COMMITTEE ON THE MEDICAL EFFECTS OF AIR POLLUTANTS

STATEMENT ON ESTIMATING THE MORTALITY BURDEN OF PARTICULATE AIR POLLUTION AT THE LOCAL LEVEL

SUMMARY

1.   COMEAP's report[1] on the effects of long-term exposure to air pollution on national mortality in the UK[2] has led to interest in estimating the mortality burdens associated with local levels of air pollution. This statement summarises our thinking on this question, and on how local estimates of mortality burden can be made.

2.   Our estimates of the national mortality burden associated with the 2008 levels of particulate air pollution were felt to be useful in communicating the importance of air pollution and its effects on public health. Local estimates might be valuable in the same way. We recommend simplified methods for carrying out these calculations which strike an appropriate balance between accuracy and the availability of data and specialist expertise.

3.   We note that the Health Protection Agency (HPA) intends to produce more detailed guidance on how to obtain and handle the data required to calculate the local mortality burdens associated with particulate air pollution.[3]

INTRODUCTION

4.   At the end of 2010, the Committee published its report "The Mortality Effects of Long-Term Exposure to Particulate Air Pollution in the United Kingdom". This included national estimates of the mortality in 2008 associated with particulate air pollution. We recognise that there is interest in carrying out similar assessments at a more local level: local level information may be more powerful than national data in communicating the importance of the health impacts of air pollution to both elected representatives and the public.

5.   We have been asked by the Health Protection Agency (HPA) to comment on technical considerations that might be particularly relevant to local, rather than

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[1] COMEAP (2010): The Mortality Effects of Long-Term Exposure to Particulate Air Pollution in the United Kingdom.

[2] The estimates of mortality burden were expressed as numbers of deaths and the years of life lost associated with those deaths, and also as loss of life expectancy from birth.

[3] See COMEAP website for further information on this and other related work, and links.

national, assessments and to advise on the appropriateness of possible approaches to such calculations. This statement provides our technical advice on these issues. The aim was to provide recommendations for a method that is simple to implement but defensible scientifically. The HPA may use these recommendations as a basis from which to develop more detailed guidance on estimating local mortality effects associated with particulate air pollution.

6.   This statement presents easy-to-implement methods which in our view will, in many instances, be sufficient for calculation of local mortality burden associated with particulate air pollution. It then discusses their strengths and weaknesses. Annex 1 provides further background to this topic, including a summary of the method used to develop our national estimates and an introduction to the simplifying assumptions underlying estimates of burden.

7.   The focus of this statement is a quantitative method to address the question "What is the mortality burden of air pollution on the local population?" The mortality *burden* is the effect on mortality attributable to air pollution at *current* levels; the statement considers the estimation of the mortality effects, in a given year, of long-term exposure to current levels of particulate pollution within the existing local population. The statement is not intended to provide information about the public health benefits that would result from measures to reduce air pollution; i.e. it does not dis*cuss ap*proaches to estimate the *impact* on mortality attributable to *changes* in air pollution at a local level.

8.   It is our view that it is more appropriate to undertake calculations of the burden associated with anthropogenic air pollution than with total concentrations. This is the approach taken in our national estimates of both the mortality impact and the mortality burden associated with long-term exposure to particulate air pollution (COMEAP, 2010). Estimates based on total $PM_{2.5}$ might give a misleading impression of the scale of the potential influence of policy interventions, as there is little that can be done to reduce pollution from natural sources.

9.   Although this statement focuses on estimating the mortality burden, we recognise that air pollution also affects morbidity and that air pollution-related illness is an additional burden on the population. Similarly, there are effects on mortality of short-term exposure to other pollutants (e.g. ozone) although the mortality burden of these is understood to be much smaller than the mortality burden of long-term exposure to fine particles. Estimations of burden are likely to be undertaken with a view to their use in communicating the public health significance of air pollution; we strongly suggest that such communication should also include mention of these other impacts.

RECOMMENDATIONS

Metrics

10.   We recommend methods to estimate local mortality burden in three metrics:
- Attributable fraction
- Attributable deaths and
- Years of life lost to the population

Attributable fraction

11.   In this context, the attributable fraction is the proportion of the local mortality burden (in terms of deaths) attributable to long-term exposure to particulate air pollution. We anticipate that this will be useful to local decision-makers faced with decisions about prioritising action to tackle different public health risks in their local area.

Attributable deaths

12.   Calculation of "deaths attributable to air pollution" will provide a local estimate of the effect of particulate air pollution on mortality in a metric (number of deaths) widely used in communication of public health risks. Nonetheless, it should not be interpreted as the number of individuals whose length of life has been shortened by air pollution, as this would only be true if air pollution were the sole cause of deaths. Rather, it is an estimate of the total mortality effect in the local population: the distribution of the mortality effect within the population is unknown although we have speculated (COMEAP, 2010) that the maximum number of deaths to which air pollution may have partially contributed is likely to be that of deaths from cardiovascular causes. Thus, we consider it more appropriate to express the results of such calculations as 'an effect on mortality equivalent to '*X*' deaths at typical ages'. Similar considerations apply to estimates of deaths attributable to other risk factors such as smoking or obesity which increase the risk of death from e.g. cardiovascular causes, without necessarily being the sole cause of these deaths in individual people.

Years of life lost to the local population

13.   The public health significance of a risk factor for mortality, such as air pollution, depends not only on the number of attributable deaths but also on the age at which the additional deaths occur, and the loss of life associated with this. Long-term exposure to particulate air pollution increases the mortality risk at typical ages of death, i.e. there is no clear evidence that, among adults aged about 30 years or more, age-specific death rates in particular age groups are disproportionately affected. Although not considered here, air pollution has been linked with an increase in risk of death among infants (WHO, 2005; COMEAP, 2008). There is an absence of evidence on long-term exposure and mortality in young people and young adults.

14.   As discussed in COMEAP (2010), the mortality burden attributable to air pollution can be estimated not only as attributable deaths, but also as the effect on

total population survival, i.e. the attributable years of life lost aggregated over the population as a whole. Although less widely used, we consider years of life lost as a more useful metric than attributable deaths for informing local decision-making, because it combines information on numbers of deaths and on age at death.

Loss of life-expectancy at birth

15.   We have not recommended a method for local estimation of loss of life-expectancy at birth, although we consider it to be a useful metric and included it in our national estimates of mortality burden. Such calculations typically involve the use of life-table analysis of age-specific death rates. These use data that are not readily accessible from published sources and the use of life-tables requires more specialist expertise than the simpler calculations recommended below. In addition, the problems of uncertainty and variability in small datasets (discussed later) apply particularly to data on age-specific deaths, as these are relatively rare events at the local level.

Methods

16.   Methods for undertaking calculations of each of these metrics are included in Annex 2.

DISCUSSION

Uncertainties and assumptions in both national and local assessments

17.   There are a number of uncertainties associated with estimating the mortality burden at a local level. Some of these uncertainties apply to a burden estimate at any level, including the national estimate. These general uncertainties are discussed in the 2010 COMEAP report. They include the uncertainties in applying the risk coefficient of 1.06 per 10 µg/m^3 increase in $PM_{2.5}$ for quantification in the UK. These have been expressed as a distribution with a 75% plausibility interval of 1.01-1.12, with a wider (95%) plausibility interval of 1.00-1.15 also recommended for quantification (COMEAP, 2009).

18.   The 2010 report explains a number of assumptions that underpin the calculation of the national burden estimates. There is discussion of the simplifying assumptions that underlie the estimates. One simplification is to treat the effects of long-term exposure to air pollution on mortality as if they are immediate (i.e. without any time lag for onset, which is known not to be the case). Alternatively, the results can be interpreted as the effect of past and current air pollution on mortality in 2008 (taking account of latency and cessation lags) if it is assumed that past pollution levels were similar to 2008, and the effect of past pollution on the population size and age structure in 2008 is ignored. Because neither of these assumptions is correct, it was recognised that the burden estimate is an approximation and should be regarded as such. This will also be true of such calculations undertaken at the local level, as indeed it will be also of estimates of burden attributable to other factors

(diet, obesity, smoking, alcohol) where there are time lags between 'exposure' and consequent mortality.

19.   As summarised in the 2010 report, there is additional uncertainty in any assessment of $PM_{2.5}$ concentrations below 7 µg/m^3, as this extrapolates beyond the lowest annual average concentration in the American Cancer Society study (Pope *et al*, 2002) used to derive the coefficient recommended by COMEAP (2009).

20.   Also, the modelling of annual average $PM_{2.5}$ concentrations has uncertainties, including whether or not to define particular sources as anthropogenic. However there is a strong evidence base for the modelling and the Committee considered that the resulting estimate of effect is of the right order of magnitude. It may be that more detailed $PM_{2.5}$ data are available at the local level than those underpinning the national estimate, though perhaps not for anthropogenic $PM_{2.5}$.

Uncertainties and assumptions enhanced in local assessments

Representativeness

21.   A number of the sources of uncertainty in the national estimates may become more important in calculations at the smaller scale. Some of these arise from the increased likelihood of differences between the local situation and the conditions of the study from which the relative risk (concentration response function) is derived[4] than is the case for the national calculations.

22.   The national estimates were based on annual average anthropogenic $PM_{2.5}$ concentrations modelled from urban and rural background data, irrespective of the composition or anthropogenic source of the particles. In its 2009 report on mortality risks, the Committee considered in detail possible variations in toxicity between the various components of $PM_{2.5}$, and especially whether secondary particles were as toxic as other components of $PM_{2.5}$, e.g. primary combustion particles. While recognising that there may be variations in toxicity, COMEAP (2009) did not find sufficient evidence to allow quantification of the components separately. Instead, the risk coefficient for all-cause mortality of 1.06 per 10 µg/m^3 increase in $PM_{2.5}$ was applied to the total concentration of anthropogenic $PM_{2.5}$.

23.   We have not revisited this conclusion during our discussion of local assessments, nor do we know of major new evidence that would now permit better quantification of any toxicity differences that may exist; and so we consider that this approach (of applying the same coefficient to $PM_{2.5}$, whatever its source or composition) is the best that can be used currently to quantify the mortality effects of the local pollutant mix. However, we note that additional uncertainty is introduced if the contributions of different sources and, hence, components to the total anthropogenic $PM_{2.5}$ concentrations are not the same in the locality assessed as in the country as a whole. Therefore, we recommend that this additional uncertainty is acknowledged appropriately in the discussion and interpretation of local estimates of mortality burden, especially where there is reason to believe that local $PM_{2.5}$ is strongly affected by untypical sources.

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[4] See the Annex for a summary of the basis of the national calculations.

24.   Another important uncertainty concerns the relationship between the modelled background $PM_{2.5}$ concentrations at the residential address (used as a proxy for exposure of the resident population) and the range of personal exposures experienced by the population under consideration. The relationship between personal exposure to air pollution and modelled background $PM_{2.5}$ concentration in the vicinity of an individual's home depends on a number of factors, including the variety of conditions locally and how widely people travel. The risk coefficient derives from a study assessing differences in mortality between cities on the basis of different city-wide background $PM_{2.5}$ concentrations. It can be expected that the further an assessment differs from this basis, the greater the uncertainty in the resulting estimate.

Variability and instability in small datasets

25.   Estimations of burden at the local level, calculated using the methods recommended here, are based on considerably smaller numbers of deaths than those involved in the national calculations. Consequently, year-on-year variations in local annual numbers of deaths are typically larger (in percentage terms) than in annual national numbers of deaths, leading to greater uncertainties if data from a single year are used for local estimates. This problem can be reduced by combining data from several years to estimate mortality burden. (Unless there is some catastrophic event, or sudden change in demographics, underlying death rates in an area tend to change slowly over time, but there may be appreciable year-on-year variations around this relatively stable underlying trend.)

26.   Year-on-year variability is particularly an issue at the local level for the number of deaths at a specific age. This is one of the reasons why we have not recommended using age-specific remaining life expectancy associated with attributable deaths in the calculation of attributable years of life lost to the local population.

Approximation introduced by the recommended methods

27.   We recognise that the estimates of local mortality burden associated with particulate air pollution produced by our recommended methods might be less accurate than those generated by applying the methods used in the development of our national estimates. This is because of the greater number of approximations we suggest can be applied. These include:
- Linear scaling of the coefficient
- Use of total number of deaths rather than those at ages 30+
- Universal application of an average loss of life per attributable death of 12 years, regardless of the underlying mortality rate, population age-structure and socio-economic status of the local area.[5]

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[5] An initial exploration of whether average loss of life associated with attributable deaths varied systematically with local life expectancy suggested that this was not the case.

KEY POINTS

28.   We have recommended methods for use in estimating the local mortality burden of long-term exposure to particulate air pollution (as $PM_{2.5}$). We consider that these recommendations strike an appropriate balance between the simplicity of undertaking the calculations (both in terms of applying the method and the ease of access to the data required) and the likely accuracy of the resulting estimates.

29.   We recognise that estimates of burden are likely to be required at the Local Authority level and we think that the methods proposed are suitable for this purpose. We agree also that the uncertainty would increase with decreasing size of the area and population under consideration especially if either the population, or the air pollution to which it is exposed, is untypical in some important respects.   The sources of uncertainty have been outlined above and thought is needed about how they may play out in any proposed application, whatever the size of the population or area being considered.

30.   Given these uncertainties, Members expressed different views on the usefulness of estimates for small populations and areas.   Some thought that estimates should not be undertaken at more local than Local Authority level.   Others considered that it is not practicable to develop guidance (e.g. based on population size or geographical area) on when a burden estimate may be too uncertain to be helpful – not least because this might depend on the use for which the estimate is intended.

31.   Our national estimates of the mortality burden associated with long-term exposure to particulate air pollution (COMEAP, 2010) are based on concentrations of anthropogenic $PM_{2.5}$.   We consider that this is the most appropriate basis for such calculations: burden estimates based on total $PM_{2.5}$ might give a misleading impression of the scale of the potential influence of policy interventions.   However, we note that there may be situations where only data on total $PM_{2.5}$ would be readily available;   if a burden estimate were to be generated using these, the basis of the calculation should be made clear.

32.   We would strongly reiterate that any burden estimate is an approximation and should be regarded as such, with attention given to the range of uncertainty around any central estimate derived.   This is even more the case for estimates at a local level, due to both the additional uncertainties inherent in calculations at the local scale and the approximations in our recommended methods.

33.   Methods are available that might give more accurate estimates of mortality burden, but their implementation requires more specialist expertise and data which are less readily accessed. We are, of course, happy if people undertake these more accurate methods in addition to, or in place of, those proposed here, if they wish to, with the caveat that life-table calculations based on local data may be unstable if the associated numbers of age-specific deaths are small.

RECOMMENDATIONS FOR FUTURE WORK

34.   We would encourage the HPA to develop guidance on undertaking local assessments. We suggest that the production of estimates of local burden for the whole of the UK at Local Authority level may be a cost-effective approach to this area of work. Alternatively, Local Authorities may consider working together to undertake or commission calculations of burden estimates.

35.   While this statement provides general guidance, we recognise that those undertaking or commissioning local assessments may have more specific questions to be addressed, for example on how the size of some of the uncertainties identified here vary with size of the local area and its annual numbers of deaths. Calculations and simulations to explore these uncertainties would be worthwhile.

36.   The recent report by COMEAP (2010) made a number of recommendations for further work with respect to estimating and communicating the mortality burden of air pollution. These are also of relevance to local assessments.

37.   We suggest some monitoring of whether, over time, individual local burden estimates are undertaken using different methods; and if so, whether a formal evaluation is needed.

COMEAP
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References

COMEAP (2008) Statement and Supporting Papers on the Effects of Air Pollution on Children's Health. Available from:
http://comeap.org.uk/component/content/article/28-page-linking/56-childrens-health-statement-and-supporting-papers.html

COMEAP (2009) Long-Term Exposure to Air Pollution: Effect on Mortality. Available from: http://www.comeap.org.uk/documents/reports/63-long-term-exposure-to-air-pollution-effect-on-mortality.html

COMEAP (2010) The Mortality Effects of Long-Term Exposure to Particulate Air Pollution in the United Kingdom. Available from:
http://www.comeap.org.uk/documents/reports/128-the-mortality-effects-of-long-term-exposure-to-particulate-air-pollution-in-the-uk.html

Pope, C.A., Burnett, R.T., Thun, M.J., Calle, E.E., Krewski, D., Ito, K., Thurston, G.D. (2002) Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. *JAMA*, **287**, 1132-1141

WHO (2005) Effects of Air Pollution on Children's Health and Development: A Review of the Evidence. World Health Organization, European Centre for Environment and Health, Bonn Office.

ANNEX 1

Background

1.   In 2009 COMEAP recommended a risk coefficient associating an increase in $PM_{2.5}$ of 10 µg/m^3 with an increase in relative risk for all-cause mortality of 1.06 (plausibility interval 1.01-1.12). This was based on the coefficient reported in the study of the American Cancer Society (ACS) cohort by Pope *et al.* (2002). The Committee used this risk coefficient in the calculations published in its 2010 report, which were based on mortality and pollution data from 2008. The report includes predictions of the effects on mortality that would result from pollution reductions of (a) 1 µg/m^3 and (b) "all anthropogenic" $PM_{2.5}$ in England and Wales, Scotland and Northern Ireland. These were summed to give UK predictions.

2.   An estimate of the mortality burden of anthropogenic $PM_{2.5}$ carried by these populations was also made. This was calculated in two ways and reported as (a) a reduction in life-expectancy from birth and (b) a number of attributable deaths and the loss of life (population survival time) associated with those deaths. To reflect the Committee's understanding that it is more likely that air pollution is one of several contributing factors to death, rather than being the sole cause of individual deaths, an expression of the results of the calculation of attributable deaths as 'an effect equivalent to '*X*' deaths at typical ages' was preferred.

Method used for the national estimate of burden

3.   The risk coefficient describes the association between mortality effects and long-term average $PM_{2.5}$ concentrations determined at background air pollution monitoring sites within each metropolitan area in the ACS study. To be consistent with this, the modelling of $PM_{2.5}$ levels used to calculate the UK's mortality burden was based on data collected at urban and rural background, but not roadside, monitors across the UK in 2008. Source-apportionment was undertaken to allow the estimation of the effects of only anthropogenic air pollution, which was the focus of the Committee's interest. The modelled concentration of anthropogenic $PM_{2.5}$ within each 1 km x 1 km square was then multiplied by the population resident within the square. The sum of this product over all of the squares in the UK was divided by the total population to calculate a national population-weighted mean $PM_{2.5}$ concentration. This was then used in the subsequent calculations of mortality effects.

4.   The calculation of mortality burden required data on the total number of deaths in 2008 for men and women at each age 30 and over. This was multiplied by an impact factor expressing the relative risk associated with the population-weighted mean concentration of anthropogenic particulate air pollution, as $PM_{2.5}$. The calculated numbers of deaths, at each age, attributable to air pollution were then summed to give a total number of attributable deaths at all ages of 30 and over. The loss of population survival time associated with these deaths was calculated by multiplying the number of deaths attributable to air pollution at each age (and by sex) with the age-specific remaining life expectancy of that age and sex. The sum of

these figures provided the estimate of the total years of life lost in 2008 attributable to air pollution.

5.   A separate estimate of the reduction in life expectancy of the 2008 birth cohort due to air pollution was undertaken.   This is the difference between the life expectancy calculated using 2008 mortality rates, and that calculated when the mortality rates at ages 30 years and older were changed by the impact factor.

6.   A full description of the concepts, method and a discussion of the simplifying assumptions made in undertaking the estimation of mortality burden is provided in the 2010 COMEAP report.

ANNEX 2:

Methods

Calculating the attributable fraction

1.   For a given relative risk, RR, associated with a ubiquitous exposure such as outdoor air pollution, the proportion of disease (or deaths) that is attributable to that exposure (the population attributable risk fraction, or attributable fraction) is calculated by a simple formula: AF = (RR-1)/RR. This is often expressed as a percentage.[6]

2.   For example, the proportion of deaths attributable to 10 µg/m^3 of PM$_{2.5}$ air pollution, assuming an associated relative risk of 1.06, would be 100 × 0.06/1.06 = 5.7%.

3.   Estimates of mortality burden in a local area need to use a relative risk (and associated attributable fraction) reflecting the risk associated with the local population-weighted[7] annual average PM$_{2.5}$ concentrations under consideration[8]. The RR applicable locally can be approximated by linear scaling (i.e. by assuming that if 10 µg/m^3 leads to a 6% change in risk, then concentrations which differ by 1 µg/m^3 should lead to differences in RRs of 0.6%. From this, the local attributable fraction can be derived. Linear scaling is inexact[9] but this approach is unlikely to lead to practically important differences when estimating local RR and attributable fraction, particularly as the PM$_{2.5}$ concentrations under evaluation are not likely to be hugely different from 10 µg/m^3.

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[6] The formula above is a special case (for universal exposures) of the more general formula:
AF = p(RR-1) / [1 + p(RR-1)], where p is the prevalence of exposure to the cause of disease (or deaths) in the population under consideration.

[7] The population-weighted mean is a useful summary statistic, which greatly simplifies the calculation of human health impacts if the concentration–response function used is linear with no threshold. In our estimation of the national mortality burden of air pollution (COMEAP, 2010) the population-weighted mean was calculated by multiplying the 1 km x1 km concentration values by 1 km x 1 km population statistics from the 2001 census. The values for all of the grid squares were summed and then divided by the total population to calculate the population-weighted mean.

[8] Our national estimates (COMEAP, 2010) were of the burden associated with PM$_{2.5}$ from anthropogenic sources. Published data on the contribution of different sources to background (i.e. not roadside or kerbside) PM$_{2.5}$ concentrations were used to estimate background PM$_{2.5}$ concentrations originating from anthropogenic sources.

[9] The way of translating the RR to other PM$_{2.5}$ concentrations that best corresponds to the concentration response function from which it derives (based on a proportional hazards model) is through the power function: RR$_c$ = 1.06^(c/10). In the case of a burden estimate, c is the PM$_{2.5}$ concentration. This approach differs increasingly from linearity for higher relative risks and higher concentration increments. (This specific formula is applicable to coefficients - such as this one linking PM$_{2.5}$ concentrations with mortality risk - that are expressed in terms of RR per 10 units (here 10 µg/m^3). The denominator in the power term would be different for RRs expressed in terms of a different increment.)

Calculating attributable deaths

4.   An estimate of the number of deaths attributable to long-term exposure to air pollution in a local area is given by multiplying the attributable fraction by the number of deaths annually in the local area.

5.   To reflect the study from which the concentration response coefficient (relative risk) was reported, we used the number of deaths at ages 30 years or more in this calculation when estimating the national mortality burdens. However, the Office for National Statistics (ONS) in England and Wales publishes data on adult mortality in 10-year age groups of 25-34, 35-44 etc, so a figure of deaths at ages 30+ at the local level might not be easy to obtain. Similar considerations apply in Scotland and Northern Ireland. An estimate could be made by combining one half of the deaths in age group 25-34 with those for 35-44. However, such an adjustment seems unnecessary: the numbers of deaths below age 35 are a small proportion of the total, and the 'cut-off' at age 30 is based on lack of evidence at lower ages – it is possible and indeed plausible that long-term exposure to air pollution affects mortality risks in younger people also. We consider that, even if deaths below age 25 were included in the calculation (i.e. total number of local deaths), the difference between total deaths and those at ages 30+ would make only a small difference to the burden estimate.

6.   Because of the variability and instability in small datasets, the reliability of local burden estimates can be improved by using death statistics from a number of years combined (e.g. 3 or 5 years) rather than basing the calculation on the number of deaths reported locally in a single year, and we recommend that this be done unless the year-on-year variation in annual deaths is small, in percentage terms.

Calculating years of life lost to the local population

7.   The years of life lost to the population can be estimated by summing the years of age-specific remaining life expectancy associated with each of the attributable deaths. This is the approach we took when estimating the national burden of air pollution (COMEAP, 2010).

8.   As this method requires the use of complex life-table analysis, we suggest a simpler approach be used to generate local burden estimates: multiplying the calculated number of attributable deaths by the average loss of age-specific life-expectancy associated with attributable deaths in our national estimates, of approximately 12 years[10] (COMEAP, 2010). In recommending this approach we re-emphasise an important issue of interpretation. We look on this calculation - using the number of attributable deaths and the associated average loss of age-specific life-expectancy - as a computationally convenient way of estimating the total mortality burden, in terms of life-years lost in a given year aggregated over the whole population. As emphasised in COMEAP (2010) and noted again in Para 8 above, the number of attributable deaths should not be interpreted as the number of

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[10] This should not be regarded as the loss of life likely to be associated with each death affected by air pollution. A figure of 11½ years was calculated (COMEAP, 2010) as being the *average* loss of life if 29,000 deaths were affected by air pollution.

individuals affected; and whatever the number of deaths affected and the average loss of life, the actual amount of life lost would vary between individuals.