimates of the premature mortality in question. It is hence relevant to revisit and explore the age profile of air pollution fatalities more carefully as a basis for considering the different approaches in EU and USA. The assumption regarding a harvesting effect of air pollution deserves more attention in view of its critical role in justification of the European approach and its implications for mortality valuation of acute as well as chronic deaths.

3. Material and methods

The evidence base for air pollution related chronic mortality applied in impact assessments is in both EU and USA provided by meta-reviews of the literature according to which an increase in annual air pollution concentrations of 10 ugPM2.5/m3 is associated with an all-cause mortality risk ratio (RR) of 1.06 (Holland, 2014; IEc, 2010:219; WHO, 2013:12). This estimate is in line with the study related to the American Cancer Society cohort by Pope et al. (1995, 2002), which identifies specific risk ratios for cardiopulmonary mortality and lung cancer as well. It provides the starting point for the methodology outlined here.

While the primary epidemiological studies hold data for age profiles of air pollution victims, it is not possible with these data to directly estimate how many years they would or could have lived and hence the number of years lost. For this purpose lifetables that hold detailed demographic data for expected survival probabilities

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[1] Discounting reflects the fact that a benefit some time in the future is less valuable to people than an immediate benefit.