Appendix 17.2.4

Literature Review of Relative Risk (RR) Estimates of Short- and Long-term Exposure to Criteria Pollutants

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According to Air Pollution and Cancer (2013), recent estimates suggest that the disease burden due to air pollution is substantial. Exposure to ambient fine particles ($PM_{2.5}$) was recently estimated to have contributed 3.2 million premature deaths worldwide in 2010, due largely to cardiovascular disease, and 223 000 deaths from lung cancer. More than half of the lung cancer deaths attributable to ambient $PM_{2.5}$ were estimated to have been in China and other East Asian countries (Lim et al., 2012).

Epidemiological studies have been widely adopted to assess the health effects of air pollution. In Hong Kong, many time-series studies have been conducted to establish the relationships between health outcomes, including daily mortality, hospital admissions and general practitioner consultations (Wong TW et al., 1997; Wong CM et al., 1998; Wong TW et al., 1999; Wong TW et al., 2000; Wong TW et al., 2001; Wong TW et al., 2002a, b; Wong TW et al., 2003; Yu et al., 2004; Wong TW et al., 2006; Wong CM et al, 2010). Time-series approach is the most commonly adopted study design to investigate the short-term effects of air pollution on health. This design specifically caters for matched daily series of exposure and outcome data which aims (Schwartz J., 1994) to quantify adverse short-term effects of the current levels of air pollutants on health. In the time-series approach, statistical modelling is performed, taking into consideration the characteristic (approximately Poisson) distribution, over-dispersion and positive autocorrelation of the outcome data. Daily meteorological variables (temperature and humidity) and others (seasonal changes, holidays, day of the week, time trends) may be included as confounding variables in the statistical model. The health effects of individual pollutants expressed as the relative risks (RR, the ratio of the incidence of disease or death among those exposed to that among the non-exposed) or excess risks (ER, derived from the corresponding relative risk minus one) are then evaluated.

Short-term Impact on Mortality and Morbidity

According to the findings from a local time-series study, the maximum number of cardiorespiratory deaths (the sum of cardiovascular and respiratory deaths) was estimated to be 243 deaths per year, based on the relative risk of SO_2 which produced the greatest effect. The number of cardiorespiratory deaths attributed to NO_2, PM_{10} and O_3 were 134, 57 and 34, respectively (Wong CM, et al., 2002).

In a recent study by Wong CM, et al., (2010), an increase of 10 ug/m^3 concentration of pollutants was associated with an increased risk of cardiovascular and respiratory hospital admission of 1.00 % and 0.75% respectively for NO_2;, 0.58% and 0.60% for SO_2; 0.2% to 0.9% for PM_{10} and 0.12% and 0.81% for O_3. Another study by Wong CM et al. (2002) shows that, except for asthma, all the criteria pollutants (NO_2, SO_2, PM_{10} and O_3), were associated with an increased risk of hospital admissions across all the disease categories. For an increase of 10 ug/m^3 concentration, there was a 0.5% to 1.9% increase for NO_2; 0.5% to 2.4% increase for SO_2; 0.4% to 1.0% increase for PM_{10}; and 0.2% to 0.6% increase for O_3.

Studies on the effects of air pollution on mortality and hospital admissions in Hong Kong have concluded that there are significant associations between air pollutant concentrations with mortality and hospital admissions. All these studies show strong short-term effects of air pollutants on human health (Wong TW et al., 1997; Wong TW et al., 1998; Wong TW et al., 2002a; Wong TW et al., 2010). A time-series study on the effects of air pollution on general practitioner (GP) consultations in Hong Kong by Wong TW et al. (2003) showed that the excess risks of GP consultations for all respiratory diseases and upper respiratory tract infections (URTI) were highest for NO_2 (at 3.8% and 3.2%, respectively), and lower for O_3 (at 2.9% for all respiratory diseases and 2.5% for URTI) and PM_{10} (at 2.3% for all respiratory diseases and 2.2% for URTI). The results of the studies were compared with similar studies in UK. Both studies showed that there was a significant association between GP consultations for respiratory diseases and air pollutant concentrations (PM_{10}, $PM_{2.5}$, NO_2 and O_3 in Hong Kong, and PM_{10} and SO_2 in UK). Findings from this study and from other earlier Hong Kong studies (Wong, TW et al., 2001; Wong, CM et al., 2002; Wong, CM et al., 2010) provide evidence that short term air pollution contributes to a significant amount of morbidity for respiratory and cardiovascular diseases in the community. It has been recommended that whenever local data are available, their use would be preferred for the assessment of health effects. The Wong, CM et al., 2010 study is the most recent, large scale and multi-city study led by a HK researcher. The study duration is around 7 years ranging from Yr 1996 – 2002. The study was under PAPA Program and was initiated by the Health Effects Institute in part to support the Clean Air Initiative for Asian Cities (CAI-Asia), a partnership of the Asian Development Bank and the World Bank to inform regional decisions about improving air quality in Asia. Other HK studies are either older (Wong TW et al, Occup Environ Med 1999), or less comprehensive in the coverage of air pollutants (Qiu et al, Environ Health Perspect 2012). Hence, we have selected the RR derived by this paper for short term health risk assessment.

The relevant ER data for short-term mortality and hospital admission for various pollutants are listed in **Table A17.2.4.1**.

Table A17.2.4.1: %Excess risk (95% confidence interval) of mortalities and morbidities attributable to a 10μg/m^3 increase in air pollutant concentration

Air Pollutant	All-cause Mortality (All ages)	Cardio-vascular Mortality	Respiratory Mortality	Cardio-vascular Diseases	Respiratory Diseases
NO_2	1.03 (0.69-1.37)	1.38 (0.75-2.01)	1.41 (0.67-2.15)	1.00 (0.73-1.26)	0.75 (0.50 - 1.00)
PM_{10}	0.51 (0.23-0.80)	0.63 (0.11-1.16)	0.69 (0.08-1.31)	0.58 (0.36-0.80)	0.60 (0.40-0.80)
$PM_{2.5}$	-	-	-	-	-
SO_2	0.91 (0.40-1.42)	1.23 (0.27-2.21)	1.31 (0.21-2.43)	0.98 (0.53-1.39)	0.13 (-0.24-0.50)
O_3	0.34 (0.02-0.66)	0.63 (0.04-1.23)	0.36 (-0.33-1.05)	0.12 (-0.12-0.37)	0.81 (0.58-1.04)

Notes:

[1] Reference: Wong CM et al, 2010

[2] % Excess risk = (relative risk - 1) %

Long-term Impact on Mortality

Cohort studies are methods designed to study the long-term health effects of air pollution. Several cohort studies have been conducted, mainly in U.S: the Harvard Six Cities study (Dockery et al., 1993), the Seventh Day Adventists Study (Abbey et al., 1999), the American Cancer Society cohort study (Pope et al., 1995) which has been extended in a recent paper (Pope et al., 2002). A recent report on the effect of long-term exposure to air pollution on mortality has studied the scientific evidence on the long-term health effect of pollution (COMEAP, 2009; WHO, 2013a). For mortality, $PM_{2.5}$ is a stronger risk factor than the coarse part of PM_{10}. (WHO, 2013b)

$PM_{2.5}$ has been associated with lung cancer mortality (or incidence) in studies carried out in different parts of the world and among non-smokers (Dockery et al., 1993; Beeson et al., 1998; McDonnell et al., 2000; Pope et al., 2002, 2004; Laden et al., 2006; Beelen et al., 2008; Katanoda et al., 2011; Turner et al., 2011; Raaschou-Nielsen et al., 2011). One extended follow-up study, the Harvard Six Cities Study from 1974 – 2009, demonstrated that the association between PM2.5 exposure and lung cancer mortality was statistically significant, with a linear concentration – response relationship without a threshold observed down to the PM2.5 level of 8 μ m/m^3 (Lepeule et al., 2012).

Positive associations between SO_2 and mortality have also been found in some but not all studies. Moreover, the associations of all-cause mortality with long term exposure to NO_2 and CO are unconvincing. It has been also showed that the overall evidence is weak for the effect of long-term exposure to ozone on mortality.

A literature review has been conducted. The American Cancer Society study by Pope (2002) was a mega scale (involving follow-up of some 500,000 people), long duration (from 1979 – 2000) and was quoted by many studies, such as Health Effects of Particulate Matter, 2013 and WHO Air Quality Guidelines Global Update 2005. Hence, this study was adopted in deriving the RR. The relevant excess risk (RR – 1 or ER) data for long-term mortality for various pollutants are listed in **Table A17.2.4.2**.

Table A17.2.4.2: %Excess risk (95% of confidence interval) of mortalities for $10\mu g/m^3$ increase in levels of air pollutants

Air Pollutant	All-cause Mortality	Cardiopulmonary Mortality	Lung Cancer Mortality
NO_2	Effects cannot be separated from PM_{10} or $PM_{2.5}$ effects		
PM_{10} [1]	5 (Not Statistically Significant)	16.3 (Not Statistically Significant)	28.5 (Not Statistically Significant)
$PM_{2.5}$ [2]	4 (1-8)	6 (2-10)	8 (1-16)
SO_2	WHO recommends a 24 hr AQG of 20 $\mu g/m^3$. No annual AQG is recommended.		
O_3	WHO considers evidence for O_3 to produce chronic effects on health as insufficient to recommend an annual AQG.		

Notes:

[1] McDonnell et al., 2000.

[2] Pope et al., 2002.

[3] Evidence for a separate RR of mortality for long-term exposure to PM_{10} is insufficient, but RRs for short-term exposure are well-documented.

[4] It is difficult to separate the long-term effects of NO_2 from PM and other traffic generated fumes. WHO maintains a long-term Air Quality Guideline of 40 $\mu g/m^3$.

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